

BME Design-Spring 2026 - Graduated Bowman's Probes Complete Notebook

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NEEL SRINIVASAN

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**Team contact Information**

CALEB WHITE - Apr 29, 2026, 9:00 PM CDT

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Project description

CALEB WHITE - Apr 29, 2026, 9:01 PM CDT

Course Number: BME 301

Project Name: Graduated Bowman Probe

Short Name: Graduated Bowman Probe

Project description/problem statement:

Design and prototype a set of Bowman probes with scribed measurements which would enable annotation of nasolacrimal system findings during probing procedure.

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (tear duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacriflow, Nunchucku, Monoka), to confirm patency of the nasolacrimal system.

Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies.

About the client:

Dr. James Law

Ophthalmology/Oculoplastics

UW Department of Ophthalmology and Visual Sciences



2/4/26 - Client Meeting #1

CALEB WHITE - Feb 06, 2026, 12:39 PM CST

Title: Client Meeting #1

Date: 02/06/2026

Content by: Caleb White

Present: Caleb White, Caden Robinson, Neel Srinivasan

Goals: Meet Dr. James Law and ask all questions the group came up with to gain clarification on the expectation and idea behind the project.

Content:

Organizational questions:

1. What is the best way to reach you? What about the alternate contact?
 1. Who should be our primary contact for this project?
 1. Email is the best way to contact
2. How can/ should we access the \$100 budget?
 1. Budget: Is \$100 budget flexible or set?
 1. Flexible budget

Design Questions:

Have actual numbers engraved on the probe that give feedback of how deep the probe is in, if the blockage is 6 mm in would be good to know how deep you are in into the duct.

Main usage is 0 and 00 and ½----- 3, 4, 5, 6 hardly used

- Are there specific guidelines to creating a probe? Are we actually creating a probe from scratch or improving an existing one?
- Are you interested in us producing different sizes of probes/ curved probes?
 - Straight
- Are there any specific features you want? Materials, shape, graduated mechanism
 - No engravings - want more like laser or different color for markings
- Are these probes specifically used to remove obstruction from the nasolacrimal passageways?
- What specifically about the probe do you want to see on it?
 - Marker for measurement, maybe number
- Do you want real time feedback on measurements? When using the probe, would you want to be able to see the exact measurements?
 - Diagnostic tool, wants measurements like lines
- In what ways do you want our design to be similar to the [Calibrated Bowmans' Probe](#)
 - In what ways do you want our design to be different?

Who are the probes meant to be used on? Demographic wise

Dr. James Law mainly works on adults

Color changing would require a very quick and rapid thermosensitivity - needs to change color within seconds, unsure about autoclave and how it could react with high temp. Laser engraving could be better route

February 23rd Monday 10 am

Richard Allen videos of nasolacrimal duct probing could be helpful

Conclusions/action items:

With the new acquired information, the team can effectively complete the PDS and begin to formulize an actual idea for the project. All discussion and research can be tailored round this information and a sense of where the project is heading can be formulized. We will reach out to Dr. Law with further questions and hopefully meet Dr. Landingham



2/18/26 - Bowman Probe Pickup

CALEB WHITE - Feb 19, 2026, 5:18 PM CST

Title: Bowman Probe Pickup

Date: 02/18/2026

Content by: Caleb White

Present: Caleb White

Goals: Meet Dr. James Law at 2880 Marshal Court, the location of the Ophthalmology Wet Lab and pickup Bowman Probes and discuss testing design.

Content:

This was a brief meeting with Dr. Law as he was working, but the main purpose was to pick up a sample set of Bowman Probes to not only give the team some hands-on feel with the devices but also to use as a demonstration for clarity for our preliminary design presentation. I met Dr. Law and whilst giving me the probes we discussed plans for testing. He was curious when the team was going to have a functional probe ready by because he wants to set up an accurate timeline with Dr. Landingham. They both desire to use human cadaveric subjects were measured lacerations would be made with the duct. From this, several medical residents would then guess the length of the laceration, half with a normal probe and the other half with a graduated probe. The accuracy of each groups general estimations would be assessed for statistical significance in relevance to the actual length of the laceration. We also briefly discussed the OR visit we had planned. Though it does not seem like we will be able to attend Monday 02/23 because of lengthy paperwork, we will still be able to go at some point as long as the paperwork is completed.

Conclusions/action items:

With the probes now acquired, the group can begin to actually visualize the work that will be done on such a microscale. Hearing Dr. Law and Dr. Landingham's testing advice was very good because it is not only a good idea but provided assurance that they are committed to actually implementing the graduated modification as a permanent solution to their issues. The group should also look out for an email for the OR paperwork so we can at some point attend.



2/25/26 - Amazon Probe Pickup

CADEN ROBINSON - Apr 29, 2026, 8:59 PM CDT

Title: Amazon Probe Pickup

Date: 02/25/2026

Content by: Caden Robinson

Goals: Pick up probes and check in with Dr Law.

Content: This was a short meeting that basically covered the logistics of ordering the surgical grade probes once these probes were fabricated. He was also curious about the timeline with when the prototypes will be done. He mentioned the possible work with and IRB but that seems like its going to be later down the line. He is a lot more focused on completing a proof of concept. There wasn't much more worth noting to the conversation after that.

Conclusions/action items: This was a good short meeting that allowed us to begin fabricating our first designs with the sample holder and actually begin marking the probes. Although this meeting was short, it made things seem very achievable and it was very nice to know we had lots of support while working on our designs.

begin creating sample holder and graduated probe prototypes



4/24/2026 - Poster Presentation

CALEB WHITE - Apr 24, 2026, 11:29 PM CDT

Title: Poster Presentation

Date: 04/24/2026

Content by: Caleb White

Present: Caleb White, Caden Robinson, Neel Srinivasan, Cole Miller

Goals: Present our final poster to our client Dr. Law

Content:

Dr. Law came to our presentation so that we could give our final presentation to him. Dr. Law was very pleased with the projects work and would like to continue the project moving into later semesters. The group is very interested in continuing the project due to the market application and experience we could gain through the patent and IRB application. Dr. Law provided information about a presentation that he and Dr. van Landingham will give about the cadaveric testing that was performed and the graduated probes fabricated. Using our final paper and our data, Dr. Law will be able to provide notification about the potential for this graduated probe which will give us very good insight into the market capability and general interest of a bowman probe.

Conclusions/action items:

Dr. Law came to our poster and was very pleased with the results. Dr. Law and the group are interested in continuing with the project next year as both see a lot of actual market application. We would like to contact Dr. P to ask if this would be a possible scenario for next year.



1/30/2026 Advisor Meeting #1

CALEB WHITE - Apr 26, 2026, 4:56 PM CDT

Title: Advisor Meeting #1

Date: 1/30/2026

Content by: Caleb White

Present: Caleb, Neel, Cole

Goals: Get acquainted with the Advisor and TA and set up general expectations for the semester.

Content:

The full team was decided at the project draft and all project roles were set. The team has begun preliminary research to begin to get information on the subject matter and have contacted the client to set up an initial meeting to set semester and project expectations.

- Team:
 - Began researching Bowman's Probe material composition, uses, existing/competing designs, and community impact
 - Reached out to client and advisor to schedule meetings

- Neel Srinivasan:
 - Conducted literature search & review for relevant materials, costs, and uses for Bowman's Probes
 - Watched videos on Bowman's Probe usage during nasolacrimal duct obstruction procedures

- Caden Robinson:
 - Met with the team and discussed positions and dates for meeting with the client
 - Started looking at competing designs
 - Began researching procedures where bowman probes are used

- Caleb White:
 - Met the team and discussed everyone's roles for the semester, myself being assigned the BWIG, responsible for the group's website.
 - Began researching all things Bowman Probe including the biological context for creation and in what clinical applications they are utilized.
 - I also looked into the economic standpoint of Bowman Probe in the current economy and their projected growth as a medical device with the gradual increase in general epiphora and other ophthalmological medical issues.

- Cole Miller:
 - Contacted Client to set up meeting
 - Performed preliminary research on background of project

- Performed literature search to find reliable sources to inform project

Conclusions/action items:

- Generate necessary design questions for first client meeting
- Continue general research & add to LabArchives
- Assign sections and work on PDS



2/06/2026 Advisor Meeting #2

CALEB WHITE - Apr 26, 2026, 4:58 PM CDT

Title: Advisor Meeting #2

Date: 02/06/2026

Content by: Caleb White

Present: Caleb, Neel, Caden

Goals: Discuss first week accomplishments and set up goals for the following week.

Content:

- Team:
 - Collectively finished PDS
 - Continued background research on bowman's probes, nasolacrimal duct obstruction, laser etching etc.
 - Met with client to pose initial design questions and understand his requirements

- Neel Srinivasan:
 - Began researching laser engraving along with material side effects due to etching
 - Finished individual sections of PDS
 - Met with client and posed questions

- Caden Robinson:
 - Continued to research about nasolacrimal blockages
 - Met with client to discuss design specifications
 - Finished drafting the PDS

- Caleb White:
 - Continued research, specifically looking into laser engraving techniques as well as the appropriate surface restoration processes.
 - Met the client and brought up all relevant concerns and questions for the project, gaining a solid basis of expectation for the project going forward.
 - Completed the miscellaneous section of the preliminary design specifications deliverable.

- Cole Miller:
 - Continued research on background information
 - Organized client meeting and brainstormed questions for client
 - Finished individual sections of PDS

Conclusions/action items:

- Brainstorm ideas and build design matrix
- Continue background research
- Potentially acquire a set of probes from Dr. Law



2/13/2026 Advisor Meeting #3

CALEB WHITE - Apr 26, 2026, 5:00 PM CDT

Title: Advisor Meeting #3

Date: 02/13/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Collectively worked on and completed design matrix
 - Continued research into methods of line markings for design matrix and general background knowledge

- Neel Srinivasan:
 - Worked with team on design matrix evaluation
 - Researched potential of electroplating/changing color of stainless steel alloy to accomplish graduating the probe

- Caden Robinson:
 - Met with team to discuss different prototype options and create design matrix
 - Continued to research potential options for creating markers for measurement on the probes

- Caleb White:
 - Researched prototyping and design options for the bowman probe design matrix, specifically electroplating and the potential of electroplating the graduated markings on the probe.
 - Met with the team to complete the design matrix, having a thorough discussion of design criteria and design ratings.

- Cole Miller:
 - Met with team to work on design matrix
 - Continued research on design options for design matrix

Conclusions/action items:

- Create slides and practice preliminary presentation
- Assign sections and complete preliminary report
- Begin research on necessary information based on chosen design from matrix
- Reach out to Dr. Law to inquire about probe ordering



2/20/2026 Advisor Meeting #4

CALEB WHITE - Apr 26, 2026, 5:01 PM CDT

Title: Advisor Meeting #4

Date: 02/20/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Created & practiced preliminary presentation as a team
 - Met with Dr. Ohnsorg to improve design matrix
 - Continued research to properly rank design choices in matrix

- Neel Srinivasan:
 - Continued research into laser annealing processes and available options on campus
 - Met with team virtually and practiced preliminary presentation

- Caden Robinson:
 - Created my section for the preliminary presentation
 - Met with the team to practice for the presentation

- Caleb White:
 - Contributed to the teams preliminary report.
 - Met with Dr. Law to receive Bowman Probe set and discuss testing methods.
 - Set up a meeting with Prof. Pfefferkorn for sometime next week to talk laser annealing.

- Cole Miller:
 - Worked on preliminary presentation
 - Practiced presenting and delivered presentation with team

Conclusions/action items:

- Assign sections of preliminary report to team members and complete by Wednesday
- Continue researching into specific laser annealing procedures, safety measures, and relevant standards
- Meet with Professor Pfefferkorn to discuss if he is able to help us with our project



2/27/2026 Advisor Meeting #5

CALEB WHITE - Apr 26, 2026, 5:03 PM CDT

Title: Advisor Meeting #5

Date: 04/26/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Delivered preliminary presentation
 - Completed preliminary report
 - Arranged meeting with Professor Pfefferkorn

- Neel Srinivasan:
 - Worked on individual sections of preliminary report
 - Delivered preliminary presentation with team
 - Researched how the team needs to program laser annealing machine for millimeter markings if Professor Pfefferkorn says this method can be done

- Caleb White:
 - Worked with the team to complete the preliminary report
 - Met with Prof. Pfefferkorn, with Neel, to gain insight into the feasibility of the fabrication design
 - Began to research paste and tape options for laser oxidization of material to create color change desired.

- Cole Miller:
 - Worked on sections of preliminary report
 - Delivered preliminary presentation with team

Conclusions/action items:

◦

Evaluate design options/fabrication plan based on meeting with Professor Pfefferkorn

- o

Begin laser annealing design & fabrication

- o

Continue to research and update lab archives



3/6/2026 Advisor Meeting #6

CALEB WHITE - Apr 26, 2026, 5:04 PM CDT

Title: Advisor Meeting #6

Date: 03/06/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Had individual conferences with Professor Ohnsorg and received group feedback on preliminary presentations
 - Reached out to Professor Williams to ask for design and fabrication advice
 - Reached out to Professor Pfefferkorn to update and inquire about his labs help with prototype fabrication

- Neel Srinivasan:
 - Revised and continued research into the differences between laser annealing and marking as Professor Pfefferkorn informed the team that there is a difference between the two
 - Began researching necessary frame/structures that we could build to keep the probe steady during the actual laser marking procedure to ensure uniformity

- Caden Robinson:
 - Researched different properties of stainless steel and how laser annealing affects them
 - Learned about autoclaving with laser annealing to see how higher temperatures and pressures affect the oxidation layers on the probes

- Caleb White:
 - Got in contact with Pfefferkorn after meeting with the Makerspace, discussed connecting with one of his graduate students.
 - Researched CerMark and TherMark, 2 spray/paste options that could be used for the laser marking of the probes.
 - Began to consider a formalized testing procedure that needs to be curated as the fabrication timeline to the first prototype will not be very long.

- Cole Miller:
 - Conducted additional research on laser marking techniques and their compatibility with stainless steel medical probes.

- Investigated potential laser parameter settings (power, speed, and frequency) that could produce consistent and readable markings without damaging the probe surface.

Conclusions/action items:

- Begin fabrication & have at least one prototype ready for show and tell on March 20, 2026
- Research necessary ceramic coatings for the laser marking procedure
- Research fixture fabrication methods for uniform laser marking procedure



3/13/2026 Advisor Meeting #7

CALEB WHITE - Apr 26, 2026, 5:04 PM CDT

Title: Advisor Meeting #7

Date: 03/13/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Worked on arranging meetings with Professor Pfefferkorn and his graduate students
 - Began brainstorming design and material ideas for fixture device
 - Worked on fabrication and testing plan for remainder of the semester

- Neel Srinivasan:
 - Researched viability of different materials that could be used in the laser bed machines
 - Researched chemistry behind ceramic coatings used in laser marking procedures
 - Worked with team to come up potential design ideas for fixture

- Caden Robinson:
 - Researched how different types of steel can affect the aerosol laser setting reaction
 - Created CAD file for potential apparatus used to secure the bowman probe while laser marking
 - Created prototype/testing protocols

- Caleb White:
 - Reached out to Pfefferkorn to get laser specs and coordinated meeting time with the graduate student Hassan.
 - Contacted Dr. Law, having him order the CerMark USA samples required for fabrication formula testing
 - Created a prototype design for the laser bed in order to keep probe graduation constant.

- Cole Miller:
 - Researched different materials to be used with the laser bed
 - Worked with team to create design ideas for fixture
 - Worked with team to create testing protocols

Conclusions/action items:

- Prepare for show and tell by having a fixture model and potential probe ready to display and receive feedback
- Finish fabrication plan
- Meet with Hassan and Professor Pfefferkorn
- Create design plans and fabricate fixture for laser marking procedure



3/20/2026 Advisor Meeting #8

CALEB WHITE - Apr 26, 2026, 5:05 PM CDT

Title: Advisor Meeting #8

Date: 03/20/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Met with graduate student Hassan in Professor Pfefferkorn's lab
 - Created 1st Bowman's Probe prototype using oxidation markings
 - Prepared and practiced elevator pitch for Friday's show and tell

- Neel Srinivasan:
 - Met with team and Hassan to obtain an initial prototype using oxidation markings
 - Met with team to discuss future plans for fabrication and testing
 - Created cad files/designs to meet laser fixture design requirements
 - Worked with team to prepare elevator pitch for show and tell

- Caden Robinson:
 - Met with the team and Hassan to obtain initial prototype and parameters for the laser machine
 - Discussed fabrication of the holder and if its even needed
 - Brainstormed ideas for the elevator pitch for show and tell
 - Discussed what award the team will decide to go for at the end of the year

- Caleb White:
 - Met with Hassan of Pfefferkorn's lab and learned the workings of the 200W fiber laser.
 - Assisted in creating our first graduated prototype.
 - Brainstormed probe holder ideas now that we are aware of what the laser stage looks like.
 - Prepared for the senior show and tell by creating rough draft elevator pitches to ensure I can get my point across with brevity.

- Cole Miller:
 - Prepared for show and tell by drafting pitches to best explain our project
 - Practiced for Show and Tell with team

- Continued to draft probe holder ideas based on newly learned information

Conclusions/action items:

- Work on executive summary draft as a team, and figure out which design award we'd like to pursue
- Obtain Ceramark and create a Ceramarked prototype, and then compare the different versions
- Fabricate the laser fixture after receiving feedback from seniors during show and tell



3/27/2026 Advisor Meeting #9

CALEB WHITE - Apr 26, 2026, 5:06 PM CDT

Title: Advisor Meeting #9

Date: 03/27/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Continued research to decide on viability of Ceramark for the graduation of Bowman's probes
 - Discussed methods to include smaller(~1mm) markings as requested by Dr. Law
 - Worked on implementation of received feedback from show and tell

- Neel Srinivasan:
 - Worked with Caleb to design and fabricate laser fixture at ECB
 - Created CAD files to model laser fixture
 - Researched methods beyond Ceramark to add 1mm markers in a different color

- Caden Robinson:
 - Investigated show and tell suggestions
 - Worked with team to fabricate prototype
 - Continued research into methods of creating smaller markers

- Caleb White:
 - Spoke to Hassan to get laser bed specifications in regard to laser range and size of fixture.
 - Worked with Neel to fabricate the probe holder using the ECB machine shop.
 - Communicated with Dr. Law about the CerMark products getting an estimate on arrival time and verified cadaver testing procedure.

- Cole Miller:
 - Created alternative designs for laser fixture
 - Researched viability of show and tell suggestions
 - Investigated alternative methods of creating markers

Conclusions/action items:

- Work on executive summary draft

- Continue researching best methods for adding distinguishable 1mm markers
- Enjoy spring break



4/10/2026 Advisor Meeting #10

CALEB WHITE - Apr 26, 2026, 5:07 PM CDT

Title: Advisor Meeting #10

Date: 04/10/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Met with Hassan to discuss laser fixture requirements
 - Worked on executive summary draft
 - Worked on engineering judgement assignment & reflected on its applicability to our project

- Neel Srinivasan:
 - Picked up parts with Caleb for second version of laser fixture
 - Researched manufacturing techniques for aluminum & stainless steel processing
 - Worked with team on creating a testing timeline

- Caden Robinson:
 - Drafted up protocols for autoclave testing
 - Found an alternative way to create the sample folder for probe fabrication
 - Worked to create the executive summary with the team

- Caleb White:
 - Helped the team complete both the ethics in engineering and executive summary draft.
 - Set up several meetings with Hassan, first to establish that the new holding fixture material was adequate and second for probe fabrication.
 - Went with Neel to the ECB shop to find a non reflective stainless steel piece for the probe holder.

- Cole Miller:
 - Helped to complete the ethics in engineering assignment
 - Worked to create executive summary with team
 - Worked with team to plan testing timeline

Conclusions/action items:

- Complete all probe fabrication

- Begin autoclave and incubator testing and reach out to Dr. Law about thawing cadaver if specimens
- Finish executive summary



4/17/2026 Advisor Meeting #11

CALEB WHITE - Apr 26, 2026, 5:08 PM CDT

Title: Advisor Meeting #11

Date: 04/17/2026

Content by: Caleb White

Present: Everyone

Goals: Discuss week accomplishments and set up goals for the following week.

Content:

- Team:
 - Created and assigned testing protocols to team members
 - Worked on executive summary as a team
 - Worked on elevator pitch for executive awards

- Neel Srinivasan:
 - Ran incubation testing to observe degradation of bowman probes in artificial tear solution
 - Collaborated with team to obtain probes from Hassan
 - Worked with Caleb on microscope framing and probe measurements

- Caden Robinson:
 - Worked with team & Hassan to manufacture laser marked prototype probes
 - Began planning autoclave cycle testing
 - Worked with team on executive summary for design awards

- Caleb White:
 - Worked with Hassan to finish full probe fabrication.
 - Developed an agar and gelatin based phantom nasolacrimal conduit for tissue pull testing.
 - Conducted tissue pull testing using microscope observation and weight alteration

- Cole Miller:
 - Assisted team with planning testing
 - Analyzed microscope images to determine accuracy of markings
 - Completed executive summary with team

Conclusions/action items:

- Work on executive awards elevator pitch

- Finish, practice, and deliver poster presentation
- Complete testing and data analysis



2/26/2026 - Prof. Pfefferkorn Introduction

CALEB WHITE - Apr 26, 2026, 5:42 PM CDT

Title: Prof. Pfefferkorn Introduction

Date: 02/26/2026

Content by: Caleb White

Present: Caleb and Neel

Goals: Discuss the possibility of using Prof. Pfefferkorn's expertise and laboratory equipment for our graduation needs

Content:

Neel and I set up a meeting with Prof. Pfefferkorn to get his insights into probe marking. After being denied by the Makerspace, we were searching for an alternative access to a laser. Discussing with Prof. Pfefferkorn, he first of all showed great enthusiasm for the project and was very confident that he could provide help for us. Discussing some terminology, he told us annealing was really the right jargon to be using and marking was a more general, and more accurate depiction of what we were trying to do. Prof. Pfefferkorn told us about his laboratory's laser and gave us confidence that it contained the capabilities for such a small scale. He gave us several points of advice to move forward with getting real markings. He first told us to look into some sort of application paste for black mark oxidation. He also told us to think about a fixture which could be used to uniformly hold the probes in place. He gave us the contact of one of his graduate students, Hassan, who he believed had the time to help us with our endeavors.

Conclusions/action items:

- Look into paste/tape applicators for clear black mark oxidation processes
- Generate some design ideas for a probe holder which could be used for precise uniformity of markings
- Reach out to Hassan to set up a time to get acquainted and get a tour of the laser setup.



3/18/2026 - Hassan Meeting #1

CALEB WHITE - Apr 26, 2026, 5:54 PM CDT

Title: Hassan Meeting #1

Date: 03/18/2026

Content by: Caleb White

Present: Caleb, Neel, Caden

Goals: Meet Hassan and learn about the laser both in its standard use and how it's modularity could be used for our project.

Content:

Caden, Neel, and I met with Hassan outside of Prof. Pfefferkorn's lab after finally setting up a meeting with him. Getting a time where we could all meet was a struggle but we were now ready to learn about the laser. The laser is a very large 200W LasX industries industrial grade laser. It is confined in a walled area with various cameras inside to give live visuals of the laser state. The laser head itself is not crazy large and the laser bed is quite small. The laser bed was circular, very different to the rectangular beds we have experience with. The laser is also fixed locationally and can only be adjusted through distal nozzle changes, altering the angle of the laser output. Using some of the amazon probes we received from Dr. Law, we tested out the laser. The first markings were very dark and very deep but there was no indication that the 420 stainless steel was incompatible with the laser itself. We then tested out various power output levels using a large rectangular steel block in order to get an understanding of how soft the laser could be. The client has clearly expressed concern about tissue snag and wants us to be weary about cutting too deep into the probe shafts. Once a relatively appropriate power output level was chosen, we used a small 5mm square to create a very rough prototype of 5mm graduation along a probe. We ended up marking each mark twice because of the square vector file setup which caused slight inaccuracy in the graduation and made the markings themselves too deep. Other than these errors however, the probe seemed to hold promise with some laser adjustments.

Conclusions/action items:

- Having seen the bed, develop an appropriate holding fixture for the probes to sit on.
- Order the CerMark materials that have been researched
- Work with Hassan to define better laser parameters.



01.24.2026 - Problem Identification - Calibrated Bowman's Lacrimal Probe

CALEB WHITE - Jan 24, 2026, 3:32 PM CST

Calibrated Bowman's lacrimal probe

Abstract: Epiphora due to the nasolacrimal duct and canaliculus obstruction is a commonly encountered clinical problem by every ophthalmologist in their day-to-day practice. Assessment of level of lacrimal system blockage using traditional method may lead to erroneous readings without any intraoperative guide for the distance reached by the surgeon. In this review, the difficulty during procedure, therapeutic procedure, usage of novel probes has been discussed. In some kind of probes on some sides, there will be a mark placed at every 1 mm to know the distance reached from the punctum.

Introduction: To improve the diagnostic as well as therapeutic ability in the novel technology related to the lacrimal drainage system, authors have made an effort by progressively engineering the machine to evaluate the ocular condition of the probe using cutting edge laser technology (Fig. 1). The probe is a new value from engineering with a novel 7 mm (Fig. 1 to 2) or 10 mm (Fig. 1B) and the other end has a measuring scale at every 1 mm (Novel 7 to 10 mm) (Fig. 1c).

Conclusion: With the help of routine probes, the procedures are time-consuming and may give a false reading about the site of obstruction. But using a calibrated probe, the exact site of obstruction from the lacrimal punctum can be measured with the probe accurately, as small as 1 mm distance. Similarly, in cases of canaliculus obstruction, the level can be ascertained with the probe before the canaliculus trephination. Using a calibrated Bowman probe, the level of obstruction within the lacrimal system can be made out more accurately with minimal wastage of crucial time.

References:

1. Kulkarni AB. Use of novel lacrimal probes. Indian J Ophthalmol. 2018;66(3):478.

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calibrated_bowman_s_lacrimal_probe.37.pdf (672 kB)

CALEB WHITE - Jan 24, 2026, 3:08 PM CST

Title: Problem Identification - Calibrated Bowman's Lacrimal Probe

Date: 01/24/2026

Content by: Caleb White

Goals: Further understand the need for a graduated Bowman's probe, specifically, why a regular, non-calibrated, non-graduated, Bowman's probe creates problems during clinical procedure.

Search Term: Bowman's Probe

Citation: Pujari A, Bajaj MS, Sharma P. Calibrated Bowman's lacrimal probe. Indian J Ophthalmol. 2018 Mar;66(3):478. doi: 10.4103/ijo.IJO_1063_17. PMID: 29480277; PMCID: PMC5859621.

URL: [Indian Journal of Ophthalmology](http://www.indianjournalofophthalmology.com)

Content:

Epiphora due to the nasolacrimal duct and canaliculus obstruction is a commonly encountered clinical problem by every ophthalmologist in their day-to-day practice. Assessment of level of lacrimal system blockage using traditional method may lead to erroneous readings without any intraoperative guide for the distance reached by the surgeon.

With the help of routine probes, the procedures are time-consuming and may give a false reading about the site of obstruction. But using a calibrated probe, the exact site of obstruction from the lacrimal punctum can be measured with the probe accurately, as small as 1 mm distance. Similarly, in cases of canaliculus obstruction, the level can be ascertained with the probe before the canaliculus trephination. Using a calibrated Bowman probe, the level of obstruction within the lacrimal system can be made out more accurately with minimal wastage of crucial time.

Conclusions/action items:

Because traditional Bowman's probe readings are very much up to subjective perception by the clinician, erroneous, incorrect assessment is more common than desired which can lead to undesired consequences including infection and injury to the lacrimal duct. To prevent this, an intraoperative measuring system is required.



02.12.2026 - Design Matrix

NEEL SRINIVASAN - Feb 13, 2026, 11:27 AM CST

Title: Graduated Bowman Probe Design Matrix

Date: 2/12/26

Content by: Whole Team

Present: Whole Team

Goals: To attach a PDF of the team's completed design matrix

Content: See file attached below

Conclusions/action items:

Work on preliminary presentation & report.

NEEL SRINIVASAN - Feb 13, 2026, 11:28 AM CST



Design Matrix

Graduated Bowman's Probes

Team Members:
Leader/BPAG: Neel Srinivasan
Communicator: Cole Miller
BSAC: Caden Robinson
BWTG: Caleb White

Client: Dr. James Law

Advisor: Dr. Monica Olmsorg

Lab Section: 304

February 12, 2026

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Graduated_Bowman_Probe_Design_Matrix.pdf (376 kB)



04.07.2026 - Ethical Considerations

CALEB WHITE - Apr 07, 2026, 11:44 PM CDT

Title: Ethical Considerations

Date: 04/07/2026

Content by: Group

Present: All

Goals: Discuss the ethical considerations of the project

Content:

What components of your design have ethical dimensions (be specific and list at least 2)?

Possibility of probes breaking during the procedure. Patients need to be aware of the potential risk of probe breakage, and it is our responsibility to make sure graduated versions of probes are mechanically similar to unmarked ordinary probes. Since the nasolacrimal duct obstruction procedure holds a level of invasiveness into the nasolacrimal duct and, of course, deals directly with the human body, transparency of potential mechanical failure is necessary. In order to improve confidence in this matter, formal testing procedures should be carried through to prove equivalence to the ungraduated predecessors in terms of mechanical integrity. Another potential point of ethical dilemma involves the laser marking process & creation of oxide layer. Generation of the oxidation-induced marks degrades a portion of the chromium oxide layer present on the stainless steel probes. Due to the small nature of the oxidation markings, the oxide layer should spontaneously reform over the marks, and therefore excessive corrosion should be prevented. However, if this oxide layer were not to reform, this could lead to sequestration of metal ions from the base layer, causing potential allergic reactions in patients during procedures. Again, complete transparency of this possibility should be outlined prior to the procedure, and confidence in this matter should be built through formal testing procedures involving material degradation testing and biocompatibility analysis. Additionally, if the probe is ground down, it 4 BME 301: Engineering ethics might not be properly cured or rounded at the tip, which may lead to a rough edge. This rough edge would introduce the possibility of impacting and damaging the epithelial lining and nasolacrimal tissue present within the duct. Due to the importance of the eye to the patients' quality of life and the close proximity of the procedure to the organ itself, it is extremely important that this potential scenario be once again completely communicated and will be a major point of decision for patients in accepting or deferring the procedure. For all three of these design aspects, safety is a tradeoff. Bowman's probes are a trusted medical component of ophthalmological procedures, and therefore changing the probes in any way will only bring doubt. In order to improve the functionality of the probe, inclusion of graduated markings brings about several points of potential failure and patient concern that need to be addressed. Whether to offer the patient the choice of an ungraduated or graduated probe for the procedure would be another ethical consideration. If the graduated probe introduces more possible points of risk for the patient but also increases the doctor's ability to appropriately diagnose, it is a tradeoff of safety versus accuracy that should potentially be given to the patient.

How will your team address the ethical dimensions? (What is your action plan?)

Our team will ensure full transparency in releasing testing results and disclosing these results to the surgeon applying the procedure. Multiple testing procedures will take place to better understand if these concerns could be a reality. Included in the testing procedures will be use of the probes on cadaveric specimens to see not only the improved accuracy of the probes but also the prevalence of these new points of risk. If problems are apparent, then obvious design changes would need to be made. It is very important to be clear about the intention of the testing procedures and explain how their results indicate a certain characteristic that either increases or decreases potential harm. When the probes are first introduced for an actual live procedure, a choice of type of probe should be given, and data on actual patients should be built. Hopefully, with enough quantitative backing and professional opinion, inclusion of the graduated probes into regular practice will be a reality.

Conclusions/action items:

It is important when designing projects that have actual market intention, to consider the ethical implications associated with the project. Ethical contemplation of all perspectives of the transaction of the product and for the use of the device are necessary for complete ethical considerations.



[Bowman Probe BPAG Expense Spreadsheet - Google Sheets](#)

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Component 1								
Set of Bowman's probes	A set of unmarked Bowman's probes used in duct procedures for the team to practice fabrication and testing	Premium Instrument	B0777N38SV	2/25/26	3	\$16.99	\$50.97	Link
Component 2								
CerMark 2 oz Aerosol Ultra	A 2 oz aerosol can of CerMark ULTRA Aerosol spray used for laser marking of various materials including metals and ceramics.	CerMark USA	CULTRA.A2	3/11/2026	1	\$17.00	\$17.00	Link
LMM6018 CerMark USA white sheet tape	A small 2"x6" sheet of white tape used for laser marking definition on typically metal surfaces.	CerMark USA	CLMM6018.SH2	3/11/2026	1	\$8.00	\$8.00	Link
Component 3								
9.54mm x 76.09 x 115 mm Aluminum 6061	Non reflective aluminum used for laser fixture fabrication	ECB Stock Room	N/A	4/10/26	1	~\$5.57	\$5.57	N/A
TOTAL:	\$81.54							



Bowman Probe Graduation Protocol

CALEB WHITE - Apr 24, 2026, 11

Title: Bowman Probe Graduation Markings

Name of fabrication step/portion of prototype: Bowman Probe Graduation Markings

Date to be completed: Apr 2, 2026

Team member(s) fabricating: Whole Team

Detailed sketch of portion of prototype being fabricated (include dimensions):



Detailed bulleted steps of fabrication:

- Obtain and put on a pair of clean nitrile gloves and an available respirator or surgical mask.
- Obtain a Bowman probe and place it on a flat table with a layer of disposable parchment underneath, making sure the surrounding area is open and absent of anything that may be damaged were it sprayed.
- Acquire the CerMark ULTRA A2-Ultra Aerosol 2 oz Spray and apply as described in the following steps.
- Coating Application:
 - Shake the aerosol can with moderate vigor for 10 seconds before use to achieve a homogenous suspension of marking material inside the can [1].
 - Start spraying away from the area to be marked in order to build up spray velocity to prevent uneven coating.
 - Apply CerMark evenly across the probe using the spray, making sure to spray uniformly at a 10" distance from the surface and move the nozzle from one side to the other, covering the whole substrate area.
 - Use a left-to-right swaying motion in order to prevent any uneven surfaces. Focusing on one location could lead to buildup at one spot and therefore uneven CerMark distribution.
 - Make sure the layer of coating is an acceptable thickness by measuring with a wet film thickness gauge. Optimal wet film layer thickness for metal laser marking is 0.5–2 mils [2].
 - Let the Cermark coating dry; it usually takes two minutes, but time can be sped up using a hair dryer or heat gun on a low heat setting. If the coating layer was not thick enough, apply a second layer after the first layer has dried.
 - If both sides are to be marked, wait for one side to dry and then flip the probe over on the parchment and repeat the coating process.
- Obtain the Bowman probe laser holder and place it into the laser bed near the corner so each end of the holder is flush with the wall of the laser bed.
- Place the probe into the groove on the inside of the holder and secure the probe down using screws around the semicircle holes in the middle of the probe.
- Aim and locate the fiber laser at the end of the probe tip that will be marked, using the manual machine laser controls.
- Adjust the laser frequency and power output to within the ranges of 50-100 kHz and 5-15 W [3].
- Put on protective eyewear and other personal protective equipment.
- Use the Mark feature on the laser marking machine to highlight the parameters of where marking should be done and select the generated laser file from the desktop.
- Laser File Generation:
 - Open a vector file-compatible software (e.g., Inkscape, Adobe Illustrator).
 - Set the document units to millimeters and match the size of the document to the dimensions of the laser bed being used.
 - Draw a single vertical line and copy and paste the line, spacing each line by the specified 5 mm amount until the intended marking distance is achieved.
 - Export the file into a .DXF or .SVG format.
 - Upload the file onto the computer and place it within the laser software.
- Press the start button and step away from the machine.
- When the markings are finished, close the software and turn off the machine.
- Wait several minutes before removing the probe and holding fixture from the laser bed to allow things to return to room temperature.
- Unscrew the probe from the fixture and wash and/or wipe away any of the excess unbonded coating material.

Probe Holder Fabrication #1 Protocol

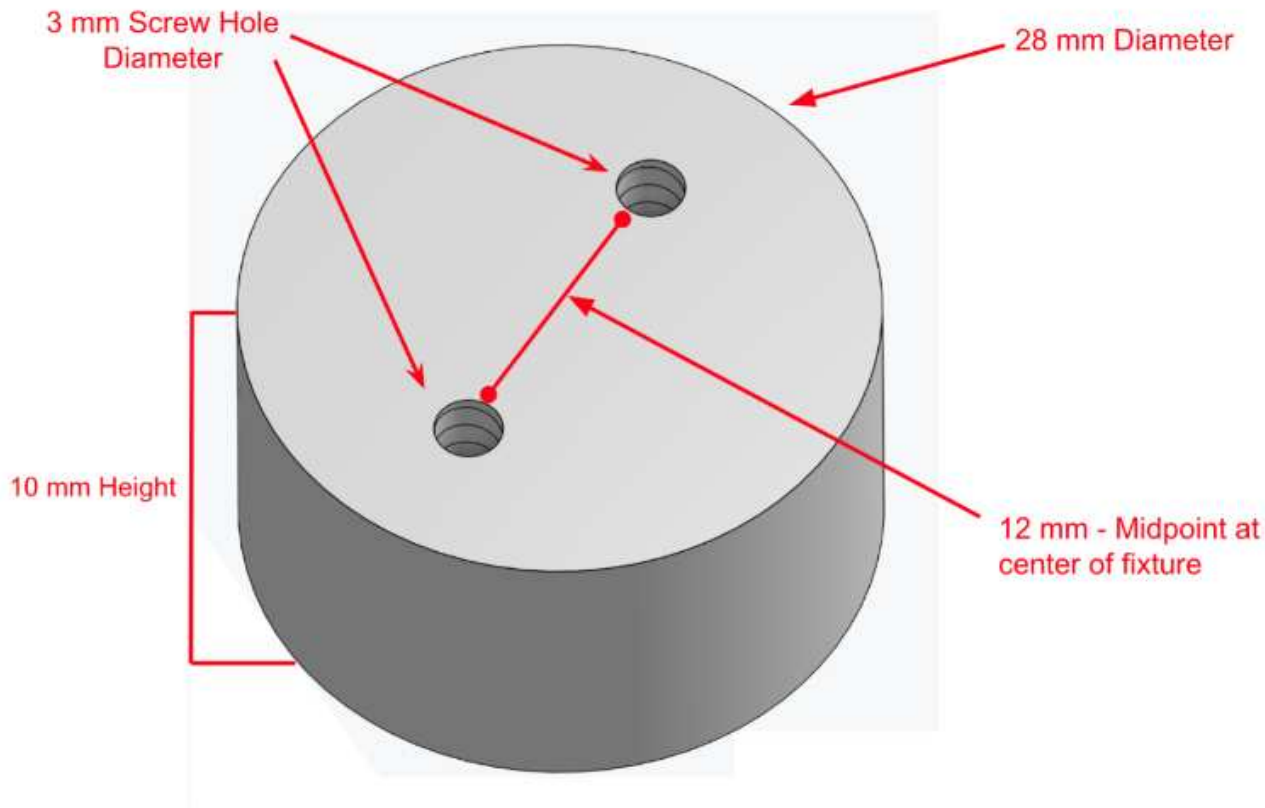
CALEB WHITE - Apr 24, 2026, 10:19 PM CDT

Title: Bowman Probe Laser Holder

Name of fabrication step/portion of prototype: Bowman Probe Laser Holder

Team member(s) fabricating: Whole Team

Detailed sketch of portion of prototype being fabricated (include dimensions):



Detailed bulleted steps of fabrication:

- Obtain a piece of aluminum 6061.
- Use calipers to measure the diameter of the stock piece of aluminum.
- Secure a stock piece of aluminum in the Eisen engine lathe 1740G, and place the aluminum cutter attachment into the other end of the lathe.
- Touch the face on the right side of the part to the aluminum cutter and zero the x-axis.
- Touch the other edge of the part facing you to the aluminum cutter tool and zero the y-axis.
- Apply oil to the edges of the part that will be machined.
- Using the aluminum cutter attachment, remove the outer layer of aluminum until the diameter of the holder is 28 mm.
- Remove the part from the lathe.
- Use a tool to deburr the edges until they become smooth.
- Place the part into the clamps of the TRAK DPM2 mills with ProtoTRAK SMX controllers so that the 28-diameter face is directed upwards.
- Use a level underneath the part to secure it in place, and use a rubber hammer to anchor the part down into the clamp.

- Touch the top of the part with the mill and zero the z-axis, and touch off of the vertical edges of the part and zero the y-axis.
- Attach a $\frac{3}{8}$ " drill bit into the head of the mill. Adjust the placement of the drill so that when lowered, it would make a hole 6 mm away from the bottom edge.
- Lower the head of the mill slowly until it makes a 5 mm hole.
- Remove the drill head and insert the $\frac{1}{2}$ " drill tap.
- Begin tapping the hole, turning the tap 3 times clockwise and $\frac{1}{2}$ turn counterclockwise until it reaches the bottom.
- Use compressed air to remove any aluminum scraps, and make sure the $\frac{1}{2}$ screw fits inside the hole.
- Repeat the previous 4 steps to create a hole near the top edge of the part.
- Remove the part from the mill and double-check that the probe securely fits inside of the holder.



Agar + Gelatin + Charcoal Soft Tissue Mimic Protocol

CALEB WHITE - Apr 26, 2026, 6:18 PM CDT

Title: Soft Tissue Mimic Protocol

Stratified soft tissue

1. Obtain 600 mL beaker
2. Fill the beaker with 200 mL of DI water using a 1000 mL graduated cylinder.
3. Place the Beaker on a stir plate and heat till water temperature reaches approx 90 deg C
4. While water is heating, weigh out 8g agar and 24g gelatin on weigh boats
5. Place a stir bar into the beaker and create a vortex in the center of the beaker, approx 600 rev/min.
6. Slowly incorporate agar into beaker and mix until dissolved
7. Once dissolved, bring the heat of stir plate down to 50 deg C and let the beaker cool.
8. Obtain 50 mL of DI water in a 100 mL graduated cylinder.
9. Sprinkle gelatin into 50 mL to allow blooming.
10. Once the bloomed gelatin is translucent, and Agar solution has come down between 50 and 60 Deg C, slowly incorporate gelatin into solution vortex until fully dissolved.
11. If have charcoal powder, skip to step 15, if have charcoal stick, continue to next step.
12. Break off a small piece of the charcoal stick and place into mortar and pestle
13. Grind up charcoal at a medium vigor for a few minutes until relatively fine. (important to not make too fine as will not be distinguishable for the computer)
14. Obtain a 20 micron filter, a coffee filter for example, and sift charcoal powder through filter.
15. Using powder, weight out 1.0 g of charcoal powder.
16. Lower stir rate to approx 300 rev/min and incorporate charcoal into the agar+gelatin mixture.
17. Once completely incorporated, solution should look very dark.
18. Using a graduated cylinder, bring the volume of solution to 400 mL using DI.
19. Using 400 mL solution, fill 15 25mL cell culture flasks.
20. Place flasks into fridge overnight to allow solidification.



Soft Tissue Epithelial Protocol

CALEB WHITE - Apr 24, 2026, 10:46 PM CDT

Title: Soft Tissue Epithelial Protocol

Mucosal epithelium, 10 mL

1. Obtain a 50 mL beaker
2. Fill the beaker with 7 mL of DI water using a 10 mL graduated cylinder.
3. Place the beaker on a hot plate and heat to between 50 and 60 deg C
4. Weigh out 1.5 g of glycerin and 0.3 g of gelatin in respective weigh boats
5. Measure out 3 mL of DI water in a 10 mL graduated cylinder
6. Mix gelatin and 3 mL of DI to allow blooming.
7. Stir glycerin powder into 7 mL of DI once at the appropriate temperature.
8. Mix bloomed gelatin into the glycerin mixture and stir till homogenous.
9. Add glycine till desired mucus-like consistency has been achieved.
10. Add 1 drop of green food coloring to the mixture and stir until mixed.
11. Obtain agar + gelatin solution from fridge if fully solidified. (can check if solidified by lightly shaking or tapping lightly with the end of a scapula)
12. Slowly and carefully pull micropipet tips out of agar + gelatin solution.
13. Fill depression from pipet tip with gelatin + glycerin solution.
14. Put into the fridge to chill and allow slight solidification. (Note, it will not fully solidify, only become slightly mucousy.



Probe Holder Fabrication #2 Protocol

CALEB WHITE - Apr 26, 2026, 5:56 PM CDT

Title: Bowman Probe Laser Holder

Name of fabrication step/portion of prototype: Bowman Probe Laser Holder

Team member(s) fabricating: Whole Team

Detailed sketch of portion of prototype being fabricated (include dimensions):

Detailed bulleted steps of fabrication:

- Obtain a piece of aluminum 6061.
- Rent and hop onto a mille located i



Agar + Gelatin + Glycerin Soft Tissue Mimics

CALEB WHITE - Apr 29, 2026, 9:52 PM CDT

Title: Protocol for Agar+Gelatin+Glycerin Soft Tissue Mimics

Date: 4/14/2026

Content by: Caleb White

Present: Caleb White

Goals: To outline a protocol on how to create the Agar+Gelatin+Glycerin Soft Tissue Mimics for tissue pull testing

Content:

Materials:

1. 600 mL beaker
2. 10000 mL graduated cylinder
3. 100 mL graduated cylinder
4. 3 Weigh boats
5. 1 20 μ m filter
6. 8g Agar
7. 24g gelatin
8. 1g of charcoal powder (or 1 charcoal stick)
9. 1 stir/hot plate
10. 15 25mL centrifuge flasks
11. 1 stir bar
12. 1 scapula
13. 1 20°C fridge

Preparation:

1. Obtain 600 mL beaker
2. Fill the beaker with 200 mL of DI water using a 1000 mL graduated cylinder.
3. Place the Beaker on a stir plate and heat till water temperature reaches approx 90 deg C
4. While water is heating, weigh out 8g agar and 24g gelatin on weigh boats
5. Place a stir bar into the beaker and create a vortex in the center of the beaker, approx 600 rev/min.
6. Slowly incorporate agar into beaker and mix until dissolved
7. Once dissolved, bring the heat of the stir plate down to 50 deg C and let the beaker cool.
8. Obtain 50 mL of DI water in a 100 mL graduated cylinder.
9. Sprinkle gelatin into 50 mL to allow blooming.
10. Once the bloomed gelatin is translucent, and Agar solution has come down between 50 and 60 Deg C, slowly incorporate gelatin into solution vortex until fully dissolved.
11. If you have charcoal powder, skip to step 15. If you have a charcoal stick, continue to the next step.

12. Break off a small piece of the charcoal stick and place into mortar and pestle
13. Grind up charcoal at a medium vigor for a few minutes until relatively fine. (important to not make too fine as will not be distinguishable for the computer)
14. Obtain a 20 micron filter, a coffee filter for example, and sift charcoal powder through the filter.
15. Using powder, weight out 1.0 g of charcoal powder.
16. Lower stir rate to approx 300 rev/min and incorporate charcoal into the agar+gelatin mixture.
17. Once completely incorporated, the solution should look very dark.
18. Using a graduated cylinder, bring the volume of solution to 400 mL using DI.
19. Using a 400 mL solution, fill 15 25mL cell culture flasks.
20. Place flasks into the fridge overnight to allow solidification.

Conclusions/action items:

Conduct Tissue Pull tests

 **Tear Duct Solution**

NEEL SRINIVASAN - Apr 29, 2026, 4:56 PM CDT

Title: Tear Duct Solution Protocol**Date:** 4/14/2026**Content by:** Neel Srinivasan**Present:** Caleb White, Neel Srinivasan**Goals:** To outline protocol for creating artificial tear duct solution**Content:****Obtain the following:**

1. 1 Corning Pyrex 500 mL storage media bottle
2. 1 stir bar
3. 500 mL Deionized Water
4. 3.655 g NaCl
5. 0.745 g KCL
6. 0.0735 g $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
7. 0.0510 g $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
8. 0.08 g NH_4Cl
9. 1.97 g Albumin
10. 1 M HCl
11. 1 M NaOH
12. 1 Weigh boat
13. 6 Scoopula's
14. 1 Fischer Scientific Weigh Scale
15. 1 ThermoFisher IsoTemp magnetic stirrer and hot plate
16. 1 pH Meter

Preparation:

1. Add 500 mL deionized water to the Corning Pyrex 500 mL storage media bottle
2. Place the stir bar inside the bottle
3. Place the bottle on top of the ThermoFisher IsoTemp magnetic stirrer and hot plate
4. Set the magnetic stirrer to 200 rpm and temperature to 37°C
5. Measure the necessary amount of each chemical on the weigh scale
6. Add in the chemicals using 1 scoopula per powder
7. Repeat steps 5 & 6 for chemicals 4-8

8. When adding Albumin, add little amounts and wait for powder to completely dissolve (if entire quantity of Albumin is added at once, it will denature and not fully dissolve)
9. Measure the pH of the solution
10. Add in drops of 1 M NaOH if the pH is below 7.4, and drops of 1 M HCl if the pH is above 7.4
11. pH balance solution to 7.4

Conclusions/action items:

Create solution and run accelerated life testing



2/26/2026 - Prof. Pfefferkorn Meeting

CALEB WHITE - Apr 29, 2026, 9:42 PM CDT

Title: Prof. Pfefferkorn Meeting

Date: 02/27/2026

Content by: Caleb White

Present: Caleb White and Neel Srinivasan

Goals: Get expert advice from Prof. Pfefferkorn and identify if first, laser annealing is a possible solution for the small scale of the probe, and second how to physically achieve this.

Content:

Prof. Pfefferkorn provided great insight into the design and the feasibility of fabrication. He showed great enthusiasm in the project and was willing to help. He confirmed that the marking is possible and that the Makerspace at Wendt should be able to supply the resources. If they are not able to, he said he would be able to supply use of the laser in his lab due to much less restriction. In general, he thinks it would be an interesting exercise into laser usage further than simple cutting. One which relies heavily on the laser finish rather than the shape. He also desires to be kept in the loop regardless of what happens moving forward.

Conclusions/action items:

Prof. Pfefferkorn will be a great resource moving forward. With his copious experience in laser fabrication his knowledge and his equipment should be very useful. His confidence that this kind of graduation is possible has given the rest of the group much confidence as well in hopes to bring the graduated Bowman probes to life.



3/18/2026 - Laser Introduction with Hassan

NEEL SRINIVASAN - Apr 29, 2026, 9:05 PM CDT

Title: Introduction to Laser with Hassan

Date: 3/18/2026

Content by: Neel Srinivasan

Present: Neel Srinivasan, Caleb White, Caden Robinson

Goals: To outline our first meeting with Hassan where we were introduced to the laser.

Content:

Conclusions/action items:



3/23/2026 - Laser Holder Fabrication #1

CALEB WHITE - Apr 29, 2026, 9:51 PM CDT

Title: Laser Holder Fabrication

Date: 3/23/2026

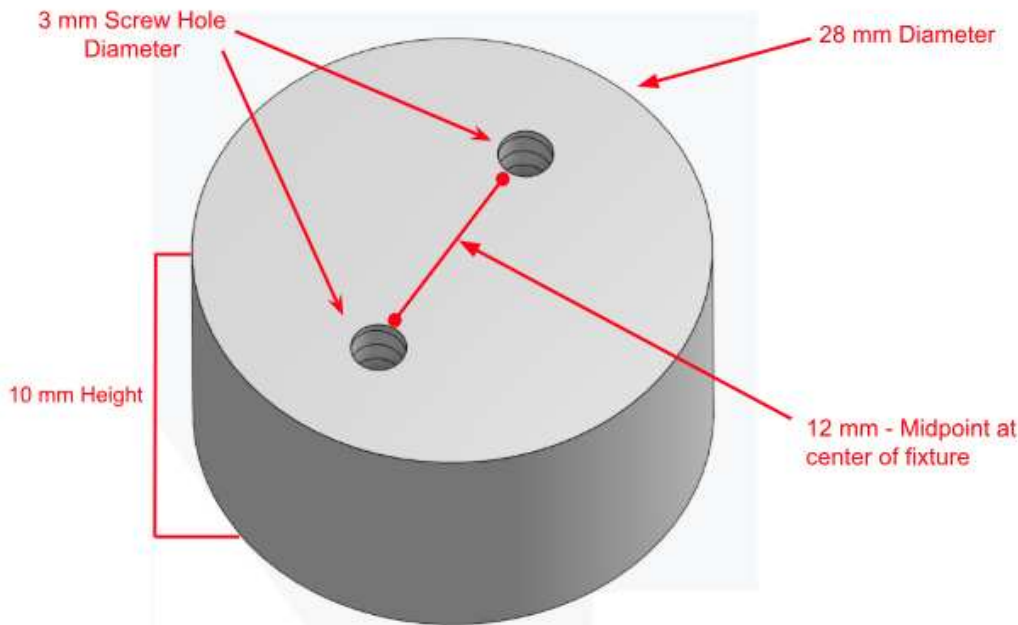
Content by: Caleb White

Present: Caleb, Neel

Goals: Fabricate a probe holder than can be used to keep the probes fixed in place so that fabrication is consistent.

Content:

In order to allow repeated, consistent graduation of the probes, a fixture needs to be created to hold the probes in place. Neel and I went to the ECB to try to fabricate a cylinder with a slit along the top center to act as a slot for the probe to sit. Using the mille and lathe at the ECB machine shop, we fabricated this fixture using a piece of stainless steel found in the blue room closet. We first polished each end of the cylinder to make sure it is flat and uniform using the lathe, and then went to the mille to create the guiding line as well as two screw holes to keep the probe down. There was some complication with the hole fabrication as the first time round, the drill bit of the mille broke, leaving it flush with the surface of the holder. We had to redrill the holes, this time on the other side to give us the desired fixation we wanted.



Conclusions/action items:

With this fabricated fixture, the team can now achieve consistent uniform graduation on the probes.



3/27/2026 - Laser Holder Shortening

CADEN ROBINSON - Apr 29, 2026, 9:07 PM CDT

Title: Laser Holder shortening

Date: 03/07/206

Content by: Caden Robinson

Present: Neel Srinivasan

Goals: Shorten the depth of the laser holder so it fits on the laser bed

Content: Brought the previously fabricated sample holder to the team labs to continue fabricating the design so it would fit properly in the laser bed. The holder was shaved down the the lowest possible depth using a lathe and then deburred to finish.

Conclusions/action items: This design should be perfect for securing a probe down and guaranteeing that it is straight under the laser and will not move if any external forces tough it. The probes fit perfectly inside of the design, but the holder may need to be modified since only 25mm can be marked since there is not enough surface area.



3/27/2026 - Probe Holder Discussion with Hassan

CADEN ROBINSON - Apr 29, 2026, 9:12 PM CDT

Title: Probe Holder Discussion with Hassan

Date: 03/27/2026

Content by: Caden Robinson

Present: Neel Srinivasan, Caleb White, Caden Robinson

Goals: Clarify if any modifications need to be made to the holder to move forward with fabrication

Content: after this meeting we found that there needed to be a couple of modifications to our holder. First, the depth was still to large causing the laser surface to be outside of the focal point which would result in inaccurate marking intervals. Secondly, the aluminum need to be sanded with a 600 grit sandpaper to remove the reflective surface to avoid any potential injury when using the laser. Once the holder was finished with its modifications, then we could being to fabricate the designs

Conclusions/action items: This all made complete sense to me, especially the idea that the surface could not be reflective. This meeting gave us some good items to complete after spring break and sets us up for success when finishing the semester out.

Complete sample holder fabrication, Begin graduated bowman probe fabrication



4/8/2026 - Probe Holder Fabrication Discussion at ECB

NEEL SRINIVASAN - Apr 29, 2026, 9:38 PM CDT

Title: Probe Holder Discussion at ECB

Date: 4/8/2026

Content by: Neel Srinivasan

Present: Neel Srinivasan & Caleb White

Goals: To summarize notes on our discussion on fabrication of a second version of the sample holder/fixture after hearing Hassan's recommendations

Content:

After our meeting with Hassan in which we showed him our first version of the sample holder, he informed us that it would be too tall and cause issues with the lasers focal point. This would essentially cause issues with the accuracy and uniformity, which is something that we can't have happen based on our design criteria. Caleb and I spoke about the creation of a new sample holder with thinner dimensions and made of a non-reflective material. We also spoke about a simpler design that doesn't feature screws, and instead relies on the midpoint of the probe to act as a balance. We also went to the ECB design labs to check out their stock materials and we chose a thin slab of non-reflective aluminum 6061. We plan to meet again with Hassan and make sure the material surface properties and thickness are acceptable, and then fabricate the second version of the laser fixture.

Conclusions/action items:

Get Hassan's approval and then fabricate new laser fixture



4/10/2026 - Laser Holder Discussion with Hassan #2

CALEB WHITE - Apr 29, 2026, 9:43 PM CDT

Title: Laser Holder Discussion with Hassan #2

Date: 04/10/2026

Content by: Caden Robinson

Present: Neel Srinivasan and Caden Robinson

Goals: Gather a new plan since the old sample holder was unable to be fabricated

Content: Hassan gave us some great instruction on where to buy non reflective aluminum and how to fabricate it. He explained how there could be 3 channels allowing us to mark 3 probes at once under the laser along with 3 horizontal channels to allow for perfect orientation so the end of the probes was exactly 2.5mm away from the first marking. He told us all of it could be achieved using a CNC Mill.

Conclusions/action items: After this meeting we were confident that we could quickly build a new sample holder that met Hassan's specifications. He gave us great direction and we had created a good action plan for the couple weeks we had left in the semester.

Fabricate the new sample holder and the graduated bowman probes



4/10/26 - Fabrication of second probe holder

CALEB WHITE - Apr 29, 2026, 9:52 PM CDT

Title: Fabrication of the Second Probe holder

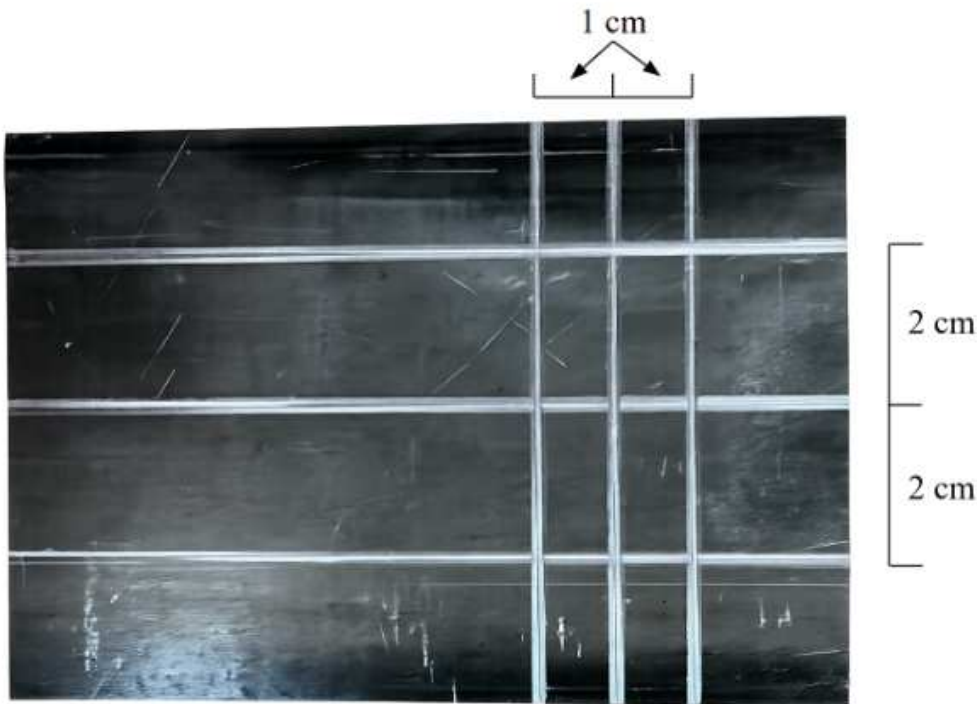
Date: 04/10/2026

Content by: Caden Robinson

Present: Caleb White and Caden Robinson

Goals: Complete the design of the second probe holder

Content: We went down to the team labs and shaved down each side of the sample holder to ensure that it lay even inside of the clamp. after that we touched off and zeroed our x and y axes allowing for uniform measurements. We made our first channel roughly 1 inch into the holder and made the other two channels 2 cm apart. After completion of the vertical channels we began working on the horizontal channels. The first channel was about 1/4 of the length down from the top and the other two channels were created 1cm apart from each other.



Conclusions/action items: This sample holder was incredibly easy to fabricate and achieved all of the specifications needed for efficient graduation of the probes. After the completion we were optimistic for successful fabrication of our next prototype and.

Fabricate the graduated bowman probes and being testing



4/13/2026 - Fabrication of full probe set for testing

CADEN ROBINSON - Apr 29, 2026, 9:32 PM CDT

Title: Fabrication of full probe set for testing

Date: 04/13/2026

Content by: Caden Robinson

Present: Neel Srinivasan, Caleb White, Caden Robinson

Goals: Finish creating the graduated bowman probe prototype.

Content: In the beginning of fabrication, there was some issues with the marking causing some raised edges which we assumed would cause skin pull if implemented into the hospital immediately. Eventually we found the correct power setting where the markings were still visible and barely tangible, which was roughly 25 percent. Hassan was worried that if he went any lower could result in instability of the laser, meaning it would say 15 percent power for example, but in reality it would be performing at a higher power. Eventually we found the correct setting where the markings were only being lasered one time instead of multiple passes and his resulting in a great prototype. Repeating the same steps from the first prototype we marked all of the probes.

Conclusions/action items: We were incredibly relieved once the probe came out successful meaning we could take the next step and being testing them on cadavers and degradation testing.

Begin cadaveric, degradation, and uniformity testing



4/15/2026 - Glycerin + glycine nasolacrimal epithelium mimic

CALEB WHITE - Apr 26, 2026, 6:44 PM CDT

Title: Glycerin + Glycine Nasolacrimal Epithelium Mimic

Date: 04/15/2026

Content by: Caleb White

Present: Caleb White

Goals: Generate a epithelial mucosal mimc to fill the conical cavities generated from the agar+gelatin soft tissue phantoms generated the day prior.

Content:

In order to fill the nasolacrimal conduit phantom generated from the previous day, I crafted a glycerin+glycine mucosal mimic to help represent the mucus-like environment within the tear duct passage. The probes we but put through the tip of these conical cavities in order to simulate the passage through the nasolacrimal duct. When the probe is brought out of the solution, it will be viewed under the microscope and weighed for pull of tissue material out of the duct itself. The protocol for these creations can be found in the fabrication protocols section.



Conclusions/action items:

With these generated samples, it is now necessary to conduct a formalized testing procedure to track the tissue mimic which is adhered and brought out of the conduit mimic. This solution was generated green to give clear difference between the agar+gelatin soft tissue and the epithelial mucus.



4/19/2026 Agar+Gelatin Soft Tissue Mimics in Culture Flasks

CALEB WHITE - Apr 26, 2026, 6:55 PM CDT

Title: Agar+Gelatin Soft Tissue Mimics in Culture Flasks

Date: 4/19/2026

Content by: Caleb White

Present: Caleb White

Goals: Generate new agar+gelatin soft tissue mimics for the tracking of nasolacrimal tissue snag.

Content:

Following the testing procedure conducted on the initial samples it came to me that the followed procedure did not at all account for the disrupted tissue that would remain within the mimic itself, not brought out by the probe. The weight change felt by the probes would only account for a very small percentage of the tissue which was disrupted during the probing process making the testing procedure unrepresentative. In order to fix this I generated a new way in which to test this disruptive nature through charcoal powder. By creating essentially a binary map across the soft tissue surface, one is able to apply a python algorithm which calculates percent change from a before and after photo of a singular instance of probing. Using a set of these soft tissue charcoal mimics, I am able to test multiple sizes of small and large ungraduated and graduated probes to help generate conclusions about their apparent snag of tissue. The fabrication process for these involved a similar process to the first, this time with minor tweaks to the agar gelatin DI ratio and the addition of the charcoal powder, omission of the soft tissue epithelial mucus. These mimics would be poured into 25 mL cell culture flasks because of their flat and clear property to allow for clear vision of the induced change by the probes. The protocol for formulating these flasks can be found in the fabrication protocol folder.

Conclusions/action items:

With these newly generated soft tissue mimics, I will now be able to get percent disruption of the soft tissue through the calculated percent change by the python algorithm.

Autoclave Protocol

NEEL SRINIVASAN - Apr 29, 2026, 8:38 PM CDT

Title: Autoclave Protocol

Date: 4/14/2026

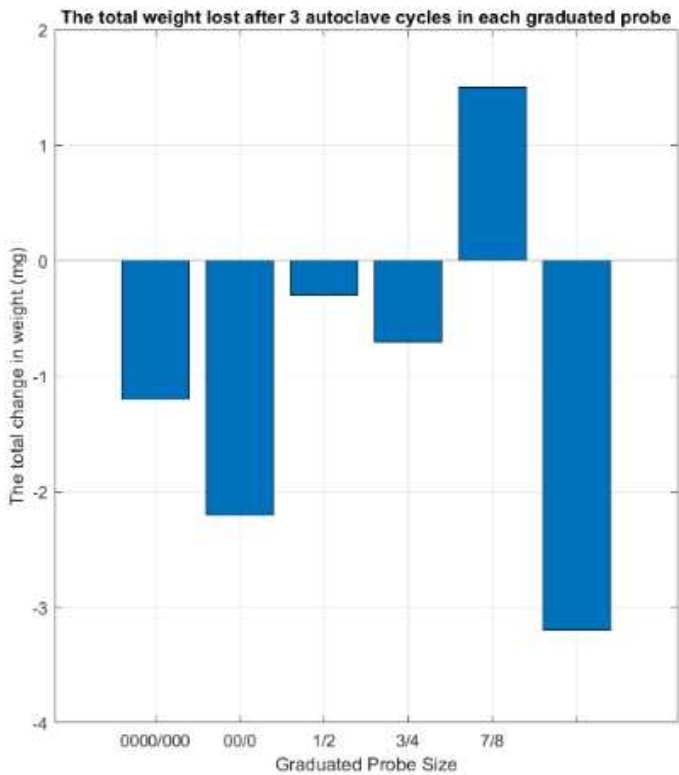
Content by: Caden Robinson

Present: Caden Robinson

Goals: To outline the protocol/details of the autoclave testing that has been conducted

Content:

In order to fulfill necessary autoclave endurance parameters defined within the PDS, the fabricated probe must endure an extensive material deposition test to ensure the integrity of the probe's safety moving towards actual ophthalmological implementation. In the test, a control group, a set of regular commercial-grade probes and a test group, an associating set of fabricated graduated probes, were put through several rounds of one hour autoclave sterilization cycles. The before and after recorded probe masses will be tracked and compared between the control and test group and then statistically analyzed for significant difference. Any observable damage or impact, including to the graduation marks, that the testing environments generated on the probes will also be qualitatively tracked and evaluated. After completion of three autoclave cycles, the mean loss of probe weight was 1.02 +/- 1.62 milligrams. Further inspection of these samples after trials showed that there was no impact to the graduation. A paired t-test was then conducted with a reported value of 0.185 indicating that there is no statistically significant difference between the probes weight prior and after autoclaving. Since there was a small sample size, it is not possible to predict the probes degradation over further autoclave testing. The graph represents the total weight change in milligrams after three autoclave cycles.



Conclusions/action items:

Run further statistical analysis.

Cadaveric Testing Protocol

CALEB WHITE - Apr 29, 2026, 2:48 PM CDT

Title: Cadaveric Testing Protocol

Content by: Caleb White

Content:

To prove the diagnostic accuracy of the graduated probes, the cadaveric laceration assessment looked to use real life probe application to demonstrate the probes equivalent capabilities to current clinical techniques. This test saw Dr. Law surgically induce a laceration somewhere along the left lower and right upper canaliculi of 5 cadaveric specimens, resulting in 10 distinct measurements. These lacerations were then measured by two medical school residents of the UWSMPH and Dr. Law using the following set of techniques: observable estimation; an ungraduated probe; an ungraduated probe in combination with an external measuring apparatus (current standard); a graduated probe.

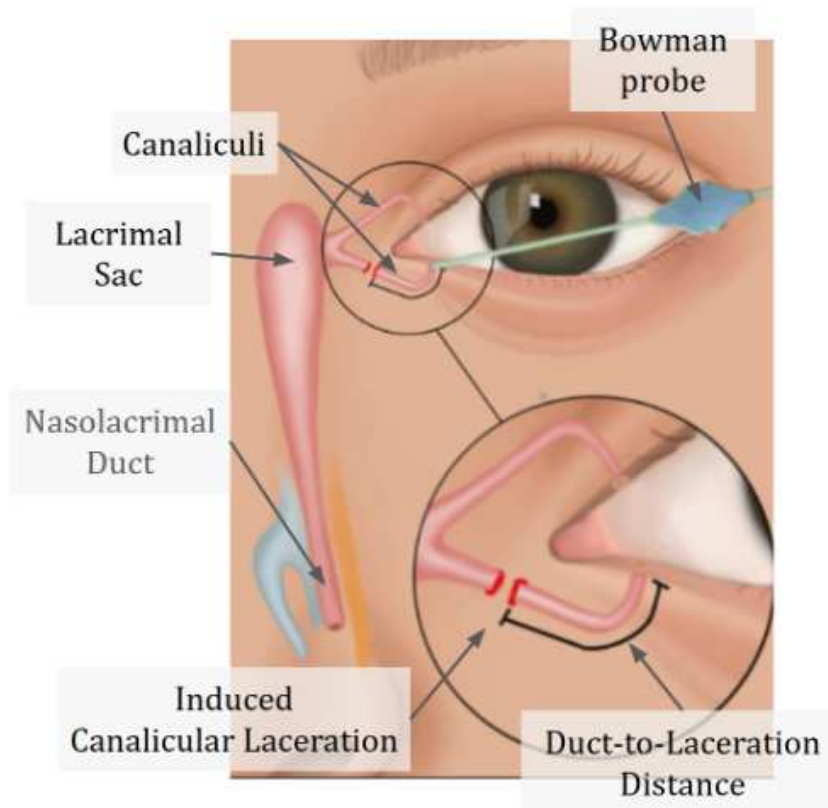


Figure X:

Once a technique was used, the participants reported the measurement for recording. Using the current standard as the 'clinical' laceration depth, each technique was evaluated in comparison to the clinical laceration depth to obtain an accuracy score defined as the absolute distance away from this value. With data for each technique, from each participant, at all 10 lacerations, two distinct statistical tests were conducted to evaluate the quantitative accuracy of the measuring techniques. The first test, was a paired TOST (two one-sided test) in order to prove equivalency between the clinical measurements and the graduated measurements and the second paired t-test to prove a difference between the ungraduated accuracy scores and the graduated accuracy scores. Combined, significant results would allow the graduated probes to be translationally defined as an equivalent or superior method of clinical quantitative characterization of lacrimal measurements with respect to the gold standard and ungraduated measurement techniques respectively.



Tissue Pull Test Protocol

CALEB WHITE - Apr 29, 2026, 2:49 PM CDT

Title: Tissue Pull Test Protocol

Content by: Caleb White

Content:

The largest concern expressed by the client for laser-induced graduated was the increased risk of tissue pull. More technically defined as soft tissue damage resulting from surgical intervention during a clinical procedure, resultant tissue pull of an uneven and jagged probe exterior would leave the probe unusable because of the increased risk of patient safety. In order to test whether or not the laser-induced graduation would result in significant soft tissue damage, development of a soft tissue disruption procedure was generated. This procedure involves the fabrication of an agar+gelatin+charcoal soft tissue phantom which can be probed and digitally examined for tissue disruption utilizing a biological image analysis script. An accurate mimic of soft tissue is paramount in importance as the according testing results must be accurately representative of real-life application of the probes. Agar-gelatin mixtures are commonplace in biological investigation of soft tissue characteristics because of its cheap, modular, and representative properties []. Agar provides necessary structural stability while gelatin offers the soft and elastic texture []; the modularity of each of these component's concentration allows for specific targeting of tissue types properties. Necessary for application, a mimic adjacent to lacrimal soft tissue requires precise stiffness with viscoelastic behavior and slow elastic recovery []. To achieve such properties, a mixture of 0.25% agar with 6% gelatin was utilized to generate the samples. Use of charcoal powder gives a stark contrast to the mixture and generates a dot-based scatter to systematically characterize the tissue sample within the Python algorithm. A more in-depth procedure of fabrication can be found in Appendix H.

Three trials of five different probe sizes; (1,2,4,7,8), both graduated and ungraduated, were performed on a set of five mimic samples. Before and after images of each individual trial were taken of the samples and ran through the Python script for acquisition of the percent change between the images. The script utilizes the same binary image thresholding techniques deployed in magnetic resonance imaging (MRI). It first orients the before and after images exactly aligned using the designated colored anchors on the test samples. Once layered, the combined image is converted into a grey scale difference overlay of the pixel-specific variation between the images. If the pixels have undergone significant change between images, they are designated as white and those which remain the exact same are designated black, with everything in between designated along a monochrome spectrum. A region of interest (R.O.I.) is then applied which focuses the algorithm to analyze a single section of the image, the region which was probed. This region application helps to eliminate noise and localize a percent change to the probed region, making the resultant quantitative change more representative of the disruption induced by the probing itself. A threshold value is then utilized to partition the image binarily, helping distinguish actual change from extraneous alterations in appearance such as lighting and glare. This threshold assigns a color value between black, 0, and white, 255, as the value in which a pixel is officially evaluated to have changed or not. A threshold value of 133 was experimentally determined and defined in this experiment through analysis of noise influence and disruption visibility. The resulting image is a binary black and white photo where each white pixel is considered changed or disrupted and each black pixel considered the same. The image in general appears mostly black as the amount of change inflicted by the probe is minimal in even the most disruptive trials. Using this binary diagram, the algorithm then computes the percent change by taking the proportion of white pixels over total pixels. Using this process for each before and after photo of each trial for each probe size of each probe type, a set of data was gathered to quantitatively characterize the influence of the graduation on the amount of tissue pull.



Accelerated Life Testing Protocol

NEEL SRINIVASAN - Apr 29, 2026, 6:24 PM CDT

Title: Accelerated Life Testing Protocol

Date: 4/14/2026

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To outline how the accelerated life tests work and observations

Content:

The graduated Bowman's probes must maintain their composition and procedural viability throughout the 5-10 year lifespan as stated by the client. To measure the potential visual degradation the probes will encounter while inside the lacrimal drainage system, an accelerated life test was conducted. Two pairs of probes of sizes 2 and 4, with one pair unmarked and the other graduated, were placed in artificial tear solution and kept in an InCu Safe incubator that maintained sterility, temperature at 37 °C, and CO₂ levels at 5%. An in depth protocol for the preparation of the artificial tear solution is outlined in Appendix I. The probes were kept in the incubator for 48 hours, equating to 2,880 procedural uses, and then observed under a Leica MZ95 stereomicroscope to check for potential discoloration and marker degradation. While the probes had a slight discoloration, the markers remained distinguishable after accelerated life testing. It is important to note however, that this discoloration is uniform across both standard and graduated Bowman's probes, and that 2,880 procedural uses is uncommon as 2,000 is the typical lifespan of clinical probes.

Conclusions/action items:

Run data analysis on results



Uniformity Testing Protocol

Cole Miller - Apr 29, 2026, 7:47 PM CDT

Title: Uniformity Testing Protocol

Date: 4/21/26

Content by: Cole M.

Goals: Determine accuracy of probe markings and reproducibility of fabrication

Content:

In order to ensure the accuracy of probe markings and reproducibility of the graduated Bowman's probe's fabrication process, Uniformity testing was performed. 28 graduated probes of sizes ranging from 0000 to 7 were captured using a Leica MZ95 stereomicroscope. The position and magnification of the microscope were not changed in between images, allowing probes to be measured on the same scale. ImageJ was used to determine the interval length in between markings and marking widths. The distance from the end of the probe to the first marking was of particular importance, as it affects the accuracy of subsequent markings.

Conclusions/action items:

Run data analysis on results



4/15/2026 - Tissue Pull Testing

CALEB WHITE - Apr 29, 2026, 9:55 PM CDT

Title: Tissue Pull Testing

Date: 4/15/2026

Content by: Caleb White

Present: Caleb White

Goals: See if there is any weight change that occurs with the tissue pull test that can be attributed to tissue still remaining on the probe

Content:

Probe Number Weight (pre-dip) (g) Weight (dip 1) (g) Weight (dip 2) (g) Weight (dip 3) (g) Weight (dip 4) (g)

Graduated

Probe 1 (7/8)	2.201 g	2.202	2.203	2.206	2.206
Probe 2 (7/8)	2.179	2.182	2.185	2.180	2.183
Probe 3 (00/0)	1.755	1.765	1.762	1.763	1.765

Ungraduated

Probe 4 (7/8)	2.255	2.257	2.260	2.258	2.260
Probe 5 (5/6)	2.096	2.097	2.096	2.099	2.102
Probe 6 (00/0)	1.728	1.732	1.731	1.727	1.728

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.



4/15/2026 - Biocompatibility Testing

CALEB WHITE - Apr 29, 2026, 9:56 PM CDT

Title: Biocompatibility testing

Date: 04/15/2026

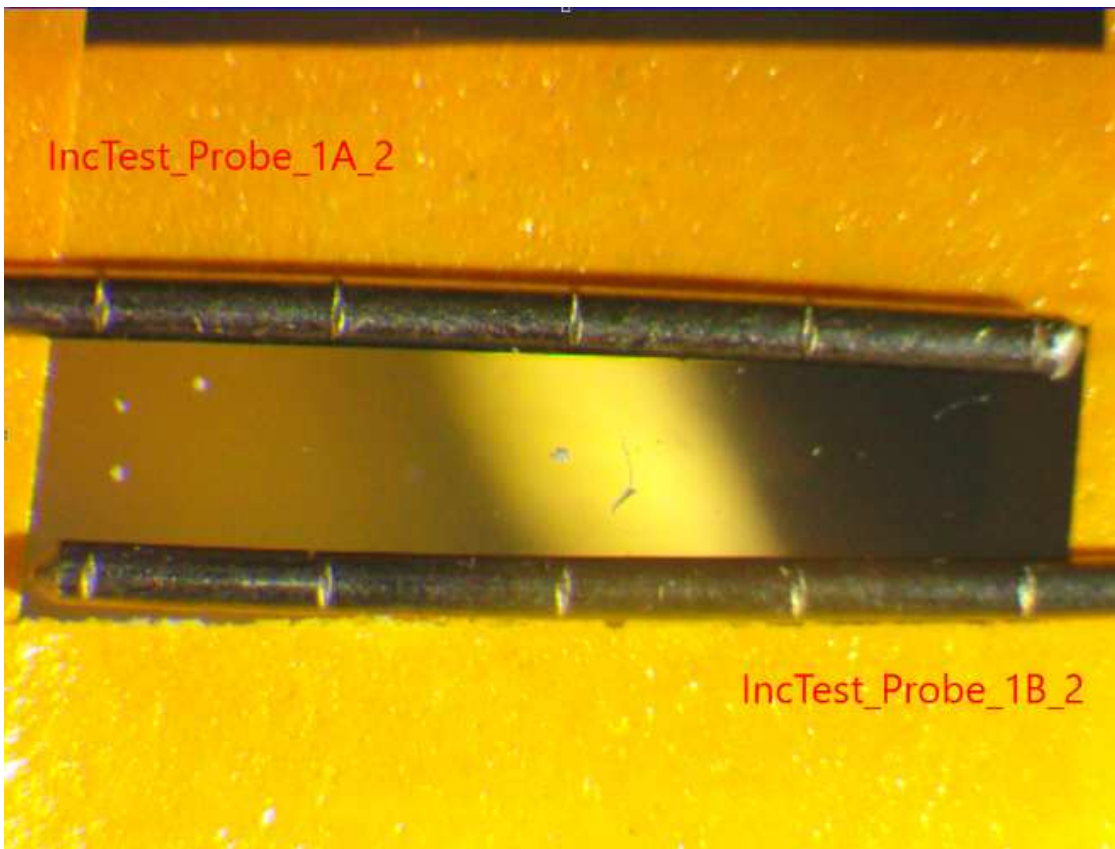
Content by: Neel

Present: Neel

Goals: Generate qualitative data for the biocompatibility of the probes related to color shifts in appearance.

Content:

As shown in the figure below, there was no visible change even under the microscope to the surface layer of the probe after multiple trials with different probe sizes.



Conclusions/action items: After multiple trials of testing, we concluded that this test showed no change in the probe material. These trials were conducted immediately after each other without sterilization cycles in between meaning that the solution was likely on the surface for longer than the intended trial period and yet there was still no change to the surface.

Complete other testing procedures draft the final poster



4/17/2026 - 48 Hour Life Cycle Testing

CADEN ROBINSON - Apr 29, 2026, 9:45 PM CDT

Title: accelerated life testing

Date: 04/17/2026

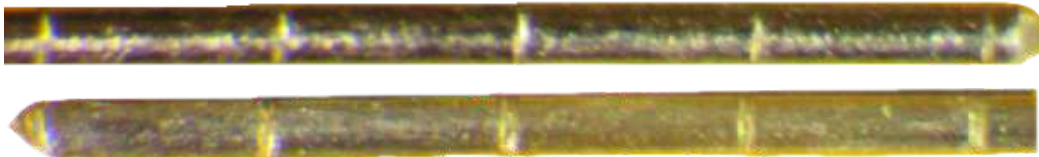
Content by: Caden Robinson

Present: Neel Srinivasan

Goals: Understand the degradation of the probes after left in biological conditions for 48 hours

Content:

The graduated Bowman's probes must maintain their composition and procedural viability throughout the 5-10 year lifespan as stated by the client. To measure the potential visual degradation the probes will encounter while inside the lacrimal drainage system, an accelerated life test was conducted. Two pairs of probes of sizes 2 and 4, with one pair unmarked and the other graduated, were placed in artificial tear solution and kept in an InCu Safe incubator that maintained sterility, temperature at 37 °C, and CO₂ levels at 5%. An in depth protocol for the preparation of the artificial tear solution is outlined in Appendix I. The probes were kept in the incubator for 48 hours, equating to 2,880 procedural uses, and then observed under a Leica MZ95 stereomicroscope to check for potential discoloration and marker degradation. While the probes had a slight discoloration, the markers remained distinguishable after accelerated life testing. It is important to note however, that this discoloration is uniform across both standard and graduated Bowman's probes, and that 2,880 procedural uses is uncommon as 2,000 is the typical lifespan of clinical probes.



Conclusions/action items: There was a noticeable color change in the probe after testing but we came to the conclusion that it was not important since the graduation of the probes was still visible. The color change was a result of the materials used in the probe and a current Bowman probe would have the same color change.

Complete all testing, finish drafting final poster, complete the final report

 **4/20/2026 - Cadaveric Testing**

Title: Cadaveric Testing

Date: 04/20/2026

Content by: Caleb White

Present: Everyone

Goals: Gather meaningful data that will allow the group to make conclusions about the accuracy and preferences surrounding the graduated prototype. Get reviews from actual medical professi

Content:

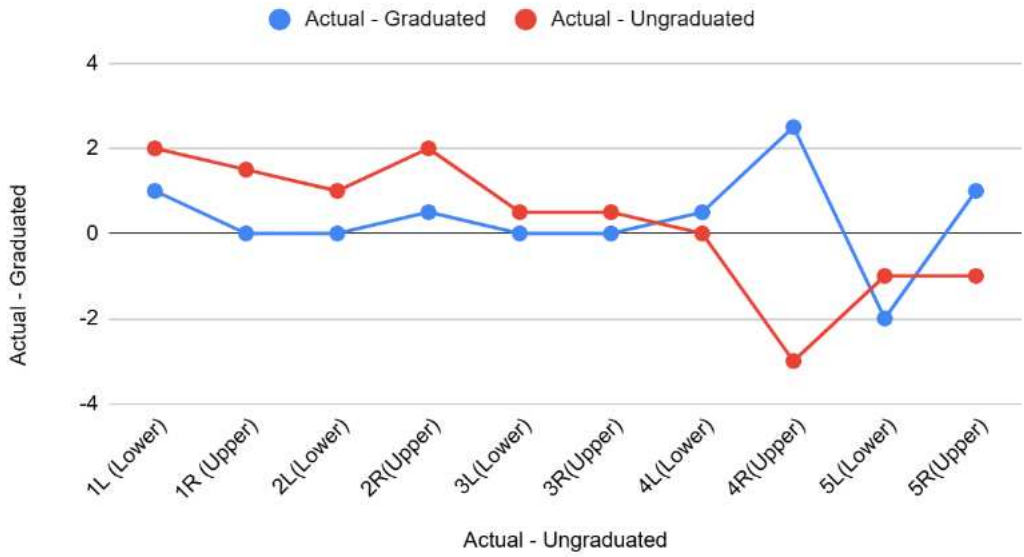
To prove the diagnostic accuracy of the graduated probes, the cadaveric laceration assessment looked to use real life probe application to demonstrate the probes equivalent laceration somewhere along the left lower and right upper canaliculi of 5 cadaveric specimens, resulting in 10 distinct measurements. These lacerations were then measured i of techniques: observable estimation; an ungraduated probe; an ungraduated probe in combination with an external measuring apparatus (current standard); a graduated prob

Station #	Estimated (no measurements)	Bowman probe + No Ruler	Bowman Probe + Ruler (Gold Standard)	Graduated Bowman Probe	Actual
1L (Lower)	4	5	7	6	
1R (Upper)	0.5	1	2.5	2.5	
2L(Lower)	2	1	2	2	
2R(Upper)	1	2	4	3.5	
3L(Lower)	2	1.5	2	2	
3R(Upper)	4	2.5	3	3	
4L(Lower)	10	8	8	7.5	
4R(Upper)	13	18	15	12.5	
5L(Lower)	12	6	5	7	
5R(Upper)	15	12	11	10	

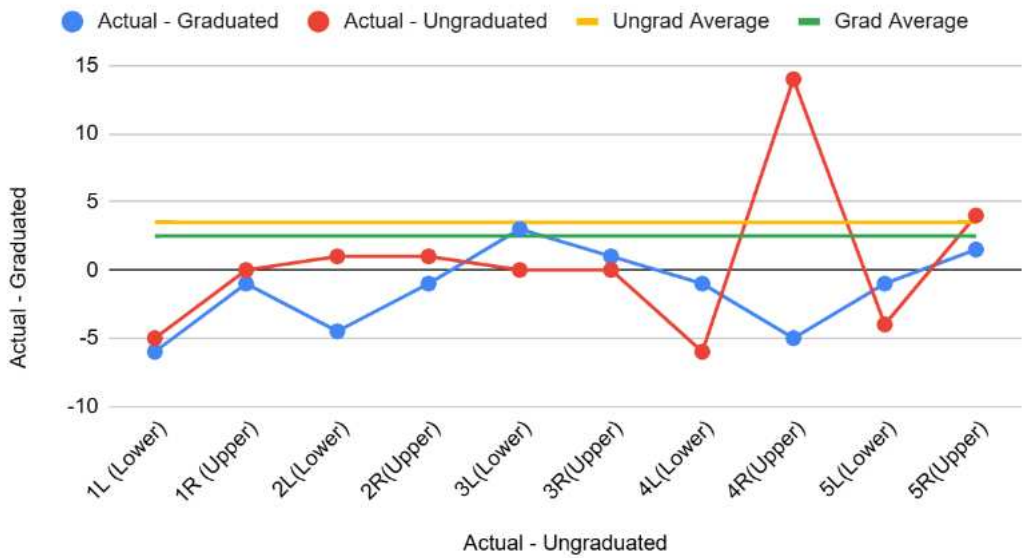
Station #	Estimated (no measurements)	Bowman probe + No Ruler	Bowman Probe + Ruler (Gold Standard)	Graduated Bowman Probe	Actual	OR
1L (Lower)		15	10	16		OR
1R (Upper)		4	4	5		ER
2L(Lower)		7	8	12.5		OR
2R(Upper)		3	4	5		ER
3L(Lower)		13	13	10		ER
3R(Upper)		6	6	5		ER
4L(Lower)		20	14	15		
4R(Upper)		5	19	24		
5L(Lower)		15	11	12		OR
5R(Upper)		10	14	12.5		ER

Station #	Estimated (no measurements) (mm)	Bowman probe + No Ruler (mm)	Bowman Probe + Ruler (Gold Standard) (Actual) (mm)	Graduated Bowman Probe (mm)			Acti
1L (Lower)	5	5	5	5	er for all		
1R (Upper)	2	3	3	2.5	er for all		
2L(Lower)	1.5	1.5	2	1.25	er for all		
2R(Upper)	15	3	3	3	or,er,er,er		
3L(Lower)	2	2	2	2	er for all		
3R(Upper)	2.5	3	3	3	er for all		
4L(Lower)	8	8	8	7.5	or for all	avulsions	
4R(Upper)	15	15	14	14	or for all	avulsions	
5L(Lower)	0	0	0	0	er for all	avulsions	
5R(Upper)	10	12	11	11	or for all	avulsions	

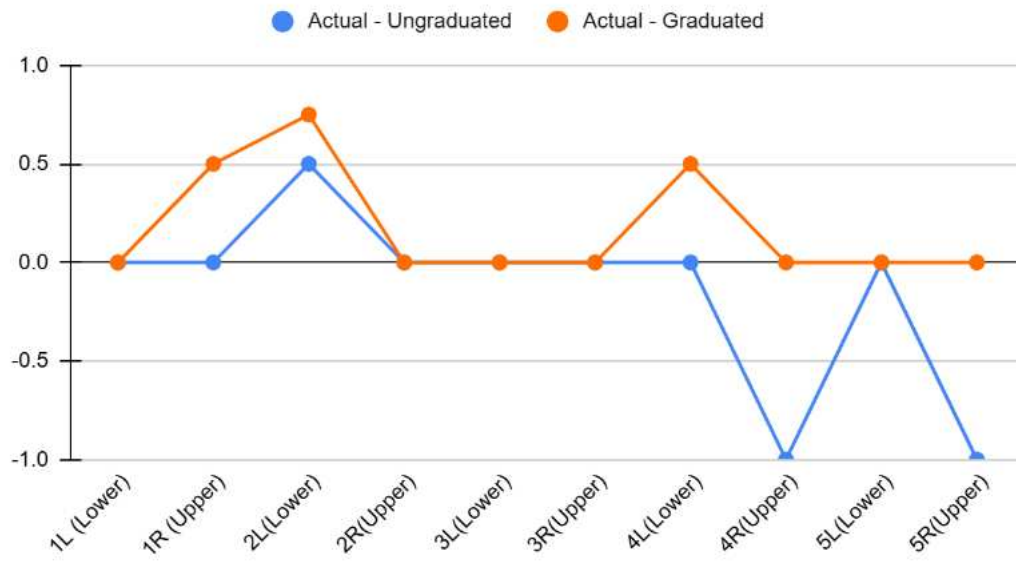
Actual - Graduated vs. Actual - Ungraduated



Actual - Graduated vs. Actual - Ungraduated



Actual - Ungraduated and Actual - Graduated



Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.



4/20/2026 - Probe Survey

CALEB WHITE - Apr 29, 2026, 2:52 PM CDT

Title: Probe Survey

Date: 4/20/2026

Content by: Caleb White

Present: Everyone

Goals: Generate a survey to ask the residents and Dr. Law after the cadaveric testing to get overall feelings of the graduated probe use.

Content:

Per client request, the graduated Bowman probe should not negatively alter current standard measurement procedures involving probe usage. In order to ensure that the fabricated design does not do so, a qualitative evaluation of the similarity and ease of use between procedure with a normal, commercial-grade probe and a fabricated, graduated probe was conducted. For this, Dr. Law and other medical school residents performed standard canalicular laceration depth estimates on cadaveric specimens with the graduated probe. They were then asked a series of questions about how the procedure went with the graduated probe, and if there were any significant ergonomic or procedural alterations that were made to routine operation as a result of the probe. A result of no procedural change will confirm the probe's theoretical implementation. The survey confirmed that during usage there was no change in technique required for the graduated probe. There was no concern of tissue pull and professional opinion from Dr. Law stated that he preferred the graduated version over using a ruler to determine the depth due to the ease and efficiency of the process.

Conclusions/action items:

The graduated probe has real market application. The preference due to accuracy and ease of use is the perfect combination for clinicians.



4/21/2026 - Tissue Pull Test Round 2

CALEB WHITE - Apr 29, 2026, 9:57 PM CDT

Title: Tissue Pull Test Round 3

Date: 04/21/2026

Content by: Caleb White

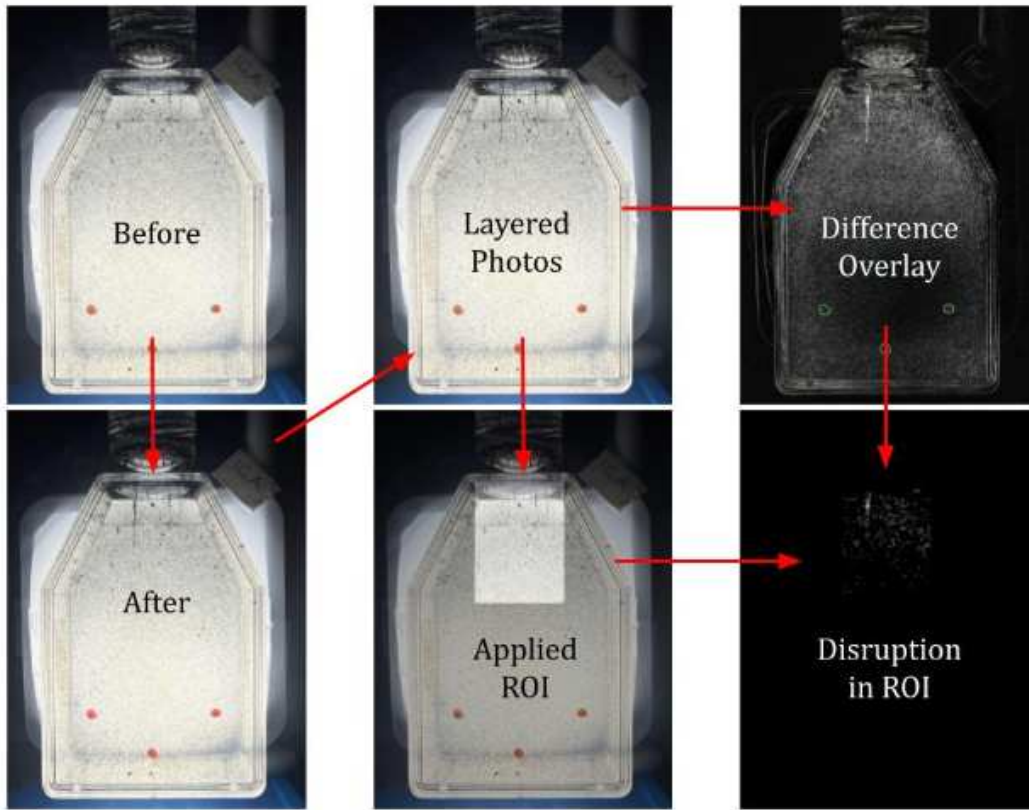
Present: Caleb White

Goals: Test the % change by different probe sizes across probe types to generate conclusions about the chance of tissue pull for the graduated probes.

Content:

The table below holds the percent disruption across 3 trials for 5 different probe sizes both graduated and ungraduated. Probe sizes 1,2,4,7,8 were test both graduated and ungraduated. The progression of the code can be seen below in how it is able to calculate percent disruption. Using the before and after photos, a layered phot using anchors is turned to a binary difference via a threshold (approx 130) and a region of interest is applied. The camera set up was configured using a dark room with an Iphone taped on an elevation with a weight boat and Iphone flashlight used as light dispersion. The results will be analyzed for significance in relation to each other.

Size	gA	gB	gC	uA	uB	uC
1	0.24	0.61	0.05	0.2	0.12	0.04
2	0.74	0.56	0.39	0.19	0.16	0.01
7	0.07	0.07	0.08	0.07	0.06	0.06
8	0.05	0.07	0.05	0.06	0.08	0.03
4	0.03	0.01	0.12	0.04	0.01	0.08
	0.31	0.02	0.12	0.2	0.02	0.03
	0.23	0.52	0.55	0.03	0.01	0.01

**Conclusions/action items:**

A paired t-test will be performed between the probe types for each probe size in order to generate conclusions about the chance of disruption to the soft tissue mimic caused by the probes. Because of the client's concern, necessary articulation was taken for this testing procedure. Because agar+gelatin is not the perfect soft tissue mimic, especially for the nasolacrimal conduit, further analysis must be done in the future for actual IRB application.

4/21/2026 - Uniformity Testing

Cole Miller - Apr 29, 2

Title: Uniformity Testing

Date: 4/21/2026

Content by: Cole M.

Present: Neel, Cole M.

Goals: Determine accuracy of probe markings and reproducibility of fabrication

Content:

	First Mark Length	Avg. Mark Length	Std Mark Length	Avg Mark Width	Std Mark Width	Mark 1 L	Mark 2 L	Mark 3 L	Mark 4 L	Mark 1 W	Mark 2 W	Mark 3 W
Probe 0000	2.921	2.6155	0.204581687	0.119	0.02	2.921	2.5	2.541	2.5	0.149	0.109	0.109
Probe 000	2.84	2.57925	0.1755170932	0.15925	0.0205	2.84	2.459	2.516	2.502	0.149	0.149	0.19
Probe 00	2.99	2.63625	0.2380019258	0.1665	0.03882009789	2.99	2.473	2.541	2.541	0.19	0.19	0.109
Probe 0	2.733	2.5685	0.111356784	0.126	0.01978214683	2.733	2.5	2.541	2.5	0.149	0.109	0.11
Probe 1A	2.948	2.6255	0.2160455199	0.2035	0.0369278576	2.948	2.502	2.504	2.548	0.149	0.217	0.217
Probe 1B	2.964	2.648	0.2106735231	0.129	0.02309401077	2.964	2.542	2.541	2.545	0.109	0.149	0.109
Probe 2A	2.69	2.56775	0.09000138888	0.16625	0.0206135069	2.69	2.5	2.581	2.5	0.19	0.149	0.177
Probe 2B	2.841	2.60775	0.1567575091	0.156	0.014	2.841	2.545	2.502	2.543	0.149	0.177	0.149
Probe 3A	2.881	2.61625	0.1775300444	0.13225	0.02005617112	2.881	2.501	2.542	2.541	0.149	0.122	0.109
Probe 3B	2.732	2.56275	0.1180095335	0.1695	0.02367136104	2.732	2.46	2.543	2.516	0.149	0.149	0.19
Probe 3C	2.692	2.569	0.08419421991	0.12225	0.01885691739	2.692	2.501	2.542	2.541	0.122	0.109	0.149
Probe 3D	2.717	2.569	0.1001199281	0.1695	0.02367136104	2.717	2.513	2.503	2.543	0.19	0.19	0.149
Probe 4A	3.057	2.653	0.2698703392	0.129	0.02309401077	3.057	2.514	2.541	2.5	0.109	0.109	0.149
Probe 4B	2.541	2.51425	0.03307944981	0.146	0.02797618034	2.541	2.473	2.541	2.502	0.149	0.177	0.149
Probe 4C	2.364	2.496	0.088	0.139	0.02	2.364	2.54	2.54	2.54	0.109	0.149	0.149
Probe 4D	2.583	2.54225	0.03348009359	0.14925	0.03306937153	2.583	2.501	2.543	2.542	0.149	0.109	0.149
Probe 5A	2.758	2.578	0.1212133106	0.15925	0.0205	2.758	2.5	2.541	2.513	0.19	0.149	0.149
Probe 5B	2.948	2.62225	0.2180250368	0.1525	0.02805352028	2.948	2.5	2.5	2.541	0.122	0.149	0.149
Probe 6A	2.759	2.579	0.1212133106	0.109	0	2.759	2.501	2.542	2.514	0.109	0.109	0.109
Probe 6B	2.907	2.612	0.1987947015	0.146	0.006	2.907	2.5	2.554	2.487	0.149	0.137	0.149
Probe 7A	2.65	2.56175	0.06009645026	0.1695	0.02367136104	2.65	2.541	2.515	2.541	0.149	0.149	0.19
Probe 7B	2.542	2.5245	0.02033879708	0.1595	0.03882009789	2.542	2.514	2.541	2.501	0.19	0.149	0.109
Probe 7C	2.649	2.558	0.0635295207	0.16625	0.0206135069	2.649	2.541	2.541	2.501	0.149	0.149	0.19
Probe 7D	2.541	2.53575	0.01459166429	0.1595	0.03882009789	2.541	2.514	2.543	2.545	0.109	0.149	0.19
Probe 8A	2.691	0.4220527259	0.09201947258	0.16625	0.0206135069	2.691	2.473	2.541	2.542	0.149	0.149	0.19
Probe 8B	2.88	2.612	0.1821629307	0.14925	0.03306937153	2.88	2.473	2.554	2.541	0.149	0.109	0.149
Probe 8C	2.921	2.636	0.1928574603	0.1695	0.02367136104	2.921	2.501	2.582	2.54	0.149	0.19	0.19
Probe 8D	3.099	2.6745	0.2832872512	0.1865	0.02805352028	3.099	2.515	2.541	2.543	0.19	0.19	0.149
Avg	2.779964286	2.510242954	0.1384053195	0.1526875	0.02378640489	Avg no First:	2.52222619					
Std	0.1770426779	0.4116095374		0.02135314022		Std no First:	0.02562818064					

Length Avg Error	0.09269642857				Error:	0.421	0	0.041	0
Length Error:	3.71%					0.34	0.041	0.016	0.002
						0.49	0.027	0.041	0.041
Width Avg Error	0.02343973214					0.233	0	0.041	0
Width Error:	0.1535144144	15.35%				0.448	0.002	0.004	0.048
						0.464	0.042	0.041	0.045
						0.19	0	0.081	0
						0.341	0.045	0.002	0.043
						0.381	0.001	0.042	0.041
						0.232	0.04	0.043	0.016
						0.192	0.001	0.042	0.041
						0.217	0.013	0.003	0.043
						0.557	0.014	0.041	0
						0.041	0.027	0.041	0.002
						0.136	0.04	0.04	0.04
						0.083	0.001	0.043	0.042
						0.258	0	0.041	0.013
						0.448	0	0	0.041
						0.259	0.001	0.042	0.014
						0.407	0	0.054	0.013
						0.15	0.041	0.015	0.041
						0.042	0.014	0.041	0.001
						0.149	0.041	0.041	0.001
						0.041	0.014	0.043	0.045
						0.191	0.027	0.041	0.042
						0.38	0.027	0.054	0.041
						0.421	0.001	0.082	0.04
						0.599	0.015	0.041	0.043

Conclusions/action items:

Run data analysis on results



04/22/2026 - Autoclave testing

CADEN ROBINSON - Apr 29, 2026, 9:38 PM CDT

Title: Autoclave testing

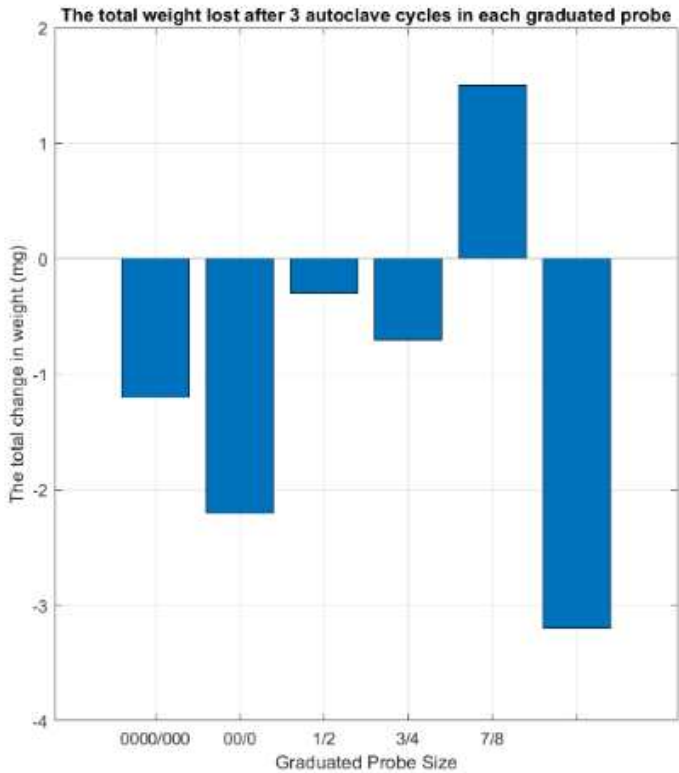
Date: 04/22/2026

Content by: Caden Robinson

Goals: Understand the degradation under the autoclave

Content:

In order to fulfill necessary autoclave endurance parameters defined within the PDS, the fabricated probe must endure an extensive material deposition test to ensure the integrity of the probe's safety moving towards actual ophthalmological implementation. In the test, a control group, a set of regular commercial-grade probes and a test group, an associating set of fabricated graduated probes, were put through several rounds of one hour autoclave sterilization cycles. The before and after recorded probe masses will be tracked and compared between the control and test group and then statistically analyzed for significant difference. Any observable damage or impact, including to the graduation marks, that the testing environments generated on the probes will also be qualitatively tracked and evaluated. After completion of three autoclave cycles, the mean loss of probe weight was 1.02 +/- 1.62 milligrams. Further inspection of these samples after trials showed that there was no impact to the graduation. A paired t-test was then conducted with a reported value of 0.185 indicating that there is no statistically significant difference between the probes weight prior and after autoclaving. Since there was a small sample size, it is not possible to predict the probes degradation over further autoclave testing.



Bowman Probe size not autoclaved (g) autoclaved (g) total weight lost (mg)

0000/000 1.7137 1.7125 1.2

00/0 1.7373 1.7351 2.2

1/2	1.8698	1.8695	0.3
3/4	1.9962	1.9955	0.7
5/6	2.0852	2.0867	-1.5
7/8	2.2513	2.2481	3.2

Conclusions/action items: from the analysis, there is one bad point of data, but this showed that there is no statistical significance before autoclaving the probes and afterwards. With the small sample size, it is not realistic to perform regression analysis to estimate their potential life span, more trials will be needed.

Finish final poster, Complete the final report

Cadaveric Testing Results

CALEB WHITE - Apr 29, 2026, 2:43 PM CDT

Title: Cadaveric Testing Results

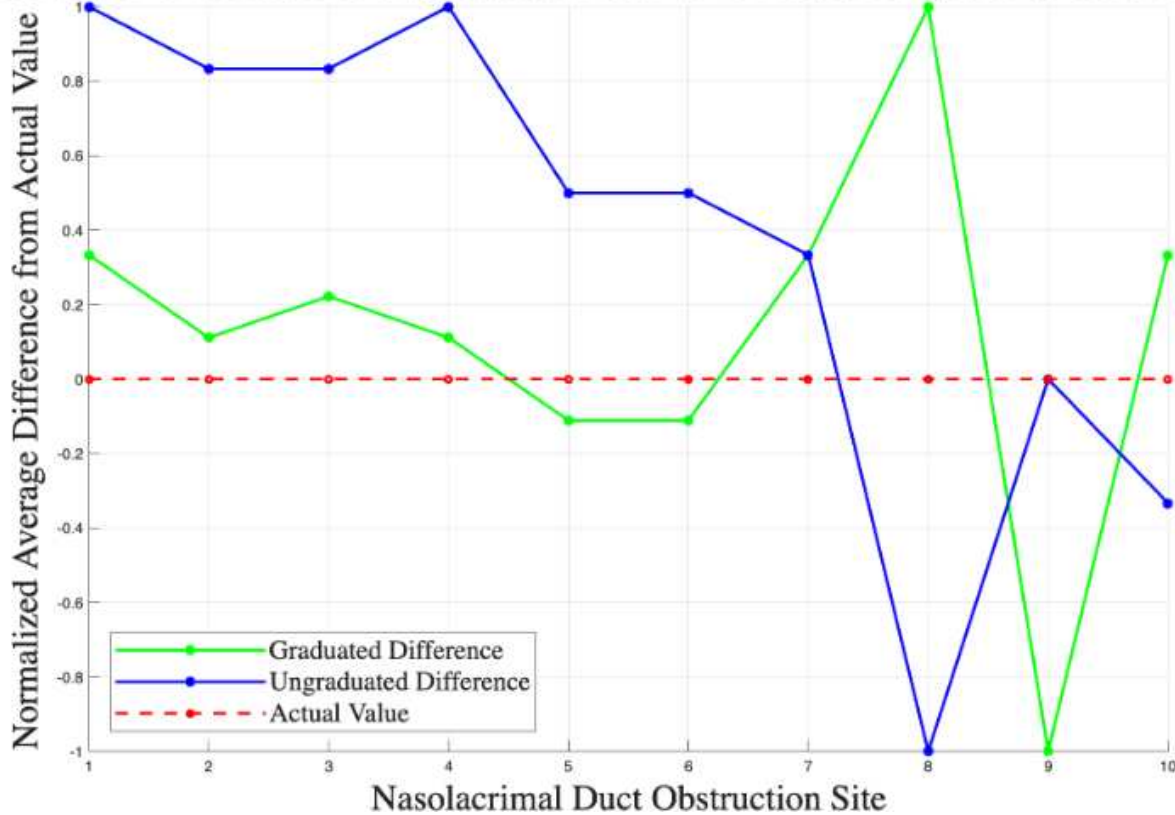
Content by: Caleb White

Goals: Analyze the data collected from cadaveric testing

Content:

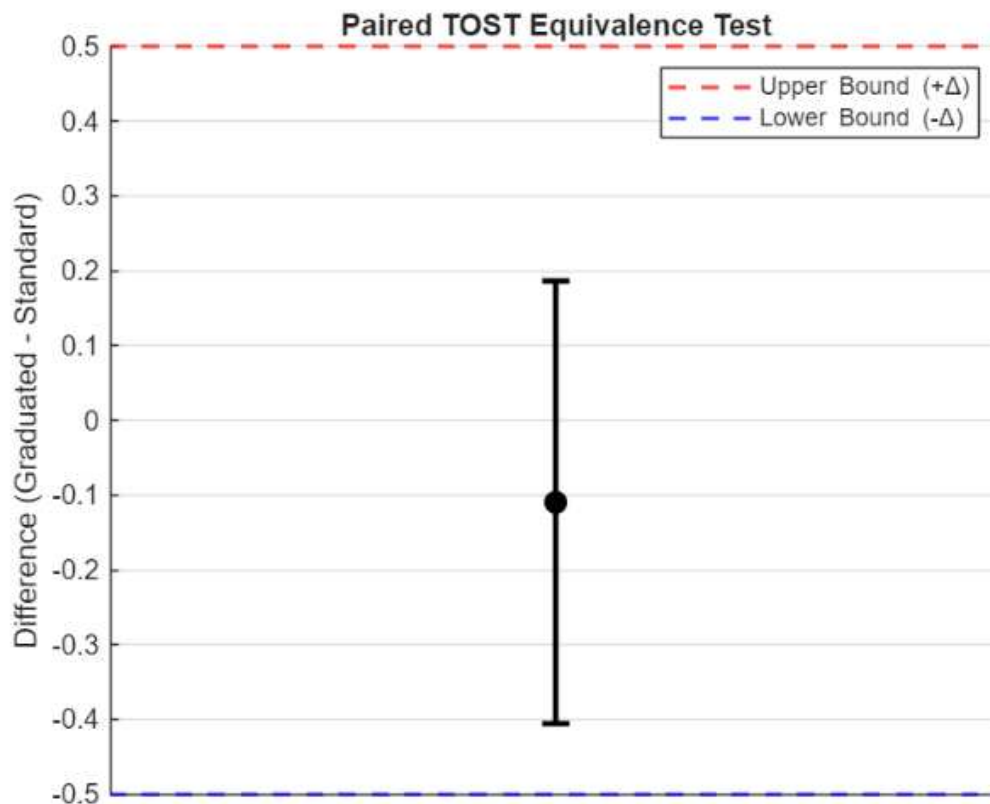
Once a technique was used, the participants reported the measurement for recording. Using the current standard as the ‘clinical’ laceration depth, each technique was evaluated in comparison to the clinical laceration depth to obtain an accuracy score defined as the absolute distance away from this value. With data for each technique, from each participant, at all 10 lacerations, two distinct statistical tests were conducted to evaluate the quantitative accuracy of the measuring techniques. The first test, was a paired TOST (two one-sided test) in order to prove equivalency between the clinical measurements and the graduated measurements and the second paired t-test to prove a difference between the ungraduated accuracy scores and the graduated accuracy scores. Combined, significant results would allow the graduated probes to be translationally defined as an equivalent or superior method of clinical quantitative characterization of lacrimal measurements with respect to the gold standard and ungraduated measurement techniques respectively.

Accuracy of Graduated vs Ungraduated Bowman's Probes compared to Gold Standard



It is important to note that because the true canalicular laceration length is not directly known, absolute measurement accuracy cannot be determined. Therefore, only agreement with the current clinical standard was assessed. While paired t-tests are used to evaluate differences between methods, equivalence TOST testing with predefined clinical margins provides a more appropriate framework for determining whether the graduated probe produces measurements comparable to the standard approach. Specifically, the TOST evaluation was conducted to answer the question of whether the graduated probes produce measurements that are clinically indistinguishable from the current standard method. Because no derived constant for acceptance of clinical measurement variability exists, a delta value of 0.5 mm was applied based on the idea that a change in 0.5 mm estimation would not significantly alter the general interpretation of the case. In this test, a 90% confidence interval is generated through comparing the paired difference mean across all measurements. It tracks whether or not the mean difference fails within the negligible range, between the upper and lower bounds. Using each participant's raw measurement value at each of the 10 obstruction sites for a value of n = 30, pairing each graduated value to its partnering gold standard value, the result was deemed equivalent. This meaning that the difference between the

measurement values is small enough that the variation can be considered clinically irrelevant, therefore deeming the measurement techniques as indistinguishable in accuracy.



The second test utilized a paired t-test with a desire to reject the null hypothesis. The null hypothesis proposed that the graduated and ungraduated probe methods were equivalent in their accuracy in reference to the clinical gold standard value. Comparing each accuracy score of the graduated and ungraduated probes at each station for each participant, a p-value less than 0.05 was returned. This conclusion indicates that the supplied data sets are statistically significant, meaning the improved accuracy seen with the use of graduated probes in comparison to the ungraduated was not down to random chance but rather a result of the graduation guiding accurate diagnostic estimation.

Conclusions/action items:

These results confirm the usefulness of the graduated probe for both its accuracy and simplicity, imploring further push for actual implementation of the graduated probes into a clinical setting. It is important to note that testing these probes on cadavers is different from their performance on a live person, since there will be other biological factors like blood and swelling that are not accounted for. It will be crucial that these probes are tested in live patients to guarantee their effectiveness. Since the obstructions inside the cadavers were not known, determining their location required a level of operator skill. This led to variability in each measurement, as both residents and the fellow reported different depths within the same specimen. Using an actual absolute known depth could help to reduce this variability and allow for more accurate evaluation of the graduations accuracy during testing.



Tissue Pull Testing Results

CALEB WHITE - Apr 29, 2026, 2:40 PM CDT

Title: Tissue Pull Testing Results

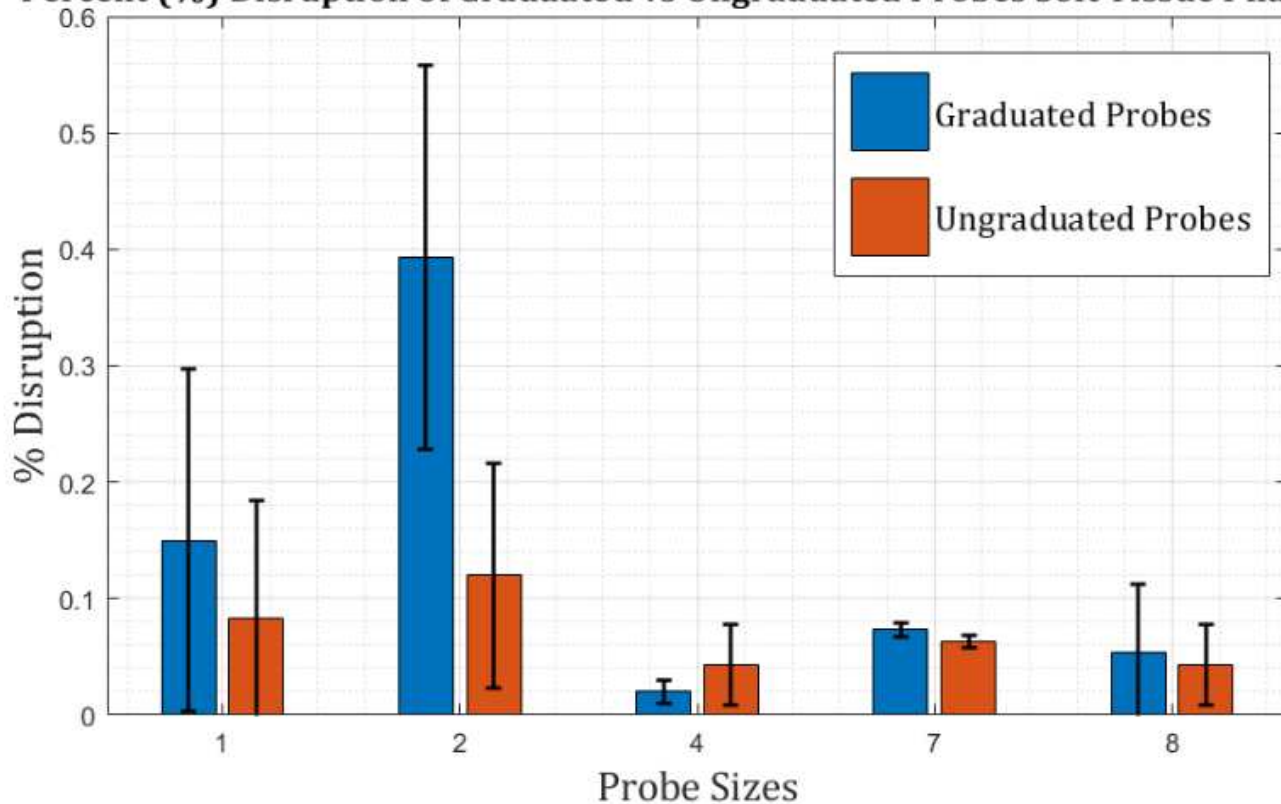
Content by: Caleb White

Goals: Analyze the data collected from cadaveric testing

Content:

Due to the independent and small nature of the samples, a test which utilizes mean difference to make inferences about similarity rather than identifying difference, such as a t-test, was deployed. Using a set of independent-sample TOST (two one-sided tests) with a delta value of 0.05 (95% confidence interval) with $n=3$, and Welch degrees of freedom, conclusions about the similarity of the probe type's disruptive influence can be made. Probe sizes 4, 7, and 8 all provided equivalence, passing the TOST test, proving similarity in tissue disruption between the ungraduated and graduated probe types. Sizes 1 and 2 however failed to prove equivalency across probe types because of the large magnitude of the percent difference found in these smaller probe sizes. To verify findings because of the small sample size, two sample t-tests were also run for each size. Aligning with TOST, each of 4, 7, and 8 failed to reject the null hypothesis meaning there was no conclusive evidence of difference between the samples. Similarly, probe size 2 also proved congruent, providing statistical significance with a p-value less than 0.05, rejecting the null and proving the difference between the probe types was down to more than simply chance, indicating these graduated probes led to significant disruption in comparison to the ungraduated probes. The probe size 1 however, failed to reject the null, meaning it was not conclusive as to if the sample could prove difference between the probe types, a result which does not support the TOST findings.

Percent (%) Disruption of Graduated vs Ungraduated Probes Soft Tissue Phantom



Conclusions/action items:

Based on the analysis, it can be observed that the smaller probe sizes struggled with increased disruption across probe types in comparison to the larger probe sizes. Causes of this may include the graduation being marked differently because of the smaller diameter of the probe shafts, or an increased stress concentration due to a smaller cross sectional area contacting the tissue mimic. For this data in general, the extremely small sample size and variability brought in by the computer analysis necessitates further experimental testing with a larger pool of data to make robust conclusions about the state of graduated tissue pull. It is also imperative

to consider that the agar-gelatin soft tissue mimic developed for this test is not a perfect representation of the true mechanical behavior of the lacrimal soft tissue. In order to develop keener insight into the graduates behavior, deeper investigation with a more finely curated phantom material is needed.



Uniformity Testing Results

Cole Miller - Apr 29, 2026, 7:39 PM CDT

Title: Uniformity Testing Results

Content by: Cole Miller

Goals: Analyze the data collected from uniformity testing

Content:

After analyzing each probe, the average interval length was found to be 2.59 mm, corresponding to an average error of 3.71% from the target length of 2.5 mm, indicating strong consistency in spacing between markings. The average marking width was measured at 0.15 mm, with a higher average error of 15.35%; however, this variation is not practically significant, as it does not meaningfully affect the visibility of the markings. The average distance from the probe tip to the first marking was 2.78 mm. While this highlights an area where the fabrication process could be refined, it does not substantially impact the overall functionality of the probe. Collectively, these results demonstrate that the fabrication method produces probes with a high degree of reproducibility and sufficient accuracy for reliable clinical application

Conclusions/action items:

Collectively, these results demonstrate that the fabrication method produces probes with a high degree of reproducibility and sufficient accuracy for reliable clinical application



Autoclave Testing Results

CALEB WHITE - Apr 29, 2026, 2:43 PM CDT

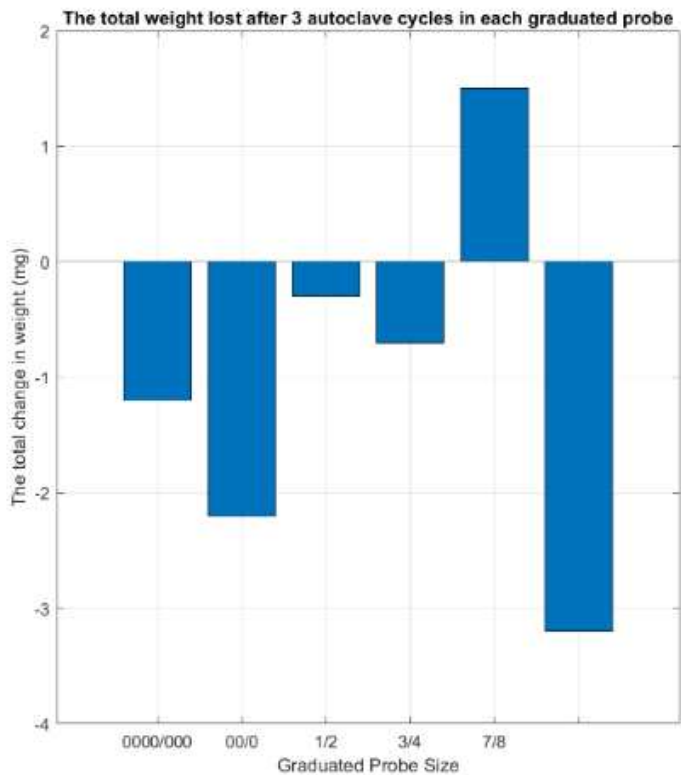
Title: Autoclave Testing Results

Content by: Caden Robinson

Goals: Analyze the data collected from autoclave testing

Content:

In order to fulfill necessary autoclave endurance parameters defined within the PDS, the fabricated probe must endure an extensive material deposition test to ensure the integrity of the probe's safety moving towards actual ophthalmological implementation. In the test, a control group, a set of regular commercial-grade probes and a test group, an associating set of fabricated graduated probes, were put through several rounds of 1 hour autoclave sterilization cycles. The before and after recorded probe masses will be tracked and compared between the control and test group and then statistically analyzed for significant difference. Any observable damage or impact, including to the graduation marks, that the testing environments generated on the probes will also be qualitatively tracked and evaluated. After completion of 3 autoclave cycles, the mean loss of probe weight was 1.02 +/- 1.62 milligrams. Further inspection of these samples after trials showed that there was no impact to the graduation.



Conclusions/action items:

A paired t-test was then conducted with a reported value of 0.185 indicating that there is no statistically significant difference between the probes weight prior and after autoclaving. Since there was a small sample size, it is not possible to predict the probes degradation over further autoclave testing. A complete data set is available in Appendix I.



Accelerated Life Testing Results

NEEL SRINIVASAN - Apr 29, 2026, 6:24 PM CDT

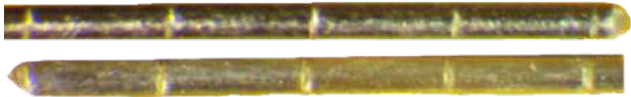
Title: Accelerated Life Testing Results

Content by: Neel Srinivasan

Goals: Analyze the data collected from accelerated life testing

Content:

The graduated Bowman's probes must maintain their composition and procedural viability throughout the 5-10 year lifespan as stated by the client. To measure the potential visual degradation the probes will encounter while inside the lacrimal drainage system, an accelerated life test was conducted. Two pairs of probes of sizes 2 and 4, with one pair unmarked and the other graduated, were placed in artificial tear solution and kept in an InCu Safe incubator that maintained sterility, temperature at 37 °C, and CO₂ levels at 5%. An in depth protocol for the preparation of the artificial tear solution is outlined in Appendix G. The probes were kept in the incubator for 48 hours, equating to 2,880 procedural uses, and then observed under a Leica MZ95 stereomicroscope to check for potential discoloration and marker degradation.



Conclusions/action items:

While the probes had a slight discoloration, the markers remained distinguishable after accelerated life testing. It is important to note however, that this discoloration is uniform across both standard and graduated Bowman's probes, and that 2,880 procedural uses is uncommon as 2,000 is the typical lifespan of clinical probe



Progress Report #1

CALEB WHITE - Apr 24, 2026, 10:56 PM CDT

Graduated Bowman Probes

Date: January 23 to January 30, 2025

Client: Dr. James Law

Advisor: Professor Monica Okunogbo

Team:

Nesi Srinivasan nesi@bwh.harvard.edu (Team Leader/BPAO)

Caden Robinson cadr@bwh.harvard.edu (BSAC)

Caleb White cwhite@bwh.harvard.edu (BWHIC)

Cole Miller cmiller@bwh.harvard.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilife, Nurochelus, Monodry) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a stent with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

The full team was decided at the project kickoff and all project roles were set. The team has begun preliminary research to begin to gain information on the subject matter and have contacted the client to set up an initial meeting to set semester and project expectations.

Summary of Weekly Team Member Design Accomplishments

- Team:
 - o Began researching Bowman's Probe material composition, uses, existing competing designs, and community impact
 - o Reached out to client and advisor to schedule meetings

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Progress_Report_1.docx (13.5 kB)



Progress Report #2

CALEB WHITE - Apr 24, 2026, 10:56 PM CDT

Graduated Bowman Probes

Date: January 30 to February 5, 2026

Client: Dr. James Law

Advisor: Professor Monica Ohnsorg

Team:

Niel Srinivasan nsriniva@bvsic.edu (Team Leader/BPAG)

Caden Robinson carobinso@bvsic.edu (BSAC)

Caleb White cwhite@bvsic.edu (BWIIC)

Cole Miller cmiller@bvsic.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilflow, Nurochelus, Monodry), to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a probe with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team had its first meeting with Dr. Law to gather preliminary information on his design requirements, potential ideas, and goals for application for the device to the clinic. The team prepared questions for Dr. Law, while keeping track of his answers in LabArchives. The team has also split up sections of the Performance Design Specification document, and plans to have it finished by Thursday, February 5th. Finally, the team plans to meet with Dr. Ohnsorg to discuss our continued research and the content of the first client meeting.

[Download](#)

Progress_Report_2.docx (13.8 kB)



Progress Report #3

CALEB WHITE - Apr 24, 2026, 10:56 PM CDT

Graduated Bowman Probes

Date: February 6 to February 13, 2026

Client: Dr. James Law

Advisor: Professor Monica Okunogb

Team:

Nesi Srinivasan nesi@psu.edu (Team Leader/BPAO)

Caden Robinson cadr@psu.edu (BSAC)

Caleb White cwhite@psu.edu (BWOIC)

Cole Miller cmiller@psu.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilife, Nurochelus, Monodry) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a stent with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team continued its research into different routes to create graduated Bowman probes. The team also worked together to create the design matrix in which we can better evaluate different designs and ultimately choose one that we wish to pursue. The team is also planning out necessary action items to work on the preliminary presentation and report. The team will update Professor Okunogb on this week's progress during the meeting on Friday, February 13th.

Summary of Weekly Team Member Design A accomplishments

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Progress_Report_3.docx (13.5 kB)



Progress Report #4

CALEB WHITE - Apr 24, 2026, 10:57 PM CDT

Graduated Bowman Probes

Date: February 13 to February 20, 2026

Client: Dr. James Law

Advisor: Professor Monica Okunogbe

Team:

Nesi Srinivasan nesi.srin@bvsu.edu (Team Leader/BPAO)

Caden Robinson cadr0002@bvsu.edu (BSAC)

Caleb White cwhite@bvsu.edu (BWIIC)

Cole Miller cmiller@bvsu.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilife, Nurochek, Monodry) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a probe with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team received feedback from Professor Okunogbe on how to improve our design matrix. Specifically, she suggested that we could add a outline for laser annealing given its significant differences compared to laser engraving. The team also created the slides for our preliminary presentation and picked up a set of Bowman's probes from Dr. Law to show our peers during the presentation. The team is also working on setting up a meeting with Professor Pfeiffer to see if he can help us with the laser annealing process and give us clarity.

Summary of Weekly Team Member Design Accomplishments

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Progress_Report_4.docx (13.5 kB)



Progress Report #5

CALEB WHITE - Apr 24, 2026, 10:57 PM CDT

Graduated Bowman Probes

Date: February 20 to February 27, 2026

Client: Dr. James Law

Advisor: Professor Monica Obuseg

Team:

Nesi Srinivasan nesi.srin@bvsu.edu (Team Leader/BPAG)

Caden Robinson cadr0002@bvsu.edu (BSAC)

Caleb White cwhite@bvsu.edu (BWIIC)

Cole Miller cmiller@bvsu.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilife, Nurochek, Monod), to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a stent with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team delivered the preliminary presentation and listened to peer presentations. The team also worked together on the preliminary report and have sent it out to our client, Dr. Law, and Prof. Obuseg. The team is planning to meet with Professor Pfefferkorn today (Thursday, February 26th) to discuss the potential of laser assisted and whether it is a route our team can take to achieve our project goals. During our Friday meeting team members will be individually meeting with Prof. Obuseg to discuss group dynamics and feedback for each other. The team also received a set of sample probes from Dr. Law for designing, fabrication, and to receive better input from Professor Pfefferkorn.

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Progress_Report_5.docx (13.5 kB)



Progress Report #6

CALEB WHITE - Apr 24, 2026, 10:57 PM CDT

Graduated Bowman Probes

Date: February 27 to March 6, 2026

Client: Dr. James Law

Advisor: Professor Monica Okunogb

Team:

Nesi Srinivasan nesi.srin@bvsic.edu (Team Leader/BFAG)

Cedric Robinson cedricr@bvsic.edu (BSAC)

Caleb White cwhite@bvsic.edu (BWIIC)

Cole Miller cmiller@bvsic.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilflow, Nurochek, Monodry) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a probe with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team continued its fabrication plan for the set of graduated Bowman's probes. The team first met with UTM makerspace staff to inquire about the capabilities their laser machines had. We found out that while they can laser anneal/anneal stainless steel, they are unable to help us out due to the small probe size & surface area. The team has also reached out to Professor Justin Williams to ask for advice on the fabrication and design plans of the Bowman's probes. The team has again reached out to Professor Pfeiffer to update him on the makerspace response and ask if he is still interested in helping us with fabrication. The team also plans to have at least one prototype completed prior to show and will seek to maximize the feedback received from our peers.

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Progress_Report_6.docx (14.7 kB)



Progress Report #7

CALEB WHITE - Apr 24, 2026, 10:57 PM CDT

Graduated Bowman Probes

Date: March 6 to March 13, 2026

Client: Dr. James Law

Advisor: Professor Monica Okrasag

Team:

Niel Srinivasan niel.srin@bvsu.edu (Team Leader/BFAG)

Caden Robinson cadr0002@bvsu.edu (BSAC)

Caleb White cwhite@bvsu.edu (BWIIC)

Cole Miller cmiller@bvsu.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (res duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilife, Nurochek, Monodry) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a stent with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team continued its fabrication plan for the set of graduated Bowman's probes. The team got in contact with Professor Pfeifferkorn and was directed towards one of his graduate students, Hassan. The team has managed to meet with Hassan on Monday, March 16th to tour the lab space, and get a better understanding of the machines and procedures we'll encounter during fabrication. The team is also working on creating a more one-long fabrication plan in order to keep ourselves on track with our goals.

Summary of Weekly Team Member Design Accomplishments

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Progress_Report_7.docx (14.7 kB)



Progress Report #8

CALEB WHITE - Apr 24, 2026, 10:58 PM CDT

Graduated Bowman Probes

Date: March 13 to March 19, 2026

Client: Dr. James Law

Advisor: Professor Monica Okuszeg

Team:

Niel Srinivasan nsriniva@bvsu.edu (Team Leader/BPAO)

Caden Robinson carobinso@bvsu.edu (BSAC)

Caleb White cwhite@bvsu.edu (BWIIC)

Cole Miller cmiller@bvsu.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilife, Nurochek, Monodry) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a probe with laser etched bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team met with Hansen, a graduate student working in Prof. Pfeiffer's lab. He showed the workings of the laser for which fabrication will be done and helped fabricate the first graduated prototype using regular oxidation methods. The probe has distinct 5mm markings and will be used at the Show and Tell as a proof of concept. The team has also continued to brainstorm probe holding fixture designs. Now having seen the laser stage layout, designs can be tailored to the specific laser and actual fabrication of the holder will be top priority in the coming days. The team has also been preparing for a show and tell on Friday where an elevator pitch will be given to the BME seniors, followed by feedback on design and prototypes. Using given advice, design, fabrication, and testing methods will be improved.

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Progress_Report_8.docx (15.1 kB)



Progress Report #9

CALEB WHITE - Apr 24, 2026, 10:58 PM CDT

Graduated Bowman Probes

Date: March 20 to March 26, 2026

Client: Dr. James Law

Advisor: Professor Monica Okrusog

Team:

Nesi Srinivasan nesi.srin@bvsic.edu (Team Leader/BPAG)

Caden Robinson cadr0002@bvsic.edu (BSAC)

Caleb White cwhite@bvsic.edu (BWIIC)

Cole Miller cmiller@bvsic.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilflow, Nurochek, Monoky) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a probe with laser etched bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team worked on fabrication of our fixture for the laser marking process. The team used the mill and lathe in the Engineering Center Building Design Lab to create an aluminum fixture that can hold all of the Bowman's probe sizes. The team also received valuable feedback and guidance from seniors during this week. We decided to follow through on one particular piece of advice, specifically having screw holes to secure the probe to the fixture to ensure uniformity. The team also has planned to meet Professor again to create another prototype with the usage of our new fixture. Finally, the team has created a tentative fabrication and testing timeline that would allow the best results before final poster presentation.

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Progress_Report_9_1_.docx (14.4 kB)



Progress Report #10

CALEB WHITE - Apr 24, 2026, 10:58 PM CDT

Graduated Bowman Probes

Date: April 3 to April 10, 2026

Client: Dr. James Law

Advisor: Professor Monica Okuszeg

Team:

Niel Srinivasan niel.srin@bvsic.edu (Team Leader/BPAO)

Caden Robinson cadr0002@bvsic.edu (BSAC)

Caleb White cwhite@bvsic.edu (BWIIC)

Cole Miller cmiller@bvsic.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilife, Nurochelus, Monodry) to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a stent with laser etched bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

This week the team worked with Hanna, Professor Phillips' graduate student, to come up with an improved version of our laser fixture. The team found out that the initial version was too tall and reflective, which would cause disruption to the laser's focal plane and overall marking procedure. The team has acquired thinner and non-reflective steel from the design lab at engineering centers building, and has a planned meeting with Hanna on Friday, April 10th to determine the parts viability. Once the team is given a clearance, we plan to fabricate the fixture and conclude prototype fabrication on Monday, April 13th.

Summary of Weekly Team Member Design Accomplishments

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Progress_Report_10_1_.docx (14.6 kB)



Progress Report #11

CALEB WHITE - Apr 24, 2026, 10:58 PM CDT

Graduated Bowman Probes

Date: April 10 to April 17, 2026

Client: Dr. James Law

Advisor: Professor Monica Okrasag

Team:

Niel Srinivasan nsriniva@bvsu.edu (Team Leader/BPAG)

Caden Robinson cadrobin@bvsu.edu (BSAC)

Caleb White cwhite@bvsu.edu (BWIIC)

Cole Miller cmiller@bvsu.edu (Communicator)

Problem Statement

Bowman probes are the standard instrument used in interrogation of the nasolacrimal (nasal duct) system in Ophthalmology. They are available in various sizes and provide tactile feedback to the surgeon when probing the canalicular/nasolacrimal system, allowing them to assess for strictures, discontinuities, obstruction, or other abnormality within its lumen. Probing is typically performed prior to the passage of implants such as nasolacrimal stents (eg. Crawford, Lacrilflow, Nurochek, Monokly), to confirm patency of the nasolacrimal system. Available probes on the market do not have any markings on them which may allow the surgeon to make measurements to points within the canalicular/nasolacrimal lumen (eg. a stricture at 30 mm distal to the punctum), which can be helpful in correlating with imaging findings, or for accurate clinical documentation and therefore inform management of nasolacrimal pathologies. We propose the development of such a stent with marked bands corresponding to millimeter markings which may be referenced during canalicular or nasolacrimal probing.

Brief Status Update

To start our work, the team obtained finished prototypes from Homan, Professor Pfeiffer's graduate student. The team is now focusing on writing protocols, in order to quantitatively and qualitatively assess our graduated Bowman's Probe prototype. The team is individually covering different testing protocols, and plan to be ready with data and proof of concept by Friday, April 24th for poster presentation. The team also has plans to meet with Dr. Law for wet sample & cadaveric testing to survey the accuracy of the prototypes.

Summary of Weekly Team Member Design Accomplishments

- Team:
 - Created and assigned writing protocols to team members

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Progress_Report_11_1_.docx (14.5 kB)



BME Design: 200, 201, 300, 301, 400 and 402



Graduated Bowman Probe
BME Design: Product Design Specification

February 5, 2026
Biomedical Engineering I/II
Section 304

Client: Dr. James Law & Dr. Suzanne van Lantingham
Advisor: Prof. Monica Olsson

Team Members:

[Neil Schubert \(Leader, SPAG\) | nschubert@wisc.edu](mailto:Neil.Schubert@wisc.edu)

[Caleb Miller \(Communicator\) | cmiller@wisc.edu](mailto:Caleb.Miller@wisc.edu)

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[Caleb White \(BWTG\) | cwhite@wisc.edu](mailto:Caleb.White@wisc.edu)

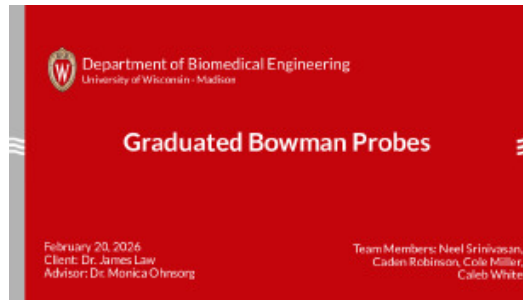
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BME_Design-PDS_Graduated_Bowman_Probe_1_.pdf (252 kB)



Preliminary Presentation

CALEB WHITE - Feb 24, 2026, 12:07 PM CST



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Preliminary_Presentation_Graduated_Bowman_Probe.pdf (1.04 MB)

Preliminary Report

NEEL SRINIVASAN - Apr 29, 2026, 12:46 PM CDT

BME Design: 200, 201, 300, 301, 400 and 402



Graduated Bowman probe BMEDesign: Preliminary Report

February 23, 2026

Biomedical Engineering 100

Series 3M

Client: Dr. James Law & Dr. Suzanne von Landtgham

Advisor: Prof. Monica Olusegbe

Team Members:

Noel Srinivasan (Leader, BPAQ) | nrsrinivasan@wisc.edu

Cole Miller (Communication) | cmiller@wisc.edu

Caden Robinson (BSAC) | carobinson@wisc.edu

Caleb White (BWGI) | cwhite@wisc.edu

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Graduated_Bowman_s_Probe_Preliminary_Report.pdf (1.39 MB)



CALEB WHITE - Apr 24, 2026, 11:05 PM CDT



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Gantt_Timeline_BME_301.xlsx (46 kB)



Executive Summary

CALEB WHITE - Apr 24, 2026, 11:08 PM CDT

Executive Summary: RME, Design Excellence Award, RME 201
Graduated Bowman's Probe for Microstrat and Duet Ophthalmoscopy
 Cole Miller, Cole Robinson, Neil Srinivasan, Caleb White
 Advisor: Professor Monica Ottaviano, Clinat, Dr. James Lee

The usage of Bowman's probes is commonplace in the treatment of Non-inferior Duet Obstruction. Doctors use Bowman's probes to measure the depth of obstructions in the macularized duct and provide treatment plans. However, without distinguishable graduation markings, surgeons have to estimate accurate depths. The design of a graduated Bowman's probe is essential in order to reduce measurement inaccuracies and increase treatment plan accuracy. While graduated Bowman probes have been implemented in laboratory settings, such as at Pennsylvania State University, the probes have not been used in clinical practice. Additionally, current medical device regulations present in the Bowman probe market have yet to implement graduated Bowman probes into their market line.

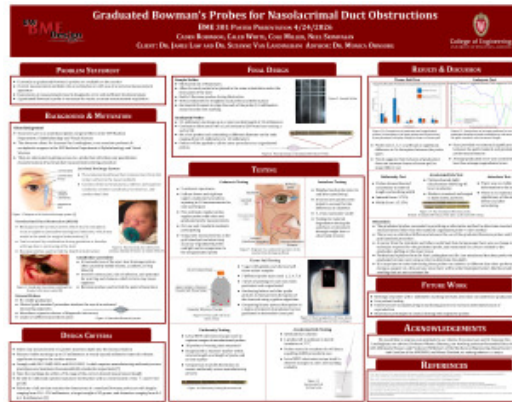
Each graduated Bowman probe consists of each mark every 2.5 millimeters over a total graduated length of 33 millimeters. The markings were produced using a 200-watt laser, creating consistent, repeatable, precise, and permanent markings on the stainless steel surface. The selected spacing represents the smallest uniform interval achievable before laser instability. During fabrication, a steel fixture was used to align each probe in the same position to ensure consistent and uniform alignment under the laser's focal point. The final design is unlike any existing Bowman probe on the market and enhances the precision of current ophthalmological assessments within the macularized duct.

To support integration of the probes into ophthalmological practice at the UW Hospital, it was necessary to demonstrate that laser-induced graduation does not adversely affect probe performance, particularly with respect to patient safety. Several sets of clinical-grade graduated probes were experimentally compared with unmodified probes through stimulation endurance, cyclic fatigue, thermal biocompatibility, and age-related phenomena in vivo pull testing procedures. The experiments looked to observe the interaction between the environment and the probes, with a specific emphasis on identifying increased degradation or adverse effects as a result of the graduation. Each test indicated no statistical distinction between the two probe types, demonstrating their functional equivalence. The probes were further validated by the client through cadaveric proof-of-concept assessment, supporting their integration into standard clinical practice.

The graduated Bowman's probe was designed to improve depth measurement accuracy while preserving the original probe's form and function. The addition of 2.5 mm laser markings using a specialized industrial-grade laser enhances the precision of graduation to the micrometer level, increasing measurement accuracy and reducing reliance on estimation. Because the process only temporarily modifies the chromium oxide surface layer, the probe maintains its biocompatibility, with testing showing no increased degradation. The design is fully compatible with standard sterilization procedures, as repeated autoclave cycles resulted in no change or fading of markings. Plasma-grade laser processing supports consistent manufacturing, while the uniaxial design allows seamless integration into existing practice. Improved measurement accuracy contributes to more effective treatment of macularized duct obstruction, reducing procedure time and the likelihood of repeat interventions. It remains cost-effective through reusability and compatibility with existing hospital practices, while enabling manufacturing capabilities, broad adoption across clinical systems.

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Executive_Summary_-_Graduated_Bowman_s_Probe.pdf (92.6 kB)



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Graduated_Bowman_Probe_Final_Poster.pdf (1.84 MB)

Final Report

NEEL SRINIVASAN - Apr 29, 2026, 11:17 PM CDT



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Graduated_Bowman_s_Probe_-_Final_Report_1_.pdf (6.97 MB)



1/27/26 Nasolacrimal Duct Obstruction

NEEL SRINIVASAN - Jan 28, 2026, 11:34 AM CST

Title: Nasolacrimal Duct Obstruction

Date: 1/27/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize some background biological information on how nasolacrimal duct obstruction is formed and the general composition of obstructions.

Content: Nasolacrimal duct obstruction is an incredibly common disorder of the lacrimal system/duct. Between 6 to 20 percent of newborns exhibit symptoms of duct obstruction. One of the main indicators of this issue is excessive fluid discharge from the eyes, and sometimes also irritated/red eyes. It has also been noted that the excess tear discharge often leads to an irritated skin around the eyes including the eye lids and the cheek area. For example in the image attached below the top eyelid is visibly slightly irritated. While the obstruction is typically treated with ointments, gentle massaging, and eye drops, bowman's probes are used if the symptoms continue to persist beyond 12 months. The lacrimal drainage are creases between the frontons and maxillary processes. There is a cord of ectodermal tissues that separates from the surface and enters this groove. This tissue eventually canalizes and forms the lacrimal sac and nasolacrimal duct (note that this is all happening in the weeks before being born!!). This process of canalization usually begins by week 8 and is completed by birth. Tears are produced by the main and accessory lacrimal glands and drain medially into the puncta, then flow through the canaliculi to the lacrimal sac, and then through the nasolacrimal duct into the nose. Incomplete canalization is the most common cause of nasolacrimal duct obstruction. While the first article mainly goes over duct obstruction and its development in newborns, it's also completely possible to be developed in adults (just very common in newborns!). The typical causes in adults are injury, infection, and very rarely a tumor. Tear glands are synonymous with lacrimal glands. They are located above each eyeball and continuously supply tear fluid that's distributed across the surface of the eye every time a person blinks. Excess fluid then drains through the tear ducts and into the nose. The main issue is the clogging of the puncta, which is essentially the narrow tube that drains fluid. With age, inflammation, and injury this tube can get even narrower which leads to the duct being obstructed. To treat/assess the issue doctors will use a bowman's probe (there are different sizes of probes) to gauge where the obstruction is and what type of treatment/operations they need to prescribe/carry out. From what I've gathered, it seems that this issue is often relatively simple to treat, but the usage of bowman's probes is essential to identifying the location of obstruction.

**IEEE Citation:**

[1] Y. Perez, "Nasolacrimal duct obstruction," StatPearls [Internet]., <https://www.ncbi.nlm.nih.gov/books/NBK532873/> (accessed Jan. 27, 2026).

[2] M. Clinic, "Blocked tear duct," Mayo Clinic, <https://www.mayoclinic.org/diseases-conditions/blocked-tear-duct/symptoms-causes/syc-20351369> (accessed Jan. 28, 2026).

Conclusions/action items:

Look into how bowman's probes can be recycled & their overall environmental impact. Also look into if there are similar biocompatible-esque materials that are longer lasting/cheaper.



1/28/26 The Usage of Stainless Steel in Medicine

NEEL SRINIVASAN - Jan 29, 2026, 12:22 PM CST

Title: The Usage of Stainless Steel in Medicine

Date: 1/28/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize the reasons behind the historical and continued usage of stainless steel for surgical and general instruments in medicine.

Content: Stainless steel has been the primary material used in the creation of surgical and general medical equipment since 1920. One of the main features that makes stainless steel attractive to doctors is its high corrosion resistance. This is due to the intrinsic layer of chromium oxide on stainless steel equipment through doping. Over the course of a medical instruments' lifetime, it will have to undergo repeated sterilization which requires a higher quality material that is able to remain structurally/intrinsically strong after numerous rounds of cleaning. The original material used in 1920 was unintentionally doped stainless steel (as pure as humanly possible). However, doping with chromium, nickel, carbon, nitrogen, copper, molybdenum, and silver has been thoroughly researched and been found to dramatically increase the corrosion resistance of stainless steel. With an increased corrosion resistance, medical instruments made of these doped stainless steel alloys are able to have significantly longer lifespans (up to 20-50 years). While stainless steel is 100% recyclable, the increased lifespan of doped alloys minimizes the amount of recycling, processing, and re-purification and therefore minimizes negative environmental effects. At certain concentrations, the elements above also don't compromise the biocompatibility of instruments which is essential to avoid any unwanted immune response or chronic inflammation.

**IEEE Citation:**

- [1] J. Jeffries, "Medical stainless steel maintenance and cleaning guide," Infinium Medical, <https://infiniummedical.com/medical-stainless-steel-maintenance-cleaning/> (accessed Jan. 28, 2026).
- [2] Y. Xu et al., "A short review of medical-grade stainless steel: Corrosion resistance and novel techniques," Science Direct, <https://www.sciencedirect.com/science/article/pii/S2238785424002400?via%3Dihub> (accessed Jan. 28, 2026).
- [3] G. T. Lueder, "Nasolacrimal duct obstruction in children," American Academy of Ophthalmology, <https://www.aao.org/education/disease-review/nasolacrimal-duct-obstruction-4> (accessed Jan. 29, 2026).

Conclusions/action items:

Understand from our client what material he primarily uses (what type of stainless steel and doping mechanisms). Also learn how Bowman's probes are made and what sizes he wants. Furthermore, understand the effects of either engraving or laser marking on the material properties.



1/29/26 Bowman's Probe Procedure

NEEL SRINIVASAN - Jan 29, 2026, 7:50 PM CST

Title: Bowman's Probe Procedure for Lacrimal Duct Obstruction

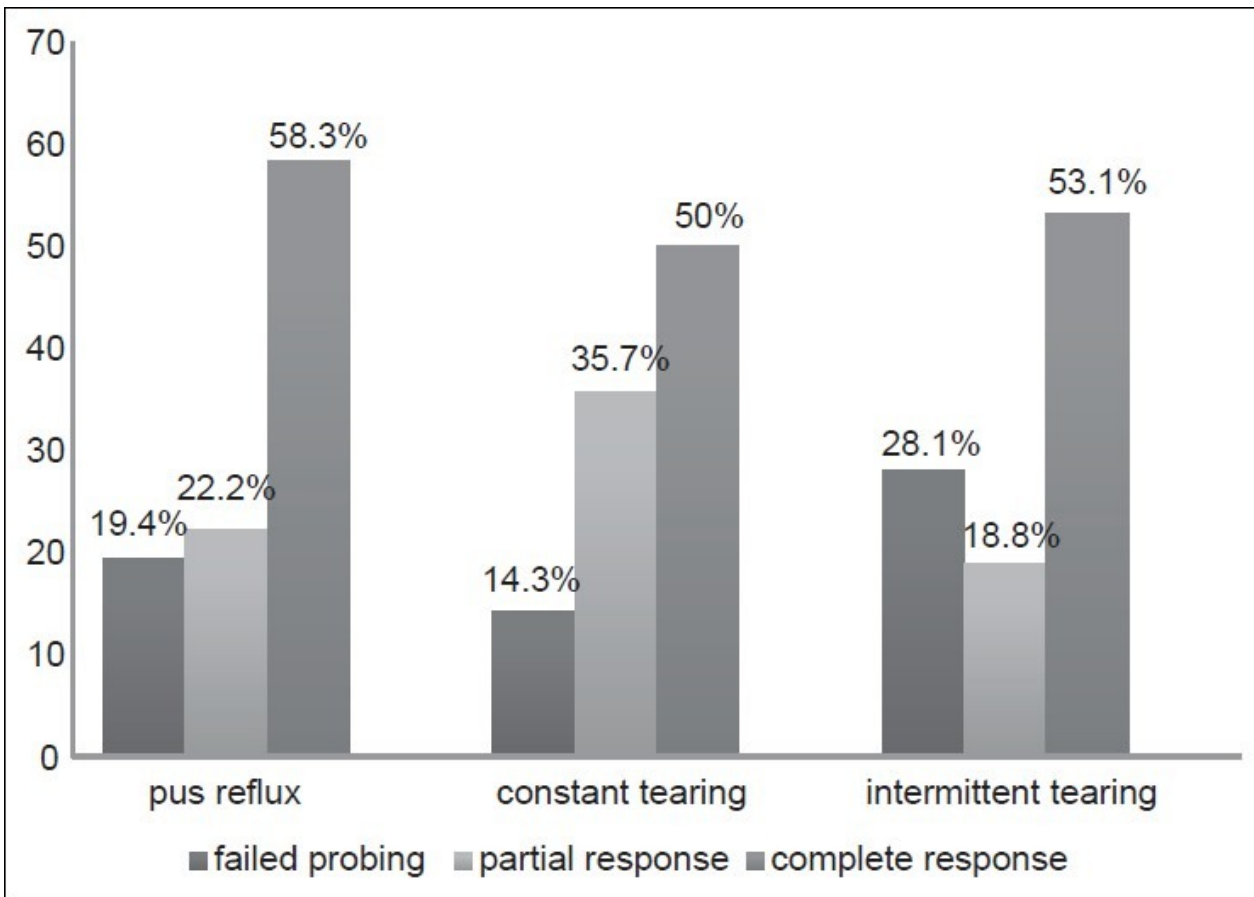
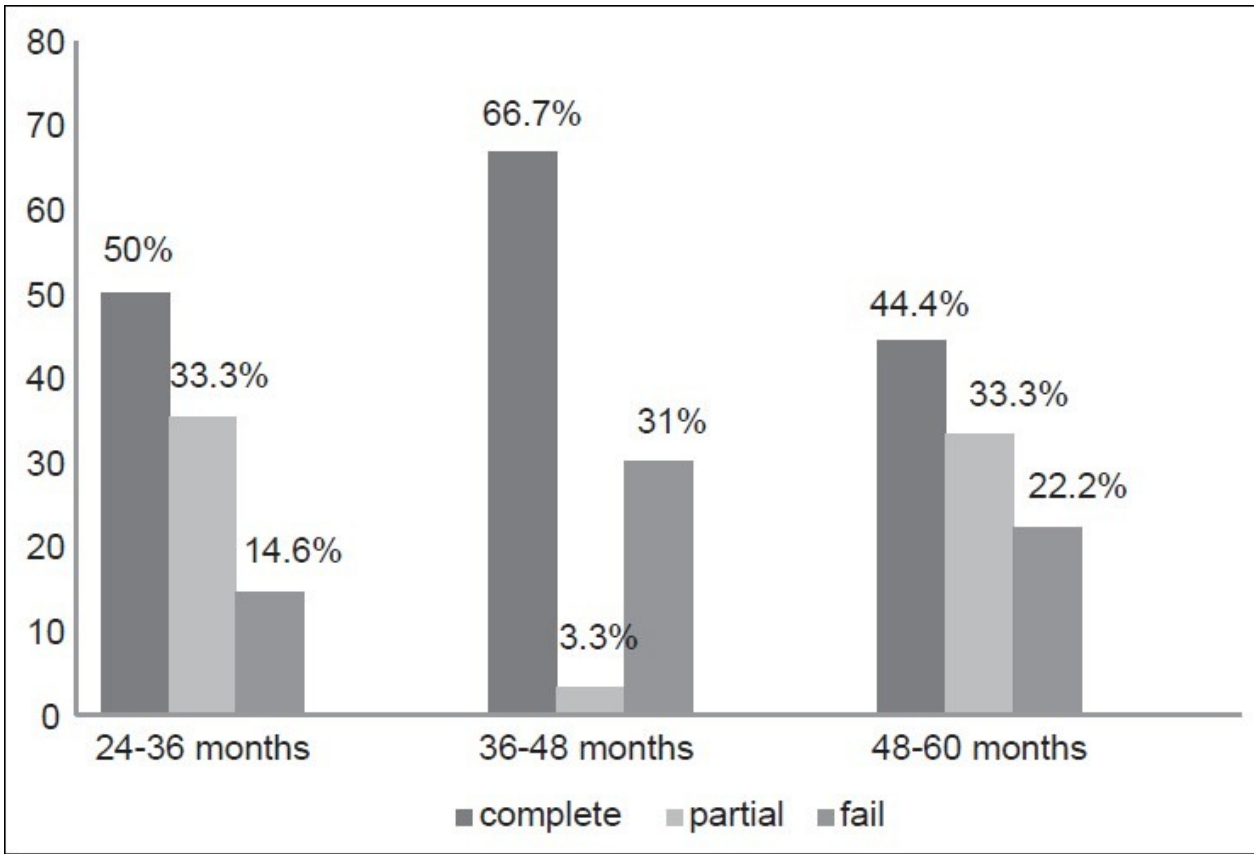
Date: 1/29/26

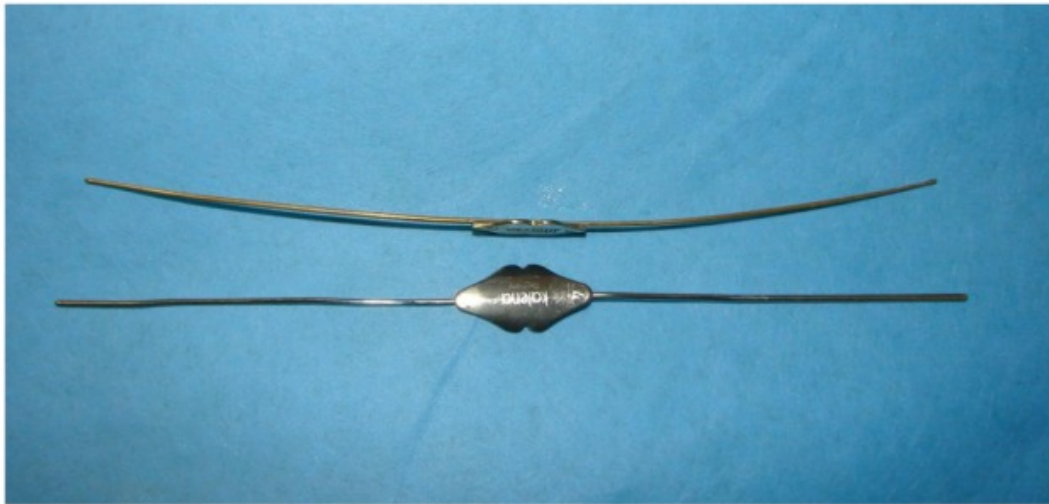
Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize a general video/journal on lacrimal duct obstruction clearance procedures and the usage of bowman's probes to obtain a better understanding of

Content: Lacrimal duct obstruction is a common occurrence, especially in newborns/infants. The procedure to clear the obstruction is relatively simple with the use of bowman's probes, which are thin rods made of doped stainless steel. The probes often come in a set ranging from thin(0.4mm diameter) to wide(1.8mm diameter) for newborns to adults respectively. The procedure starts with general/local anesthesia in the eye/surrounding areas. Then there is dilation of the upper punctum where bowman's probes of size 0 & 00 are vertically inserted into the punctum and ampula. The bowman's probes are then rotated horizontally(in the same plane) 90 degrees such that they can insert into the canaliculus. During this step there is an emphasis on establishing tension in the lateral lid. The probe is then guided through the path until it reaches a firm/bony feeling structure(doctors gauge this based on relative stiffness) which is identified as the lacrimal sac. Then another probe is inserted to confirm the latency and location of the obstruction, upon which saline solution is ran through the lacrimal system and then patients are prescribed topical ointment. The study shows that after 1 month about 50% of patients across all age groups tested experienced partial to no symptoms as displayed in the top figure below. I believe that understanding the overall procedure will help us understand what design/functionality constraints our bowman probes need to have.



**IEEE Citation:**

[1] B. Eshragi, M. A. Fard, B. Masomian, and M. Akbari, "Probing for congenital nasolacrimal duct obstruction in older children," Middle East African journal of ophthalmology, <https://pmc.ncbi.nlm.nih.gov/articles/PMC3841956/> (accessed Jan. 29, 2026).

Conclusions/action items:

Research costs and material fabrication procedures to understand how our team should go about designing our probe set. For example if we plan to engrave our probes do we need to treat it in a certain way to maintain its biocompatibility? research will be necessary to find this out.



2/12/26 ThermoChromic Coatings

NEEL SRINIVASAN - Feb 13, 2026, 11:38 AM CST

Title: ThermoChromic Coatings

Date: 2/12/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize how thermoChromic coatings work

Content: ThermoChromic coatings have microcapsules that contain encapsulation agents and pigments such as urea-formaldehyde and leuco dyes respectively. When heated, the solvent inside the capsules melts which allows the weak acids to interact with the leuco dyes. This process changes the capsule's chemical composition and results in the probe's surface changing color. There is also the possibility of adding stereoisomeric agents to the coating to allow for a more rapid change in color. However, our client has informed us that the probing procedure takes less than 60 seconds, which means that our probe would require a high ratio of stereoisomeric agents in the coating. Furthermore, rapid color change means that when the doctor pulls the probe out to measure the range of color change, it will likely fade away and would be quite complicated to measure manually. There is also the risk of permanently damaging the coating due to autoclaving. Over time, with constant autoclaving for sterilization, the probe will be subject to high temperatures which could mess with the chemical composition of the stereoisomers and pigments and lead to a permanent color change.



IEEE Citation:

[1] Olikrom, "Discover the main families of ThermoChromic Materials," Olikrom, <https://www.olikrom.com/en/blog-olikrom/the-expert-eye/all-about-thermoChromic-materials/> (accessed Feb. 13, 2026).

Conclusions/action items:

Continue research into laser annealing and whether it's accessible on campus.



2/12/26 Laser Annealing vs Etching vs Engraving

NEEL SRINIVASAN - Feb 13, 2026, 11:24 AM CST

Title: Laser Annealing vs Etching vs Engraving

Date: 2/12/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize the noted differences between laser engraving, annealing, and etching

Content: As summarized in design ideas 2/5/26 Effect of Laser Engraving, laser engraving is a process in which a high energy laser cuts into a material and removes part of it to create patterns or symbols based on a computer program and users decision. This method, similar to the rest of them, are all highly precise and can be customized to the finest note. While laser engraving is a good first step, our client has requested that the material surface remains smooth to avoid the probe catching onto patients tissues. Laser engraving also takes material away so there is a risk of mechanical failure. Laser etching is a similar process, except the laser used operates at a lower energy, causing this method to take off a minimal amount of material. However, with some of our probes having very small diameters, even a minimal amount of material taken off could lead to mechanical failure. Laser annealing on the other hand uses a lower energy laser and removes no surface material. Instead it adds heat to discolor the surface without disrupting the material's polish, surface finish, or dimensional accuracy. It does this through forming an oxide layer that allows the heat to darken the surface appearance without damaging any of the existing coating or material.



Laser Annealing~~~~



Laser Engraving~~~~



Laser Etching^^^^

IEEE Citation:

[1] Laserax, "Medical device laser marking: Applications & solutions," Laserax, <https://www.laserax.com/blog/medical-laser-marking> (accessed Feb. 13, 2026).

Conclusions/action items:

Research thermochromic coating capabilities and the quickness.



3/12/26 Class 4 Lasers

NEEL SRINIVASAN - Mar 12, 2026, 11:01 PM CDT

Title: Class 4 Lasers

Date: 3/12/26

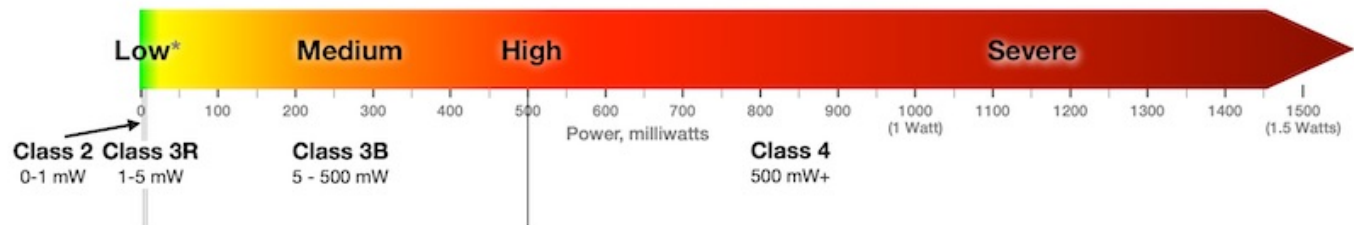
Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize the parameters of class 4 lasers, their distinct features, and potential hazards if mishandled.

Content: Laser setups are classified into 5 sections (1, 2, 3A, 3B, & 4) with each depending on the amount of power the laser runs on. Professor Pfefferkorn has informed our team that his lab uses a 200W fiber laser, which falls into class 4. Class 4 includes any lasers operating above 500mW of power. Given that the laser our team will be working with is operating well above the normal region, it is important that we understand the potential dangers and how we can adapt our setup to minimize any dangers. Class 4 lasers are extremely dangerous if they come into contact with your skin, eyes, or dark colored object(even clothing!!). Regardless of whether the laser makes direct contact or upon reflection, the damage is high. For example shiny surfaces can reflect portions of the beam back at observers which could lead to eye or skin damage. If this laser came into contact with someones eye, they wouldn't even be able to blink fast enough to prevent retinal damage. The Nominal Ocular Hazard Distance (NOHD) is the minimum distance upon which if the laser hit someone it wouldn't cause retinal damage. To put it into perspective, the NOHD for a 5W laser is 1640ft/500m. With our laser being 40 times as powerful, it's essential that we follow all lab safety protocols and comply with ANSI Z136.1 to ensure our safety while prototyping. I think if we are to use a stainless steel fixture, we should inquire/assess how reflective or safe this would be in case there would be any beam reflection on to observers. For example, if we are to use wood there would be less risk in terms of safety, however our designs lifespan and functionality would be compromised. I think potentially creating another design matrix could be beneficial.

Eye injury hazard



*Eye injury hazard descriptions above are valid for for exposures relatively close to the laser. Because the beam spreads, less light will enter the pupil at greater distances. The hazard decreases the farther a person is from the laser, and the shorter the exposure time (e.g., do not deliberately look or stare into the beam). For example, a 1mW Class 2 laser beam is eye safe for unintentional exposures after about 23 ft (7 m), a 5mW Class 3R beam is eye safe after about 52 ft (16 m), a 500 mW Class 3B beam is eye safe after about 520 ft (160 m), and a 1500 mW Class 4 beam is eye safe after about 900 ft (275 m).
(Calculations are for visible light, a 1 milliradian beam, and a 1/4 second Maximum Permissible Exposure limit.)

IEEE Citation:

[1] J. Hadler, Laser Safety Facts, <https://www.lasersafetyfacts.com/laserclasses.html> (accessed Mar. 12, 2026).

Conclusions/action items:

Talk to Professor Pfefferkorn about necessary safety precautions

Assess material properties and choose the best one in terms of functionality and safety.



1/27/26 Calibrated Bowman's Lacrimal Probe

NEEL SRINIVASAN - Jan 27, 2026, 9:47 PM CST

Title: Calibrated Bowman's Lacrimal Probe

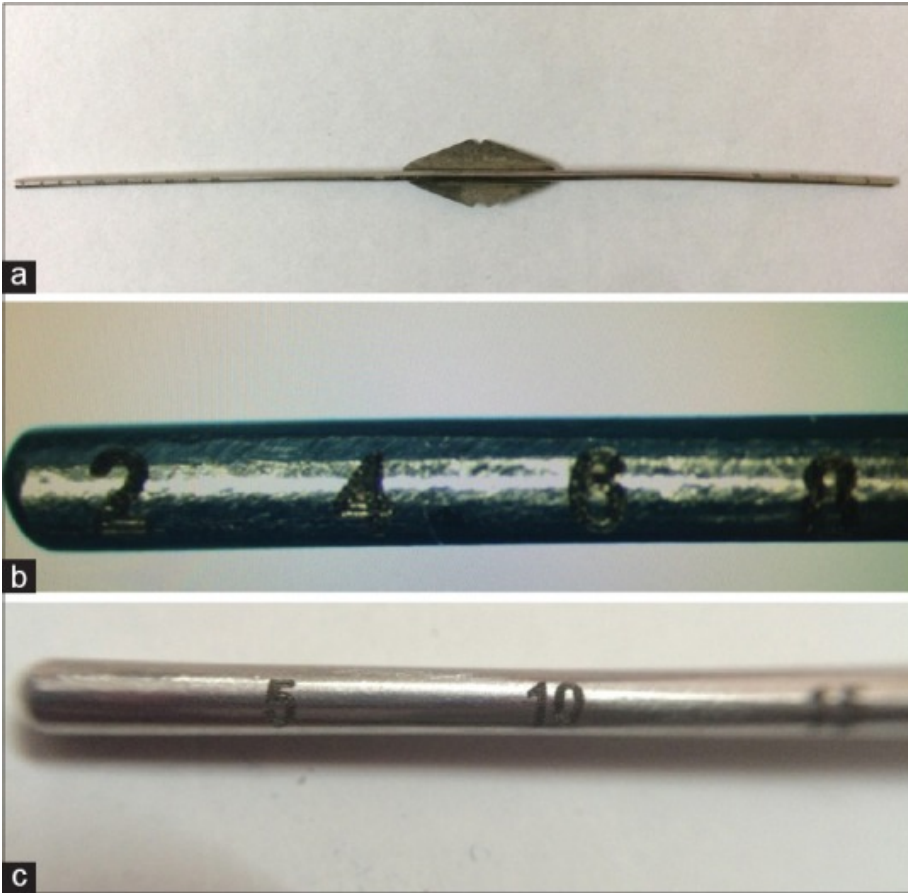
Date: 1/27/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize the features of a competing design of bowman's probes that achieves the problems that our team aims to solve.

Content: Epiphora is when a patient is experiencing an overflow of tears due to blockage in the nasolacrimal ducts and canalicular obstruction. To resolve this issue, ophthalmologists will insert a bowman's probe into these ducts via the lower eyelid to gauge the area in which the blockage is located. The new design featured below is meant to help doctors take accurate measurements of blockage location based on precisely engraved measurements. Similar to the majority of bowman's probes, these graduated designs are made of stainless steel, and feature the exact same size as standard probes. The usage of stainless steel is due to its high biocompatibility, strength, and corrosion resistivity. While this design is in the right direction in terms of our project, I believe there are a couple parameters where it could be improved. The first would be to use some type of laser engraving or biocompatible markings as opposed to engraving. Engravings could get caught on parts of the nasolacrimal ducts and result in tissue damage. The engravings as shown in the image below also don't seem to be as easily recognizable for viewers. I think it would be beneficial to instead use line markings as this would be more accurate. For example, how are probe users supposed to know which part of the number is where that exact measurement is? As in, does 2 mm mark fall in the center, right, or left part of the marking on the probe. Line markings would greatly ease this confusion, especially if doctors want their measurements to be as precise as possible rather than a rough estimate.



IEE Citation:

[1] A. Pujari, M. S. Bajaj, and P. Sharma, "Calibrated Bowman's lacrimal probe," *Indian journal of ophthalmology*, <https://pmc.ncbi.nlm.nih.gov/articles/PMC5859621/> (accessed Jan. 27, 2026).

Conclusions/action items:

Look into how laser engraving could change the biocompatibility of stainless steel, and what type of trainings would we need to have that done at the UW. Also investigate the formation/background biology of nasolacrimal duct blockage, and the overall surgical procedure that is done to solve this.



1/28/26 Lecture #2

NEEL SRINIVASAN - Jan 28, 2026, 1:57 PM CST

Title: Lecture #2 Notes

Date: 1/28/26

Content by: Neel Srinivasan

Present: Whole Class

Goals: To summarize notes on literature search and assessing good citations/sources

Content: ChatGPT is often inaccurate and can result in false data/bias. It often hallucinates its data and makes confidently false claims. Using the wisc libraries website can be especially helpful as it incorporates many different databases along with resources to find exact sources that could be prevalent to users based on keyword searches and needs. For example a user can click on engineering and then a specific database within the engineering section to narrow their search into a more accurate window. Scopus is a very useful tool for scientific research in a broad sense, as it isn't just engineering but biology/sciences as a whole. SCOPUS is an abstract only database, however wisc libraries offers full pdf readings through scopus such that users can read the entire paper. Zotero is a great tool for citation organization and overall group collaboration. The app allows users to add citations in real time from the internet to a groups citation pool and automatically indents and includes IEEE in text citations, with a fully automated reference list that outputs at the end of a paper.

Conclusions/action items:

Create a group Zotero library for citation management

Look into scopus to better understand nasolacrimal duct obstruction and find more in depth/relevant articles



2/11/26 Lecture #4

NEEL SRINIVASAN - Feb 11, 2026, 1:48 PM CST

Title: Lecture #4 Notes

Date: 2/11/26

Content by: Neel Srinivasan

Present: Whole Class

Goals: To summarize notes on lecture #4

Content: It's important to hit the highlights as opposed to trying to pack the entire project into ten minutes. Keeping titles, bullets, and words brief but clear is helpful as opposed to having long drawn out thoughts. Figure captions are also clear, refer to slides for exact formatting that is necessary. Use valuable figures as opposed to random nonsense ones. For example, use cad images that feature 3D models as opposed to the measurement sheet. A sketch, especially during preliminary presentations and reports, is acceptable as long as it clearly displays the features of the design and is easily legible. Don't put raw data into any of the slides or reports, and data graphs should be properly scaled for easy viewing. An exploded view can be good for rubric points, as we want to be able to storytell through figures. Being personal is a good tool to use during interviews.

Conclusions/action items:

2/13/26 BPAG Meeting

NEEL SRINIVASAN - Feb 13, 2026, 12:21 PM CST

Title: BPAG Meeting

Date: 2/13/26

Content by: Neel Srinivasan

Present: All of the BPAG's

Goals: To summarize notes on the BPAG meeting

Content:

You can either get you client to purchase for you or you can pay or get reimbursed. If there is a purchase over \$1000, you need departmental and client approval. All original receipts must be in the notebook - invoice, table, and should be easily findable. The client and project type is important for funding. For example if the client is UW affiliated, they may want to use UW funding which means you have to shop at UW approved vendors. If the client doesn't want to use UW funding, it is up to the team to purchase from wherever. Many clients also don't want to reimburse the team especially those at the hospital, because it is much more difficult to send money to someone who doesn't work for the hospital. Instead it's imperative that the team sends an option that is on shopUW+ such that payment and shipping is easily accessible. If you are using outside sources, you must prove that the purchase is not available through shopUW+. Orders through the UW can be shipped to Dr. Puccinelli using his office as the address along with the teams short form name (eg. Graduated Bowman Probe). If you want to print at wendt, anyone on the team is approved to enter BMEDesign into the wendt computers to access the \$50 budget. The client also can set up an account at the makerspace for further funding. There is a 90 day reimbursement rule in which any team that needs to be reimbursed by a UW affiliated client must submit the forms within 90 days. The idea is that when you fill out the expense template you must fill it out in such a specific way that anyone reading your notebook could reproduce your results and understand exactly how much it costs. All expense sheets should be in progress reports, PDS, and final reports.

Conclusions/action items:

Attend weekly advisor meeting.

NEEL SRINIVASAN - Feb 13, 2026, 12:12 PM CST



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Screenshot_2026-02-13_at_12.12.01_PM.png (283 kB)



2/25/26 Diversity in Engineering

NEEL SRINIVASAN - Feb 25, 2026, 2:05 PM CST

Title: Diversity in Engineering

Date: 2/25/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize notes on diversity in engineering

Content:

List: Ideas, past experiences, wide accessibility, the golden rule, promote differences, learn from others, open mind to perspectives, diverse stuff. Universal design means that a design is accessible to everyone and caters to everyone (UNIVERSAL). Essentially the device could be used for everyone.

In class activity

I think we could change the material used in our bowman's probes such that people who may have an allergy to stainless steel/the alloys are still able to have a pain-free experience with nasolacrimal duct probing. This change would target equitable use. We would essentially be changing the alloys to something that people aren't allergic/have a reaction to in order to make our bowman's probes more accessible.

Conclusions/action items:

Understand how to redesign our device to fit more into the universal design criterion.



3/4/26 Library and Standards Lecture #2

NEEL SRINIVASAN - Mar 04, 2026, 2:07 PM CST

Title: Library and Standards Lecture #2

Date: 3/4/26

Content by: Neel Srinivasan

Present: Whole Class

Goals: To summarize notes on standards and how to use the library properly

Content: Data Axle Reference Solutions is a directory of information on businesses and demographic and lifestyle information on consumers. IBISWorld Industry Reports are market research reports on over 700 U.S. industries. ProQuest One Business has a library of full-text business journals, newspapers, dissertations, and industry reports. A bit of a review of prior art - Patent examiners evaluate applications against prior art which includes inventions disclosed in U.S. and foreign patents including applications. They'll also include inventions disclosed in publications and inventions currently for sale or in public use. Being able to understand how to use Lens.org is critical to understanding how an invention compares to prior art. Using the 'and'/'or' function, and works cited is very helpful to get a wider view in understanding what prior art the patent you're looking at has based itself off of. Independent claims are standalone and contain all limitations necessary to define an invention. A dependent claim on the other hand must refer to a previous claim and must further limit the claim. Dependent also includes all limitations of claims made before.

Conclusions/action items:

Research standards that are relevant to nasolacrimal duct obstruction and Bowman's probes.



3/6/26 Tong Lecture

NEEL SRINIVASAN - Mar 06, 2026, 12:08 PM CST

Title: Tong Lecture Notes

Date: 3/6/26

Content by: Neel Srinivasan

Present: Whole class

Goals: To summarize content covered during Tong Lecture delivered by Professor Justin Williams.

Content: This lecture

Conclusions/action items:



3/11/26 Lecture #8

NEEL SRINIVASAN - Mar 11, 2026, 1:53 PM CDT

Title: Lecture #8 Notes

Date: 3/11/26

Content by: Neel Srinivasan

Present: Whole Class

Goals: To summarize notes on material covered in lecture 8

Content: being as specific as possible is essential as the goal is that someone who reads your process/experience can reproduce it exactly. Using references, and maintaining a detailed notebook is what makes processes reproducible. For example the data table in the slides of a 201 student show raw data with minimal specifics into units/values measured, along with improper sigfig uniformity. They also did not include any pictures or tablets, along with no figures/graphs. Small observations are helpful to include in order to correlate results. Being as detailed as possible will help with future data analysis and eliminates the need for backtracking. When doing 3D printing, or manufacturing as a whole, you need to include all of the make and model and processes that were used to create the prototype. This can be very helpful if the design is to be mass produced, as having the exact procedure is necessary to replicate the design. Furthermore, it is essential to remember that machining can't always mimic what 3D printing can do, as in 3D printing has greater versatility than normal industry machining techniques. A fabrication plan is a good tool that should include detailed sketches of prototypes being fabricated with dimensions and detailed bullet point steps that include the steps in which this fabrication plan will carry out.

Conclusions/action items:



3/18/26 Lecture #9

NEEL SRINIVASAN - Mar 18, 2026, 1:44 PM CDT

Title: Brevity in Communication

Date: 3/18/26

Content by: Neel Srinivasan

Present: Whole Class

Goals: To summarize notes on today's lecture content on brevity in communication

Content: To craft an elevator pitch, you need to know your audience, practice, be authentic, keep it simple, and adapt and iterate. It's very important to be open to feedback and refine your pitch based on feedback, responses, and outcome. While you should know your content well, it should not seem rehearsed. It's also important to have an attention grabber, an introduction, value proposition, benefits, and a call to action. You really want to be able to outline the most important parts of the project and why it is necessary - what are you trying to solve/fix? Why is it important? How does your design differ or present itself as unique. Being concise is very important as an elevator pitch is typically only one minute long, so you must be able to condense the important information only in order to get at the biggest parts. If the audience is interested, or has questions, they will ask and then you can answer with more detailed answers. But to give an introduction and background it should focus on the underlying problem and how your design aims to solve it. In terms of Tong lecture presentations, you should use the flow of introduction, attention grabber, value proposition, benefits, and a call to action. You're presenting why the design could be marketable and why it's important. The judges are also looking for the potential market impact of your design, so you also need to look beyond the clients request and see the larger market potential. When giving these presentations, eye contact, confidence, and audience tailoring are essential. Engaging with the audience is also important as it is meant to be a pitch and conversation type as opposed to a stiff presentation. Deadline for executive summary is Thursday after spring break (APRIL 9). Brevity is not about saying less, it's about saying more with less. The abstract is typically 250 words, and you should write it last. It provides a clear, concise, and specific summary of your project and work through the semester. In your reports you should eliminate extraneous text, avoid conversational text, spell out acronyms when first introduced, remove redundancies, and DO NOT INCLUDE RAW DATA. You should also always proofread the entire document as a team.

Conclusions/action items:

Use these presentation and writing skills in your show and tell and reports respectively.



3/25/26 Lecture #10

NEEL SRINIVASAN - Mar 25, 2026, 2:11 PM CDT

Title: Lecture 10

Date: 3/25/26

Content by: Neel Srinivasan

Present: Whole Class

Goals: To summarize notes on ethics in engineering

Content:

Question: Where do ethics come from? --> Personal experience, how you grew up, religion, unique lifestyles/moral compass

Question: what is the difference between personal ethics and professional ethics? --> Different ways to evaluate things ethically from a person to a company - structural violence vs Utilitarianism.

Ethical Decision-Making Process: Awareness - understand when you're facing a problem with ethical dimensions. Stakeholders - Imagine their needs. Options - Generate a range of possible actions. The analysis of options include Harm, Publicity, Reversibility, Universality, Respect for Persons, Utilitarian, and Social Justice tests.

Discussion points for assignment

Consider the different perspectives on this case listed below, and discuss these questions in detail. Type your responses as a team. Identify one team member to report out to the class.

1. **The Guidant VPs:** Most of the VP's at Guidant are very much against reporting the data to the FDA. (a) How might they continue to justify their case? (b) What would be the moral foundations of their perspective?
 - a) The Guidant VP's might continue to justify their case by arguing that the patients who've had successful implantation of the device had their lives saved. The VP's could also justify their case using doctors statements as proof of expert approval.
 - b) They are primarily focused on saving as many people as possible, which they see as an act of good, and could be willing to make sacrifices to reach the point when this material has no negative impact. The trial and error is important to them to eventually reach the perfect device
2. **Patients and doctors:** Think about the position of those directly impacted: primarily patients who might be candidates for this surgery and the doctors who use the device: (a) What arguments would those people want to ensure are considered by both the VPs and the design engineers about whether to report or not report the complications data? (b) What might be the ethical foundations of their perspective?
 - a) Patients want to ensure that the device is fully functional with minimal error. The patient would want to have as much information as possible from the doctor about the possible complications of the device to ensure safety. If I was in this situation I would be skeptical about putting a larger device inside my body and want more information related to success rates of the device implementation.
 - b) Having a device implanted within the body inherently requires complete transparency for personal safety. Having professional backing that the device is safe is important, but it is just as important to have a complete data set that proves the professionals' statements. Professional surgeons would use the idea that because it is specifically suited to certain types of complicated aneurysms than one other competing device that was then on the market, that a level of design failure is outweighed by the potential failure.
3. **The design engineers:** (a) What else can they say or do? (b) What arguments can they try to make, and to whom?
 - a) The design engineers can report their findings directly to the FDA. As they've already reported these findings to the highest level personnel in the company, and seen no action, directly informing the FDA would be the best course of action.
 - b) The design engineers can offer the excluded data to the FDA as proof that shortcuts were taken during clinical trials. They can also argue that the patients who died during the procedure were all over 60 with preexisting health conditions, and their deaths were intentionally blamed on prior conditions such as obesity.

4. **The design engineers:** What options do they have? Generate a list of possible options (a minimum of 3 from the perspective of the design engineers), describe how each stakeholder is affected, then analyze them using the BME Code of Ethics (<https://www.bmes.org/2025/cmbconference/codeofconduct>) and a couple of tests from the [ethical decision-making system](#). Explain in detail the best option you would consider trying to act on.

Utilitarianism and Harm Test

- Copy and paste your design-specific ethics responses into your design notebook.
 - What components of your design have ethical dimensions (be specific and list at least 2)?

Possibility of probes breaking during procedure

The laser marking process & creation of oxide layer could lead to sequestration of metal ions from the base layer, causing potential allergic reactions in patients during procedures.

If the probe is ground down, it might not be properly cured or rounded, leading to a rough edge and possibly impacting inner tissues

- How will your team address the ethical dimensions? (What is your action plan?)

Our team will ensure full transparency in releasing testing results, and disclosing these results to the surgeon applying the procedure. Multiple testing procedures will take place to better understand if these concerns could be a reality.

Conclusions/action items:

Fabricate and spring break.



4/8/26 Lecture #11

NEEL SRINIVASAN - Apr 08, 2026, 1:45 PM CDT

Title: Lecture 11 Notes

Date: 4/8/26

Content by: Neel Srinivasan

Present: Whole Class

Goals: To summarize content covered on engineering judgement during lecture 11

Content: Engineering judgement is to make an educated approximation based on the available tools. ABET is the ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions. How do you learn engineering judgement?: Real world problems, open ended problems, teamwork, critical thinking, communication, handling uncertainty, intuition, asking questions, and embracing life long learning. Deesha Chada from the Imperial College of London interviewed many engineers and came up with three domains of the model: attitudes, behaviors, and cognitive.

Conclusions/action items:



2/5/26 ISO 10993-1 Standard Review

NEEL SRINIVASAN - Feb 05, 2026, 9:05 PM CST

Title: ISO 10993-1 Standard Review

Date: 2/5/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize notes on the ISO 10993-1 standard and how that relates to the graduated bowman probe project

Content: ISO 10993-1 provides guidelines ensuring that biomaterials are properly tested for toxicity/human allergies to prepare for tissue interactions. The guidelines are based on devices material, how it interacts with the body, and the contact duration. It provides an in-depth risk analysis, evaluation, and control procedure for material/device biocompatibility. As it is an 'ISO', this standard is an internationally recognized biocompatibility assessment that is required for a majority of regulatory applications. The Bowman Probe comes in direct contact with the human body and therefore if it is to be used in actual procedures, falls under the ISO 10993-1 guidelines. Below is a table featuring the type of tissue contact and duration that allows categorical organization of different devices. While our client has described the probing procedure taking less than 1 minute, it is still essential that our team takes the proper precautions to follow the guidelines to ensure safe biomaterial-tissue interactions during the procedure as the probe will be inserted into the punctum/human body.

 Biocompatibility standard ISO 10993 - UBORA

[1] "ISO 10993-1:2025," ISO. Accessed: Feb. 04, 2026. [Online]

[2] "Double Ended Ophthalmic Bowman Lacrimal Passage Probe." Accessed: Feb. 05, 2026. [Online]

Conclusions/action items:

The team should understand how to follow these guidelines and properly assign certain category and duration to the chosen design. I also think potential certification could be good if the team/Dr. Law decides to market these probes.



2/5/26 ISO-13485 Standard Review

NEEL SRINIVASAN - Feb 05, 2026, 4:15 PM CST

Title: ISO-13485 Standard Review

Date: 2/5/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize and scribe notes on the ISO 13485 standard that outlines quality management control for medical devices

Content: ISO 13485 is an international standard that outlines necessary requirements/guidelines for quality management control in the creation of medical devices. The standard is a certification that ensures companies that sell and organizations that use medical devices are able to maintain the safety of device usage. The following (down below) requirements and guidelines are major parts of ISO 13485 certification, and are key indicators that a company is equipped to properly manage the production and testing of medical devices to maximize safety in medical device creation.

1. Quality management system (QMS)

- Determine the processes the quality management system requires and what's needed to apply these processes throughout the organization, taking into account the various roles involved,
- Apply a risk-based approach to the control of the appropriate processes needed for the quality management system, and
- Determine the sequence and interaction of these processes

2. Management responsibility

- Communicate the importance of meeting regulatory requirements
- Establish high-value quality policy
- Ensure that quality objectives are established
- Conduct management reviews
- Ensure availability of quality management system resources

3. Resource management

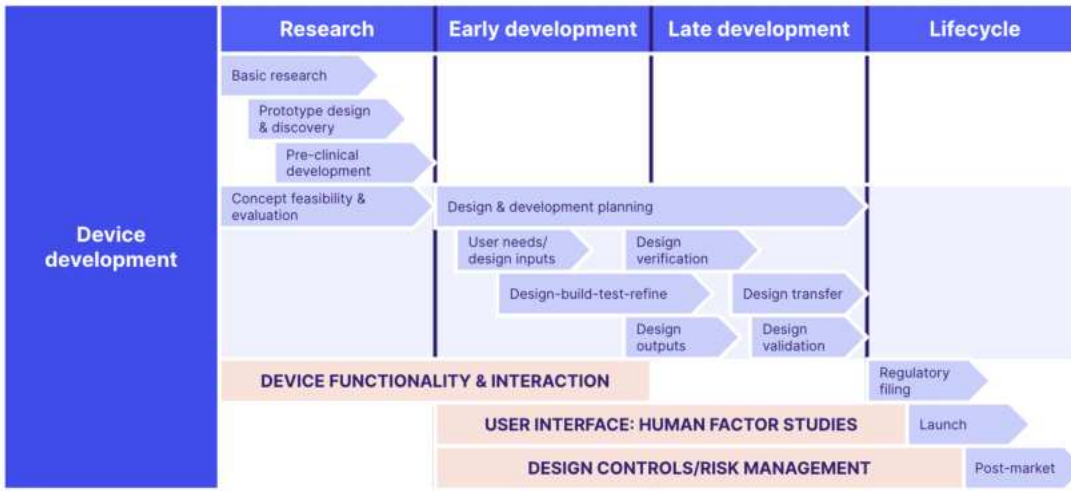
- The provision of resources
- Human resources
- Infrastructure
- Work environment
- Contamination control

4. Product realization

- Establish the quality requirements for your product(s)
- Define what your required processes will be and what supporting documentation will be needed for those processes
- Outline the company infrastructure that will need to be created and what the work environment should be like
- Define employee qualification and training requirements
- Establish your processes for verification, validation, measurement, monitoring, handling, inspection, storage, distribution, and traceability

5. Measurement, analysis, improvement

- Demonstrate conformity of product
- Ensure conformity of the quality management system
- Maintain the effectiveness of the quality management system



IEEE Citation:

[1] Center for Devices and Radiological Health, "Quality Management System Regulation: Final rule - FAQ," U.S. Food and Drug Administration, <https://www.fda.gov/medical-devices/quality-management-system-regulation-qmsr/quality-management-system-regulation-frequently-asked-questions> (accessed Feb. 5, 2026).

[2] S. Kondabolu, "ISO 13485: The Essential Guide," #1 Cloud-based Quality Management Software for MedDevice & Pharma, <https://www.qualio.com/blog/iso-13485-standard> (accessed Feb. 5, 2026).

Conclusions/action items:

Figure out what methods our team needs to take to ensure we are following this standard - making sure our production/design is uniform along with testing. Also make sure analysis is done across all probes created, not just a few of certain sizes.



3/12/26 ANSI Z136.1 Standard Review

NEEL SRINIVASAN - Mar 12, 2026, 11:03 PM CDT

Title: ANSI Z136.1 Standard Review

Date: 3/12/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize notes on the ANSI Z136.1 standard that outlines safe usage of laser bed machines.

Content: This standard (.1) outlines the necessary safety specifications for laser operation in industry, military, lab spaces, and universities. The Z136 family of standards outlines general laser safety practices while the .1 version has been amended to specifically reference its usage in these fields. This standard outlines the basic requirements of users to wear proper PPE and keep systems up to date with maintenance in order to protect users and operation areas. This standard is quite applicable to our project as Professor Pfefferkorn's laser setup uses a 200W fiber laser, so for our own safety during fabrication we should make sure to follow both the standards requirements along with the lab staff's safety practices. This standard refers to class 3B and 4 lasers, which Professor Pfefferkorn's setup fits into.

Beam Hazards

- Potential injury to the eye
- Potential injury to the skin

Non-Beam Hazards

- Electrocutation
- Fire
- Exposure to air contaminants, gasses, and laser dyes

Laser classes that relate to ANSI Z136.1 Standard classifications.

ANSI and IEC laser classification	Class 1		Class 2		Class 3		Class 4	Notes
	Class 1	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4	
Sub-class								
U.S. FDA laser classification	Class I	No special FDA class	Class II	No special FDA class	Class IIIa (definition is different but results are similar)	Class IIIb	Class IV	Newer ANSI/IEC number classes are now preferred over older FDA Roman numeral classes
Human-accessible laser power (for visible light)	For visible light, emits beam less than 0.39 milliwatts, or beam of any power is inside device and is not accessible during operation.		Emits visible beam of less than 1 milliwatt.		For visible light, emits beam between 1 and 4.99 milliwatts.	For visible light, emits beam between Class 3R limit (e.g. 5 milliwatts) and 499.9 milliwatts	For visible light, emits beam of 500 milliwatts (1/2 Watt) or more	Non-visible lasers emitting infrared or ultraviolet are not included in this chart. Only visible lasers are discussed.
Label descriptive text		DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS	DO NOT STARE INTO BEAM	DO NOT STARE INTO BEAM OR EXPOSE USERS OF TELESCOPIC OPTICS	AVOID DIRECT EYE EXPOSURE	AVOID EXPOSURE TO BEAM	AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION	For visible-light lasers, the word "light" can be used instead of "radiation". The latter is more accurate for lasers emitting infrared and ultraviolet radiation.
EYE AND SKIN HAZARDS								
Eye hazard for intraocular exposure (having a direct or reflected beam enter the eye)	Safe, even for long-term intentional viewing. For visible light, usually applies when the laser is enclosed inside a device (ex: CD or DVD player) with no human access to laser light.	Safe for unaided eye exposure. May be hazardous if viewed with optical instruments such as binoculars or eye loupe.	Safe for unintentional exposure less than 1/4 second. Do not stare into beam.	Safe for unintentional (< 1/4 sec) unaided eye exposure. May be hazardous if viewed with optical instruments such as binoculars or eye loupe.	Unintentional or accidental exposure to direct or reflected beam has a low risk. Avoid intentional exposure to direct or reflected beam.	Eye hazard; avoid exposure to direct or reflected beam.	Severe eye hazard; avoid exposure to direct or reflected beam.	
Maximum or typical Nominal Ocular Hazard Distance (for 1 milliradian beam, exposure time less than 1/4 second)	Not an eye hazard -- does not apply	Consult an LSO as described in the Technical Note below	NOHD of 0.99 mW beam: 23 ft (7 m)	Consult an LSO as described in the Technical Note below	NOHD of 4.99 mW beam: 52 ft (16 m)	NOHD of 499.9 mW beam: 520 ft (160 m)	NOHD of 1000 mW (1 Watt) beam: 733 ft (224 m). NOHD of 10 W beam: 2320 ft (710 m)	Avoid eye exposure to a direct or reflected laser beam, within the NOHD. The closer you are to the laser, the greater the chance of hazard and the more serious the injury potential.
Eye hazard for diffuse reflection exposure (looking at the laser "dot" scattered off a surface)	None	Consult an LSO	None	Consult an LSO	None	Generally safe. Avoid staring at the laser "dot" on a surface for many seconds at close range.	To avoid injury, do not stare at laser "dot" on a surface. The light is too bright if you see a sustained afterimage, lasting more than about 10 seconds.	
Skin burn hazard	None	Consult an LSO	None	Consult an LSO	None	Can heat skin if beam is held long enough on skin at close range	Can instantly burn skin. Avoid direct exposure to the beam.	
Materials burn hazard	None	Consult an LSO	None	Consult an LSO	None	Can burn materials if beam is held long enough on substance at close range	Can instantly burn materials. Avoid direct exposure to the beam, for materials susceptible to burning.	Dark materials which absorb heat, and lightweight materials such as paper and fabric, are most easily burned by visible laser light.
VISUAL INTERFERENCE DISTANCES								
Maximum or typical flashblindness distance (FAA 100 µW/cm², for 1 milliradian beam, 555 nm green light)	Not applicable; beam is usually contained inside a device such as a CD or DVD player	Consult an LSO	For a 0.99 mW beam: 117 ft 36 m	Consult an LSO	For a 4.99 mW beam: 261 ft 80 m	For a 499 mW beam: 2,614 ft (1/2 mile) 797 m (0.8 km)	For a 1 Watt beam: 3,696 ft (0.7 mile) 1,127 m (1.1 km) For a 10 W beam: 11,689 ft (2.2 miles) 3,563 m (3.5 km)	Value given is for 555 nm, the green wavelength that appears brightest to the light-adapted human eye. This gives the longest hazard distance. To approximate for red laser light, divide the distance by about 5; for blue, divide by 20.
Maximum or typical glare distance (FAA 5 µW/cm², for 1 milliradian beam, 555 nm green light)	See above	Consult an LSO	523 ft 159 m	Consult an LSO	1,169 ft 356 m	11,688 ft (2.2 miles) 3,563 m (3.5 km)	For a 1 Watt beam: 16,531 ft (3.1 miles) 5,039 m (5 km) For a 10 W beam: 52,275 ft (9.9 miles) 15,933 m (16 km)	See above
Maximum or typical distraction distance (FAA 0.05 µW/cm² or 50 nanowatts/cm², for 1 milliradian beam, 555 nm green light)	See above	Consult an LSO	5,227 ft (1 mile) 1,593 m (1.6 km)	Consult an LSO	11,689 ft (2.2 miles) 3,563 m (3.5 km)	116,890 ft (22 miles) 35,628 m (35.6 km)	For a 1 Watt beam: 165,307 ft (31 miles) 50,386 m (50 km) For a 10 W beam: 522,746 ft (99 miles) 159,333 m (160 km)	See above
Technical Notes	For a 1/4 second exposure to accessible visible-light beams, Class 1 limits are the same as Class 2, and such lasers are usually labeled as Class 2.	We are unaware of any Class 1M laser devices intended for consumer use. If you do have such a laser, consult a qualified Laser Safety Officer for more detailed analysis.	Class 2 (and 2M) only applies to visible lasers. Infrared and ultraviolet lasers cannot be Class 2 (or 2M).	We are unaware of any Class 2M laser devices intended for consumer use. If you do have such a laser, consult a qualified Laser Safety Officer for more detailed analysis.	Class 3R is either: (1) From 1 to 4.99 mW into a 7mm aperture (e.g., pupil of the eye) or (2) five times the Class 2 limit of 2.5 mW/cm², which works out to be 12.5 mW/cm². The second method is used by LaserSafetyFacts to determine NOHD.			
	Class 1	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4	
	Class 1		Class 2		Class 3		Class 4	

IEEE Citation:

[1] J. Hadler, Laser Safety Facts, <https://www.lasersafetyfacts.com/laserclasses.html> (accessed Mar. 12, 2026).

[2] Laser Institute of America, "ANSI Z136.1 - safe use of lasers," ANSI Z136.1 - Safe Use of Lasers | The Laser Institute, <https://www.lia.org/resources/laser-safety-standards/ansi-z1361-safe-use-lasers> (accessed Mar. 12, 2026).

Conclusions/action items:

Meet with Hassan to discuss what safety considerations we need to take during the fabrication process.



2/5/26 Effect of Laser Engraving on Intrinsic Material Properties

NEEL SRINIVASAN - Feb 05, 2026, 7:29 PM CST

Title: Effect of Laser Engraving on Intrinsic Material Properties

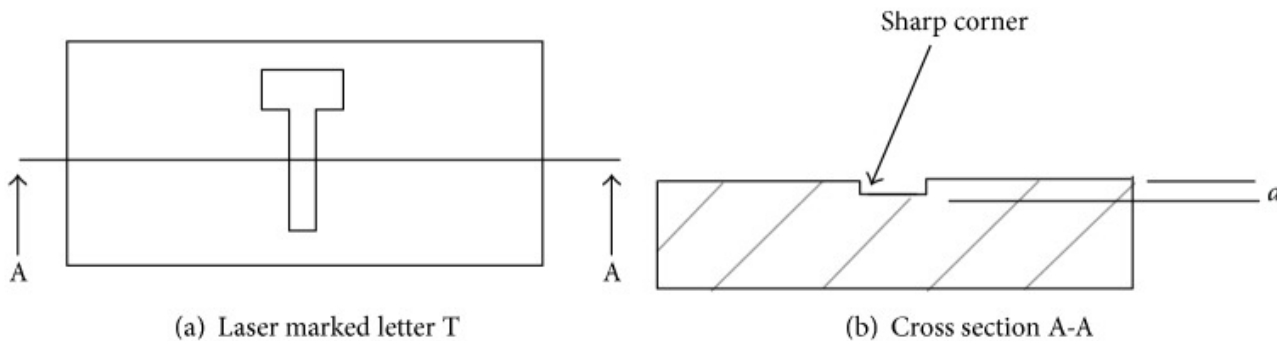
Date: 2/5/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize the effects that laser engraved line markers could have on our bowman's probe properties in terms of mechanical strength, thermoresistivity, and coatings.

Content: As the client has requested for the final design to avoid deep engraving, our focus is shifted toward minimal material penetrating methods such as laser engraving. Laser engraving uses a high energy laser beam to vaporize or melt a thin layer of a materials surface, and can be programmed with a computer to etch certain shapes onto the material. As typically seen with stainless steel, and most materials, is a darkening of the target location on the instrument. While the laser engraving method is less damaging/features shallower cuts compared to machine engraving, it has been noted that at increasing width laser engravings the material tends to lose some structural integrity. For example, a larger width laser engraving would make a deeper cut at that location. If one was to perform a cross sectional analysis of the laser engraving location, they would notice a weakness and see that the instrument would mechanically fail at that cross section. It's also clear from figure 2b that the laser engraving results in ridges that disrupts the otherwise smooth texture of the instrument. In order to minimize structural integrity change and texture, I believe that our graduated markings should use the thinnest width of laser engravings such that markings aren't causing ridges to be formed and that the probe will not snap at marker points. I also think that using a lower powered laser for even slight discoloring could be beneficial such that on the smaller sized probes the chances of snapping are minimal.



(a) Lettering



(b) Close up of "2"

[1] P. J. Ogrodnik, C. I. Moorcroft, and P. Wardle, "The effects of laser marking and symbol etching on the fatigue life of medical devices," *Journal of medical engineering*, <https://pmc.ncbi.nlm.nih.gov/articles/PMC4782668/> (accessed Feb. 5, 2026).

Conclusions/action items:



2/5/26 Changes in Material Surface Chemistry due to Laser Engraving

NEEL SRINIVASAN - Feb 05, 2026, 11:27 PM CST

Title: Changes in Material Surface Chemistry due to Laser Engraving

Date: 2/5/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize notes on the changes that laser engraving has on a materials surface chemistry, and how we can mediate these effects in our bowman probe design

Content: While laser engraving is mainly thought to mechanically weaken medical devices in terms of failure/fatigue cycling, it also can change the materials surface chemistry. Implantable biomaterials are typically coated with a mixture of polymers, proteins, or other enzymes to minimize inflammatory or potentially undesirable reactions from the human body. While our probes will only be in the body for under a minute, it will still come into contact during insertion and the procedure, which means that it will require some time of chemical surface coating either preexisting(sold to us with a coat) or originally created(our team creates it). However, laser engravings damage to the existing surface chemistry could introduce potential toxicities to patients during the probing procedure. When damaging the initial coating, we expose the body to whatever stainless steel alloy and its properties that are below the coating, effectively getting rid of the coatings protective and safety features. In order to safely laser engrave, we must either ensure that the depth of engraving is minimal such that the surface chemistry coating remains intact, or reapply the protective coating after the markings are engraved. Attached below is an image of a medical device featuring laser engraved markers.



IEEE Citation:

[1] M. Szymański, D. Przystacki, and P. Szymański, "The influence of selected laser engraving parameters on surface conditions of hybrid metal matrix composites," *Materials* (Basel, Switzerland), <https://pmc.ncbi.nlm.nih.gov/articles/PMC10574004/> (accessed Feb. 5, 2026).

[2] "Laser marking for the medical technology," KKS, <https://kks-surfacetreatment.com/en/expertise/laser-marking/> (accessed Feb. 5, 2026).

Conclusions/action items:

Figure out the depth to which we can engrave, where we can get hands on access to these tools, and whether or not we will need to further add protective layers



2/12/26 Electroplating Accuracy for Line Markers

NEEL SRINIVASAN - Feb 13, 2026, 11:02 AM CST

Title: Electroplating Accuracy for Line Markers

Date: 2/12/26

Content by: Neel Srinivasan

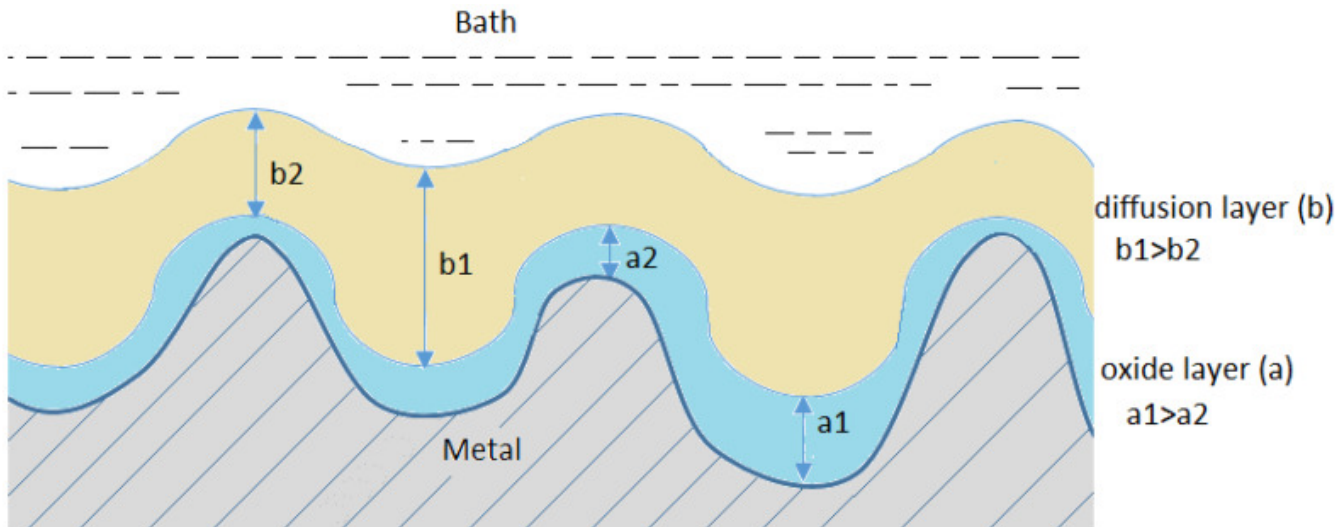
Present: Neel Srinivasan

Goals: To summarize the levels of accuracy that can be achieved for line markers using electroplating

Content: There are a couple things that can go wrong with electroplating, especially during the preparation and actual insertion into the bath. Below is a list of issues that would result in a poor design for our bowman probe.

1. Cold Shuts - Basically the coating/metal are not joining together which results in multiple weld points as opposed to one strong base.
2. Pitting - Air bubbles trapped under the coating, leading to bumps and grooves on the materials surface.
3. Sharp Edges - Welding doesn't come together and leaves gaps, similar to cold shuts except this results in a very rough-textured surface.
4. Cleavage Points - Points of weakness/ where fracture can very easily occur
5. Unclean Manufacturing - Leaving dust/debris or any material on the probe that can lead to any of the above 4 issues.

Essentially if we decide to use electroplating, our preparation and procedure must be as clean and precise as possible to ensure our design isn't faulted by any of the above standards. While these measures are a concern at lower end electroplating machines, higher quality/price machines are able to minimize these effects and maximize accuracy.



IEEE Citation:

[1] S. Sharretts, "Complete guide to electroplating defects & issues: SPC Blog," Sharretts Plating Company, <https://www.sharrettsplating.com/blog/electroplating-defects-issues/> (accessed Feb. 13, 2026).

Conclusions/action items:

Research low energy laser engraving & whether UW-Madison has high level electroplating that our team could use.



2/20/2026 Drawing/Descriptions for Preliminary Designs

NEEL SRINIVASAN - Apr 29, 2026, 5:14 PM CDT

Title: Drawings & Descriptions for Preliminary Designs

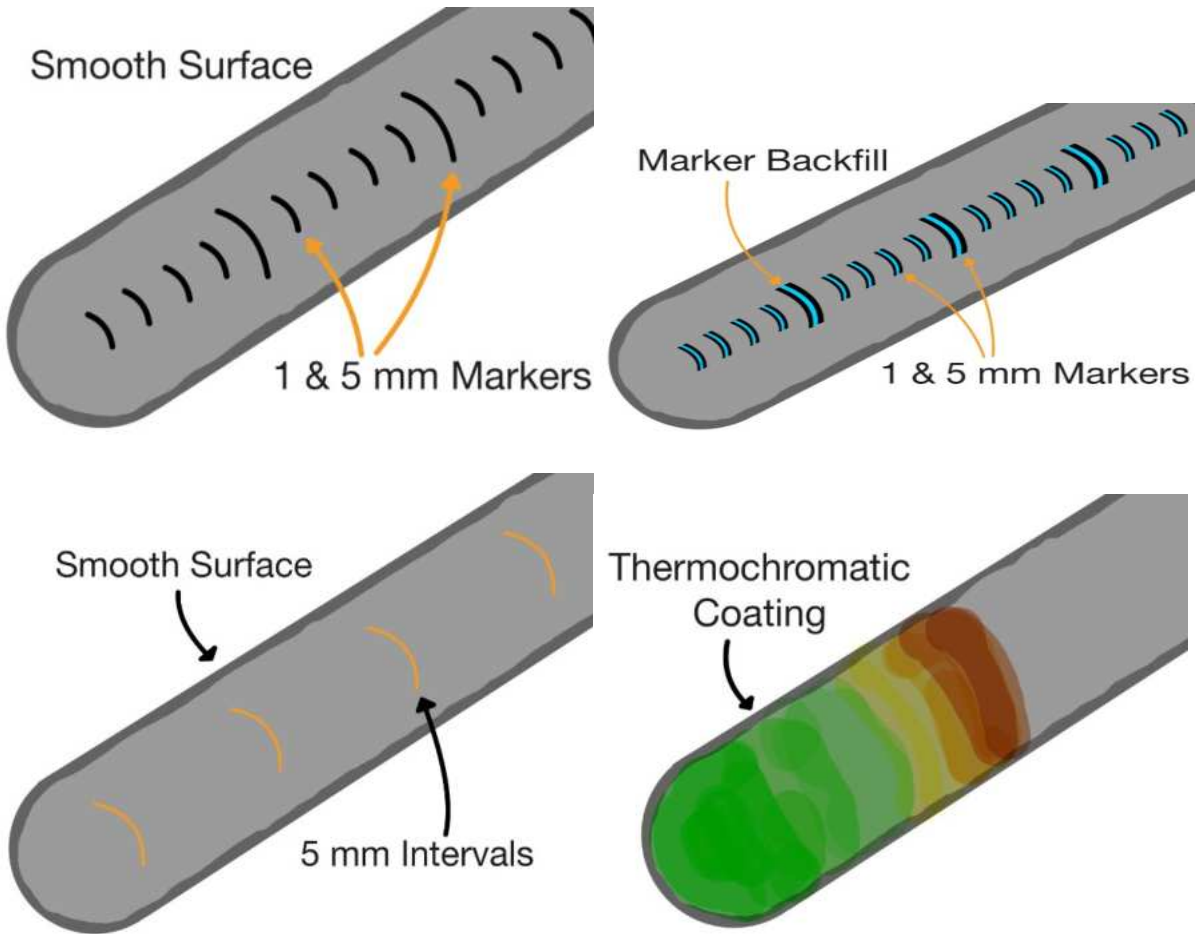
Date: 2/20/2026

Content by: Drawings by Neel Srinivasan

Present: Neel Srinivasan

Goals: To add drawings of potential design ideas for prelim presentation

Content:



Conclusions/action items:

Finish design matrix and get better drawings



3/12/26 Probe Fixture for Laser Bed

NEEL SRINIVASAN - Mar 12, 2026, 8:24 PM CDT

Title: Probe Fixture Design for Laser Bed

Date: 3/12/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To summarize a design idea on a potential fixture that could be used to calibrate the laser to accurately mark the probe surface

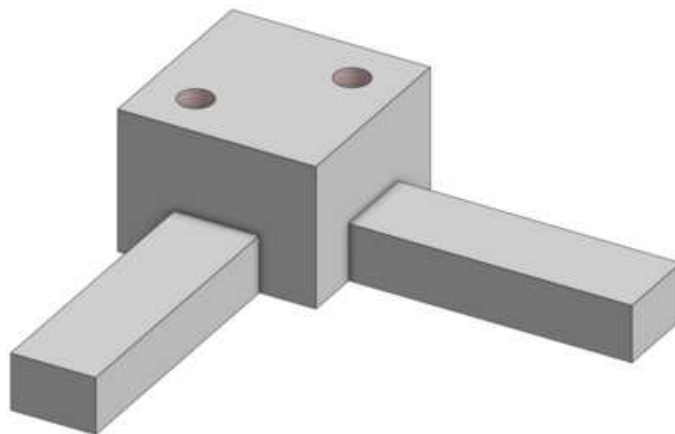
Content: See attached design image. This design would feature screw threads that would align with the center notches of the probes midpoints. This would allow for screws to be threaded in that would hold the probe in place during laser marking procedures. The extruding side pieces are meant to help align the probe to the laser beds' walls such that the laser only needs to be calibrated once. The fixture would have to be made out of a metal, likely stainless steel in order to ensure that the screw threads have a longer lifespan. For example, if we were to use wood, the lifespan of the threads with constant unscrewing and rescrewing would be shortened. Metal would maximize the structures durability.



Conclusions/action items:

Ask graduate student during meeting what materials work best for fixtures, and then complete fixture fabrication with chosen material.

NEEL SRINIVASAN - Mar 12, 2026, 7:49 PM CDT



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Screenshot_2026-03-12_at_7.48.55_PM.png (223 kB)



3/12/26 Ceramark Application Procedure

NEEL SRINIVASAN - Mar 12, 2026, 11:53 PM CDT

Title: Ceramark Application Procedure

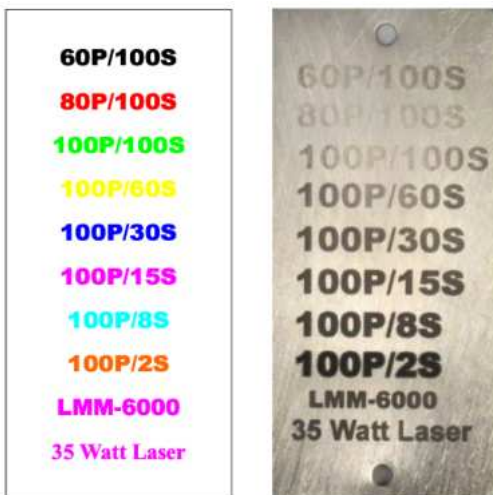
Date: 3/12/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To outline a potential procedure our team could follow to apply the Ceramark coating onto the bowman's probes

Content: The addition of Ceramark is essential in order to safely mark the exterior of our Bowman's probes. If we weren't using a coating, the laser would end up removing material from the probe itself. Ceramark application minimizes any contact between the laser and the base surface, allowing us to focus the laser at the specific 5mm markings and washing off the remaining areas that were not contacted by the laser. While this does add a small layer of the Ceramark coating to the probe's surface, the difference in surface texture should be minimal as long as we are conservative about how thick of a layer we add prior to laser marking.



1. Coating Application:

A. Apply Ceramark evenly across the probes using the spray (we ordered 2oz aerosol), You should use a left to right swaying motion in order to prevent any uneven surfaces. Focusing on one location could lead to buildup at one spot and therefore uneven ceramark distribution

B. Dry the Ceramark coating, usually takes two minutes to dry in the air but time can be sped up using a hair dryer

C. Make sure coating is even

2. Laser Exposure: The fiber laser is aimed at the coated area, specifically where we program the markings to go (5mm intervals)

3. Thermal Reaction: The ceramic coating absorbs the lasers energy, generating localized thermal energy which causes the coating to melt (note this is at very precise levels due 4. to the laser having a very small width, so only localized melting not probe wide!!!)

5. Bonding and Fusing: The melted ceramic agents form strong covalent bonds with the probes surface

6. Finalizing: The laser-treated area becomes a permanent part of the surface which causes a distinct discoloration at those marks. Any of the excess unbonded coating can be washed or wiped away

Storage:

The Ceramark coating has a wide range of temperatures that it can be stored in (40 to 95 degrees Fahrenheit). However, it does settle easily should it should be regularly stirred or used in order to avoid it becoming solid.

IEEE Citation:

[1] Vibrantz Technologies, "Technical information laser marking materials," Vibrantz Technologies, https://vibrantz.com/wp-content/uploads/2023/02/Vibrantz_PC_Laser-Marking-Materials_FG02_TDS_012023.pdf (accessed Mar. 13, 2026).

Conclusions/action items:

Obtain Ceramark coating from Dr. Law, and work with Hassan to see which setting would work best on the laser machine for our project. We should make sure to emphasize that while we want distinct markings, we don't want to compromise the structural integrity of the probe as it will be inserted into the human body, and used numerous times. The graduated version should have the exact durability or maybe even better than common bowman's probes.



4/14/2026 - Tear Duct Solution

NEEL SRINIVASAN - Apr 29, 2026, 4:58 PM CDT

Title: Tear Duct Solution Protocol**Date:** 4/14/2026**Content by:** Neel Srinivasan**Present:** Caleb White, Neel Srinivasan**Goals:** To outline protocol for creating artificial tear duct solution**Content:****Obtain the following:**

1. 1 Corning Pyrex 500 mL storage media bottle
2. 1 stir bar
3. 500 mL Deionized Water
4. 3.655 g NaCl
5. 0.745 g KCL
6. 0.0735 g $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
7. 0.0510 g $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
8. 0.08 g NH_4Cl
9. 1.97 g Albumin
10. 1 M HCl
11. 1 M NaOH
12. 1 Weigh boat
13. 6 Scoopula's
14. 1 Fischer Scientific Weigh Scale
15. 1 ThermoFisher IsoTemp magnetic stirrer and hot plate
16. 1 pH Meter

Preparation:

1. Add 500 mL deionized water to the Corning Pyrex 500 mL storage media bottle
2. Place the stir bar inside the bottle
3. Place the bottle on top of the ThermoFisher IsoTemp magnetic stirrer and hot plate
4. Set the magnetic stirrer to 200 rpm and temperature to 37°C
5. Measure the necessary amount of each chemical on the weigh scale
6. Add in the chemicals using 1 scoopula per powder
7. Repeat steps 5 & 6 for chemicals 4-8

8. When adding Albumin, add little amounts and wait for powder to completely dissolve (if entire quantity of Albumin is added at once, it will denature and not fully dissolve)
9. Measure the pH of the solution
10. Add in drops of 1 M NaOH if the pH is below 7.4, and drops of 1 M HCl if the pH is above 7.4
11. pH balance solution to 7.4

Conclusions/action items:

Create solution and run accelerated life testing



4/14/2026 Accelerated Life Testing with Tear Duct Solution

NEEL SRINIVASAN - Apr 29, 2026, 5:04 PM CDT

Title: Accelerated Life Testing with Artificial Tear Duct Solution

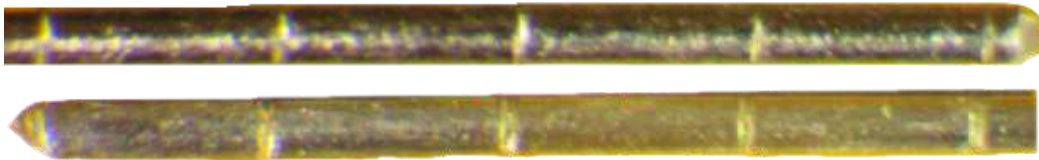
Date: 4/14/2026

Content by: Neel Srinivasan

Present: Neel Srinivasan / Caleb White

Goals: To outline an idea I had on how to observe the changes in the long term usage of the probe

Content: The graduated Bowman's probes must maintain their composition and procedural viability throughout the 5-10 year lifespan as stated by the client. To measure the potential visual degradation the probes will encounter while inside the lacrimal drainage system, an accelerated life test was conducted. Two pairs of probes of sizes 2 and 4, with one pair unmarked and the other graduated, were placed in artificial tear solution and kept in an InCu Safe incubator that maintained sterility, temperature at 37 °C, and CO₂ levels at 5%. An in depth protocol for the preparation of the artificial tear solution is outlined in Appendix I. The probes were kept in the incubator for 48 hours, equating to 2,880 procedural uses, and then observed under a Leica MZ95 stereomicroscope to check for potential discoloration and marker degradation. While the probes had a slight discoloration, the markers remained distinguishable after accelerated life testing. It is important to note however, that this discoloration is uniform across both standard and graduated Bowman's probes, and that 2,880 procedural uses is uncommon as 2,000 is the typical lifespan of clinical probes. The initial stages of this test was to dip the probes for 60 seconds and observe changes over every cycle, however we quickly realized that one or two dips and observation periods would yield no results. Due to the lack of change in short term, we decided to use the incubator to mimic the probe being used for 2880 times as opposed to one at a time.



Conclusions/action items:

Run data analysis

Title: Citi Training Files

Date: 10/31/25

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To attach a link/file of CITI training completion certificate(s)

Content: See attached files

Conclusions/action items:

Begin calibration testing



[Download](#)

citiCompletionCertificate_15025616_73254039.pdf (77.6 kB)

**COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)
COMPLETION REPORT - PART 1 OF 2
COURSE/REQUIREMENTS***

* Score on PE (Requirements) (Part 1) indicates completion of the base of requirements for the course were met. The Targeted Report (Part 2) lists more about your course, including base or optional (supplemental) use not otherwise.

- Name: NEEL SRINIVASAN (ID: 1622816)
- Institution Affiliation: University of Wisconsin - Madison (ID: 1-93)
- Institution Email: nsrinivas@wisc.edu
- Certificate Design: Basic/Refresher Course - Human Subjects Research
- Course/Learner Group: UW Human Subjects Procedures Course
- Stage: Stage 1 - Level 1
- Record ID: 73254039
- Completion Date: 31-Oct-2025
- Expiration Date: 31-Oct-2028
- Minimum Passing: 83
- Required Score: 83

REQUIRED AND ELECTIVE MODULES ONLY*	DATE COMPLETED	SCORE
UW-Madison Human Subjects Research Introduction (ID: 16362)	31-Oct-2025	No Due
Intelligence Phenomena (ID: 16371)	28-Oct-2025	6.6 (100%)
Defining Research with Human Subjects (ID: 481)	31-Oct-2025	9.8 (100%)
History and Ethical Principles (ID: 491-496)	31-Oct-2025	9.8 (100%)
Informed Consent (ID: 505)	31-Oct-2025	9.8 (100%)
Research Risk (ID: 508)	31-Oct-2025	9.5 (100%)
Population in Research: Preparing Additional Considerations and/or Protections (ID: 1658)	31-Oct-2025	9.5 (100%)
University of Wisconsin - Madison (ID: 12728)	31-Oct-2025	No Due
Introduction To Community-Based Research (ID: 1698)	31-Oct-2025	9.8 (100%)
Introduction to Community-Based Participatory Research (ID: 1695)	31-Oct-2025	9.5 (100%)

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citiCompletionReport_NEEL_SRINIVASAN.pdf (78.7 kB)

 **2025/03/18 Biosafety Training**

NEEL SRINIVASAN - Mar 18, 2025, 12:23 PM CDT

Title: Bio/Chemical Safety Training

Date: 2025/03/18

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: Attach link of training completion

Content: See attached screenshot

Conclusions/action items:

Start working on reports/lab archives

NEEL SRINIVASAN - Mar 18, 2025, 12:24 PM CDT



The screenshot displays a table titled "VCRGE Training Information Lookup Tool" from the University of Wisconsin-Madison. It certifies that Neel Srinivasan has completed training for several courses. The table includes columns for Course, Assignment, Completion, and Expiration.

Course	Assignment	Completion	Expiration
2025.03.HIPAA Privacy & Security Training	HIPAA Training Quiz	3/18/2025	
2025.03.HIPAA Privacy & Security Training	HIPAA Assessment	3/18/2025	
Biosafety Required Training	Biosafety Required Training Quiz 2024	3/18/2025	3/18/2026
Chemical Safety: The OSHA Lab Standard	Final Quiz	3/18/2025	
Environmental & Occupational Health	Animal Contact Risk Questionnaire	4/10/2024	4/10/2025
Risk Communication in Animal Facilities	Risk Communication in Animal Facilities Quiz 2024	4/10/2024	4/10/2025
Safety for Personnel with Animal Contact	Animal Contact Personnel Quiz 2024	4/10/2024	4/10/2025

Data last updated: 03/18/2025 11:17 PM

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Screenshot_2025-03-09_at_2.05.43_PM.png (356 kB)

 **4/10/26 HIPAA Training**

NEEL SRINIVASAN - Apr 10, 2026, 9:48 AM CDT

Title: HIPAA Training

Date: 4/10/26

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To upload a screenshot of proof of my completion of the HIPAA required spring 26 BME training

Content: See screenshot

OVCR Training Information Lookup Tool
University of Wisconsin-Madison



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This certifies that Neel Srinivasan has completed training for the following course(s):

Expand All
Collapse All

Course	Assignment	Completion	Expiration
2022-23 HIPAA Privacy & Security Training	HIPAA Training Quiz	10/30/2022	
2023-24 HIPAA Privacy & Security Training	HIPAA Attestation	6/11/2024	
2024-2025 HIPAA Privacy & Security Training	2024-2025 HIPAA Privacy & Security Training	5/19/2025	
2025-2026 HIPAA Privacy & Security Training	2025-2026 HIPAA Privacy & Security Training	3/13/2026	
Biosafety Required Training	Biosafety Required Training Quiz 2024	2/19/2025	2/19/2030
Chemical Safety: The OSHA Lab Standard	Final Quiz	3/8/2025	
Environmental & Occupational Health	Animal Contact Risk Questionnaire	4/30/2024	4/30/2025
Risk Communication in Animal Facilities	Risk Communication in Animal Facilities Quiz: 2024	4/1/2024	4/1/2027
Safety for Personnel with Animal Contact	Animal Contact Personnel Quiz 2024	4/1/2024	4/1/2029
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/31/2025	10/31/2028

Data Last Imported: 03/14/2026 11:06 PM

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Conclusions/action items:

Work on laser fixture fabrication



2025/03/18 Intro to Machining Training

NEEL SRINIVASAN - Mar 18, 2025, 12:25 PM CDT

Title: Intro to Machining Training

Date: 2025/03/18

Content by: Neel Srinivasan

Present: Neel Srinivasan

Goals: To attach a screenshot of proof of completion of Intro to Machining training

Content:

See attached link

Conclusions/action items:

Continue lab archives upload from google docs notes

NEEL SRINIVASAN - Mar 18, 2025, 12:26 PM CDT

Membership Type	Start Date	Expiry Date	Renew	Card Info
Machining	Thu, Aug 08 2024	Permanent	Not Renewable	N/A
Learn Center	Wed, May 15 2024	Wed, Dec 3 2025	Not Renewable	N/A
Shop Track	Thu, May 15 2024	Wed, Dec 3 2025	Not Renewable	N/A
Lab Orientation	Wed, Jul 3 2024	Tue, Dec 30 2025	Not Renewable	N/A
Shop Track - Training Eligible	Thu, Dec 5 2024	Tue, Dec 30 2025	Not Renewable	N/A
Learn Center - Training Eligible	Thu, Dec 5 2024	Tue, Dec 30 2025	Not Renewable	N/A

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Screenshot_2025-03-11_at_1.13.56_PM.png (433 kB)



01/30/2026 Nasolacrimal Obstructions

CADEN ROBINSON - Jan 30, 2026, 11:53 AM CST

Title: Nasolacrimal Obstructions

Date: 01/30/2026

Content: Caden Robinson

Present: Me

Goals: Develop a baseline understanding of what causes these obstructions and who is affected

Citation:

1] " Bony Congenital Nasolacrimal Duct Obstruction - ClinicalKey." Accessed: Jan. 30, 2026. [Online]. Available: <https://www-clinicalkey-com.ezproxy.library.wisc.edu/#!/content/playContent/1-s2.0-S0161642023008734?returnurl=null&referrer=null>

Content:

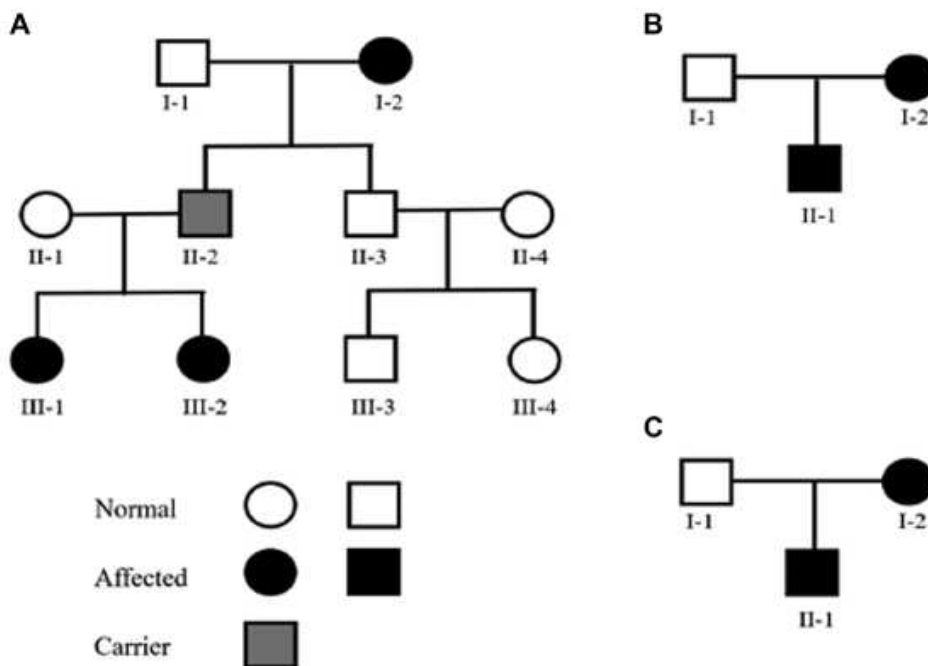
Congenital nasolacrimal duct obstruction (CNLDO) is a prevalent lacrimal drainage disorder affecting 6% to 20% of the pediatric population. Many of these congenital diseases stem from hypoplasia and aplasia resulting in limiting growth factors of the salivary glands and lacrimal system. The specific congenital disorder results from a heterozygous mutation in the Fgf10 gene. These syndromes are caused by the haploinsufficiency (a genetic condition where a functional copy of the gene is insufficient because it cannot create enough protein) of the Fgf10 gene resulting from various missense and nonsense mutations. Although multiple patients may contain the same mutation, different patients exhibit distinct manifestations of the disease.

Affected patients showed symptoms of:

- Chronic epiphora (clinical term for overproduction of tears causing irritation since there is limited drainage) since childhood
- Reduced tear production and tear breakup time
- MRI showing aplasia or hypoplasia of lacrimal, parotid, and submandibular glands

findings confirmed that this specific variant of nasolacrimal obstructions was a result of aplasia


FERG ET AL. • BONY CNLDO



Conclusions/action items: This study provided some very important background information to understanding what nasolacrimal obstructions could entail. However, this specific variant of obstruction that was researched does not correlate the greatest with the use of probing to clear these ducts since the disease is congenital and a result of bone formation. Some of the information that could still be used is the genetic pathways of this disorder and how it transfers between generations.

Continue researching nasolacrimal obstructions, begin drafting the PDS

CADEN ROBINSON - Jan 30, 2026, 11:51 AM CST

 **Bony Congenital Nasolacrimal Duct Obstruction**
A Novel Phenotype of Agenesis of Lacrimal and Major Salivary Glands

Zhao Yun Peng, MD,^{1,2,3,4} Wen Liu, MD,^{1,2} Shuang Li, MD,^{1,2} Yanhui Cao, MD,¹ Li Li, MD,¹ Chengze Shang, MD,¹

Purpose: Agenesis of lacrimal and salivary glands (ALSG) is a syndromic disease characterized by aplasia of lacrimal and salivary systems. Reported ophthalmic manifestations of ALSG include aplasia of lacrimal glands, partial agnathia, lacrimal sac agenesis, and membranous congenital nasolacrimal duct obstruction (CNLDO). Bony CNLDO, some clinical entities, has not been associated with any syndrome disease. This study investigated the relationship between genetic mutations and bony CNLDO in 3 Chinese families with ALSG.

Design: Single-center observational case study.

Participants: Three Chinese families with bony CNLDO, including 7 affected and 9 healthy family members.

Methods: 34-lamp ophthalmic examination, comprehensive physical examination, orbital computed tomography (CT) imaging, conventional magnetic resonance imaging, audiology, and whole exome sequencing on peripheral blood were performed. Variants were cross-referenced with 1000 control genomes and various population databases. Pathogenic variants were identified using bioinformatic tools.

Main Outcome Measure: Clinical examination, diagnostic imaging, whole exome sequencing, and bioinformatic analysis findings.

Results: Affected patients showed decreased tear production on the Schirmer I test and reduced tear breakup time. Bony CNLDO was observed on CT, showing unilateral or bilateral bony terminations at the retrobulbar lateral segment of the nasolacrimal canal. Magnetic resonance imaging showed glands or absence of lacrimal, parotid, and submandibular glands. Physical examination revealed normal ears, digits, and facial morphology. Audiometry and dental examination were conducted on the pediatric patients and yielded normal results. The clinical characteristics of patients aligned with a diagnosis of ALSG. Genomic analysis revealed 3 novel heterozygous missense mutations of the *FGFR3* gene: c.516C>G, c.327G>G, and c.302T>G. The inheritance pattern was a disorder consistent with recessive inheritance. These variants were not observed in 1000 control genomes and population databases. These variant positions also were known to be highly conserved across various animal species. Mutated genes and proteins were predicted as deleterious with most computational models, with a low supporting they may be benign.

Conclusions: Bony CNLDO was identified as a novel phenotype of ALSG implicated by missense mutations of highly conserved residues in the *FGFR3* gene. These cases broadened our knowledge of *FGFR3*-related phenotype and suggested clinicians to consider syndromic associations in patients with bony CNLDO.

Financial Disclosures: The authors have no proprietary or commercial interest in any materials discussed in this article. Ophthalmology 2024;131:588-594 © 2023 by the American Academy of Ophthalmology

Congenital nasolacrimal duct obstruction (CNLDO) is a pervasive lacrimal drainage disorder affecting 4% to 30% of the pediatric population.¹ The most prevalent cause is the presence of a membrane at the valve of Hasner. Typically, the membranous form of CNLDO responds well to treatments such as nasolacrimal massage or lacrimal probing. However, in cases where multiple probing attempts fail, consideration for more complex, including endoscopic, canalicular stenting, and bony obstruction, becomes critical.

Bony CNLDO arises from incomplete embryogenesis of the nasolacrimal canal, leading to a bony termination at the lateral portion of the maxilla. The disease is characterized by the hypoplasia of the middle or distal portion of the nasolacrimal canal evident through diagnostic imaging.² Unlike the membranous type, bony CNLDO is not amenable to probing. In our case series of 43 children with bony CNLDO, high-resolution success was achieved via dacryocystorhinostomy.³

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Bony_nasolacrimal_obstructions.pdf (765 kB)



01/30/2026 Nasolacrimal Obstructions cont.

CADEN ROBINSON - Jan 30, 2026, 12:23 PM CST

Title: Nasolacrimal Obstructions cont.

Date: 01/30/2026

Content by: Caden Robinson

Present: Me

Goals: Grow my understanding of how nasolacrimal obstructions occur and possible treatment techniques.

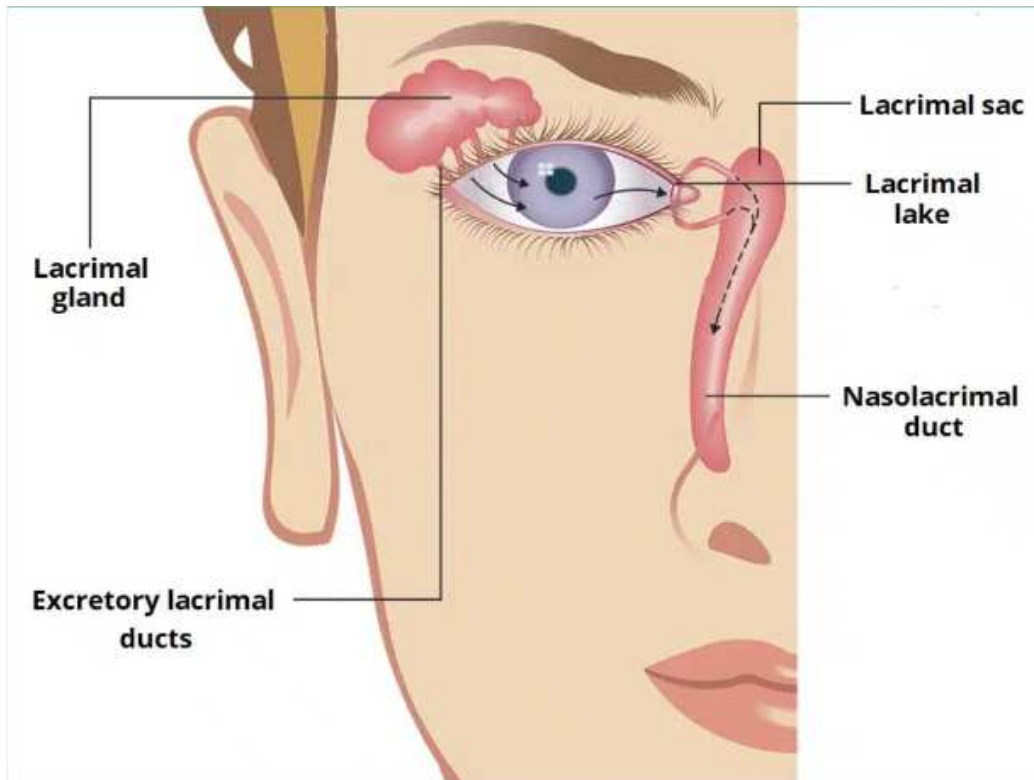
Citation:

[1] Y. Perez, "Nasolacrimal duct obstruction," StatPearls [Internet]., <https://www.ncbi.nlm.nih.gov/books/NBK532873/> (accessed Jan. 30, 2026).

Content:

typically Nasolacrimal duct obstruction (NLDO) or dacryostenosis is the most common disorder of the lacrimal system and typically affects newborn patients. Typically, NLDO presents more often in the first weeks or months of life with symptoms beginning when normal tear production occurs, presenting as excessive tearing and ocular discharge. Most cases resolved spontaneously or with minimal intervention by the first year of life; however unresolved cases need to be referred to the pediatric ophthalmologist for probing and may require surgical intervention.

The lacrimal drainage structures form during the fifth week of gestation as a crease between the frontons and maxillary process known as the nasolacrimal groove or naso-optic fissure 10. A cord of ectodermal tissues separates from the surface and enters this groove. this tissue eventually canalizes and forms the lacrimal sac and nasolacrimal duct. incomplete canalization is the most common cause of NLDO.



[2] "Lacrimal Glands and Apparatus - Vasculature - Innervation - TeachMeAnatomy." Accessed: Jan. 30, 2026. [Online]. Available: <https://teachmeanatomy.info/head/organs/eye/lacrimal-gland/>

There is a high rate of spontaneous resolution with approximately 80% of affected children being free of the symptoms by 3 months of age, and over 90% recovering by their first birthday.

The primary treatment of NLDO is a regimen of nasolacrimal massage, usually 2 to 3 times per day, accompanied by a cleansing of the lids with warm water and topical antibiotics; this will resolve the infection in 76% to 89% of cases. In cases that do not resolve by age 6 to 10 months, lacrimal duct probing is performed by pediatric ophthalmology. During the procedure the physician inserts a probe or irrigation cannula and advances it through the

lacrimal drainage system until it touches the obstruction; the probe is then pushed through the obstruction into the nose. The advantages of early probing in the office setting are avoidance of general anesthesia, speedy resolution of symptoms, fewer physician visits, fewer antibiotic prescriptions, and less costly procedures.

Conclusions/action items: This article gave a great description of the causation of nasolacrimal obstructions and potential treatment options. With my basic understanding of them, designing a bowman probe to remove these obstructions should be easier. Still though, it sounds like there are conditions where probing is not easily done, I'm wondering if any adjustments to these probes can be made to increase the success rate.

Continue researching Nasolacrimal obstructions, Begin drafting the PDS

CADEN ROBINSON - Jan 30, 2026, 12:24 PM CST

11/20/2025, 12:24 PM Nasolacrimal Duct Obstruction - StatPearls - NCBI Bookshelf

NCBI Bookshelf. A service of the National Library of Medicine, National Institutes of Health.
StatPearls [Database]. Treasure Island (FL): StatPearls Publishing; 2025.

Nasolacrimal Duct Obstruction

Yoravita Perez; Giuseppe C. Pizzi; Magda D. Mendez.
Author Information and Affiliations
Last Update: August 8, 2025.

Continuing Education Activity

Nasolacrimal duct obstruction (NLDO) or dacryostenosis is the most common disorder of the lacrimal system, and approximately 6 to 20 percent of newborns exhibit symptoms of this condition. Typically, NLDO presents in the first weeks or months of life with symptoms that begin when normal tear production starts, presenting with excessive tearing and ocular discharge. Erythema of the periorbital skin, upper and lower eyelids may result from irritation from tears and discharge due to inadequate drainage. As a result, the condition may mimic chronic unilateral conjunctivitis. This activity examines the presentation, evaluation, and management of nasolacrimal duct obstruction and reviews the role of an interprofessional team approach to the care of affected patients.

Objectives

- Describe the typical exam findings in a patient with nasolacrimal duct obstruction.
- Review how to properly evaluate for nasolacrimal duct obstruction.
- Identify treatment considerations for patients with nasolacrimal duct obstruction.
- Explain the importance of improving coordination amongst the interprofessional teams to enhance the delivery of care for patients affected by nasolacrimal duct obstruction.

Access three multiple choice questions on this topic.

Intend to learn

Nasolacrimal duct obstruction (NLDO) or dacryostenosis is the most common disorder of the lacrimal system.[1] Approximately 6% to 20% of newborns present with acute symptoms.[2] Typically, NLDO presents more often in the first weeks or months of life with symptoms beginning when normal tear production occurs, presenting as excessive tearing and ocular discharge. Erythema of the periorbital skin, upper and lower eyelids may result from irritation and rubbing produced by dripping of tears and discharge due to inadequate drainage. As a result, the condition may be apparent as chronic unilateral conjunctivitis. Most the cases resolved spontaneously or with minimal intervention by the first year of life; however, unresolved cases need to be referred to the pediatric ophthalmologist for probing and may require surgical intervention. In children younger than 6 months of age, a conservative approach is a typical management. Managing the lacrimal sac, eye drops, and topical antibiotics are commonly used, and surgical treatment is considered for patients whose symptoms persist after 12 months of age.[3]

Etiology

https://www.ncbi.nlm.nih.gov/books/NBK522872/ 1/6

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Nasolacrimal_Obstruction_Overview.pdf (251 kB)



01/30/2026 Dacryocystitis in infancy

CADEN ROBINSON - Jan 30, 2026, 12:45 PM CST

Title: Dacryocystitis in infancy**Date:** 01/30/2026**Content by:** Caden Robinson**Present:** Me**Goals:** Continue to grow my understanding of nasolacrimal blockages**Citation:**

[1 O. O. Ffooks, "DACRYOCYSTITIS IN INFANCY*," *Br J Ophthalmol*, vol. 46, no. 7, pp. 422–434, Jul. 1962, doi: [10.1136/bjo.46.7.422](https://doi.org/10.1136/bjo.46.7.422).
]

Content:

Dacryocystitis is the actual infection/inflammation caused by an obstruction in the nasolacrimal channel. There are multiple different reasons that could cause this infection, 2 of which being aplasia and delayed duct development and infection. The neonatal conjunctival or nasal infection causes this inflammation and prevents normal duct canalization resulting in the developmental membrane to become fibrosed (thickening or scarring of connective tissue), leading to persistent obstruction. Severe cases of this infection can cause permanent damage or "bony" obstructions. about 1/3 of these cases are bilateral, meaning they impact both sides of the face.

The primary goal of treatment is to control the infection. If this infection isn't contained, the thin developmental membrane becomes a thick fibrous block and normal canalization fails permanently. Dacryocystitis can become recurrent since of the poor drainage resulting from the "bony" obstruction in the nasolacrimal canal. More invasive surgery other than probing is necessary to remove this obstructions since probing becomes significantly more difficult to remove this obstruction. Many of these symptoms can be aggravated by cold or windy weather and other upper respiratory infections and can persist later into childhood and even adulthood if not responded to appropriate

Probing Procedure: Probing involves dilating the lacrimal puncta and passing a probe through the nasolacrimal duct under general anesthesia. Antibiotics are administered before and after probing to control infection. Probing is usually successful, especially when performed early, but some cases may require multiple attempts or additional surgery, such as dacryocystorhinostomy.

Results of Treatment: In the study of 334 cases, 309 were cured, with 229 requiring only one probing. Persistent symptoms were more common in children probed after the age of one year. A small percentage of cases resulted in permanent stenosis of the nasolacrimal duct.

Conclusions/action items: This article was a lot of repeated information with more quantitative data. It also demonstrated to me that the blockage can cause more critical conditions even though it has a relatively high recovery rate. I wonder if some sort of antibacterial agent can be added to the bowman probe so that a treatment approach can be applied directly to the infection site.

Continue researching about nasolacrimal blockages, Draft the PDS

CADEN ROBINSON - Jan 30, 2026, 12:45 PM CST

Br. J. Ophthalmol. (1962) 46, 422.

DACRYOCYSTITIS IN INFANCY*

By
O. O. FFOOKS†
From the Ocular Clinic,
Royal Free Hospital, London

Dacryocystitis in Infancy occurs as the result of an obstruction at the lower end of the nasolacrimal duct which may be developmental or acquired in origin, and the treatment will depend upon the nature of this obstruction.

It has been amply demonstrated that the last portion of the nasolacrimal duct to become canalized is the point of coalescence between the nasal sprout of the mother cord of the developing lacrimal duct and the nasal mucous membrane. This stage may be delayed until weeks or later in up to 25 per cent. of cases (Bilwaha, 1933), and it figure as high as 75 per cent. has been found by Casady (1955).

The relationship between infantile dacryocystitis and delayed development of the nasolacrimal duct was first suggested by Peters (1911), Robinson-Davies and (1939), Stephenson (1939), and Owen (1940), and it is now generally believed that this condition is the direct result of the failure of the membrane at the lower end of the nasolacrimal duct to rupture at birth (Kraemer, 1922; Crisler, 1923; Casady, 1948a, b; Duke Elder, 1952; Mann, 1957; and many others). As Casady (1948b) stated,

"The lacrus is usually obstructed by rupture of the membrane before tear starts, but if it is not, the sac distends, becomes inflamed and dacryocystitis of infancy occurs."

It is, however, possible that infantile dacryocystitis is the direct result of infection itself at or soon after birth, and Sampson (1945) was firmly of the opinion that inflammation and oedema of the naso-lacrimal duct, secondary to nasal infection, was the cause of a large number of cases. He suggested that infection caused obstruction by itself, or hastened the formation of a mass of intra-membranous plug.

An epithelial plug, representing a failure of the normal epithelial cells to separate and become necrotic, has also been suggested (Riker, 1937; Hamlin, 1956; and others). However, this state of affairs, if indeed it is possible, is directly related to delayed development of the naso-lacrimal duct itself.

Although, as has been stated, it is generally assumed that the presence of a developmental membrane at the lower end of the naso-lacrimal duct is the

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Dacryocystitis_in_infancy.pdf (1.39 MB)



02/06/2026 Simple and complex pediatric nasolacrimal obstruction

CADEN ROBINSON - Feb 06, 2026, 10:10 AM CST

Title: Simple and complex nasolacrimal obstruction

Date: 02/06/2026

Content by: Caden Robinson

Present: Me

Goals: Continue to understand some of the issues present during surgeries.

Citation:

[1 K. J. Williams, "Simple and Complex Pediatric Nasolacrimal Duct Obstruction," in *Oculoplastic Surgery: A Practical Guide to Common Disorders*,] E. A. El Toukhy, Ed., Cham: Springer Nature Switzerland, 2024, pp. 255–264. doi: [10.1007/978-3-031-59777-0_24](https://doi.org/10.1007/978-3-031-59777-0_24).

Content:

in children with bilateral acquired nasolacrimal duct obstruction, it is prudent to consider alternative etiologies such as amyloidosis and consider a lacrimal sac biopsy at the time of the procedure. to maintain patency of the ostium during healing, most surgeons use silicone stent intubation for a period of six weeks to three months or longer as needed. External dacryocystorhinostomy (DCR) has been used in persistent nasolacrimal duct obstruction with reported success rates between 79 and 97%. In a study with 114 children with a mean age of 9.6 years, the success rate was reported as 91 and 90.3% functional and anatomic success. Understanding nasal anatomy and landmarks is crucial to undertaking the endoscopic approach in this procedure, and having pediatric sized instruments and endoscopes can be helpful in visualization.

Children have smaller nares and vertical nasal height, lower skull base, and tend to have an exuberant healing response predisposing to scarring at the osteotomy, and surgeons undertaking this procedure should be aware of these differences prior to proceeding. For children with highly altered anatomic landmarks (for example, following trauma), the use of vitrectomy light pipe on a low setting to avoid iatrogenic burn injury passed through the puncta and canaliculus to the nasolacrimal sac can be a useful adjunct to illuminate the entirety of the sac. It is important to note the posterior and thinner lacrimal bone will more readily be transilluminated than the thicker anterior maxillary bone of the frontal process, and removing the thicker bone present anterior and superior is crucial to forming an appropriate osteotomy in endoscopic DCR.

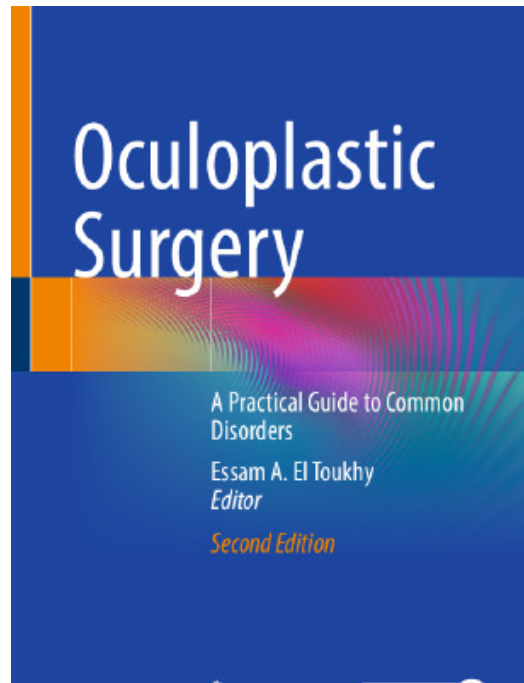


Image above represents a CT scan from a teenage patient with the absence of the lacrimal and salivary glands

Conclusions/action items: This reading allowed me to further expand my learning when it comes to nasolacrimal blockages and some of the causes for them. For this project and design, it is crucial to understand the anatomy and risk factors associated with these blockages to create a device that will be as effective as possible without injuring the patient. Furthermore after this reading, I am realizing that I should be researching the anatomy more to understand some more of the language used.

Continue researching about nasal anatomy, Begin researching human testing guidelines and how to set up animal testing.

CADEN ROBINSON - Feb 06, 2026, 10:11 AM CST



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978-3-031-59777-0.pdf (97.9 MB)



02/06/2026 Nasolacrimal Anatomy

CADEN ROBINSON - Feb 06, 2026, 11:23 AM CST

Title: Nasolacrimal Anatomy

Date: 02/06/2026

Content by: Caden Robinson

Present: Me

Goals: Get a better understanding of the anatomy of the nasolacrimal anatomy to be able to create a product that complies with the anatomy

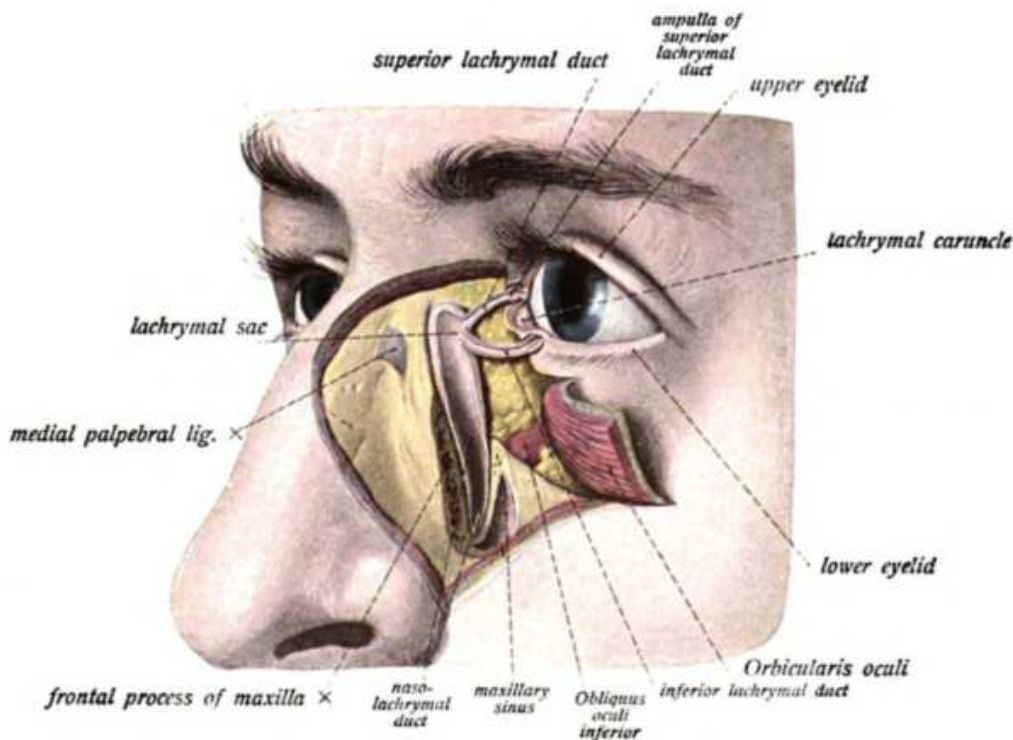
Citation:

[1 M. L. Cochran, S. Aslam, and C. N. Czyz, "Anatomy, Head and Neck: Eye Nasolacrimal," in *StatPearls*, Treasure Island (FL): StatPearls Publishing, 2025. Accessed: Feb. 06, 2026. [Online]. Available: <http://www.ncbi.nlm.nih.gov/books/NBK482213/>]

Content:

both the upper eyelid and the lower eyelid have a small opening on the surface of the eyelid margin near the medial canthus. These are called puncta. Each puncta leads to a drainage canal that eventually flows into the lacrimal sac and then the nasal cavity. Within the lower eyelid, the punctum leads to a 2 mm long ampulla, which runs perpendicular to the eyelid margin. The ampulla turns 90 degrees medially, becoming the inferior canaliculus and travels 8 to 10 mm before reaching the common canaliculus. The common canaliculus drains into the lacrimal sac. Within the junction between the common canaliculus and the lacrimal sac is the valve of Rosenmuller. This apparatus is a one-way valve that prevents reflux from the lacrimal sac to the puncta.

The nasolacrimal duct starts forming around five weeks of gestation. it starts out as linear thickening of ectoderm located in a groove between the nasal and maxillary process. this thickening eventually separates into a solid cord and sinks into the surrounding mesenchyme. Over time the cord canalizes forming the lacrimal sac and the beginning of the nasolacrimal duct. The nasolacrimal duct extends intranasally until it exits under the inferior turbinate. The lacrimal sac extends caudally to complete the canalicular system. The inside of the canal breaks down and forms a lumen so that the nasolacrimal system is patent. Typically the process is completed by birth.



Conclusions/action items: After learning more about the anatomy, I feel that I have a better understanding of where each organ/opening is and their names. From here on, each time we have a conversation with the client and they mention a specific area of the anatomy that causes problems, i can

associate the name to the actual structure. Understanding the anatomy is a great start to understanding the probes usage.

Continue researching about nasolacrimal blockages, look at competing products, begin prototyping.



02/06/2026 Calibrated Bowman's lacrimal probe

CADEN ROBINSON - Feb 06, 2026, 11:43 AM CST

Title: Calibrated Bowman's lacrimal probe

Date: 02/06/2026

Content by: Caden Robinson

Present: Me

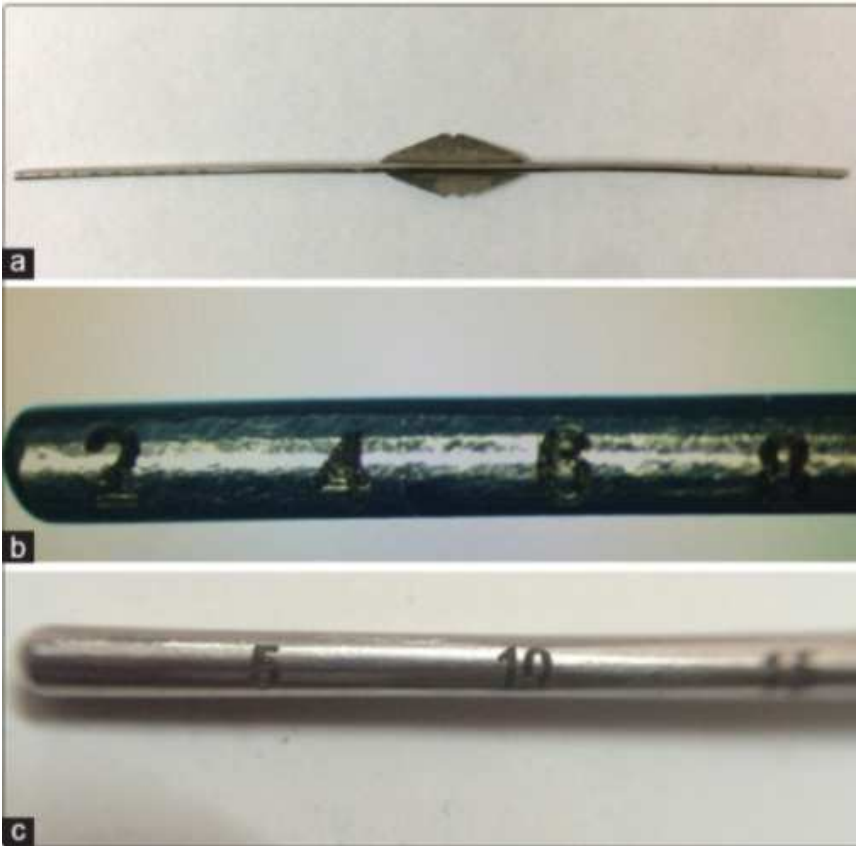
Goals: Understand some competing designs on the market to help me brainstorm some ideas for our probe.

Citation:

[1 A. Pujari, M. S. Bajaj, and P. Sharma, "Calibrated Bowman's lacrimal probe," *Indian J Ophthalmol*, vol. 66, no. 3, p. 478, Mar. 2018, doi: [10.4103/jjo.IJO_1063_17](https://doi.org/10.4103/jjo.IJO_1063_17).]

Content:

there is a design that has 10 mm markings every 10mm to allow the surgeon to know the distance reached from the punctum. The technique used to create this specific probe was to laser engrave numbers on these probes. The probe on one side has measuring scale at every 2mm from 2 to 20mm and the other side has 5mm to 20mm.



Conclusions/action items: I have a couple problems with this design, first of which being since the numbers are laser engraved onto the probe, meaning there is some divot inside these probes, it seems that when using them in practice I would be worried about pulling the skin of the regions, and the divots in the probes, with the probes already being extremely tiny in diameter, would be extremely hard to sterilize and keep clean. Also visually, its hard to tell exactly how deep you are into the ducts. Each marking has the number located on the probe but no hash or other indicator to give feedback to the surgeon of their exact distance inside. If the surgeon needs to make a marking at 8.5mm, there is no real way to be accurate with the probe since its just blank space. Looking at this design has me wondering since the diameter of these probes are so small, how difficult it will be to actually engrave on them and be accurate.

Continue researching nasolacrimal obstructions, begin prototyping.

Indian Journal of Ophthalmology Volume 66, Issue 1

Calibrated Bowman's lacrimal probe

Download

Abstract
 Objective: To describe the use of the calibrated Bowman's lacrimal probe in the diagnosis of dry eye disease. The probe is a commonly used clinical device to measure tear meniscus height. Assessment of level of lacrimal system blockage using this device is often subjective. The probe is used to measure the distance between the upper eyelid and the lower eyelid during positive, therapeutic, positive, negative, and neutral pressure. In these kinds of probes, the distance between the eyelids is measured. The probe is used to measure the distance between the eyelids.

Introduction
 There are no corneal reflexes of interest.

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Reference
 1. Kulkarni M. Use of calibrated lacrimal probe. Indian J Ophthalmol. 2019;67(1):1-2.

Figure 1
 The figure shows three photographs of the calibrated Bowman's lacrimal probe. The top photograph shows the probe in its closed position. The middle photograph shows the probe in its open position, with the eyelids being held together. The bottom photograph shows the probe in its open position, with the eyelids being held together, and the distance between the eyelids is being measured.

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IJO-66-478a.pdf (672 kB)



02/13/2026 Polymer composites

CADEN ROBINSON - Mar 13, 2026, 12:59 AM CDT

Title: Polymer Composites

Date: 02/13/2026

Content by: Caden Robinson

Goals: Learn about possible polymers to implement in the laser engraving

Citation:

[1 "Rehabilitation of Metallic Structural Systems Using Fiber Reinforced Polymer (FRP) Composites," ScienceDirect. Accessed: Feb. 13, 2026.] [Online]. Available: <https://www.sciencedirect.com/book/edited-volume/9780443220845/rehabilitation-of-metallic-structural-systems-using-fiber-reinforced-polymer-frp-composites>

Content:

The document mentions the use of Fiber Reinforced Polymer (FRP) composites, specifically Carbon Fiber Reinforced Polymer (CFRP) and Glass Fiber Reinforced Polymer (GFRP) materials. These materials are used to enhance the stability of steel structural sections. The properties of these materials include:

1. CFRP (Carbon Fiber Reinforced Polymer):

- High modulus (e.g., 230 GPa)
- High tensile strength (e.g., 2.8 GPa)
- Thickness (e.g., 1.4 mm, 0.165 mm)
- Used in wraps, strips, and plates for bracing and strengthening steel sections.
 - mainly used to enhance material properties especially the stiffness and other mechanical properties
 - increases the actual strength of the probes
 - very very lightweight

2. GFRP (Glass Fiber Reinforced Polymer):

- Lower modulus compared to CFRP (e.g., 41.4 GPa)
- Tensile strength (e.g., 895 MPa)
- Thickness (e.g., 1.4 mm)
- Used in strips, panels, and stiffeners for bracing and enhancing ductility.
 - again used to enhance the mechanical properties
 - poor bonding - potential issues during surgeries
 - usually thermoset - liquid to rigid solid form

3. Adhesive Layer:

- Used to bond FRP materials to steel substrates.
- Properties: tensile strength (e.g., 31 MPa) and modulus (e.g., 3.9 GPa).

Additionally, mortar, PVC, and honeycomb core materials are mentioned as part of hybrid systems to enhance the performance of steel sections.

Conclusions/action items: These are all potential materials that could be used to cover the holes in the bowman probes but it seems that they are all for repair and rehabilitation. They would all increase the physical properties which is not necessarily what the project demands. I think that more research should be done considering these materials and some of the devices that they are used in.

Continue researching materials, begin drafting preliminary presentation.



02/13/2026 Thermosetting Polymers

CADEN ROBINSON - Feb 13, 2026, 12:24 PM CST

Title: Thermosetting polymers

Date: 02/13/2026

Content by: Caden Robinson

Goals: Try to understand what polymers can be thermoset and if it is compatible with bowman probes

Citation:

[1 L. D. Tsai and M. R. Hwang, *Thermoplastic and Thermosetting Polymers and Composites*. Hauppauge, UNITED STATES: Nova Science] Publishers, Incorporated, 2011. Accessed: Feb. 13, 2026. [Online]. Available: <http://ebookcentral.proquest.com/lib/wisc/detail.action?docID=3021402>

Content:

Thermosetting polymers are historically used as matrix for production of composite with several particulates fillers and fibers. The thermosetting resins before cure reaction are found as a viscous fluid that is be able to involve the fibers or fillers particles, promoting high distribution of reinforcement and excellent homogeneity of the composites . After cure reaction of polymeric resin is generated a crosslink chemical structure that physically anchor the reinforcement in the matrix, leading to the excellent combination between matrix and reinforcement properties without to require the utilization of coupling agents . On the other hand, the thermosetting composites present some disadvantage such as impossibility of thermo-mechanical reprocessing, which difficult the use of versatile production operations such as extrusion and injection molding. Recycling of thermosetting composites is also a technological challenge. Recently, thermosetting composites have been preferable used for specific applications with lower amount in demand, however with higher cost such as electronic devices and aeronautic industry.

Epoxy resins are most likely to be thermoset to other metals. Epoxy as well as phenolic resins can form covalent crosslinks with natural fibers via reaction of epoxy groups with hydroxyl present in fiber. The considerable improvement of mechanical properties is achieved when epoxy resin is reinforced with natural fibers. However the cost-benefit ratio is a challenger to be wined, mainly when compared to the traditional epoxy composites.

Conclusions/action items: This book goes in depth about potential ways to thermoset polymers into metals and other materials. It seems like a very achievable strategy to fill in the gaps of the laser engraving but im not sure if there are any materials to actually do this on campus. I am also worried that these probes are too small of scale to actually bind effectively to the epoxies.

Continue researching, begin working on preliminary presentation.



03/12/2026 laser induced color markings

CADEN ROBINSON - Mar 13, 2026, 11:42 AM CDT

Title: Laser induced color markings

Date: 03/12/2026

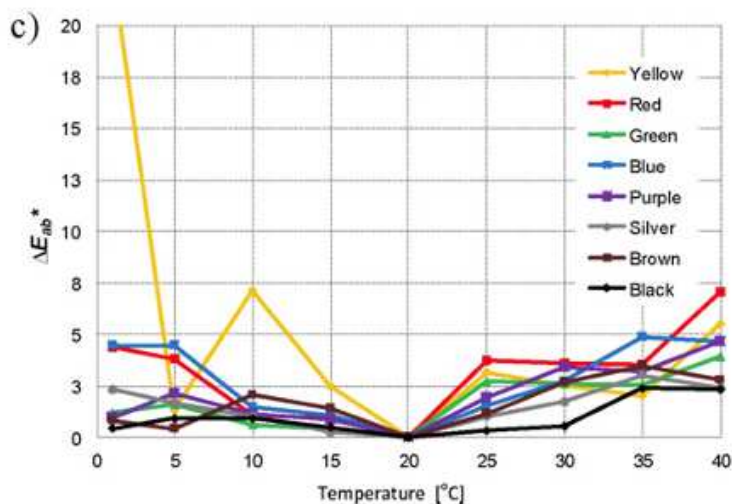
Content by: Caden Robinson

Goals: Develop a better understanding of how the oxidation reaction between the stainless steel and the aerosol spray

Citation:

[1 A. J. Antończak, D. Kocoń, M. Nowak, P. Kozioł, and K. M. Abramski, "Laser-induced colour marking—Sensitivity scaling for a stainless steel,"] *Applied Surface Science*, vol. 264, pp. 229–236, Jan. 2013, doi: [10.1016/j.apsusc.2012.09.178](https://doi.org/10.1016/j.apsusc.2012.09.178).

Content:



Tests were carried out for plates of multipurpose stainless steel of grade AISI 304 (0H18N9, chemical composition Cr = 19%, Ni = 9.5%, Mn = 2%max, C = 0.08%max) with dimensions of 100 nm × 100 mm and thicknesses of 0.6, 0.8 and 1.0 mm. The oxidative layering after laser engraving reacts with the Chromium inside of the stainless steel. Chromium is a key component of stainless steel, and its oxidation contributes to the formation of oxide layers that are responsible for the color effects observed in laser marking. Initial material temperature, thickness, and marked area size showed minimal impact on color changes. yellow color was more sensitive to temperature changes. UV radiation and salt spray tests revealed that laser color marking is relatively resistant to aging, with minimal color changes. Depending on the intensity of the laser changes the color oxidized onto the metal.

- $\Delta E_{ab} = 1^*$: The smallest color difference that a typical human eye can perceive.
- $\Delta E_{ab} \geq 4^*$: Color differences are noticeable to the average observer.
- $\Delta E_{ab} \geq 7^*$: Color differences are considered acceptable in industrial applications, such as printing

Conclusions/action items: After reading this article, as I understand it, the difference in stainless steel properties doesn't specifically have an effect on the actual laser marking. Stainless steel are mainly made of chromium ranging from the 10-30% range, and the amount present does not change the markings as much resulting in no issues with marking unless there are other components inside the steel. Also it is important to note that there will be some color change with increasing temperature so it will be crucial that these probes are tested in autoclaves to see how great this change in color will be.

Finish fabricating laser holder, create prototype.

CADEN ROBINSON - Mar 13, 2026, 1:15 AM CDT

Laser-induced colour marking—Sensitivity scaling for a stainless steel

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ARTICLE INFO

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Laser colour marking
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Laser parameters
Colour marking
Colour marking

ABSTRACT

This paper presents the results of measurements and analysis of the self-action of laser marking process parameters on the colour obtained. The study is conducted for different configurations of laser beam and a commercially available industrial laser system. In addition, we have determined some parameters such as colour gamut, colour resolution, and colour contrast. The results show that the colour obtained is dependent on the laser parameters and the material properties. The results show that the colour obtained is dependent on the laser parameters and the material properties. The results show that the colour obtained is dependent on the laser parameters and the material properties.

1. Introduction

Colour marking on metal surfaces is typically performed by grinding, sandblasting, coating or electroplating and laser (analogical) techniques. Such processes, just like etching, the complexity of the process and colour fading over time are typical drawbacks of these processes. Anodizing process, does not make it possible to obtain colour selective marking, or more than one colour at a time.

Laser colour marking as a process has been known for 15 years [1], but it has not been used widely in the industry, because it is expensive and difficult to control, and there are many problems. There are many methods of laser colour marking but we have reported on the laser system. The first surface is laser as a base colour, which allows the formation of a homogeneous or semi-homogeneous color film on the metal surface [2,3]. When light illuminating the sample surface is reflected from the surface of both oxide and metal, as a result of interference of the reflected waves, a colour effect can be obtained. The thickness of the oxide layer, the order of interference [4] and refractive index determine the colour spectrum.

Secondly, colour can be obtained on the surface of various metals by laser-induced vapour formation of particles, surface molecules (LIPPL), so-called "laser-induced vapour", on the surface using direct or processed laser [5].

In most applications laser marking is the laser and the character of the mark. There is a strong demand to extend the capabilities of these systems, as regards the possibility of colour marking. The main problems are the reproducibility and stability of the process. Other, experimentally determined parameters to obtain a specific colour on one system does not give a positive result for other systems, even if very similar (the same material). Several descriptions of laser colour formation on a metal surface can be found in the literature, but there is still a lack of information about colour of the process parameters have an impact, and to what extent, on the reproducibility of the colour obtained.

2. Experimental details

The study was performed for the commonly used M DF's configuration: Triplix fibre laser (100 W) with output power 20 W, beam quality factor $M^2 = 1.3$, pulse duration 100 ns and pulse repetition rate 20–100 kHz (PC type PLP-C-1-100-20-20). The system was equipped with a galvanometer, so we were able to move the laser

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http://dx.doi.org/10.1016/j.apusc.2012.09.016

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laser-induced_color_marking.pdf (1.58 MB)



03/13/2026 Laser color marking on stainless steel

CADEN ROBINSON - Mar 13, 2026, 11:38 AM CDT

Title: Laser color marking on stainless steel

Date: 03/13/2026

Content by: Caden Robinson

Goals: Increase my understanding of the factors that involve laser marking stainless steel

Citation:

[1 A. Schkutow and T. Frick, "Laser color marking of stainless steel – Investigation of the fluence-dependent and thermal mechanisms in generating] laser induced surface modifications," *Procedia CIRP*, vol. 124, pp. 661–664, Jan. 2024, doi: [10.1016/j.procir.2024.08.196](https://doi.org/10.1016/j.procir.2024.08.196).

Content:

Low Energy Input: Yellow colors are created due to the formation of chromium oxide on the surface. High Energy Input: Multilayer oxide films form, leading to more homogeneous and intense colors

Increased average power and temperature lead to stronger oxidation, influencing the color results

scan speed refers to the speed at which the laser beam moves across the powder bed while melting the material during the additive manufacturing process. With fast scan speeds and therefore low total applied energies brownish-yellow colors are generated. With decreasing scan speeds these colors are getting darker and more intense, before some uneven and strongly deviating, slightly blueish colors appear. By further decreasing the scan speed a steady transition between homogeneous colors from pink to purple, blue-green and gray colors is achieved.

It has been reported previously, that depending on the irradiation conditions and the temperature conditions duplex oxide films, consisting of an outer Fe₂O₃ layer and an inner Cr₂O₃ layer, can form on the surface of stainless steel substrates under laser irradiation. This is due to the different oxygen-affinities and temperature-dependent diffusion mobilities of iron and chromium.

- forms two oxide layers, chromium near the surface which bonds with oxygen and iron, when heated up diffuses to the top of the surface
- Stronger these oxide layers, the more they reinforce each other's wavelength to create an optical interference

Investigations on different substrates have shown that multilayered structures and the formation of a transparent oxide layer can greatly enhance the achievable color gamut, and homogeneity and reduce the angle dependence of the interfering colors. It is likely, that the formation of the outermost oxide layer of the multilayer film is highly dependent on both the temperature of the lower, thicker oxide layer and therefore the overall energy input and the local temperature conditions at the surface, which can be efficiently altered by suitable laser processing parameters. High pulse frequencies, moderate pulse energies and homogeneous temperature distributions achievable by moderate scan speeds and small hatch distances seem to favor the generation of intense, homogenous colors.

- Oxide properties are impacted by different pulse frequencies
- the amount of time a laser is on one area
- and homogenous temperature distributions

Conclusions/action items: From this article, it seems that depending on the color wanted for the graduation of the probes can be changed depending on multiple factors. This article also does a better job at explaining how some of the different grades of stainless steel could interact under laser marking, and the formation of their two oxide layers.

3D print holder for laser marking, create graduated prototype.

CADEN ROBINSON - Mar 13, 2026, 11:39 AM CDT



13th CIRP Conference on Photonic Technologies [LANE 2024], 15–19 September 2024, Flensburg, Germany

Laser color marking of stainless steel – Investigation of the fluence-dependent and thermal mechanisms in generating laser induced surface modifications

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Abstract

Laser color marking is an attractive process to generate fluence- and time-dependent color changes on visible and invisible marks such as stainless steel or titanium. The color generation is mainly based on interference effects on thin oxide layers, usually formed by non-resonant pulsed laser irradiation. Due to the large number of fluence-dependent processing parameters and different thermal, chemical, structural, and topological surface modifications on the color generation, the process is still not fully understood. In contrast, the reproducibility of the markings and the processing times can be increased by the implementation of digital manufacturing processes. To improve the understanding of the color generation, this paper presents a study on the generation of laser induced surface modifications on stainless steel using different processing parameters. Spectroscopic, microscopic, and SEM/EDS analyses are conducted to investigate the effects of the surface morphology, oxide layer properties, chemical composition, and heat treatment on the color marking results.

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Peer review under responsibility of the International Association for the CIRP-Congress on Photonic Technologies [LANE 2024].

Keywords: Laser color marking; stainless steel processing; oxide layers; thin film interference.

1. Introduction

In laser color marking processes, the generation of functional labels or markings like serial numbers, production dates, quick response (QR) codes, logos or other product information can be combined with aesthetic, decorative features, and design elements [1, 2]. The process involves no chemicals, dyes, or inks and is therefore eco-friendly, flexible, scalable due to automation and offers high potential for an automated and fully digital workflow. The color generation is usually generated by pulsed laser processing of visible and/or infrared laser systems containing ultrashort pulses, leading to localized modifications of the structural, morphological and chemical properties of the surface in the irradiated areas. A combination of multiple factors contributes to the overall appearance of the markings. For non-resonant pulsed laser marking processes, the main mechanisms are the

generation of oxide layers due to the laser-induced effects on the oxide layer, the color of the generated oxide thin layers and the surface morphology [3]. Although most authors attribute the primary significance to the thin film interference effect, there are still discrepancies between theoretical calculations and experimental observations. With experimentally measured oxide layer thicknesses up to 100 nm, the color generation is not fully understood. In [4] it is stated that the oxide layer thicknesses are up to 100 nm [2, 6, 7]. Despite the experimental results usually show a single peak through a limited color scale [1, 2, 5] indicating that the color generation mechanisms are not fully understood.

Numerous studies investigated the process of laser color marking and the major influencing processing parameters on the generated colors have been identified. In most of these studies the color of the marking is determined by the

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Laser_coloring_stainless_steel.pdf (1.27 MB)



03/13/2026 Experimental investigations on fiber laser color marking of steels

CADEN ROBINSON - Mar 13, 2026, 12:37 PM CDT

Title: Experimental investigations on fiber laser color marking of steels

Date: 03/13/2026

Content by: Caden Robinson

Goals: Continue to understand how the oxidation process works

Citation:

[1 E. H. Amara, F. Haïd, and A. Noukaz, "Experimental investigations on fiber laser color marking of steels," *Applied Surface Science*, vol. 351, pp. 1–12, Oct. 2015, doi: [10.1016/j.apsusc.2015.05.095](https://doi.org/10.1016/j.apsusc.2015.05.095).

Content:

- The laser heats the metal surface.
- Oxygen in the air reacts with the heated metal.
- A thin oxide layer forms on the surface.
- Light reflects from the oxide layer and the metal underneath.
- Optical interference between these reflections produces visible colors.

a pulsed fiber laser can produce colored markings on stainless steel surfaces. The researchers investigated how different laser parameters, such as laser power, pulse frequency, and scan speed, affect the formation of surface colors. They found that when the laser heats the steel in air, a thin oxide layer forms on the surface due to thermal oxidation. The thickness of this oxide layer changes depending on the amount of laser energy applied, which is controlled by the processing parameters. Light reflecting from the oxide layer and the underlying metal interferes, producing different visible colors. By adjusting the laser settings to control the oxide thickness and surface temperature, the researchers were able to generate a range of stable colors on the steel surface. The study concludes that careful control of laser parameters allows reliable and repeatable color marking on steel, which is useful for industrial applications such as product identification, decoration, and anti-counterfeiting.

fiber-laser irradiation the surface temperature can reach roughly 300 °C to 700 °C .

Higher temperatures increase:

- Diffusion of iron and chromium atoms
- Reaction rate with oxygen
- Growth rate of the oxide layer

Conclusions/action items: This article added some more information related to the environments that the lasers put these metals under. These temperatures range way outside of the autoclave temperature which is great since that should hopefully mean that multiple sterilization cycles from the autoclave shouldn't actually impact the markings.

3D print apparatus for laser marking, create graduated prototype

CADEN ROBINSON - Mar 13, 2026, 12:37 PM CDT

ARTICLE INFO

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ABSTRACT

Working an experimental approach with the aim of contributing to the comprehension of the marking phenomena during laser color marking of steels. Different marking processes were applied. After laser has been used to treat steel samples under different laser beam operating parameters. In order to compare the effects of the operating and technical parameters. The treated samples were analyzed either by optical and scanning electron microscopy, as well as by energy dispersive spectroscopy. The results show the influence of the operating parameters on the obtained colors.

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1. Introduction

Nevertheless, the modern technologies and the related industries are in constant development, and the marking of the materials is becoming essential for many reasons. Within the reasons that have led to marking products in manufacturing industries, improving security and efficiency in daily activities is used for control or batch production numbers, for 2D matrix codes to fight against forging counterfeits [1–4]. More color production on metallic surfaces represents a specific process that is addressed in particular applications, since color could be a key potential differentiator. Among the conventional techniques that are used for color marking of metals, the chemical treatment is considered as the most traditional technique [5]. The obtained films are however characterized by limited thickness and penetration, corrosion, and an excessive chemical treatment is necessary in the following [6]. Otherwise, the treatment by thermal oxidation also leads to color changes which are high temperature which could be more than 500 °C. These conventional techniques often lead to thermo-mechanical treatments can damage the material and moreover lead to the generation of significant quantity of secondary waste which must be recycled afterwards.

A clear control of laser input is therefore essential to avoid thermal effects and to obtain higher quality products. In this context, the laser beam color marking features are thus

investigated in terms of efficiency and spatial-temporal volume coordinate resolution to achieve controlled laser input on metal surfaces. The process of laser marking can mainly be achieved by two methods. The marking by mark and scanning laser marking is marking by mark, the focused laser beam goes through a mask before hitting the surface of the workpiece or laser control on shape of the mark image can be prepared over the material surface by an adapted mask or mask. Generally, this marking method requires the use of high energy pulsed laser beams [7]. The other method consists in adapting the focused laser beam on the workpiece surface by the means of non-guided elements, mirrors, where such mirror deflects the laser beam in a given direction. In an adequate control of the mirrors, it is possible to obtain the wanted trajectory of the laser beam. In regard to the classical methods of material marking, the advantage of using a laser source is that it allows a very local modification of the physico-chemical properties of the sample surface, without producing changes on the bulk material properties. This advantage permits the generation of various colors on small surfaces.

It is pointed out that under normal atmospheric conditions, the optical modification during laser beam marking of the material surface and color generation depends on the nature of the material surface. Accordingly, obtaining given color is related to the laser beam operating parameters, the metallic workpiece physical properties, and the environmental conditions. The main operating parameters are the laser power, the scanning velocity, the laser frequency, the beam spot diameter, and to obtain a given output characterized by a desired color, a series of experiments must be conducted by varying the laser beam operating parameters. However,

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1-s2.0-S0169433215012143-main.pdf (4.99 MB)



02/12/2026 Laser engraving

CADEN ROBINSON - Feb 13, 2026, 12:47 PM CST

Title: Laser Engraving

Date: 02/13/2026

Content by: Caden Robinson

Goals: Draft a possible prototype idea

Content:

Small hashes or dots will mark every 2 millimeters on the probe, which will be made by using a laser to engrave on the probes. The markings will not penetrate far into the probe so there is no harm to the structural integrity. The largest concern with this specific design is the engravings, when used during a procedure, could pull on the inner tissues of the nasolacrimal cavities causing more complications for the surgery and possible injury to the patient. To eliminate this issue, these engravings will be filled with a similar material with multiple of the same properties to smoothen the surface out. This version of the device will be much easier to fabricate and provide the real time feedback the client desires.

Polymer composites would be used to enhance the properties of the probe and fill in the gaps. A key disadvantage of this specific design is the actual combining of a polymer epoxy or resin. Depending on the polymer attached could bring potential mechanical failure during procedure or enhance the probe to possibly break off from the probe itself. It could also add new chemical properties that could not be biocompatible with the human body and not follow standard regulations.

Conclusions/action items: This is a really strong idea but it introduces multiple complications into the probe and these new variables could have impacts on the patient. From my understanding of the research I've done, the actual thermosetting will be incredibly difficult and having college students preform this procedure would create a probe that would not be up to standard.

Continue researching, begin preliminary presentations



03/05/2026 Holder for flatbed laser marking

CADEN ROBINSON - Mar 13, 2026, 1:24 AM CDT

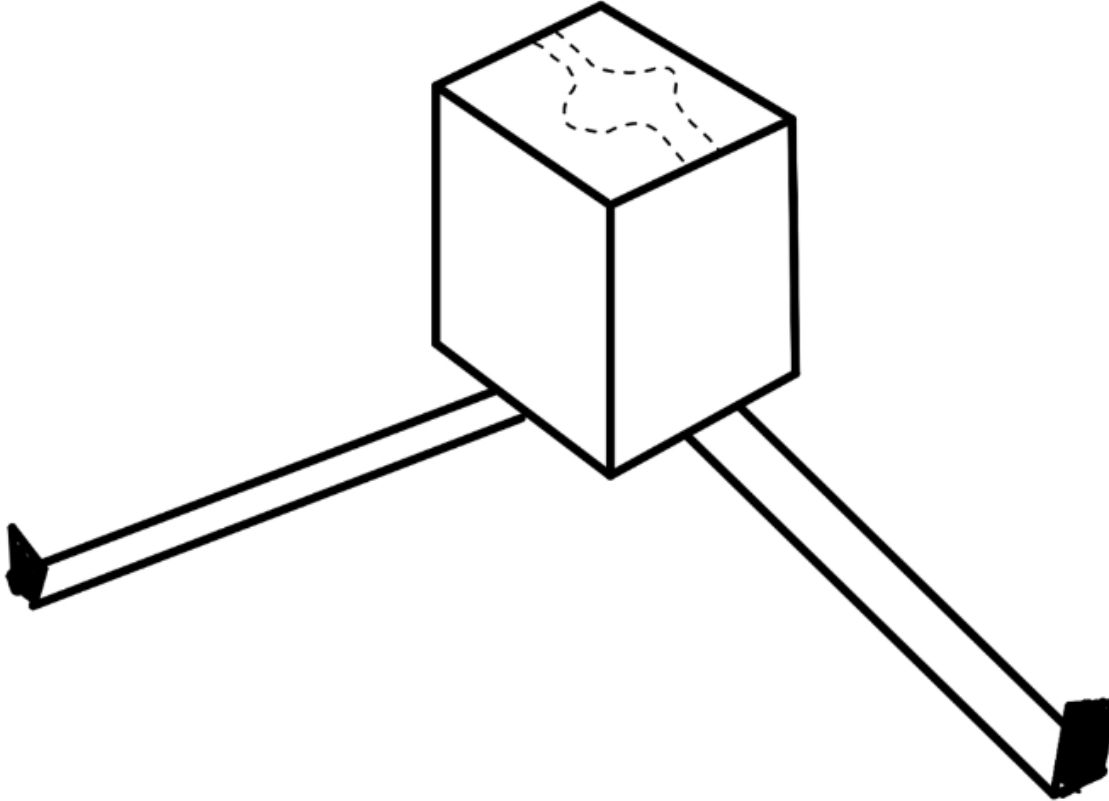
Title: Holder for flatbed laser marking machinery

Date: 03/05/2026

Content by: Caden Robinson

Goals: Create a design of the apparatus to secure the probes for repeatable graduation

Content:



Engravings on the top to secure the probe into place by the middle, since the size of the diamond shape is uniform for each bowman probe size.

Legs to extend to the edges of the laser bed so the holder is always oriented the same way under the laser

dimensions are arbitrary at the moment since we haven't actually seen the laser marking machine yet and the laser bed that we will be working with

Conclusions/action items: Ultimately, this apparatus does not need to be complex, all it needs to do is securely hold the probe in the same position for repeatable use. Key concerns about this idea is the laser bed might not be flat, the orientation the probe is secured is not optimal for graduation. One thing we should also keep in mind is to make sure that the material of the holder wont degrade under the laser resulting in micro-adjustments possibly introducing errors among graduation of these probes.

Create a CAD file for the probe holder, 3D print holder and make sure the probe securely fits, create graduated probe prototype



03/12/2026 Vertical Holder design

CADEN ROBINSON - Mar 12, 2026, 6:45 PM CDT

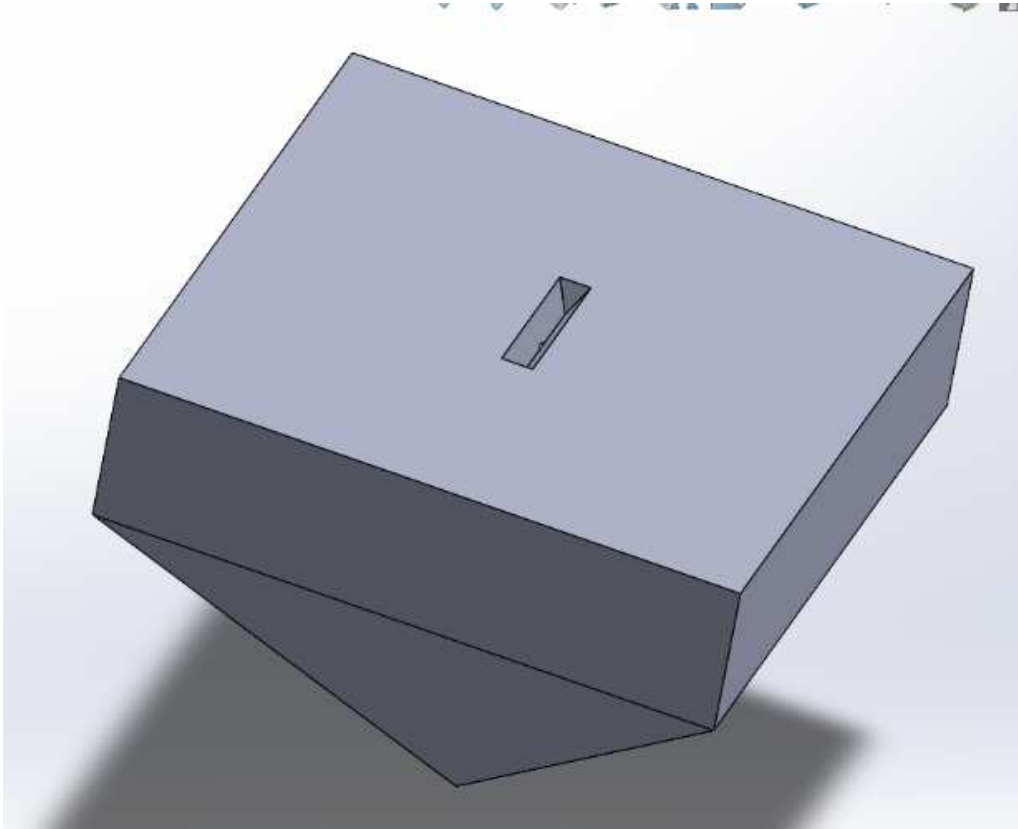
Title: Vertical Holder Design adjusted for laser bedding with rows of teeth

Date: 03/12/2026

Content by: Caden Robinson

Goals: Create a rough idea of a possible holder idea to secure probes down to laser mark

Content:





<https://www.1800ceiling.com/products/clean-cut-laser-bed>

Conclusions/action items: This design was in mind of laser bedding like the one shown above. Its a very rough design idea that allows the laser marking machine to mark the probes in the way that the ophthalmologists would hold them allowing for them to easily see the graduation. Key issues with this design, there is no real way to secure the probe into the apparatus which could result in errors during graduation from probe to probe.

Create apparatus used to hold probe, fabricate the prototype.

CADEN ROBINSON - Mar 12, 2026, 6:43 PM CDT



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holderdesign_vertical.SLDPRT (139 kB)



04/06/2026 Channel Sample Holder

CADEN ROBINSON - Apr 29, 2026, 8:31 PM CDT

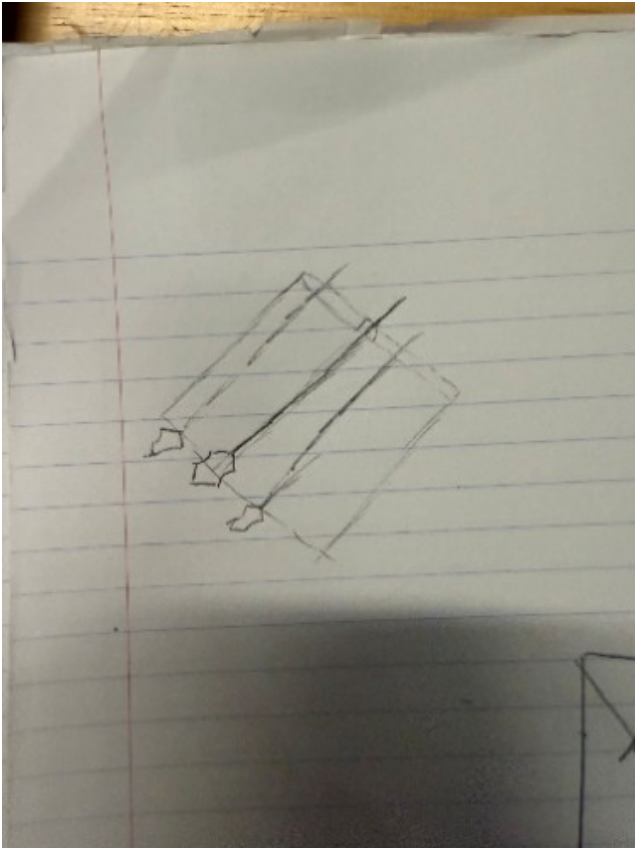
Title: Channel Sample Holder

Date: 04/06/2026

Content by: Caden Robinson

Goals: Create a new sample holder as the previous cannot be fabricated

Content:



Conclusions/action items: We decided to not overcomplicate things and made this new holder which will be a length long enough to fit the entire probes and have their center of gravity positioned on the holder. This design can hold 3 probes while they are being lasered at once and is a great improvement to the previous design

Fabricate final prototypes, begin testing, draft the final poster



02/06/2026 UW human subjects training

CADEN ROBINSON - Feb 06, 2026, 12:22 PM CST

Title: UW human subjects training

Date: 02/06/2026

Content by: Caden Robinson

Present: me

Goals: Refamiliarize myself with the requirements of testing with human subjects and the processes that must happen if wanting to test with human subjects.

Citation:

[1 "CITI - Collaborative Institutional Training Initiative." Accessed: Feb. 06, 2026. [Online]. Available: <https://www.citiprogram.org/members/index.cfm?pageID=665&ce=1#view>]

Content:

There are multiple guidelines that must be followed for human subject training:

Autonomy: people must be empowered to make decisions concerning their own actions and well-being. According to the principle of respect for persons, researchers must acknowledge the "considered opinions and choices" of research subjects. Individuals must be given the choice to participate in research and must be provided with the sufficient information and possess the mental competence to make that choice.

Voluntariness: more than offering people the choice to participate in or withdraw from research. researchers should be aware of situations in which prospective subjects may feel pressured to participate in a study. In situations where a relationship between the researcher and subjects already exists, such as when a volunteer at a homeless shelter decides to conduct research with that population, the lines between voluntariness and undue influence may be blurred.

Informed consent: Researchers must provide essential points of information, such as: participation is voluntary and subjects are free to withdraw at anytime, purpose of the research, any foreseeable risks of harm, description of what the subject will be expected to do.

respect for persons: informed consent will be sought from each prospective subject or the subject's legally authorized representative, in accordance with, and to the extent required by 46.116. When appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of data. When some or all of the subjects are likely to be vulnerable to coercion or undue influence, such as children, prisoners, individuals with impaired decision-making capacity, or economically or educationally disadvantaged persons, additional safeguards have been included in the study to protect the rights and welfare of these subjects.

Conclusions/action items: This was a good reminder on some of the requirements for testing with human subjects, Especially since it is likely we could be testing on animals and maybe have professionals use our product to test on other humans. I know that there is more research related to the guidelines to actually get approval to test our product but this is at least a good start.

Continue researching, begin prototyping

**04/09/2026 Training through the curriculum**

CADEN ROBINSON - Apr 10, 2026, 12:42 AM CDT

Title: Autoclave training**Date:** 04/09/2026**Content by:** Caden Robinson**Goals:** learn how to use the autoclave safely and efficiently**Content:**

This certifies that Caden Robinson has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/21/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	3/17/2025	3/17/2030
Chemical Safety: The OSHA Lab Standard	Final Quiz	3/17/2025	
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/31/2025	10/31/2028

Data Last Imported: 04/10/2026 12:24 AM

Conclusions/action items: After completing this training I will be able to operate the autoclaves proficiently so the group can test the different graduated bowman probes in them. This will allow us to take the next step forward with testing and see how the graduation actually improves or causes issues with the bowman probes



04/19/2026 Cryogen Training

CADEN ROBINSON - Apr 29, 2026, 8:29 PM CDT

Title: Cryogen training

Date: 04/19/2026

Content by: Caden Robinson

Goals: Understand how cryogenes are used and their implications

Content:



This certifies that Caden Robinson has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/21/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	3/17/2025	3/17/2030
Chemical Safety: Cryogen Safety Training	Part 1 Final Quiz	4/19/2026	4/19/2031
Chemical Safety: Cryogen Safety Training	Part 2 Final Quiz	4/19/2026	4/19/2031
Chemical Safety: The OSHA Lab Standard	Final Quiz	3/17/2025	
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/31/2025	10/31/2028

Data Last Imported: 04/29/2026 06:57 PM

Conclusions/action items: This training was very interesting since it highlighted things to watch out for, oxygen depletion for example, when handling these materials. Completing this training gave me complete access to using the autoclaves for testing.

Analyze the autoclave results, finish final poster, complete final report



01/28/2026 Lecture 1

CADEN ROBINSON - Jan 28, 2026, 1:57 PM CST

Title: Lecture 1

Date: 01/28/2026

Content by: Caden Robinson

Present: Whole group

Goals: learn more about library resources

Content:

Zotero allows you to collect all of your resources into one page with your group members and sites them into the correct format for you. finding these sources can sometimes be difficult so using keywords and other filters to find more relevant and timely information is super useful.

technical reports publish the results of scientific or technical research often using federal funds. the research is performed and reports are produced by companies, universities and government laboratories. You can find a bunch of technical reports on the defense technical information center

There are multiple techniques to find research topics like using quotation marks around words you want to appear together or boolean expressions like 'and' and 'or'.

Conclusions/action items:



02/11/2026 Lecture 3

CADEN ROBINSON - Feb 11, 2026, 1:46 PM CST

Title: Lecture 3

Date: 02/11/2026

Content by: Caden Robinson

Present: Whole Group

Goals: Learn how to make more descriptive and legible slides for presentations.

Content:

Make sure to label all figures giving a brief description of the image in the caption and make sure to include the citation if the figure is not yours.

Specifically for CAD designs, use a good picture of the figure including dimensions, don't use the CAD sketch that you would use to actually create the prototype. Especially if there are multiple different views of the drawing, it takes away from the actual content of the drawing and might be hard to actually read.

Never show raw data, always use some sort of graphical representation of the data and show statistical analysis when you can. Graphs must have some legend or caption to give a brief explanation of what they are demonstrating.

Visualize and descriptive context of use. Must show how the design would work to some extent. Block diagrams, flow charts, help the person reading the slides to understand how the software or hardware actually works.

Conclusions/action items:



02/25/2026 Lecture 5

CADEN ROBINSON - Feb 25, 2026, 2:08 PM CST

Title: Lecture 5

Date: 02/25/2026

Content by: Caden Robinson

Present: Whole Group

Goals: Consider diversity principles for our design

Content:

Diversity

- ideas
- past experiences
- wide accessibility
- the golden rule
- promote differences
- learn from others
- open mind to perspective
- inclusivity in design consideration

Universal design

- a design that highlights everyone's needs
- very cost effective for all people
- can be used by any socioeconomic class
- adaptable to peoples needs

Tolerance for error: We can adjust our probes mechanical properties to ensure that it navigates the nasolacrimal ducts minimizing risk. Adjust the probe itself to make it more flexible than it already is to adjust to irregularities inside of these canals

Conclusions/action items:



03/04/2026 Lecture 6

CADEN ROBINSON - Mar 04, 2026, 1:46 PM CST

Title: Lecture 6

Date: 03/04/2026

Content by: Caden Robinson

Present: Whole Group

Goals: Learn about standard and patent searching

Content:

Database Information

- full text via database: ASTM, ASABE, IEEE
- Find information on companies, industries, consumer trends with business databases.

Patents

- patent examiners evaluate applications against prior art, which includes
 - inventions disclosed in SU and Foreign patents and patent applications
 - inventions disclosed in publications
 - inventions currently for sale or in public use
- Lens.org is a good patent searching site, type in patent number
- can use CPC numbers or codes inside of the summary menu for patents you know existed to find for other that may have similar topics
- every utility patent has a claim which is typically 1 sentence, followed by a transition, then goes into the antecedent basis.

examiners look for: usefulness, novelty, non-obviousness

Conclusions/action items:



03/06/2026 Tong Lecture

CADEN ROBINSON - Apr 29, 2026, 8:53 PM CDT

Title: Tong Lecture

Date: 03/06/2026

Present: whole group

Goals: Gain insight of what industry in BME may look like

Content:

The talk was about Dr. Williams upbringing and college in the beginning. During schooling, key lessons he learned to becoming a successful student and reaching his own personal goals. Post graduation, we followed the companies that Dr Williams helped to create and the impressive work related to neurological engineering. He gave out many good pointers to learning from your mistakes and also some important insights to what working in industry could look like.

Conclusions/action items: From this lecture, I am definitely more fascinated about neurobiology and some of its uses in the biomedical industry. It scares me of what the future holds and the potential advancements in surgery and even every day life. I am curious to learn more and would love to talk to Dr Williams briefly.

Finish creating the final graduated probe prototype and sample holder and begin testing



03/11/2026 Lecture 8

CADEN ROBINSON - Mar 11, 2026, 1:55 PM CDT

Title: Lecture 8

Date: 03/11/2026

Content by: Caden Robinson

Present: Whole group

Goals: develop a good prototype plan

Content:

should be low fidelity prototyping, when using circuitry, assemble each part individually and test it before the whole design is put together to ensure that it works.

If the design is ever intended to be publicated, make sure to include the make type of any machines used in testing or prototyping. Make sure that you are very specific to your protocol. Must be repeatable by unfamiliar reader

3D printing

- manufacturer and model of the printer, filament material
- actual file used

Manufacturing

- consider throughout the process
- cannot manufacture everything you can 3D print
- common methods: molding, machining, joining.

Conclusions/action items:



03/18/2026 Lecture 9

CADEN ROBINSON - Mar 18, 2026, 1:48 PM CDT

Title: Lecture 9

Date: 03/18/2026

Content by: Caden Robinson

Present: Whole Group

Goals:

Content:

Elevator Pitches:

- Make sure to know your audience: tailor your pitch to the interests and needs of your audience
- Practice: rehearse your pitch until it flows naturally and confidently
- Be authentic: Let your passion and enthusiasm shine through
- keep it simple: avoid jargon and technical language that may confuse your audience
- Be able to adapt

General Structure

- Introduction
- Attention Grabber
- Value proposition
- Benefits
- Call to Action

Tong award structure:

- Introduction
- Attention Grabber: We've developed a device to do X
- Value Proposition: Currently there is not a device to do X as existing technologies and patents fail because Y
- benefits: it is estimated that Z people would benefit from this device which has a potential market of \$, we have filed for a patent with WARF. Demonstrate the prototype fully
- Call to action: Do you have any questions

Do's

- Maintain Eye contact and exude confidence
- do keep it concise and focused
- do tailor your pitch to different audiences

Don'ts

- Don't overwhelm with unnecessary details
- Don't forget to listen and engage with your audience
- Don't sound rehearsed or robotic

Conclusions/action items:



03/25/2026 Lecture 10

CADEN ROBINSON - Mar 25, 2026, 1:41 PM CDT

Title: Lecture 10

Date: 03/25/2026

Content by: Caden Robinson

Present: Whole Group

Goals: Have a discussion about ethics in engineering

Content:

Personal ethics: decided by your ideas individually

Professional ethics: decided by a collective of people, society, etc.

solving an ethical dilemma: establish a need, understand the problem, generate solutions and evaluate, develop detailed design and document & test.

harm test: does this position have fewer negative consequences than the other options

publicity test: would you want your decision published online

respect of persons: does this decision best respect the rights and dignity of others

Conclusions/action items:



04/08/2026 Lecture 11

CADEN ROBINSON - Apr 08, 2026, 1:46 PM CDT

Title: Lecture 11

Date: 04/08/2026

Content by: Caden Robinson

Present: Whole Group

Goals: Learning about engineering judgement

Content:

ABET outcome 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgement to draw conclusions

engineering judgement is gained from:

real world engineering problems, open ended problems, ask questions, embrace life long learning, communication-all forms, critical thinking-evaluate solutions, testing/analysis

attitudes: what you feel and believe about a specific issue

behaviors: how you demonstrate and act upon your knowledge and attitudes while addressing a specific issue

Conclusions/action items:



04/20/2026 Cadaveric Testing

CADEN ROBINSON - Apr 29, 2026, 8:39 PM CDT

Title: Cadaveric testing

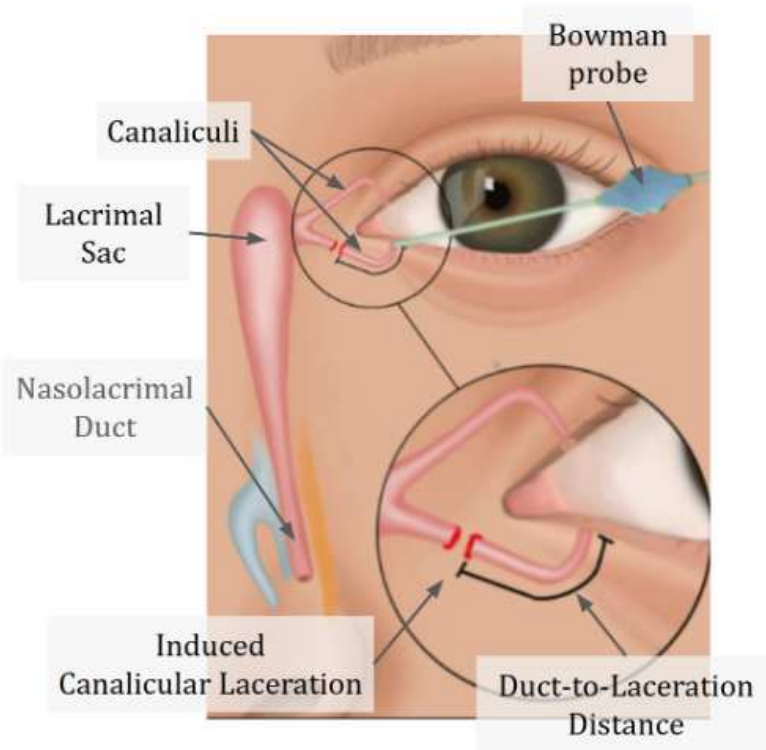
Date: 04/20/2026

Content by: Caden Robinson

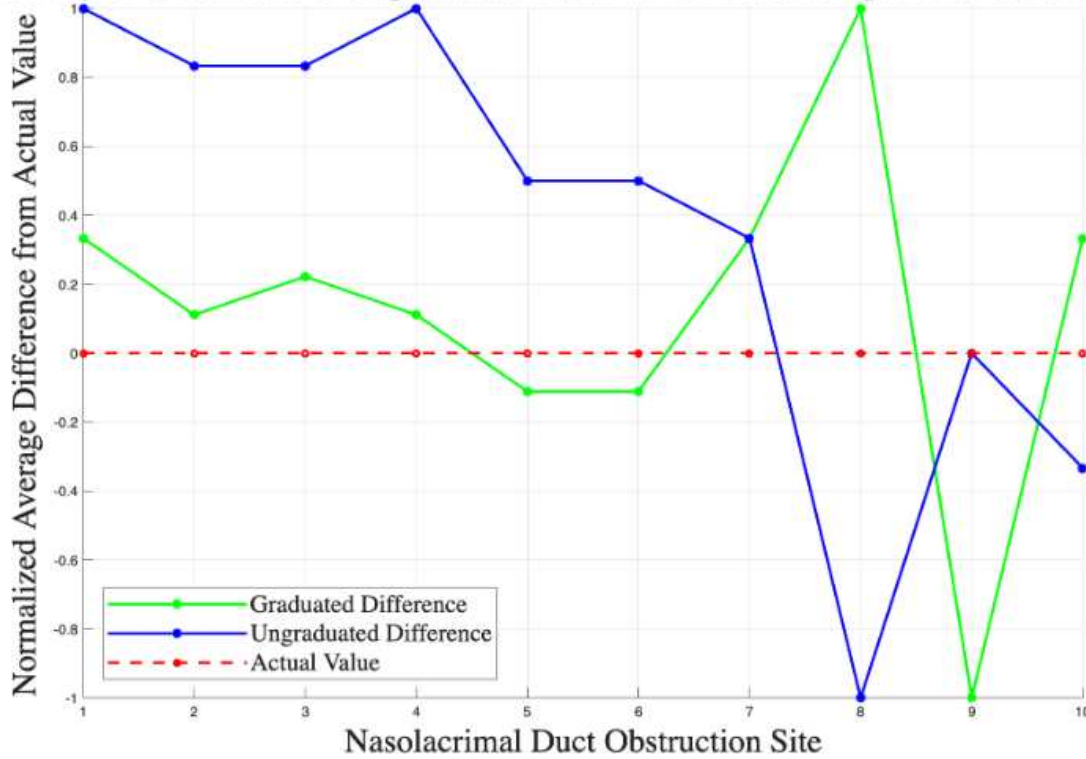
Present: whole group

Goals: test our probes on cadaver specimens and receive feedback from out clients

Content:



Accuracy of Graduated vs Ungraduated Bowman's Probes compared to Gold Standard



To prove the diagnostic accuracy of the graduated probes, the cadaveric laceration assessment looked to use real life probe application to demonstrate the probes equivalent capabilities to current clinical techniques. This test saw Dr. Law surgically induce a laceration somewhere along the left lower and right upper canaliculi of 5 cadaveric specimens, resulting in 10 distinct measurements. These lacerations were then measured by two medical school residents of the UWSMPH and Dr. Law using the following set of techniques: observable estimation; an ungraduated probe; an ungraduated probe in combination with an external measuring apparatus (current standard); a graduated probe.

Station #	Estimated (no measurements) (mm)	Bowman probe + No Ruler (mm)	Bowman Probe + Ruler (Gold Standard) (Actual) (mm)	Graduated Bowman Probe (mm)
1L (Lower)	5	5	5	5
1R (Upper)	2	3	3	2.5
2L(Lower)	1.5	1.5	2	1.25
2R(Upper)	15	3	3	3
3L(Lower)	2	2	2	2
3R(Upper)	2.5	3	3	3
4L(Lower)	8	8	8	7.5
4R(Upper)	15	15	14	14
5L(Lower)	0	0	0	0
5R(Upper)	10	12	11	11

Conclusions/action items: Our designed probes proved that they were more accurate than the ungraduated probes and estimating the depth with them. From peer feedback from our clients, they actually preferred the graduated method instead of the current gold standard procedure.

Autoclave testing, poster presentation, final report



04/21/2026 Autoclave testing

CADEN ROBINSON - Apr 29, 2026, 8:43 PM CDT

Title: Autoclave testing 1

Date: 04/21/2026

Content by: Caden Robinson

Goals: Familiarize myself with the autoclaves in room 2048

Content: Brenton Halvorson my TA from BME 201 taught me how to use both autoclaves in the room, indicating what to do and what not to do.

To get an idea of how it worked, we placed the probes that were used during the cadaveric testing into a beaker with autoclave tape and ran a cycle. Afterwards the probes were weighed to get an initial weight to start testing

Conclusions/action items: From this I was able to get access to room 2048 and begin testing the probes the next day. the machine was very easy to use and provided good sterilization practice.

being analyzing the cadaveric testing, work on poster, prepare for poster presentation



04/22/2026 Autoclave testing cont.

CADEN ROBINSON - Apr 29, 2026, 8:47 PM CDT

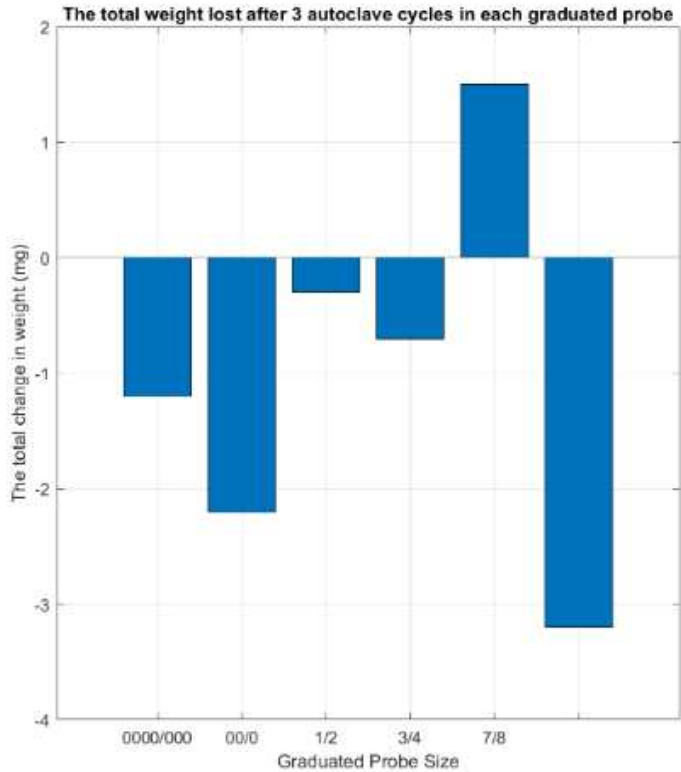
Title: Autoclave testing Cont.

Date: 04/22/2026

Content by: Caden Robinson

Goals: finish the autoclave testing and read results

Content:



In order to fulfill necessary autoclave endurance parameters defined within the PDS, the fabricated probe must endure an extensive material deposition test to ensure the integrity of the probe's safety moving towards actual ophthalmological implementation. In the test, a control group, a set of regular commercial-grade probes and a test group, an associating set of fabricated graduated probes, were put through several rounds of one hour autoclave sterilization cycles. The before and after recorded probe masses will be tracked and compared between the control and test group and then statistically analyzed for significant difference. Any observable damage or impact, including to the graduation marks, that the testing environments generated on the probes will also be qualitatively tracked and evaluated. After completion of three autoclave cycles, the mean loss of probe weight was 1.02 ± 1.62 milligrams. Further inspection of these samples after trials showed that there was no impact to the graduation. A paired t-test was then conducted with a reported value of 0.185 indicating that there is no statistically significant difference between the probes weight prior and after autoclaving. Since there was a small sample size, it is not possible to predict the probes degradation over further autoclave testing.

Conclusions/action items: this testing was not able to prove the total predicted life of each probe for autoclave cycles since I ran out of time. Assuming after each autoclave cycle, each probe loses 0.33mg of mass, after 2000 cycles, the expected lifetime, they would lose about 66mg of mass which is quite significant.

Continue analyzing data, draft the final report, finish final poster



01.24.2026 - Lacrimal gland choristoma in lacrimal sac as a probable cause of nasolacrimal duct obstruction

CALEB WHITE - Jan 24, 2026, 3:32 PM CST

Clinical & Experimental Ophthalmology - WILEY

FINANCIAL DISCLOSURES
S. W. is supported by the Sydney Medical School Foundation.

CONFLICT OF INTEREST
None declared.

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Lacrimal gland choristoma in lacrimal sac as a probable cause of nasolacrimal duct obstruction

Incidentally detected lesions during routine dacryocystorhinostomy include dacryocystitis, agnathous papillomas and apical inflammation related to systemic disease. The lacrimal gland has been only rarely found in the lacrimal sac.^{1,2} We describe a rare occurrence of lacrimal gland choristoma in the lacrimal sac, detected incidentally during an endoscopic dacryocystorhinostomy.

A 72-year-old man presented with left-ocular epiphora associated with discharge for more than 2 years. Irrigation and probing were suggestive of a complete nasolacrimal duct (NLD) obstruction on the left side, and the patient underwent a postoperative endoscopic dacryocystorhinostomy on the lacrimal sac side. A full-length horizontal slit lamp examination was performed with a 40x power field probe after exposing the lacrimal sac in situ. Incidentally, a nodular 6-mm × 4-mm lacrimal gland lesion was noted along the inferior wall of the lacrimal sac at the entrance of the NLD (Figure 1A). The tip of the ball probe could not be passed into the NLD. The lesion

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[Clinical Exper Ophthalmology - 2018 - Singh - Lacrimal gland choristoma in lacrimal sac as a probable cause of nasolacrimal.pdf \(10.3 MB\)](#)

CALEB WHITE - Jan 24, 2026, 4:25 PM CST

Title: Lacrimal gland choristoma in lacrimal sac as a probable cause of nasolacrimal duct obstruction

Date: 01/24/2026

Content by: Caleb White

Goals: Understand the damage that is actually being induced to both the nasolacrimal duct and lacrimal gland during misuse of Bowman's probes during clinical procedure

Search Term: "Bowman's Probe"

Citation:

[1 S. Singh, C. James, D. S. Curragh, and D. Selva, "Lacrimal gland choristoma in lacrimal sac as a probable cause of nasolacrimal duct obstruction," *Clinical & Experimental Ophthalmology*, vol. 47, no. 5, pp. 675–677, 2019, doi: [10.1111/ceo.13447](https://doi.org/10.1111/ceo.13447).

Link: [Lacrimal gland choristoma in lacrimal sac as a probable cause of nasolacrimal duct obstruction - Singh - 2019 - Clinical & Experimental Ophthalmology - Wiley Online Library](#)

Content:

Epiphora: Excessive tearing or watery eyes

Dacryocystorhinostomy (DCR): Surgical procedure to create a new pathway for tear drainage from the eyes into the nasal cavity

Marsupialization: A surgical technique used to treat certain types of cysts or abscesses by creating a permanent open pouch to allow free drainage.

Choristoma: Masses of normal tissues found in abnormal location

A 72-y-old man presented with left-sided epiphora associated with discharge for more than 2 y. Irrigation and probing were suggestive of a complete nasolacrimal duct obstruction on the left side, and the patient underwent a powered endoscopic dacryocystorhinostomy as per routine technique. A full-length lacrimal sac marsupialization was performed with side port blade after exposing the lacrimal sac in toto. Intraoperatively, a reddish 6 ×4-mm intrasac nodular lesion was noted along the inferolateral wall of the lacrimal sac at the entrance of the NLD. The tip of the ball probe could not be passed into the NLD. The lesion was soft to touch with the ball probe and had a smooth surface. It was located submucosally, adherent to the wall of the lacrimal sac with a broad base. The clinical suspicion was of an intrasac granuloma or papilloma, and the lesion was carefully excised with Blakesley thru-cutting forceps. Histopathological examination reported the features of chronic dacryocystitis with a nodule of lacrimal gland tissue in the lacrimal sac. There was a moderate lymphocytic inflammation in the sac wall extending to involve the lacrimal gland. Strong immunoreactivity for gross cystic disease fluid protein expression, and presence of zymogen granules were suggestive of lacrimal gland. No mucinous glands were detected on staining with Periodic acid–Schiff–diastase and Alcian blue.

The present case had a fairly large visible mass lesion on endoscopy. Its location at the entrance of NLD might act as a predisposing factor for tear stasis, which along with secondary inflammation resulted in complete NLD obstruction. Unfortunately, we did not have any pre-operative dacryocystography to confirm our hypothesis. We came across two cases of choristoma implicated in causing NLD obstruction. In one case, the obstruction was due to the pressure effect from an inferomedial orbital phakomatous choristoma. There was no direct involvement of the lacrimal drainage system. The second case by Ali et al revealed frank involvement of lacrimal sac and NLD by a complex choristoma.

Conclusions/action items:

The generation of benign cysts and growths in and around the eye and lacrimal gland can cause of further damage to various components of the eye duct system. This damage leads to things such as epiphora and potentially further complications that can be relieved through the use of a Bowmans probe. This further emphasizes the need for the improvement of the clinically active model of a bowman's probe due to its consistent use in optomology practice.



01.24.2026 - Lacrimal drainage anatomy in the Japanese population

CALEB WHITE - Jan 24, 2026, 4:22 PM CST



[Download](#)

LacrimalAnatomy.pdf (4.76 MB)

CALEB WHITE - Jan 24, 2026, 4:31 PM CST

Title: Lacrimal drainage anatomy in the Japanese population

Date: 01/24/2026

Content by: Caleb White

Goals: Understand the anatomy of the eye duct and the lacrimal drainage system to better understand where problems occur and where a Bowman's Probe is required

Search Term: "Lacrimal Anatomy"

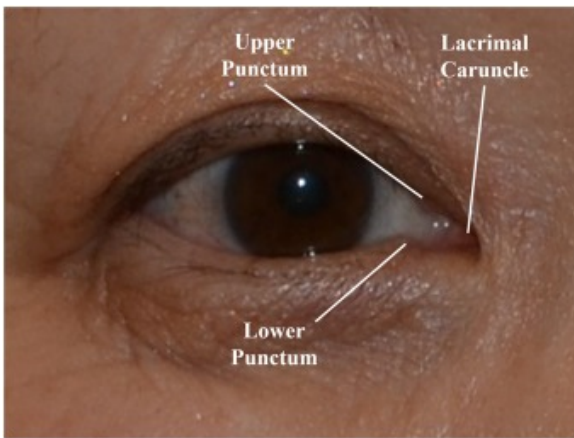
Citation:

[1 Ma. R. P. Valencia, Y. Takahashi, M. Naito, T. Nakano, H. Ikeda, and H. Kakizaki, "Lacrimal drainage anatomy in the Japanese population," *Annals of Anatomy - Anatomischer Anzeiger*, vol. 223, pp. 90–99, May 2019, doi: [10.1016/j.aanat.2019.01.013](https://doi.org/10.1016/j.aanat.2019.01.013).

Link: [Lacrimal drainage anatomy in the Japanese population - ScienceDirect](#)

Content:

A thorough understanding of the lacrimal drainage anatomy is necessary in order to perform the appropriate lacrimal surgery with a successful outcome. Through the years, various anatomists and lacrimal surgeons have published their reports in order to establish the foundation of lacrimal anatomy. Subsequently, certain variations that are of clinical significance have also been reported for advancement of our understanding of lacrimal anatomy.



The lacrimal caruncle is a soft, ovoid, pinkish tissue, measuring 1.5–3.0 mm in height, 2.3–5.0 mm in vertical length, and 1.1–2.5 mm in transverse length. Its epithelium is well-developed and similar to the skin, rather than the conjunctiva. It is composed of stratified squamous epithelium (flat cells that form a protective barrier) stratified, hair follicles, sebaceous glands (microscopic glands that secrete oily sebum), and goblet cells (epithelial cells that secrete mucus).

Adjacent to the caruncle, the Lacus lacrimalis (lacrimal lake) is located and is seen as a triangular space that is vertically aligned with the lacrimal papilla, allowing accumulation of tears.

The lacrimal punctum is situated on top of a fibrous mound known as the lacrimal papilla. The punctum has a funnel-form and the shape of its orifice varies from oval, linear, and fish-mouth according to age.

The punctum courses posteriorly towards the lacrimal lake. The positioning of this triad (punctum, caruncle, and lacus lacrimalis) is essential for a fully functioning lacrimal system. Any disturbance of some sort, such as when the lacrimal papilla is not aligned with the lacus lacrimalis, may result in epiphora.

The lacrimal sac fossa is a conically-shaped concavity in the anteromedial orbital wall that contains the lacrimal sac. The fossa comprises the frontal process of the maxillary bone and the lacrimal bone. There are anterior and posterior ridges, called the anterior and posterior lacrimal crests, respectively, and the lacrimo-maxillary suture is located between the crests. The bone posterior to the suture is thinner and is easily punched out during dacryocystorhinostomy (DCR). The anteroposterior location of the lacrimo-maxillary suture is subject to anatomical variability. Our computed tomography (CT)-based study demonstrated that the proportion of lacrimal sac fossa that is comprised by the lacrimal bone was 38.2–42.1%. This indicates that the lacrimo-maxillary suture runs posterior to the center of the lacrimal sac fossa in most cases. The sutura notha is not a true suture but a vessel groove formed by a branch of the inferior orbital artery. This runs nasal and parallel to the anterior lacrimal crest. As the bone nasal to the groove is also thin, surgeons can easily start creating a bony window here during external DCR.



A. The lacrimal sac fossa is a conically-shaped concavity. The lacrimal fossa is located between the anterior and posterior lacrimal crests. The lacrimo-maxillary suture also runs between the crests.

B and C. The anteroposterior inclination of the lacrimal fossa and bony nasolacrimal canal. B. The posterior type. The lacrimal sac directs posteriorly and the bony nasolacrimal canal runs more posteriorly. C. The anterior type. The lacrimal sac inclines posteriorly and the bony nasolacrimal canal curves anteriorly (broken line) against the long axis of the lacrimal sac.

D and E. The horizontal inclination of the lacrimal fossa and bony nasolacrimal canal. D. The outward type. The lacrimal sac directs laterally and the bony nasolacrimal canal runs more laterally. E. The inward type. The lacrimal sac inclines laterally and the bony nasolacrimal canal curves medially against the long axis of the lacrimal sac.

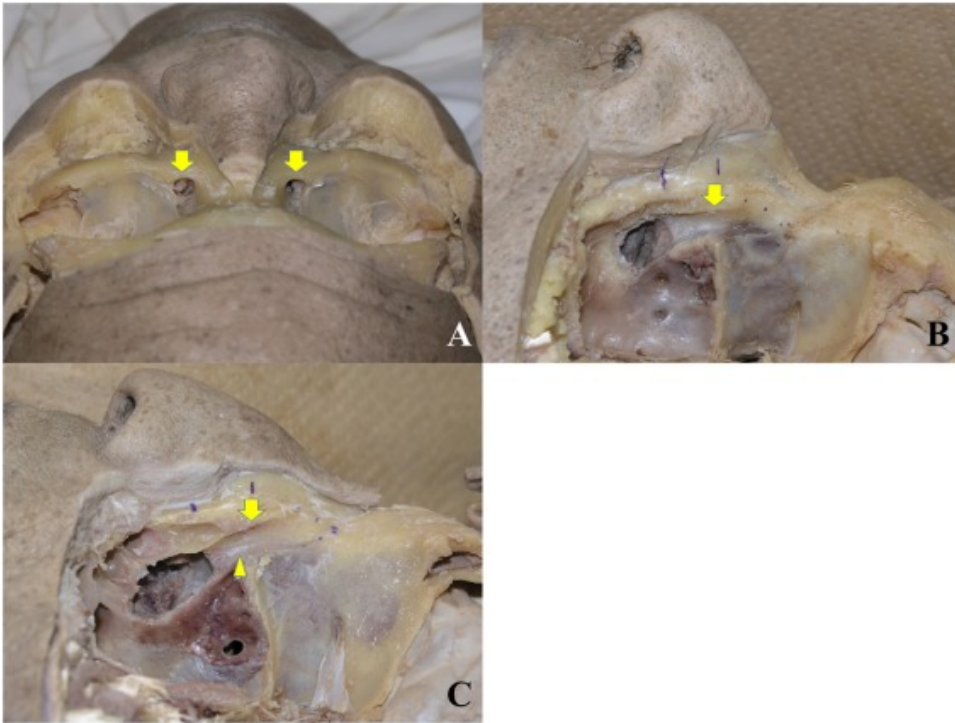


Figure: Bony nasolacrimal canal entrance and the narrowest part of the bony nasolacrimal canal.

The nasolacrimal duct is divided into 2 parts: the intraosseous and intrameatal parts. The intraosseous part passes through the bony nasolacrimal canal and the intrameatal part runs in the inferior meatus. The valve of Krause is occasionally seen as mucosal folds of eminences in the nasolacrimal duct lumen. The valve of Hasner refers to the part where the nasolacrimal duct continues several millimeters beneath the nasal mucosa, after it leaves its osseous channel. Furthermore, this valve is essential in order to prevent air or fluid within the nose from going up into the nasolacrimal duct. The shape of nasolacrimal duct opening into the inferior meatus is classified into 4 types: wide-open, valve-like, sleeve-like, and adhesive type.

Conclusions/action items:

A comprehensive review on the lacrimal drainage anatomy, with much information left within the document itself. Using this information, patient-specific differences can be identified and also appreciated in both the determination of the clinical procedure carried out and the approach to that clinical procedure. Because of the complexity of the lacrimal system, biological complication can come up in numerous spots which emphasizes the importance of appropriate ophthalmological practice with the use of Bowman's Probe. This biological background gives me and the rest of the group a deeper understanding of the anatomy that is being worked with which allows for the tactful consideration of design parameters for the Graduated Bowman's Probe.



01.26.2026 - Primary Probing for Congenital Nasolacrimal Duct Obstruction with Manually Curved Bowman Probes

CALEB WHITE - Jan 26, 2026, 5:09 PM CST

Title: Primary Probing for Congenital Nasolacrimal Duct Obstruction with Manually Curved Bowman Probes

Date: 01/26/2026

Content by: Caleb White

Goals: Use the investigation into Bowman Probe shape in relation to performance to help the group determine criteria and general characteristics for the fabricated model.

Search Term: "Research into Bowman's Probe Performance"

Citation:

[1 D. Serin, I. B. Buttanri, M. S. Sevim, and B. Buttanri, "Primary probing for congenital nasolacrimal duct obstruction with manually curved Bowman] probes," *Clin Ophthalmol*, vol. 7, pp. 109–112, 2013, doi: [10.2147/OPHTH.S39926](https://doi.org/10.2147/OPHTH.S39926).

Link: [Primary probing for congenital nasolacrimal duct obstruction with manually curved Bowman probes - PMC](#)

Content:

NLD = Nasolacrimal Duct

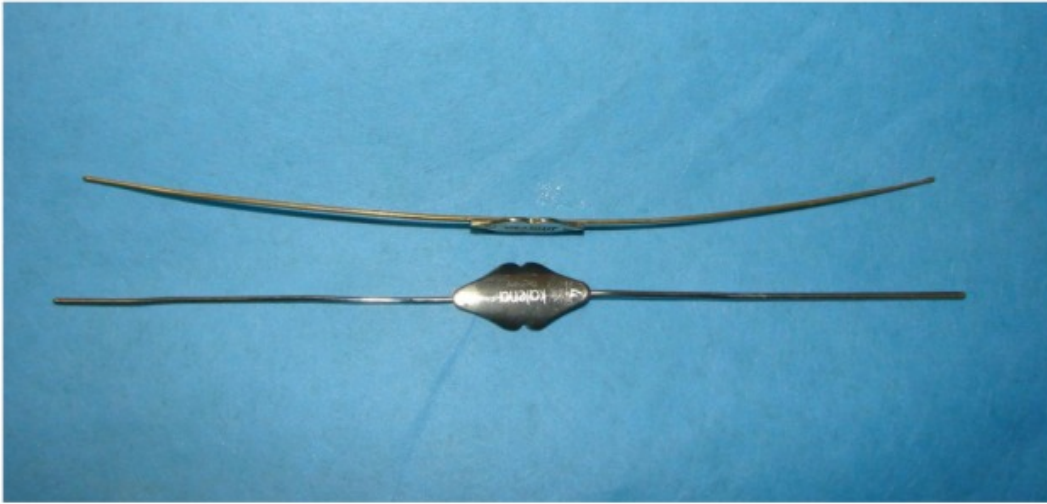
CNLDO = Congenital Nasolacrimal Duct Obstruction

The study looked at records of 42 nasolacrimal duct obstructions in 37 children who underwent probing with straight Bowmans probes (group A) and 128 nasolacrimal duct obstructions in 110 children who underwent probing with Bowman probes (group B) manually bent to mimic the natural curve of the bony nasolacrimal pathway. Specifically, the probes were bent approximately 15 degrees. All children under the age of 2. The outcome being looked at was whether or not the probing was successful, that is, whether or not there was a complete resolution of signs and symptoms.

A detailed ophthalmological examination was performed to eliminate any other ophthalmological problem which may cause epiphora such as congenital glaucoma, trichiasis, conjunctivitis, keratitis, and metabolic disorders. Patients < 2 years of age were included in the study. Patients with congenital craniofacial and lid abnormalities, punctal agenesis, a history of trauma, nasolacrimal surgery, previous probing or other nasolacrimal intervention, and postoperative follow-up <3 months were excluded from the study.

The surgeon dilated both puncta with a fine punctal dilator. The probe was inserted through the upper punctum into the ampulla of the upper canaliculus and then rotated horizontally to fit in the canaliculus. Lateral traction was applied to the eyelid to prevent kink formation. After a "hard stop" was felt, the probe was slightly retracted and rotated 90 degrees. At this point, in group A, the straight Bowman probe was directly advanced toward the NLD; in group B, the curve of the probe was turned posteriorly and medially while advancing toward the NLD. After a popping sensation was felt, passage into the nose was confirmed by metal-to-metal contact under the inferior turbinate with another probe. The same procedure was repeated from the lower punctum to exclude any lower canalicular obstruction. After the operation, all patients received a topical steroid and antibiotic treatment four times daily for 10 days and a nasal decongestant for 5 days. The patients were evaluated at 1 week, 1 month, and 3 months. A fluorescein disappearance test was repeated at 3 months. Successful probing was defined as a complete resolution of signs and symptoms at 3 months postoperatively. The chi-squared test was used for the comparison of success rates. $P < 0.05$ was considered statistically significant.

The success rate was 76.2% (32/42) in group A and 91.4% (117/128) in group B. The difference was statistically significant ($P < 0.01$). Manually curved probes can be used efficiently during probing and increase the success rates.



For effective probing, an ophthalmologist must pass the probe through the bony nasolacrimal canal and perforate the embryological membrane without traumatizing other anatomical structures or creating a false passage. In the current study, a complete resolution of signs and symptoms was achieved in 76.2% of eyes with a straight Bowman probe and in 91.4% of eyes with a curved Bowman probe and the difference was statistically significant ($P < 0.01$). In children, the slope of the NLD may make it difficult to pass a straight Bowman probe through the NLD without trauma. Strenuous attempts to pass a straight Bowman probe through a curved NLD may cause mucosal damage, submucosal passage, and synechia formation in the duct. In group B, the Bowman probe was gently bent to mimic the curve of the bony nasolacrimal pathway. This may lead to an easy introduction of the probe into the duct, and advancement through the duct without rubbing and traumatizing the mucosa or the bony structures of the canal may be possible and this may be the reason of the high success rate of probing with recontoured probes.

Conclusions/action items:

For children, because of the curved nature of nasolacrimal duct, a curved Bowman Probe to mimic this shape leads to statistically significant higher success rate for the clearing of a congenital obstruction in the nasolacrimal duct. This important change to the shape of the probe should be brought up with the client during meetings to get an idea of both, what age group the team will be designing these probes for, and if the inclusion of a curved probe is even safe due to its potential lack of known data and study.



03.28.2026 - Canalicular Lacerations

CALEB WHITE - Apr 29, 2026, 7:51 PM CDT

Title: Canalicular Lacerations

Date: 03.28.2026

Content by: Caleb White

Goals: Understand canalicular lacerations better from a clinical point of view.

Search Term: Canalicular Lacerations

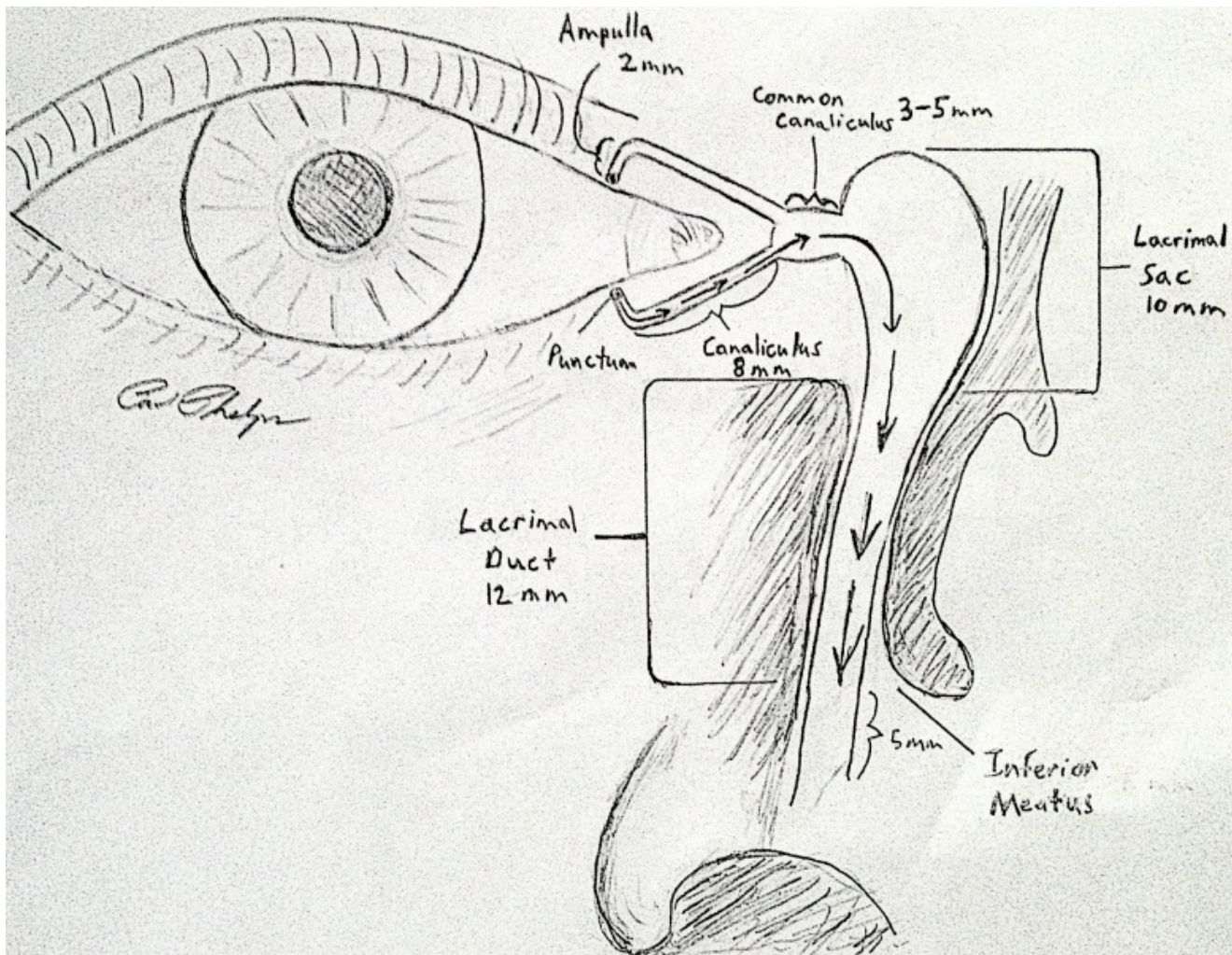
Citation: [10] P. Phelps, "Canalicular laceration (trauma) - eyewiki," American Academy of Ophthalmology - EyeWiki, [https://eyewiki.org/Canalicular_Laceration_\(Trauma\)](https://eyewiki.org/Canalicular_Laceration_(Trauma)) (accessed Apr. 29, 2026).

Link: [https://eyewiki.org/Canalicular_Laceration_\(Trauma\)](https://eyewiki.org/Canalicular_Laceration_(Trauma))

Content:

Canalicular trauma refers to sudden physical injury that results in damage to the canaliculus, part of the lacrimal drainage system of the eye. The lacrimal canaliculi are located within the medial aspect of the eyelid. This area is unlike the rest of the eyelid because it does not contain a tarsal substructure. Therefore, a force which displaces the eyelid from its strong attachment at the medial canthal tendon, lacrimal, and maxillary bone, tend to cause avulsion in the medial aspect of the eyelid. Many types of trauma to the face may result in damage to the lacrimal drainage system. Dog bites are a common cause of canalicular lacerations because of the propensity of this type of injury to occur near the medial canthus as are blunt shear injuries.[1] Canalicular trauma is best evaluated by a physician experienced in the repair of canalicular lacerations. Members of the American Society of Ophthalmic Plastic and Reconstructive Surgery are qualified to perform even complex repair of the lacrimal drainage system.

The canaliculus is located in the medial portion of each of the four eyelids. In most patients, the punctum of the eyelid sits against the conjunctiva in the tear lake, approximately 6.5 mm from the medial commissure in the upper eyelid and 6.0 mm from the medial commissure in the lower eyelid. The punctum wicks up tears into the ampulla, which is approximately 2 mm long and perpendicular to the eyelid margin. While some of the tear drainage is passive, there is also an active pumping mechanism through blinking which creates negative pressure in the system and thus draws tears into the drain. There is an elevated junction between the luminal surface of the punctum and beginning of the vertical canaliculus, which at this time is of uncertain physiologic significance. The lacrimal drainage system then makes a 90 degree turn and becomes the canaliculus (which is parallel to the eyelid margin). This pathway is approximately 8 mm between the ampulla and the common canaliculus. The common canaliculus (or common opening into the lacrimal sac) is present in 98% of patients. The common canaliculus is 3 to 5 mm long and inserts onto the lateral wall of the lacrimal sac. In the 2% of patients without a common canaliculus, the canaliculi from the upper and lower eyelids separately insert into the lacrimal sac. The lacrimal sac is bounded by the anterior lacrimal crest (maxillary bone) and the posterior lacrimal crest (lacrimal bone). The anterior ramus of the medial canthal tendon inserts on the maxillary bone while the posterior ramus inserts on the lacrimal bone.[4] Medial canthus anatomy is complex and involves several support structures in addition to the canthal tendons and lacrimal drainage system. Damage to the facial bones and other more significant trauma to the eye and ocular adnexa is beyond the scope of this article.



Conclusions/action items:

Canalicular trauma refers to sudden physical injury that results in damage to the canaliculus, part of the lacrimal drainage system of the eye. The lacrimal canaliculi are located within the medial aspect of the eyelid. Bowman Probes are used to assess laceration depth following traumatic events.



04.02.2026 - Pediatric Traumatic Canalicular Lacerations

CALEB WHITE - Apr 29, 2026, 7:54 PM CDT

Title: Pediatric traumatic canalicular lacerations

Date: 04.02.2026

Content by: Caleb White

Goals: Discover deeper the causes of lacerations and what demographics are affected.

Search Term: Lacerations in Kids

Citation: [11] R. Zhao et al., "Pediatric traumatic canalicular lacerations: Characteristics and prognostic factors," *Journal of ophthalmology*, <https://pmc.ncbi.nlm.nih.gov/articles/PMC12045685/> (accessed Apr. 29, 2026).

Link: <https://pmc.ncbi.nlm.nih.gov/articles/PMC12045685/>

Content:

Eyelid lacerations represent nearly one-fifth of pediatric ocular-related hospital admissions. Among these cases, canalicular lacerations constitute approximately 16%. These injuries typically result from either penetrating or blunt trauma to the eyelids and periorbital area. Disruption of the lacrimal drainage system can lead to posttraumatic epiphora, which can significantly affect quality of life and mental health.

Canalicular lacerations can occur across all age groups, but they are more commonly reported in children and young adults. Previous studies have identified predictive factors that influence outcomes after canalicular laceration repair in both adults and children. However, children differ from adults in terms of exposure to distinct trauma mechanisms and a generally slower or diminished regenerative capacity of the skin with age. There has been limited discussion focusing exclusively on the pediatric population. Although reports by Agarwal et al. and Huang and coauthors provide relevant insights, their findings cannot be directly extrapolated to our region due to differences in demographics, lifestyle, and socioeconomic status.

The majority were males ($n = 66$; 74.2%) with a mean age of 7.26 years (range, 1–17 years). Right eye damage was observed in 51 patients (57.3%) and none of the cases involved bilateral canalicular lacerations.

Most patients (94.4%) had isolated canalicular lacerations, while 5 patients (5.6%) presented with concurrent upper and lower canalicular lacerations. The injuries more commonly affected the lower lacrimal canaliculi (77.4%) than the upper lacrimal canaliculi (22.6%). The leading cause of canalicular lacerations was scratches caused by sharp objects (47 patients, 52.8%), followed by electric bicycle accidents (16 patients, 18.0%), falls (16 patients, 18.0%), dog bites (7 patients, 7.9%), altercations (2 patients, 2.2%), and sports-related incidents (1 patient, 1.1%). Most patients (60.7%) experienced penetrating trauma including scratched by sharp objects and dog bites.

All 89 patients had at least one follow-up assessment to evaluate postoperative epiphora, even under environmental stressors. Three patients (3.4%) underwent surgical intervention more than 48 h after injury, and two of these experienced postoperative epiphora. All other surgeries occurred within 48 h, and there were no intraoperative complications.

Conclusions/action items:

Eyelid lacerations represent nearly one-fifth of pediatric ocular-related hospital admissions. Among these cases, canalicular lacerations constitute approximately 16%. These injuries typically result from either penetrating or blunt trauma to the eyelids and periorbital area. Disruption of the lacrimal drainage system can lead to posttraumatic epiphora, which can significantly affect quality of life and mental health.



04.03.2026 - Clinical Characteristics, intraoperative findings and surgical outcomes

CALEB WHITE - Apr 29, 2026, 8:06 PM CDT

Title: Clinical characteristics, intraoperative findings, and surgical outcomes

Date: 04.03.2026

Content by: Caleb White

Goals: To dig deeper first into the demographics of canalicular lacerations but also common treatments following Bowman Probe use.

Search Term:

Citation: [14] C.-H. Lin, C.-Y. Wang, Y.-C. Shen, and L.-C. Wei, "Clinical characteristics, intraoperative findings, and surgical outcomes of canalicular laceration repair with monocanalicular stent in Asia," *Journal of ophthalmology*, <https://pmc.ncbi.nlm.nih.gov/articles/PMC6636491/> (accessed Apr. 29, 2026).

Link: <https://pmc.ncbi.nlm.nih.gov/articles/PMC6636491/>

Content:

This study examines the clinical characteristics and surgical outcomes of patients undergoing canalicular laceration repair using monocanalicular stents. It includes a patient population from Asia and provides insight into common injury mechanisms, which are often trauma-related, such as traffic accidents or blunt facial injuries. The authors aim to evaluate the effectiveness of monocanalicular stenting in these cases. The paper details intraoperative findings, including the location and extent of canalicular damage. It also describes the surgical approach used to repair the lacerations and place the monocanalicular stent. This technique is designed to stabilize the घायल canaliculus while minimizing invasiveness and simplifying the procedure compared to bicanalicular methods.

Outcomes reported in the study are generally favorable, with high rates of anatomical success and functional tear drainage. The authors note that monocanalicular stents are associated with advantages such as easier insertion, reduced operative time, and improved patient comfort. These benefits make them an appealing option for many surgeons.

The study also analyzes factors that influence surgical success, including the timing of repair and severity of injury. Early intervention and careful surgical technique were associated with better outcomes. Complication rates were low, supporting the reliability of monocanalicular stenting as a treatment strategy. The authors conclude that this approach is effective and should be considered a standard option in appropriate cases.



Conclusions/action items:

- Most injuries involved the lower canaliculus, and trauma was the primary cause.
- Use of a monocanalicular stent was found to be effective, with high rates of anatomical success (proper healing of the duct).
- Functional success (normal tear drainage) was slightly lower, showing that anatomical repair doesn't always guarantee perfect function.
- Early intervention and proper surgical technique were key factors in better outcomes.
- There was not a ton of information on the surgical intervention criteria.



04.10.2026 - Canalicular Laceration Repair

CALEB WHITE - Apr 29, 2026, 8:03 PM CDT

Title: Canalicular Laceration Repair

Date: 04.10.2026

Content by: Caleb White

Goals: Understand the surgical procedures that go into canalicular lacerations as well as the criteria used to choose certain surgical techniques.

Search Term: OR vs ER Canalicular Laceration Evaluation

Citation: [15] A. P. Murchison and J. R. Bilyk, "Canalicular Laceration Repair: An Analysis of Variables Affecting Success," *Ophthalmic Plastic & Reconstructive Surgery*, vol. 30, no. 5, pp. 410–414, Sep. 2014, doi: 10.1097/IOP.000000000000133. [12] M. L. Cochran, "Anatomy, head and neck: Eye Nasolacrimal," StatPearls [Internet]., <https://www.ncbi.nlm.nih.gov/books/NBK482213/#:~:text=Structure%20and%20Function,is%20the%20valve%20of%20Rosenmuller.> (accessed Apr. 29, 2026).

Link: <https://www.ncbi.nlm.nih.gov/books/NBK482213/#:~:text=Structure%20and%20Function,is%20the%20valve%20of%20Rosenmuller.>

Content:

This study investigates the factors that influence the success of canalicular laceration repair, a procedure aimed at restoring the integrity of the lacrimal drainage system after trauma. The authors analyze a series of clinical cases to determine how patient characteristics, injury mechanisms, and surgical variables contribute to outcomes. Canalicular lacerations are often associated with eyelid trauma, particularly near the medial canthus, and require precise repair to prevent long-term tearing issues.

A major focus of the paper is the timing of surgical intervention. The authors highlight that early repair—generally within 24 to 48 hours—significantly improves both anatomical and functional success rates. Delayed treatment can lead to fibrosis and scarring, making identification and alignment of the canalicular ends more difficult. This underscores the importance of prompt referral and management in suspected cases.

The study also emphasizes the role of surgical technique, particularly the use of silicone stents to maintain canalicular patency during healing. Proper placement of the stent and accurate reapproximation of the canalicular ends are critical for successful outcomes. The experience of the surgeon is identified as an important variable, as these procedures require careful microsurgical skills.

Finally, the authors discuss complications and predictors of failure. These include infection, scarring, poor alignment, and associated injuries that may complicate repair. Despite these risks, the overall success rate of canalicular repair is high when performed under optimal conditions. The study concludes that early intervention, meticulous technique, and appropriate use of stenting are key determinants of success.

Conclusions/action items:

This paper discusses the use of various surgical techniques for repairing of canalicular lacerations. It describes the framework of criteria for determining surgical intervention and describes common points of failure and what things are the biggest in trying to reach quick and full patient recovery.



04.12.2026 - Canalicular Lacerations, StatPearls

CALEB WHITE - Apr 29, 2026, 8:09 PM CDT

Title: Canalicular Lacerations, StatPearls

Date: 04.12.2026

Content by: Caleb White

Goals: Discover more about canalicular lacerations in general to create a better grasp about what I am reseraching.

Search Term:

Citation: [13] C. R. Rishor-Olney, "Canalicular laceration," StatPearls [Internet]., <https://www.ncbi.nlm.nih.gov/books/NBK560802/> (accessed Apr. 29, 2026).

Link: <https://www.ncbi.nlm.nih.gov/books/NBK560802/>

Content:

This article focuses on canalicular lacerations, detailing their causes, presentation, and management. These injuries typically result from trauma to the medial eyelid, such as blunt force, sharp objects, or animal bites. Because the canaliculi are small and delicate structures, they are particularly vulnerable to disruption in these types of injuries.

The article emphasizes the importance of early recognition and diagnosis. Canalicular involvement may not always be immediately obvious, so careful examination is required in patients with medial eyelid trauma. Techniques such as probing and irrigation can help confirm the presence of a laceration and assess the extent of injury.

Management of canalicular lacerations is primarily surgical, with the goal of restoring the continuity of the lacrimal drainage system. The article describes the use of stenting techniques, including monocalicular and bicanalicular stents, to support healing and maintain patency. Precise alignment of the canalicular ends is critical to achieving a successful repair.

Prognosis is generally favorable when treatment is performed promptly and correctly. However, complications such as canalicular stenosis, infection, or persistent tearing can occur, particularly in delayed or inadequately treated cases. The article highlights the importance of proper technique and follow-up care to optimize outcomes.

Conclusions/action items:

This paper again brings up the use of bicanalicular and monocalicular stents which were not mentioned previously. They seem to be a common form of intervention and can possibly closely related to Bowman probe evaluation. This paper also pushes similar ideas to others in relation to causes, necessary response time, and need for careful examination.



01.26.2026 - Anthony Products Bowman Lacrimal Probes

CALEB WHITE - Jan 26, 2026, 4:42 PM CST

Title: Anthony Products Bowman Lacrimal Probes

Date: 01/26/2026

Content by: Caleb White

Goals: Understand the market for Bowman Probes, specifically where the pitfalls can be seen. This will give insight into what the group will be looking to improve and keep consistent with the updated design.

Search Term: "Bowman's Probe"

Citation:

[1 "Bowman Lacrimal Probes," Anthony Products. Accessed: Jan. 26, 2026. [Online]. Available: <https://anthonyproducts.com/bowman-lacrimal-probes>]

Link: [Bowman Lacrimal Probes. Anthony Products](https://anthonyproducts.com/bowman-lacrimal-probes)

Content:

Bowman Lacrimal Probe Features

- Used for clearing nasolacrimal ducts and restoring normal tear flow to the lacrimal drainage system
- Double-ended with a tongue tie center plate handle
- Central plate connects two thin probes
- Sizes marked on central plate handle
- Malleable with rounded blunt ends
- Overall size: 5 1/2"

Available Probe Sizes

- Size #0000-000 (60-34-00E)
- Size #00-0 (60-34-01E)
- Size #1-2 (60-34-02E)
- Size #3-4 (60-34-04E)
- Size #5-6 (60-34-06E)
- Size #7-8 (60-34-08E)

Multiple diameters range from 0.4mm-0.5mm to 1.8mm-1.9mm



Regular retail price is \$57.00, sale price is \$26.00

Conclusions/action items:

Anthony Products INC. retails mainstream Bowman's probes with various size options between 0.4mm and 1.8mm in diameter. Each probe has a central plate handle which serves to give the clinician full control during a procedure. The ends are rounded blunt cylinder ends that are used for clearing nasolacrimal ducts. These probes lack any marker distinctions which make the clinical procedure a very subjective assessment. The main shape and of course purpose should be modeled, but modifications to the probe ends and even the ergonomics of the plate handle must be considered.



02.02.2026 - Sklar Bowman Probe

CALEB WHITE - Feb 02, 2026, 9:59 PM CST

Title: Sklar Bowman Probe

Date: 02/02/2026

Content by: Caleb White

Goals: Understand why the Sklar Bowman Probe is so highly rated and so successful in the market. Identify key features that make it stand out.

Search Term: "Sklar"

Citation:

[1 "65-4099 Sklar Bowman Lacrimal Probe," Sklar Corporation. Accessed: Feb. 02, 2026. [Online]. Available: <https://www.sklarcorp.com/p/sklar-bowman-lacrimal-probe/65-4099>]

Link: <https://www.sklarcorp.com/p/sklar-bowman-lacrimal-probe/65-4099>

Content:

Sklars Lacrimal Bowman Probe is a very thin malleable rod with a rounded end used for clearing of the nasolacrimal duct, or in procedures involving or within the lacrimal system. The instrument is double ended and offers various different size tips, distinct sizes on each end of a singular probe.

Various different materials used both stainless steel and silver, stainless steel in the pack set.

Silver specified use with plastic surgery and orthopedic uses.

They have the characteristic plated hand hold. They are all non-sterile, reusable, non-latex, trade agreement act compliant.

The tips come in a range of 0.45 to 1.4 mms in diameter and the working edges are cross-serrated or smooth. They are straight curvature and 140mm long (5 1/2 in)



Nothing on the website about instrument care, instructions for use, or safety data sheets.

Long standing reputation for quality and assurance. Thin and malleable whilst still being strong and anti-corrosive. Very high grade and very precise.

They also provide a lifetime guarantee against manufacturing defects.

Conclusions/action items:

The Sklar bowman probe stands as the top of the food chain in the Bowman Probe market because of the company's reputation of being reliable and the rapport they have built with hospitals and clinics over the years. The Bowman Probes they manufacture are similar to what have been researched before but have an emphasis on malleability and thin, sleek design that allows for simple wielding and effective application during clinical practice.



02.02.2026 - BR Surgical Bowman Probe

CALEB WHITE - Feb 02, 2026, 10:45 PM CST

Title: BR Surgical Bowman Probe

Date: 02/02/2026

Content by: Caleb White

Goals: Understand why the BR Surgical Bowman Probe is so highly rated and so successful in the market. Identify key features that make it stand out.

Search Term: "BR Surgical"

Citation:

[1 "BOWMAN-WILLIAMS Lacrimal Probe," BR Surgical. Accessed: Feb. 02, 2026. [Online]. Available: <https://brsurgical.com/product/bowman-williams-lacrimal-probe/>]

Link: <https://brsurgical.com/product/bowman-lacrimal-probe/>

Content:

The BR Lacrimal Probes are German stainless steel and come in 7 sizes. Again they have the characteristic shape with two working ends of different sizes and a center plate that acts at the grip handle for the user. Similar to Sklar, it uses the 00, 0 naming convention assigned to the sizes of the probes, from 00 to 8 in ascending size order.



The specific sizes include: 0000/000 7/8; 0000/000; 00/0; 1/2; 3/4; 5/6; 7/8. All cylindrical, all malleable, all stainless steel.

BR Surgical also offers Bowman-Williams probes which looks to differ based on the shape of the probe ends, which take an hourglass shape in the Williams probe, specifically a ball-tip end, rather than the straight cylindrical end. Again, these Bowman-Williams probes are malleable and German stainless steel, coming in 7 sizes. A ball-tip end is preferred when attempting to minimize tissue trauma and enhance navigation through delicate structures, as well as provide better tactile feedback regarding the nature of the obstruction. The ball-tip is preferred in pediatric cases with CNLDO (congenital nasolacrimal duct obstruction as child tissues are more delicate).

Conclusions/action items:

The BR Surgical bowman probe is another top competitor in the Bowman Probe industry. It provides consistent quality Bowman Probes to its clientele. It stands similar to Sklar in its material, malleability and ergonomic feel in the hand of the user. The use of an hourglass Williams end in combination

with the ball-tip make a very delicate instrument that should be used for fine tuned cases where prevention of tissue damage is the number one priority, in pediatric cases.



02.05.2026 - Electropolishing and Shaping of Mico-Scale Metallic Features

CALEB WHITE - Feb 05, 2026, 12:45 PM CST

Title: Electropolishing and Shaping of Micro-Scale Metallic Features

Date: 02/05/2026

Content by: Caleb White

Goals: Learn about the electropolishing process and understand how it can be applied to our specific project and evaluate the process at a feasible method of use.

Search Term: "Electropolishing"

Citation:

[1 "Electropolishing and Shaping of Micro-Scale Metallic Features - PMC." Accessed: Feb. 05, 2026. [Online]. Available:] <https://pmc.ncbi.nlm.nih.gov/articles/PMC8955333/>

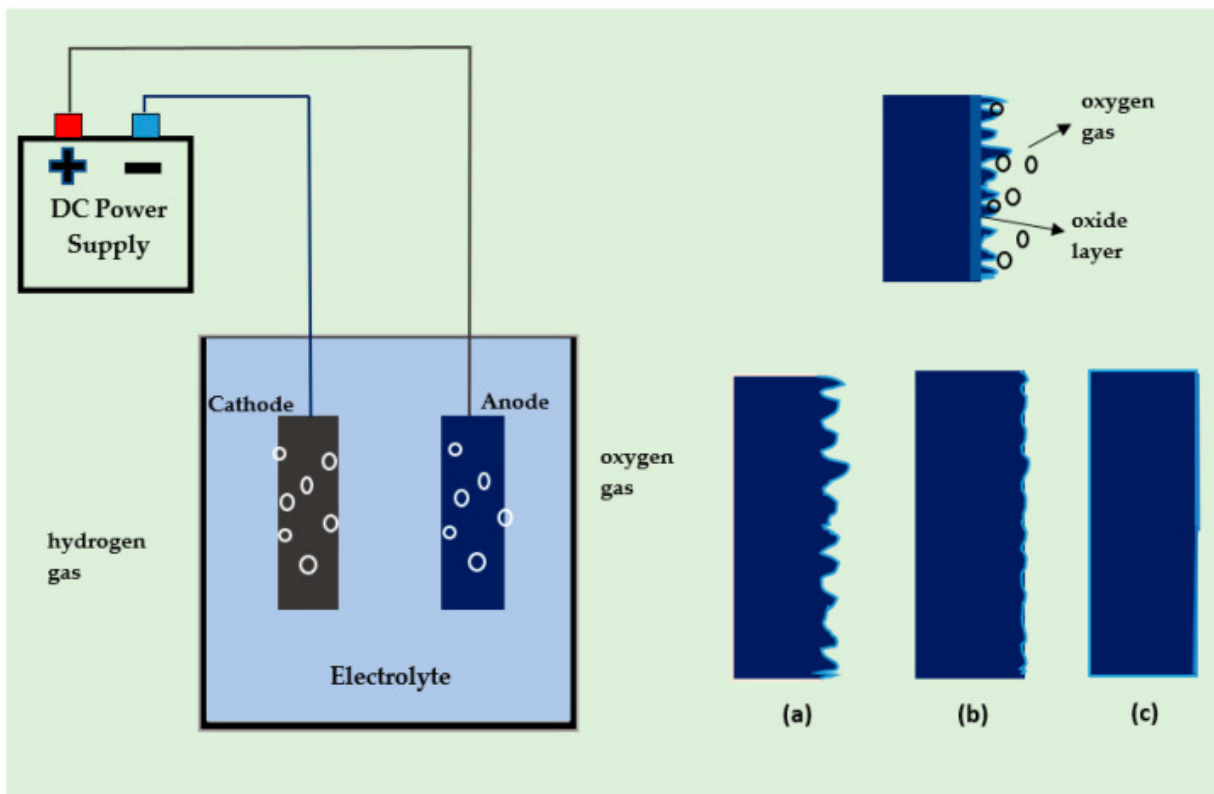
Link: [Electropolishing and Shaping of Micro-Scale Metallic Features - PMC](#)

Content:

Electropolishing is most commonly used as a metal finishing process. It is a non-contact electrochemical process that can clean, passivate, deburr, brighten, and improve the biocompatibility of surfaces.

Electropolishing is an electrolytic process for brightening, smoothening, and deburring metals. It levels the surface of a metal by removing material through an electrochemical process that is similar to, but the reverse of, electroplating

Steel is the most commonly electropolished metal, due to its widespread use, ranging from macro-scale tools to micro-scale biomedical stents and nano-textured applications



The basic setup of the electropolishing process.

The metal intended to be electropolished acts as an anode, while the corresponding cathode is a counter electrode immersed in an appropriate electrolyte. Oxidation will occur at the anode, while hydrogen will be liberated at the cathode. The electrolyte needs to be a conductive medium for ions and metal dissolution.

Conventionally, it is a strong acid, with some surfactants or additives being used to improve the electrodes' viscosity, wettability, and reactivity. Sulfuric and phosphoric acids are used widely to electropolish metals and alloys

The principles of electrochemistry are based on Faraday's law from the 19th century. These laws are related to the removal and dissolution rates of metal immersed in an electrolyte. It is an anodic treatment of the workpiece when immersed in an electrolytic solution. When both electrodes are immersed in an electrolyte, a double layer is formed at the electrode interfaces (comprised of charges: one on the side of the electrode, and the other in the electrolyte).

Lasers are used in diverse applications: cutting, welding, engraving, drilling, soldering, ablation, etching, and curing. Even micro-/nano-scale polishing has been achieved with laser polishing/ablation, resulting in high surface finish.

Conclusions/action items:

If the Bowman Probes are engraved, there will be opportunity for alloy deposition into the nasolacrimal duct during procedure if post surface restoration is not done. Electropolishing is a very common form of surface restoration especially with steel and other common manufacturing metals. Seeing as the Bowman Probes are stainless steel; electropolishing would be a great solution for the surface refinement if laser engravings are made.



02.10.2026 - Electroplating in the Medical Device Industry: Surface Treatment

CALEB WHITE - Feb 11, 2026, 3:07 PM CST

Title: Electroplating in the Medical Device Industry: Surface Treatment

Date: 02/10/2026

Content by: Caleb White

Goals: Learn how electroplating is already used in the medical device industry and understand ways that it could be applied to Bowman probes.

Search Term: "Electroplating of Medical Devices"

Citation:

[1 C. Katchmark, "Electroplating in the Medical Device Industry-Surface Treatment," ProPlate®. Accessed: Feb. 11, 2026. [Online]. Available:] <https://www.proplate.com/medical-product-outsourcing/>

Link: [Electroplating in the Medical Device Industry-Surface Treatment| ProPlate®](#)

Content:

Medical device manufacturers (MDMs) are especially interested in hydrophilic, antimicrobial, and drug-eluting coatings for the cardiovascular and orthopedic markets. Advances in medical technologies, including imaging equipment, ultrasonic and other sensor-based tools, and delivery systems for medicines, all require specialized coatings. In particular, thin-film coatings that enhance electrical properties such as impedance and charge storage capacity of electrodes used for stimulation and sensing of electrical signals within the body are increasingly popular for applications such as pacemakers and neuromodulation devices.

Other platforms, such as transcatheter aortic valve replacement, require engineered coatings that provide excellent dielectric properties, low friction, and the other beneficial characteristics that are typically provided by polytetrafluoroethylene (PTFE). Advanced tight-tolerance masking capabilities are also a common requirement for this type of medical device.

Newer, more exotic substrates often create the need for coatings with lower cure temperatures and maintain lubricity and bondability. As medical devices and their components become smaller, it is also essential to achieve very thin, uniform, high-performance biocompatible coating capabilities.

Combining electrically enhancing coatings with laser-roughened or laser-modified surfaces can result in some remarkable additive functionality. For example, coatings deposited on a microstructure provided by a laser-roughened surface can provide electrical properties greater than the laser roughening or thin-film coating processes. "The cumulatively increased surface area provides more surfaces for charge exchange. With appropriate laser surface restructuring, it may be possible to increase cell adhesion and proliferation," said Saxon Tint, a manufacturing engineer at the Johnson Matthey facility in San Diego.

As devices get smaller and more complex, coating providers must stay ahead of the technology curve and integrate new technologies and materials into their processes to meet ever-evolving OEM demands or regulatory issues. For example, Specialty Coating Systems' ParyFree conformal coating was recently developed to meet the growing demand for halogen-free products in the electronics and medical markets. New materials and alloys, application technologies, and other production methods are advancing rapidly, making it increasingly difficult for MDMs to keep up. This includes finding coating solutions for new substrates that often do not "take" to existing coating methods—which often pushes material science to the limits to find an innovative solution.

Conclusions/action items:

Plating technology is mainly used for characteristic improvements in desired qualities of medical devices. Specific use of electroplating for coloring purposes was not identified in this paper. Electroplating is routinely used for medical, dental, and pharmaceutical components to improve biocompatibility, corrosion resistance, electrical conductivity, and antimicrobial properties. It's applied to implants, surgical instruments, connectors, orthodontic devices, catheters, and more



02.11.2026 - Experimental investigation on the fabrication of electroplating masks for silicon heterojunction solar cell grid electrodes via inkjet printing

CALEB WHITE - Feb 11, 2026, 4:30 PM CST

Title: Experimental investigation on the fabrication of electroplating masks for silicon heterojunction solar cell grid electrodes via inkjet printing

Date: 02/11/2026

Content by: Caleb White

Goals: Understand if using electroplating would be possible to the degree and precision that we want on these small bowman probes.

Search Term: "Graduated Electroplating"

Citation:

[1 S. Wang *et al.*, "Experimental investigation on the fabrication of electroplating masks for silicon heterojunction solar cell grid electrodes via inkjet] printing," *International Journal of Heat and Fluid Flow*, vol. 112, p. 109729, Mar. 2025, doi: [10.1016/j.ijheatfluidflow.2024.109729](https://doi.org/10.1016/j.ijheatfluidflow.2024.109729).

Link: <https://www.sciencedirect.com/science/article/pii/S0142727X24004545>

Content:

Replacing screen-printed silver grids with electroplated copper grid technology enables the large-scale production and application of silicon heterojunction solar cells. The grid electroplating mask is crucial for forming well-defined copper grids with high aspect ratios. This paper introduces a novel process for fabricating grid electroplating masks for silicon heterojunction solar cells using inkjet printing, which indirectly prepares the masks through two rounds of inkjet printing

Compared to screen-printed silver grids, copper electroplated grids exhibit narrower widths, higher aspect ratios, and lower bulk resistivities, reducing both optical and electrical losses while significantly lowering production costs

Piezoelectric Inkjet Printing System

- A printer with a piezoelectric printhead capable of dispensing very small droplets (controlled rise/fall times, tight waveform control).
- Adjustable height, waveform, and speed settings to control droplet size & mask geometry

Instead of tape or hand-applied masks, this uses inkjet printing to define where plating will and won't occur, yielding very tight pattern control that is:

- repeatable,
- high-resolution (tens of micrometers),
- less dependent on manual masking skills.

Narrow, high-aspect-ratio opening trenches help:

- reduce *edge plating creep*,
- promote straight metal growth,
- and limit plating to desired zones
- Pros
- Very high resolution (~20 μm or even lower).
- Extremely sharp plated edges — almost no parasitic plating.
- Cons
- Requires specialized printing hardware (expensive).
- Needs controlled environment and trained operators.

- Greater *setup cost* and skill requirement.
- Repeatable and scalable for many parts.

Conclusions/action items:

This research looked to utilize a piezoelectric inkjet s=dispensing printer to dispense tiny droplets of wax onto their solar cells to act as the mask from the electroplating process. Very effective but very complex and time consuming. This is the very top of the top manufacturing quality that is necessary for the 10s of microns precision wanted for this solar cell project. This is much different than simple electrical tape. A simpler method will be taken to allow electroplating.



02.11.2026 - Thick photoresist patterns for Electroplating.

CALEB WHITE - Feb 11, 2026, 4:28 PM CST

Title: Thick photoresist patterns for selective electroplating

Date: 02/11/2026

Content by: Caleb White

Goals: Find more realistic approaches to bowman probe electroplating.

Search Term: "Graduated Electroplating"

Citation:

[1 J. J. Maes, A. G. van Nie, and G. B. A. Hut, "Thick photoresist patterns for selective electroplating," *Microelectronics Reliability*, vol. 17, no. 2, pp.] 325–332, Jan. 1978, doi: [10.1016/0026-2714\(78\)90733-3](https://doi.org/10.1016/0026-2714(78)90733-3).

Link: <https://www.sciencedirect.com/science/article/pii/0026271478907333?utm>

Content:

Photoresist patterns with a thickness of 2 μm –16 μm are often applied in selective electroplating processes. We will treat some problems concerning the generation of such thick photoresist patterns and especially discuss the obtainable accuracy and edge definition of these patterns. We have investigated several positive photoresists which have been deposited by spraying or roller coating.

The obtainable accuracy has been established with the aid of a test pattern. Gap widening and strip narrowing are dependent on u.v. exposure time and developing time; both relationships have been investigated.

Post baking of some kinds of photoresist is necessary, because the patterns must be suitable for selective electroplating. Deviations of the patterns due to post baking are also discussed.

Surface Preparation (Critical)

- Ultrasonic clean
- Degrease (acetone or IPA)
- Light micro-etch if stainless (acid activation step)
- Rinse in DI water
- Dry without touching

Stainless requires activation (e.g., Wood's nickel strike) before plating.

Spray Photoresist (Moderate Equipment)

- Spin coating isn't ideal for a curved probe.
- Use sprayable positive photoresist.
- Airbrush works for small-scale setup.

Dry/bake according to resist spec.

Create Graduation Pattern

Design your graduations in CAD:

- Lines at 1 mm intervals
- Longer marks at 5 mm
- Include numbers if desired

Print pattern on:

- High-resolution transparency film (laser printer)

Wrap the mask tightly around the probe and expose under UV.

For cylindrical objects, you rotate during exposure or use a UV box.

After exposure:

- Develop resist
- Graduation lines become exposed metal
- Everything else remains protected

You now have precise, narrow exposed lines.

Electroplate

Plate with:

- Gold (biocompatible, high contrast)
- Nickel (harder, more durable)
- Black nickel (for high contrast)
- Or copper + blackening

Low current density recommended for clean edges.

Because resist walls are vertical, you get:

- Sharp metal boundaries
- Minimal creep
- Repeatable line thickness

Vinyl Plotter Cut Mask

- Use a craft cutter (e.g., Cricut/Silhouette)
- Cut thin vinyl graduation marks
- Wrap precisely around probe
- Plate
- Remove vinyl

Precision ~200–300 μm

Much easier than photoresist

More repeatable than tape by hand

Conclusions/action items:

Using photoresist, electroplating could potentially be used as a solution for graduating the bowman probe. It is a medium complexity method. I will like to try multiple methods, increasing in complexity. Tape seems the easiest and I think could work in separating plating definition but I think the precision could be a problem. I will need to reach out to professors who have experience in the electroplating process.



03.04.2026 - CerMark and TherMark

CALEB WHITE - Mar 04, 2026, 11:05 PM CST

Title: TherMark laser marking materials

Date: 03/04/2026

Content by: Caleb White

Goals: Find ways to do easy laser marking

Search Term: "CerMark USA"

Citation:

[1 "About Cermark." Accessed: Mar. 04, 2026. [Online]. Available: https://cermarkusa.com/about-cermark?utm_source=chatgpt.com]

Link: [CerMark LMC6044, Aerosol Spray Premium Black, 12 oz](#)

Content:

CerMark:

CerMark is a brand of laser marking materials designed to create durable, high-contrast marks on metals, glass, ceramics, and other hard surfaces. The coatings bond chemically during laser engraving, producing permanent, wear-resistant marks widely used in manufacturing, identification, and product branding.

CerMark coatings consist of a proprietary mix of inorganic compounds and pigments. When applied to a substrate and then exposed to a compatible laser beam, the coating fuses to the surface through localized heat and oxidation. The result is a black or dark gray mark that is chemically bonded, permanent, and resistant to abrasion, heat, and solvents. After marking, unbonded coating washes off easily with water.

The LMM14 and LMM6000 are in paste form and once applied either by airbrush or brush require marking to be done soon after application. The spray product can cause the application of the product to vary in coating thickness and this will result in uneven marking quality. The adhesive tape is more homogeneous and even over the entire surface.

The advantage of CO₂ laser marking is that the mark is made on the surface of the substrate, vaporizing the material and without causing wear or abrasion. A notch is formed, almost always in the shape of a cone due to the shape of the beam. Multiple passes can create a deep engraving, eliminating the possibility of the mark wearing off in harsh environmental conditions.

TherMark:

TherMark is a brand specializing in laser marking materials that enable permanent, high-contrast marks on metals, glass, ceramics, and other surfaces. Its products are widely used in industrial, commercial, and creative applications where durable, non-invasive identification or decoration is required.

TherMark coatings consist of finely engineered ceramic and metal oxide compounds suspended in a liquid carrier. When a laser passes over the coated area, its energy fuses the marking material to the substrate surface, creating a bonded, high-contrast image. The substrate itself remains largely unaffected, preserving its structural and visual integrity. The process works with common laser types such as CO₂, fiber, and diode-pumped systems.

Comparison:

Both would work relatively well. CerMark works with Co₂ and Fiber lasers while TherMark is mainly fiber lasers. Because of the small surface area and curved geometry of Bowman Probes, CerMark LMM6000 specifically seems best practice. It preserves corrosion resistance, leaves no added material on the surface, and survives sterilization.

Conclusions/action items:

In order to laser mark the probe, a coating must be placed on the probe in order to burn the graduation on the probe via a CO₂ and fiber laser. In order to execute this, we need to purchase the CerMark LMM6000 or a similar spray or paste and begin to trial. This is the sort of the thing that Pfefferkorn described during our meeting.



03.05.2026 - Small Quantity Purchasing Options for Laser Marking

CALEB WHITE - Mar 05, 2026, 10:11 PM CST

Title: Small Quantity Purchasing Options for Laser Marking

Date: 03/05/2026

Content by: Caleb White

Goals: Find cheap spray options for laser marking testing on the probes

Search Term: "Cheap Laser Marking Spray"

Link:

<https://www.jpplus.com/cermark-ultra-spray-for-laser-marking?sku=CERMULTRA2-EA>

<https://cermarkusa.com/index.php/cermark-ultra-aerosol-2-oz.html>

<https://cermarkusa.com/index.php/cermark-tape-lmm6018-lmm6018-sh-2-x-4.html>

<https://cermarkusa.com/index.php/cermark-tape-lmm6018-marking-tape-5.html>

Content:

CerMark ULTRA Spray Adhesive Can:

- 2 oz, \$17.00

- JPP also sells for \$15.00



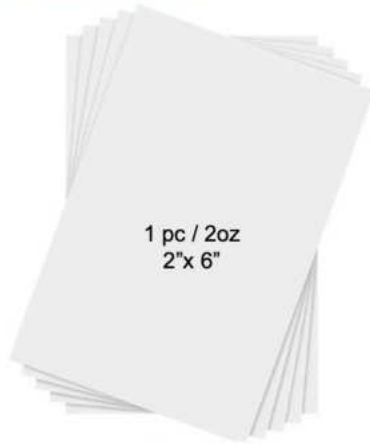
2 oz.

CerMark Adhesive Tape

- 2 x 6 inches, \$8.00



LMM6018
Marking Tape



CerMark Adhesive Tape Test Strip

- \$0



Also several less reputable options on Amazon for around similar prices, maybe a bigger quantity for more expensive.

Conclusions/action items:

In order to see which graduation marking material is best, several different samples would ideally be bought. The team could buy a single larger can but would be a waste if it didn't work. There was nothing on the Makerspace website that spoke about Laser Marking Materials in stock. These options above seem to be a combination of reputable and cheap, all coming from CerMark. There were no cheap options for liquid pastes, all over 100 USD. Because of the budget constraint of the project, the team needs to be very strategic about purchases. Hopefully when discussing with Dr. Williams at some point he can give us insight.



03.09.2026 - CerMark Product Instructions

CALEB WHITE - Mar 12, 2026, 11:41 PM CDT

Title: CerMark Product Instructions

Date: 03/09/2026

Content by: Caleb White

Goals: Learn the appropriate step-wise procedure of CerMark Product application

Search Term: "CerMark USA product usage"

Link:

Content:

No matter which product and supply form you choose, the process of bonding between laser marking material and substrate occurs at a molecular level so it is important the substrate be free of all kinds of contamination such as oil, debris, or coatings. Consequently, the substrate should be thoroughly cleaned before the application of CerMark laser marking material: the quality of your mark strongly depends on the cleanliness of the substrate prior to material application. Depending on the substrate, it should be cleaned with a solvent such as alcohol or rinsed with soap and water and completely dried. Be careful not to use a cleaning agent that leaves a residue behind.

Aerosol ULTRA:

Aerosol cans have the added benefit of removing the variable of dilution. However, aerosol products still require some experimentation to learn the application process and generate reproducible and consistent results.

Shake the aerosol can thoroughly before use to achieve a homogenous suspension of marking material inside the can. Spray uniformly at a 10" distance from the surface and move the nozzle from one side to the other covering the whole substrate area. Start spraying away from the area to be marked and move towards the opposite side and past the target area. Over-spraying before and after the target area allows the constant velocity of movement and will help provide an even coating on the substrate. As in all liquid/paste ink products, consistency in the application process is important for the quality of the mark.

Again, the desired coating thickness varies by product and substrate, so it is important to consult the individual page for your product for exact guidelines prior to application. Generally, however, the optimal wet film layer thickness for metals is about 0.5 – 2 mils. As both aerosol products are for use on metal, one or two coatings are typically enough. You will achieve better marks using our recommended coating thicknesses than simply applying more ink. If your material coating is too thick it will absorb too much laser energy and fail to bond to the substrate. If your material coating is too thin the pigment density of the material layer will not be high enough to create an optimal mark. It is important to realize that correct coat thickness is often even more important than the accuracy of laser settings for creating optimal marks.

Allow the applied marking material to dry. Unaided air drying typically requires several minutes. A fan, heat gun, or hair dryer can be used to accelerate the process to 10 seconds or less.

Marking Tape:

CerMark's self-adhesive tape, LMM6018, removes the variables of dilution and coating thickness during the application, making it the easiest product to use. To apply, unroll a sufficient amount of tape to cover the surface area to be marked and stick it down carefully. It is important the tape have uniform contact with the substrate surface otherwise some areas may not bond properly during laser marking. Care should be taken to remove any air bubbles from under the tape: smoothing down gently with fingers should be adequate to remove air bubbles. If you wish to mark on a surface that is highly irregular with too many bumps or crevices, the self-adhesive tape may not be appropriate because uniform tape-to-substrate contact may be impossible.

LMM6018 Laser Marking Tape. Self-adhesive laser marking tape for creating permanent, high-contrast, high-resolution black markings on raw metal and anodized aluminum

Usage instructions :

- 1-Make sure that the surface to be marked is free and clear of oils, cleaning films and dust
- 2-Stick the black adhesive side down carefully. Smooth down gently with a finger to remove air bubbles and ensure uniform contact.
- 3-Adjust laser power and speed setting based on the chart on the back
- 4-Laser mark through the white paper backing of the tape
- 5-Peel away and discard excess tape. If tape remnants remain in the fine detail of your image, these can be removed by wiping with an alcohol-damp cloth
- 6-If having difficulty removing tape sample from card, use hair dryer to apply heat to release tapePad printing ink

Conclusions/action items:

When prototype fabrication begins, it is important we are appropriately applying and utilizing the ordered CerMark materials in order to give them a proper evaluation in the decision for most optimal probe marking formula. Hopefully, fabrication will begin next week and the group can get a decision on the best method so larger scale production and subsequent testing can commence.



03.11.2026 - AISI 420 German Stainless Steel

CALEB WHITE - Mar 13, 2026, 12:18 AM CDT

Title: AISI 420 German Stainless Steel

Date: 03/11/2026

Content by: Caleb White

Goals: Learn about the specific qualities of AISI 420 German Stainless Steel

Search Term: "AISI 420 German Stainless Steel"

Link:

[AISI 420](#) | [1.4021](#) | [BS 420S37](#) | [X20Cr13](#) | [Martensitic steel](#)

[420 Stainless Steel: Definition, Composition, Properties, Applications and More - SteelPRO Group](#)

Content:

The AISI 400 series refers to a classification of stainless steels known for their high strength and corrosion resistance.

It primarily includes martensitic stainless steels, which can be hardened through heat treatment.

Common grades in this series include 410, 420, and 440, each with varying levels of carbon content and hardness.

These steels are often used in applications like cutlery, surgical instruments, and industrial equipment.

Composition: AISI 420 has higher carbon content than 410 and 430, enhancing hardness.

420 stainless steel is also called UNS S42000. It is a family of martensitic stainless steel. It is composed of approximately 85-88% iron, 12-14% chromium, and 0.15-0.45% carbon. It has high hardness and wear resistance. It is ideal for cutting tools, medical instruments, industrial gears, and automotive components. It can be categorized into different types like 420J1 and 420J2.

AISI 420 is a carbon-rich stainless steel with a chromium content of at least 12%. When annealed, AISI 420 has good ductility and excellent corrosion resistance.

Stainless steel AISI 420 is a martensitic chromium steel that is also known under the designations 1.4021, BS 420S37, and X20Cr13. Due to its high chromium content, the material has good corrosion resistance (PREN value 12.0 - 14.0). The material can be used at temperatures up to 400°C. It has a hardness of ≤ 230 HB, a density of 7.7 kg/dm³ (at room temperature) and a tensile strength of 750 to 850 N/mm². This stainless-steel grade is characterized by its good polishability, which also allows it to be polished to a high gloss. The material can be processed using all common welding methods (except arc welding) and is also well suited to forging. Other processing options include cold forming and machining. This steel is not normally used for cold heading. It is frequently used in the manufacture of cutting tools such as knives, or for decorative purposes in architecture and design.

Melting Point	1450°C (2642°F)
Thermal Conductivity	24.9 W/m·K (14.4 BTU/ft·h·°F)
Thermal Expansion	10.3 $\mu\text{m}/\text{m}\cdot^{\circ}\text{C}$ (5.7 $\mu\text{in}/\text{in}\cdot^{\circ}\text{F}$)
Specific Heat Capacity	460 J/kg·K (0.11 BTU/lb·°F)

Tensile Strength	620-750 MPa
Yield Strength	345-415 MPa
Brinell Hardness (HB)	207-235
Rockwell Hardness (HRC)	50
Vickers Hardness (HV)	540
Elongation	20%
Elastic Modulus	200 GPa

Conclusion/Action Items:

AISI 420 Stainless steel is a common steel type used in various different manufacturing applications. It is commonly used because of its superior corrosion resistance and is specifically applied in the medical industry because of its sterilizability. It can handle intense force and has effective elasticity. Its able to endure almost all common manufacturing modification methods and is relatively easy to work with. A rough 86/14 iron chromium split, it provides magnetic qualities that can be manipulated with heat treatment and a high carbon percentage compared to other 400 series stainless steel types increasing hardness, making it good for cutting tools and medical devices.



03.11.2026 - Surface Hardening of AISI 420 Stainless Steel by Using a Nanosecond Pulse Laser

CALEB WHITE - Mar 13, 2026, 12:44 AM CDT

Title: Surface Hardening of AISI 420 Stainless Steel by Using a Nanosecond Pulse Laser

Date: 03/11/2026

Content by: Caleb White

Goals: Learn about findings related to AISI 420 stainless steels performance under laser-based modification.

Search Term: "Lasering of AISI 420 German Stainless Steel"

Link: [Surface Hardening of AISI 420 Stainless Steel by Using a Nanosecond Pulse Laser | Scientific.Net](#)

Citation:

[1 O. Netprasert, V. Saetang, and C. Dumkum, "Surface Hardening of AISI 420 Stainless Steel by Using a Nanosecond Pulse Laser," *Materials Science Forum*, vol. 911, pp. 44–48, 2018, doi: [10.4028/www.scientific.net/MSF.911.44](#).

Content:

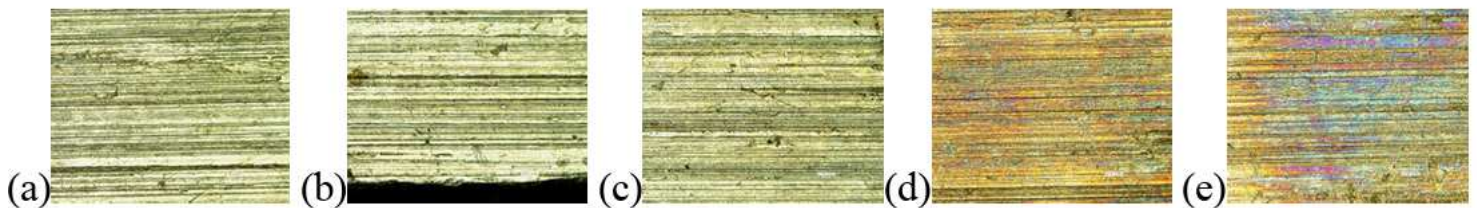
To elucidate a better understanding of process performance, this paper presents an investigation of laser hardening process for AISI 420 martensitic stainless steel. A nanosecond pulse laser was used as a heat source to harden the metal surface. The effects of laser power scan overlap and scan speed on micro-hardness and case depth were experimentally examined. The results revealed that the micro-hardness of stainless-steel surface increased from 242 HV to 1700 HV without any sign of surface melting. The depth of hardened layer was found to be 60–80 μm depending on laser power, scan speed and scan overlap applied.

A nanosecond pulse fiber laser emitting a wavelength of 1064 nm was used in this study. The laser machine provided the pulse duration of 120 ns and pulse repetition rate of 250 kHz, while the average laser power can be varied up to 30 W.

Average laser power, P [W] Laser scan speed, v [mm/s] Scan overlap, SO [%] 15 and 21 0.05 and 0.06 30, 40, 50 and 60

When the laser power of 21 W was applied to the process, the laser-scanned area also evidenced no melting in the workpiece surface but some burning marks for the scan overlap of 30% and 60%, respectively. Such discoloration of work surface is a consequence of substantial oxidation under a high heat input. The laser energy density (H) irradiating at the workpiece surface is a function of average laser power (P), laser beam diameter (D) and scan speed (v). This relationship can be expressed as follows: $H = P / (D \cdot v)$

The use of 21-W laser power and 0.05 mm/s scan speed introduce the energy density of $8.4 \times 10^4 \text{ J/cm}^2$, which is the highest value among the tested conditions. According to Fig. 2, there was no surface melting occurred even at the maximum energy density although the oxidation-induced discoloration can be apparent. Therefore, all hardening conditions investigated in this study can be of high potential to cause the phase transformations of AISI 420 martensitic stainless steel without significantly damaging the metal surface.



Conclusion/Action Items:

The use of a low power laser in comparison to the one in Pfefferkorn's lab was successful at 21 W in inducing oxidizing discoloration of a AISI 420 grade stainless steel. With low energy, there is no melting of the surface and simple oxidized color change. In addition to the aerosol and tape from CerMark, simple oxidation should also be tested, supporting what Pfefferkorn was describing.



01.29.2026 - Bowman Lacrimal Probe Industry Overview and Projections

CALEB WHITE - Feb 05, 2026, 5:03 PM CST

Title: Bowman Lacrimal Probe Industry Overview and Projections

Date: 01/28/2026

Content by: Caleb White

Goals: Understand the current probe market and the value that the Bowman Probe holds in the ophthalmology and general medical device circuit currently.

Search Term: "Bowman's Probe Industry"

Citation:

[1 "Bowman Lacrimal Probe Industry Overview and Projections." Accessed: Jan. 28, 2026. [Online]. Available:] <https://www.datainsightsmarket.com/reports/bowman-lacrimal-probe-1755038>

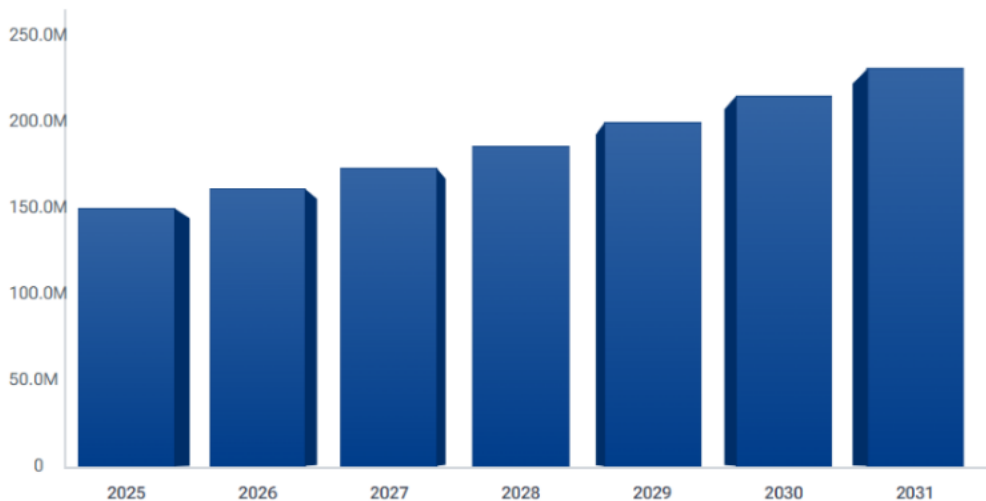
Link: [Bowman Lacrimal Probe Industry Overview and Projections](#)

Content:

The Bowman Lacrimal Probe market is poised for substantial growth, projected to reach approximately \$150 million in 2025 with a Compound Annual Growth Rate (CAGR) of 7.5% through 2033. This expansion is primarily driven by the increasing prevalence of lacrimal duct disorders, such as dacryocystitis and epiphora, which necessitate specialized surgical interventions. An aging global population, a key demographic susceptible to these conditions, further fuels demand. Advancements in medical device technology, leading to more precise, minimally invasive, and cost-effective lacrimal probes, also contribute significantly to market dynamism. The growing emphasis on outpatient surgical procedures and same-day surgeries, facilitated by the development of advanced lacrimal probes that enable quicker patient recovery, is another pivotal factor bolstering market size. Furthermore, rising healthcare expenditure in both developed and developing economies, coupled with increased awareness among patients and healthcare professionals regarding the benefits of timely intervention for lacrimal issues, underpins this positive market trajectory.

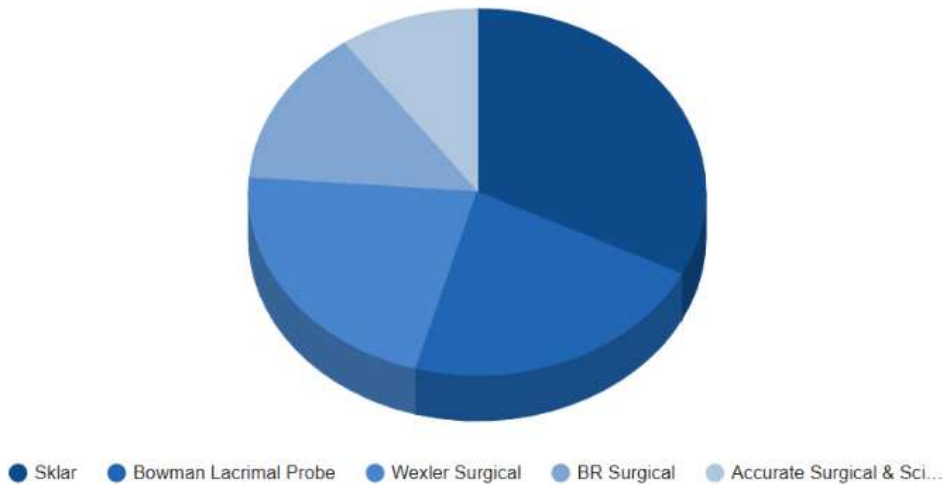
DiMarket

Bowman Lacrimal Probe Market Size (In Million)



The market segmentation by application highlights the dominance of Hospitals, accounting for an estimated 60% share in 2025, owing to their comprehensive facilities and specialized ophthalmology departments. Surgery Centers are also emerging as significant contributors, driven by their focus on specific procedures and increasing adoption of advanced surgical equipment. In terms of types, Stainless Steel probes are expected to command a larger market share due to their durability, reusability, and cost-effectiveness in long-term use, representing approximately 70% of the market. However, the Silver Type, offering enhanced antimicrobial properties and improved biocompatibility, is projected to witness steady growth. Geographically, North America and Europe are anticipated to remain the leading markets, driven by well-established healthcare infrastructures, high disposable incomes, and a strong presence of key market players. The Asia Pacific region, however, is expected to exhibit the highest growth rate, fueled by a large patient pool, improving healthcare access, and increasing adoption of advanced medical technologies. Restraints such as stringent regulatory approvals and the cost of advanced probes can pose challenges, but the overall outlook remains robust due to the unmet medical needs and continuous innovation within the segment.

Bowman Lacrimal Probe Company Market Share



Driving Forces: Increasing incidence of lacrimal duct obstructions: Driven by an aging global population and rising prevalence of eye conditions; Growing demand for minimally invasive surgical procedures: Bowman probes are essential tools for these less invasive interventions; Advancements in medical technology and material science: Leading to more precise, durable, and biocompatible probes; Expansion of healthcare infrastructure in emerging economies: Increasing access to specialized eye care services.

Challenges and Restraints: Stringent regulatory requirements for medical devices: Can increase product development and approval timelines; Price sensitivity in certain markets: May limit the adoption of premium-priced probes; Availability of alternative treatment modalities: While not always direct substitutes, other interventions can influence probe usage; Risk of infection and the need for effective sterilization protocols: A continuous concern for reusable instruments.

Emerging Trends: Development of specialized probes for complex anatomical variations; Exploration of antimicrobial coatings for enhanced infection prevention; Integration with digital imaging and navigation systems for improved surgical planning; Increased focus on ergonomic designs to minimize surgeon fatigue.

Stainless Steel Type: Stainless steel is the preferred material for surgical instruments due to its excellent strength, durability, corrosion resistance, and cost-effectiveness. Bowman lacrimal probes manufactured from stainless steel offer reliable performance and can withstand repeated sterilization cycles, making them a staple in surgical instrument trays worldwide. The established manufacturing processes and widespread availability of high-quality stainless steel contribute to its market leadership. The market size for stainless steel lacrimal probes is projected to be around \$750 million in 2025.

Conclusions/action items:

The Lacrimal probe industry is on the steady incline due to the natural increase of probe necessity and advancement in medical technology. The probe offers a minimally invasive procedure that is effective at treating common eye problems, making it a very much preferred path of clinical practice. The industry is booming in term of monetary worth and will continue to rise due to its simple and effective characteristics. The probes are most commonly manufactured out of stainless steel as well as newly introduced silver due to its biocompatible qualities. This document provides a detailed summary of the economic standpoint of lacrimal probes in both the medical device and general economic markets.



01.29.2026 - Are the environmental impacts, resource flows and economic benefits proportional? Analysis of key global trade routes based on the steel life cycle

CALEB WHITE - Jan 29, 2026, 8:35 PM CST

Title: Are the environmental impacts, resource flows and economic benefits proportional? Analysis of key global trade routes based on the steel life cycle

Date: 01/29/2026

Content by: Caleb White

Goals: Understand the coupled economic and environmental impact of metal ore mining and manufacturing of stainless steel due to its heavy dominance in the Bowman Probe production industry

Search Term: "Stainless Steel Manufacturing Environmental Impact"

Citation:

[1 Y. Liu, H. Li, H. An, J. Guan, J. Shi, and X. Han, "Are the environmental impacts, resource flows and economic benefits proportional? Analysis of] key global trade routes based on the steel life cycle," *Ecological Indicators*, vol. 122, p. 107306, Mar. 2021, doi: [10.1016/j.ecolind.2020.107306](https://doi.org/10.1016/j.ecolind.2020.107306).

Link: <https://www.sciencedirect.com/science/article/pii/S1470160X20312486>

Content:

The coordinated relationship between the environment, resources and economy is necessary for global sustainable development. As the basis of many countries' economies, the steel industry has received much attention. Considering the three typical stages in the steel life cycle of ore mining, crude steel production and scrap recycling, this study aims to identify the current unbalanced relationship between environmental impacts, resource flows and economic benefits. To that end, life cycle assessment is conducted to analyze 18 trade routes involving 8 major steel trading countries, a sustainability evaluation model is constructed containing three indicators at different levels, and the coupling coordinated degree in the steel trade routes under four scenarios is simulated and discussed. The results show that, first, the category of ecotoxicity has the greatest impact on the environment during the whole steel life cycle.

To improve the economy, resource overexploitation and environmental pollution used to neglect. However, with the global emphasis on sustainable development, the relationship between environmental impacts, resource flows and economic benefits has attracted increasing attention.

Table 3. LCI of crude steel production at the process level.

Countries	Unit	China	Korea	Russia
<i>Input flows</i>				
Dolomite	t	1.60E-02		
Hard coal	t	4.32E-01		5.86E-01
Iron ore	t	1.00E + 00	1.00E + 00	1.33E + 01
Limestone	t	2.84E-03		
Natural gas	MJ	1.85E + 00		
Oil	t	2.96E-02		
Electricity, high voltage	MJ			8.86E + 02
Iron pellet	t			1.40E-01
Iron scrap	t	5.06E-02		1.27E-01
Lime	t			4.00E-02
Electricity, low voltage	kWh		4.93E + 02	
Oxygen	t		4.35E-01	
<i>Output flows</i>				
Carbon dioxide	t	1.48E + 00		1.57E + 00
Carbon monoxide	t	1.85E-02		
Methane	t	7.78E-04		

Countries	Unit	China	Korea	Russia
Particulates, <10 um	t	1.48E-03	3.77E + 01	
Steel	t	1.00E + 00	1.00E + 00	1.00E + 00
Suspended solids	t	4.69E-04		
Blast furnace slag	t		2.61E + 02	4.14E-01
Dust	t		1.19E + 00	1.00E-03
VOC	t	7.16E-05		
COD	t	2.35E-04		
Dioxins	t	1.36E-11		
Hydrogen chloride	t	6.05E-05		
Nitrogen dioxide	t	2.10E-03	4.93E-07	
Sulfur dioxide	t	2.35E-03	6.96E-02	
Digester sludge	t		3.04E-02	
Ammonium sulfate	t			4.00E-03
Coal tar	t			1.00E-02

Table 5. LCI of scrap steel recycling at the process level.

	Unit	US	UK	Japan
Empty Cell				
<i>Input flow</i>				
Carbon dioxide	t	1.60E-02		
Coal	t	6.26E-01	1.40E-02	9.31E-01
Dolomite	t	9.46E-02		1.67E-04
Oxide powder	t	5.31E-15		
Iron ore	t	9.66E-01		7.13E-02
Lignite	t	3.20E-02		
Limestone	t	2.43E-02		
Natural gas	MJ	6.09E + 00	9.76E-01	1.01E-01
Oil	t	5.88E-02		6.27E-02
Scrap steel	t	4.39E-01	1.11E + 00	1.32E + 00
Uranium	t	3.54E-06		
Zinc ore	t	9.66E-02		2.53E-09
Anode	t		3.00E-03	
Electricity	kWh		4.24E-01	
Oxygen	t		5.10E-02	
Quicklime	t		5.50E-02	
Refractory	t		1.40E-02	
Manganese	t			5.19E-08
Water	t			7.48E + 00
<i>Output flow</i>				
Ammonia	t	3.18E-08		1.42E-07
BOD5	t	6.06E-09		
Cadmium	t	1.27E-10		6.09E-07
Carbon dioxide	t	1.13E-05		1.36E + 00
Chromium	t	1.51E-09		6.50E-07
COD	t	6.35E-07		1.40E-03
Dioxins	t	8.73E-16		
Hydrogen sulfide	t	8.21E-08		
Iron	t	2.52E-07		
Lead	t	1.19E-09		3.66E-06

Empty Cell	Unit	US	UK	Japan
Mercury	t	6.00E-11		5.32E-08
Methane	t	4.55E-06		4.09E-04
Nickel	t	2.09E-10		4.66E-05
Nitrogen dioxide	t	3.24E-08		
Nitrogen oxide	t	6.86E-06		1.72E-07
NMVOC	t	3.10E-07		6.18E-04
Steel	t	1.00E + 00	1.00E + 00	1.00E + 00
Sulphur trioxide	t	4.88E-06		
Zinc	t	2.61E-09		2.13E-03
Dust	t		1.07E-01	
Calcium	t			1.53E-05
Carbon monoxide	t			3.64E-03
Dinitrogen monoxide	t			2.19E-05
Hydrogen chloride	t			2.24E-04
Iron	t			1.40E-05
Oils	t			2.41E-04
Particulates	t			9.60E-04
Sulfur dioxide	t			4.00E-03
Suspended solids	t			2.91E-04

Conclusions/action items:

The environmental byproducts of crude steel mining and manufacturing can be seen above. What is important to understand is the impact of stainless steel production. Stainless steel production produced a large carbon footprint by contrarily is 100% recyclable and therefore a sustainable practice. It is also corrosive resistant but is less biocompatible then other synthetic biomaterials.



02.05.2026 - ASTM B912

CALEB WHITE - Feb 05, 2026, 4:37 PM CST

Title: ASTM B912 Standard

Date: 02/05/2026

Content by: Caleb White

Goals: Understand the ASTM B912 standard and identify which of its regulations are applicable to the Bowman Probe project.

Citation:

[1 "ASTM B912-02 - Standard Specification for Passivation of Stainless Steels Using Electropolishing." Accessed: Feb. 05, 2026. [Online]. Available:] <https://webstore.ansi.org/standards/astm/ASTMB91202>

Link: <https://compass.astm.org/content-access?contentCode=ASTM%7CB0912-02R18%7Cen-US>

Content:

This specification covers the passivation by electropolishing of stainless steel alloys in the 200, 300, and 400 series, as well as precipitation-hardened alloys. Basis materials shall be free of clearly visible defects, and if necessary, shall undergo preparatory cleaning procedures prior to electropolishing. Post-coating procedures such as post dip and final rinsing shall be performed as well. The performance of the specimens during passivation shall be evaluated by one or more of the following procedures: water immersion test; humidity test; salt spray test; copper sulfate test; and modified ferroxyl test for free iron.

1 electropolishing, n—electrochemical process in which the article(s) to be passivated are treated anodically in a suitable acid medium. 3.1.2 passivation, n—rendering of a stainless steel surface into a lower state of chemical reactivity.

3.1.2.1 Discussion—Passivated surfaces are characterized by the absence of free iron, as defined by Practice A380/A380M.

3.2 Definitions of Terms Specific to This Standard:

2 Appearance—The purchaser shall specify the appearance required, for example, bright or dull. Unless otherwise specified by the purchaser, a bright luster shall be acceptable. Alternatively, samples showing the required finish, or range of finish, shall be supplied or approved by the purchaser. When required, the basis material may be subjected, before electropolishing, to such mechanical polishing as may be required to yield the desired final surface characteristics.

4.1.3 Contact Marks—Visible contact marks may occur. The location of electrical contact marks shall be agreed upon between purchaser and supplier.

4.1.4 Metal Removal—Some metal is removed from the surface of the article during electropolishing, typically 5 to 10 μm . As much as 50 μm may be removed for additional smoothing. The ordering document shall include the maximum amount of metal to be removed.

Product Requirements

5.1 Visual Defects—When specified, the significant surfaces of the article to be passivated by electropolishing shall be free of clearly visible defects such as pits, roughness, striations, or discoloration when examined with 20/20 eyesight at a distance of approximately 0.5 m.

NOTE 2—Defects in the surface of the basis material such as scratches, porosity, inclusions, and so forth, may adversely affect the appearance and performance of the article. Visible examination shall include wearing correctional glasses if the inspector normally wears them.

5.2.1 Surface Preparation—Preparatory procedures and cleaning of the basis material may be necessary; see Practices A380/A380M and B322.

5.2.2 Electropolishing—Following the preparatory operations, the articles are introduced into the electropolishing solution for a period of time at the current density and temperature required to produce the passive surface and required surface finish, if any. NOTE 3—A typical electropolishing solution and operating conditions suitable for many stainless steel alloys is shown in Appendix X1. Proprietary electropolishing solutions are available offering special features such as low sludging, better bright throwing power, longer life, or better performance with specific stainless steel alloys.

NOTE 4—Intricately shaped articles may not receive the same degree of passivation in recessed area as a result of low-current densities. Increasing time or overall current density, or both, or the use of auxiliary cathodes, may be used to improve electropolishing in these areas and to pass subsequent passivation tests.

5.2.3 Post Dip—Articles withdrawn from the electropolishing solution will have a residual film that may adversely affect the appearance or performance of the product. The preferred method of removing this film is by rinsing the articles in a room-temperature solution of 10 to 30 % v/v nitric acid (specific gravity 1.42, 70 % w/w).

5.2.3.1 Where local conditions prevent the use of nitric acid (nitrates) for film removal, other options may be used as long as the articles meet the

requirements of 5.3.

NOTE 5—A 60-g/L solution of citric acid has been used for film removal; however, note that this procedure may pose waste treatment/difficulties. The use of other mineral acids, such as sulfuric or hydrochloric acids, is not recommended as the passive film may be compromised. Neutralization procedures such as immersion in alkaline solutions should not be used as they can have a tendency to “set” the residual film and detract from appearance and performance.

5.2.4 Final Rinsing—Rinsing subsequent to passivation is necessary to remove all traces of acidified water that may affect the appearance and performance of the passive part. Deionized or distilled water may be used to avoid water spots.

Conclusions/action items:

This standard provides succinct detail of the methods to which someone should appropriately passivate a stainless-steel medical device via electropolishing, a potential option for the group. The standard provides information on the surface preparation, what visual cues to look for, and what the final product should expect to look like. There are various further standards and sources linked within the standard that provide further details needed for the full completion of the electropolishing process so that it passes all regulatory standards.



02.13.2026 - ASTM B488 - Standard Specification for Electrodeposited Coatings of Gold for Engineering Uses

CALEB WHITE - Feb 13, 2026, 11:24 AM CST

Title: ASTM B488 Standard Specification for Electrodeposited Coatings of Gold for Engineering Uses

Date: 02/13/2026

Content by: Caleb White

Goals: Understand the ASTM B488 standard and identify which of its regulations are applicable to the Bowman Probe project.

Citation:

[1 "Standard Specification for Electrodeposited Coatings of Gold for Engineering Uses." Accessed: Feb. 13, 2026. [Online]. Available:] <https://store.astm.org/b0488-18.html>

Link: [B488 Standard Specification for Electrodeposited Coatings of Gold for Engineering Uses](#)

Content:

This specification establishes the requirements for electrodeposited gold coatings for engineering applications, employed specifically for their corrosion and tarnish resistance (including resistance to fretting corrosion and catalytic polymerization), bondability, low and stable contact resistance, solderability, and infrared reflectivity. This specification does not cover gold coatings produced from autocatalytic, immersion, and vapor deposition. Coatings shall be classified into types, which characterize minimum purity, and codes, which designate Knoop hardness. Coatings shall be sampled, tested and conform to specified requirements as to purity, hardness, appearance, thickness, mass per unit area, ductility, adhesion (assessed by either bend, heat, or cutting test), and integrity (including gross defects, mechanical damage, and porosity).

1.1 This specification covers requirements for electrodeposited gold coatings that contain not less than 99.00 mass % gold and that are used for engineering applications.

1.2 Specifically excluded from this specification are autocatalytic, immersion, and vapor deposited gold coatings.

1.3 Gold coatings conforming to this specification are employed for their corrosion and tarnish resistance (including resistance to fretting corrosion and catalytic polymerization), bond ability, low and stable contact resistance, solderability, and infrared reflectivity. Several types of coatings, differing in gold purity and hardness, are covered by this specification.

1.4 The values stated in SI units are to be regarded as the standard. Values provided in parentheses are for information only.

1.5 The following hazards caveat pertains only to the test methods section, Section 9, of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.6 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Purpose: To establish the requirement for electrodeposited gold coatings that contain at least 99.00% mass gold. The coatings are primarily used for their corrosion and tarnish resistance, bond ability, low contact resistance, solderability, and infrared reflectivity.

- It excludes coatings produced through autocatalytic, immersion, and vapor deposition methods, focusing solely on electrodeposited coatings.

Applications: The standard is essential for industries that require high performance gold coating, such as aerospace, defense, and electronics. It ensures that the coatings provide the necessary durability and reliability for critical components.

Conclusions/action items:

This standard provides succinct detail of the methods to which someone should appropriately use gold for engineering applicable biomedical uses. If electroplating is used as a method for fabrication, and gold was the chosen material, a good choice for biomedical applications, then this standard would have to be used. There are also several other standards which exist which don't apply to gold but similar materials that can be used for electroplating such as chromium and nickel.



04.15.2026 - Development of Phantom Material that Resembles Compression Properties of Human Brain Tissue for Training Models

CALEB WHITE - Apr 29, 2026, 8:24 PM CDT

Title: Development of Phantom Material that Resembles Compression Properties of Human Brain Tissue for Training Models

Date: 04.21.2026

Content by: Caleb White

Goals: Learn about possible ways to mimic the soft tissue found within the lacrimal passage.

Search Term:

Citation: [1] M. Navarro-Lozoya, M. S. Kennedy, D. Dean, and J. I. Rodriguez-Devora, "Development of Phantom Material that Resembles Compression Properties of Human Brain Tissue for Training Models," *Materialia (Oxf)*, vol. 8, p. 10.1016/j.mtla.2019.100438, Dec. 2019, doi: 10.1016/j.mtla.2019.100438.

Link: <https://pmc.ncbi.nlm.nih.gov/articles/PMC7021247/#:~:text=As%20can%20be%20seen%20in,stress%2Dstrain%20relationship%20of%20brain.>

Content:

Research on the mechanical properties of soft tissues was initially motivated by the desire to improve the fundamental understanding of the relationship between the tissue's mechanical properties to their biological processes and to design biomimetic engineered tissues. Research has also resulted in the development/improvement of mathematical models applicable to silicone brain models used for surgery and injury simulation. Furthermore, the need to study brain mechanical properties has recently been motivated by the need to improve the training of medical professionals by developing more accurate haptic devices, simulating brain tissue for research studies tied to shock, and the need to test computer-integrated tools and robot-aided surgery and virtual reality techniques. To improve physical brain phantoms, it is critical to create materials with the mechanical behavior similar to that of brain tissue that can be used in the training of surgeons, realistic haptic devices, and/or within research studies on personal protective gear, such as helmet testing.

The ideal phantom aims to reproduce the physical, chemical, and mechanical properties of brain tissue. The goal of this study was to either develop a new or identify an existing a brain phantom material with properties suitable for clinical training and surgical planning. We considered three design requirements for the material development: similar compressive stiffness, be structurally stable at room temperature and easy to manipulate while maintaining its structure for manufacturing. The synthetic materials explored for this study included silicones of different hardness, gelatin with and without a chromium crosslinker, agarose, and two emulsions with varying composition.

Most prior studies on the development of phantoms that simulated brain mechanical properties have used silicones and/or hydrogels. Silicones are considered relatively easy to manufacture and handle. However, they are typically stiffer than brain tissues. Hydrogels or hydrophilic gels are polymer networks that have the ability to swell by retaining significant amounts of water. Gelatin and agarose are hydrogels often used in the biomedical engineering field for tissue culture and are currently considered phantom materials for soft tissue when considering only mechanical properties. Gelatin is a product derived from collagen that is the principal component of skin, connective tissue, cartilage and bone. Whereas, agarose is a polymer generally extracted from seaweed and is frequently used in molecular biology for electrophoresis. In this study, we tested silicone gels, agarose and collagen hydrogels, as well as two newly developed emulsions with compositions mimicking brain tissue.

Conclusions/action items:

There are a lot of different ways to model soft tissue. There is also a lot of consideration that has to go into the formula in order to appropriately model the biological, mechanical, and chemical environment. For the tissue pull test, we will only need to be worried about the mechanical aspects and therefore should look to find materials which can be easily modulated for mechanical mimicry.



04.15.2026 - Narrative review of tissue-mimicking materials for MRI phantoms: Composition, fabrication, and relaxation properties

CALEB WHITE - Apr 29, 2026, 8:31 PM CDT

Title: Narrative review of tissue-mimicking materials for MRI phantoms: Composition, fabrication, and relaxation properties

Date: 04.15.2026

Content by: Caleb White

Goals: Find out more about what materials are best for mechanical representation of soft tissue

Search Term: Soft Tissue mechanical mimic

Citation: [1] H. Yusuff, S. Chatelin, and J.-P. Dillenseger, "Narrative review of tissue-mimicking materials for MRI phantoms: Composition, fabrication, and relaxation properties," *Radiography*, vol. 30, no. 6, pp. 1655–1668, Oct. 2024, doi: 10.1016/j.radi.2024.09.063.

Link: <https://www.sciencedirect.com/science/article/pii/S107881742400292X>

Content:

Agarose, one of the two main components of agar, is obtained by purifying agar to remove the other major component, agaropectin.⁷ Agar, a hydrophilic colloid derived from specific marine algae of the Rhodophyceae class stands out as the most frequently utilized gelling agent in the fabrication of phantoms for diverse applications, a trend supported by the current literature search. This prevalence can be attributed to several advantages agar offers over alternative gels like gelatin, carrageenan, and polyvinyl alcohol (PVA). These advantages include a faster and more cost-effective production process and high melting point of near 78 °C which makes it an idea material for thermal studies. Agar's versatility allows it to be easily shaped into various configurations, ensuring the creation of stable and enduring phantoms. Its tissue-like magnetic resonance (MR) signal further establishes agar as the preferred material for MRI studies. However, agar is classified as a hydrophilic organic material, which makes it prone to microbial growth. This susceptibility can lead to changes in its imaging, acoustic, and thermal properties over time. Additionally, agar is known to have relatively low toughness, making it easily prone to fragility. When used alone, agar can also suffer from the extrusion of an aqueous solution at its boundaries. To address this issue, Rice et al. combined animal-hide gelatin with agar to introduce a protein background spectrum, which helps prevent this problem.

Agar has found extensive use as a gelling agent in tissue-mimicking materials (TMMs) employed for various studies, including MR imaging, thermal and Ultrasound studies where it not only served as the gelling agent but also as a T2 modifier. T1 modifiers in these materials have included paramagnetic ion salts such as manganese (II) chloride (MnCl₂), copper (Cu) ions and glycerol. D'Souza et al. noted that copper ion requires a special compound known as Ethylenediaminetetraacetic acid tetrasodium hydrate (EDTA) which combines with Cu ions to form a stable free molecule; Cu-EDTA, Otherwise, copper ions will deposit on agar and lose their T1-modifying capacity. Altermatt et al. also noted that diffusion of contrast agent reduces the long-time stability of a phantom.

Gelatin is a protein-based substance usually derived from animal tissues. It has been widely used as a material to mimic soft tissue for MR imaging and ultrasound. Alginate and gelatin can be combined to create a more stable system. The process involves preparing a complex solution that, when cooled below 25 °C, results in the formation of an opaque gel.

Gelatin powder exists in varying bloom values e.g. 125-bloom, 175-bloom, and 250 bloom as defined by the manufacturer. Farrer et al. observed a robust correlation between the bloom value and the mechanical property, noting that a higher bloom value corresponds to a higher young modulus. Additionally, the incorporation of evaporated milk was found to enhance the young modulus of gelatin phantoms. A gelatin phantom with a bloom value of 250 was discovered to exhibit T1 and T2* values very similar to those of brain white matter.

The gelation process involves dissolving gelatin powder in aqueous solutions. To accurately mimic several soft tissues, additional ingredients are introduced to the base recipe at an appropriate concentration. This method allows for the creation of gel-like structures that resemble the properties of specific soft tissues. Hofstetter et al. used psyllium husk as a scattering agent, the choice of psyllium husk was due to its property of not inducing significant susceptibility artifacts in MR magnitude and phase images. T2 and T2* relaxation rates was found to decrease with increasing psyllium husk concentration. In the same study, Evaporated milk was chosen as

the primary attenuation component due to its widespread availability and its past use in agar-based phantoms. Kim et al. used 10 % neutral buffered formalin solution to minimize water diffusion between the gel boundaries, this induced crosslinking of the polymers to raise the melting point and reduce the gel porosity.

Gelatin has also been combined with Agar to simulate hepatocellular carcinoma (HCC). The addition of agar in the phantom was found to reduce the phantom's density close to human liver density, making it more representative of actual liver tissue. Another common component in gelatin phantoms is oil. These phantoms are often termed oil-in-gelatin phantoms and are primarily employed in elastography studies, where the elastic modulus is influenced by the volume percentage of oil. Notably, studies have demonstrated that the concentration of oil has a discernible impact on the magnetic resonance (MR) relaxation properties of oil-in-gelatin dispersions.

Rice et al. addressed the challenge of low mechanical strength and low melting point of gelatin by using formaldehyde to cross-link the gelatin, thereby increasing its thermal stability and raising the melting point to above 65 °C. Additionally, they incorporated NaCl to enhance electrical conductivity for simulating coil loading, and thimerosal as a preservative to prevent bacterial growth. For T1 relaxation time modification, they used a combination of copper (II) chloride (CuCl₂) and tetrasodium ethylenediaminetetraacetic acid.

Conclusions/action items:

Agar and gelatin are two very commonly used soft tissue mimic materials because of their easy modularity and representative structure. Their combination allows for a semi-viscoelastic behavior which is exactly what is desired. It is important to make sure to keep agar concentration low to not make the mimic too stiff.



04.16.2026 - Nasolacrimal mechanical properties

CALEB WHITE - Apr 29, 2026, 8:37 PM CDT

Title: Nasolacrimal mechanical properties

Date: 04.16.2026

Content by: Caleb White

Goals: Learn about nasolacrimal mechanical properties and imaging techniques and the ways in which it can be mimicked for imaging purposes. Maybe these processes can be translated over to mechanical mimicry.

Search Term: Nasolacrimal soft tissue mimicry

Citation: [1] A. Maliborski and R. Różycki, "Diagnostic imaging of the nasolacrimal drainage system. Part I. Radiological anatomy of lacrimal pathways. Physiology of tear secretion and tear outflow," *Med Sci Monit*, vol. 20, pp. 628–638, Apr. 2014, doi: 10.12659/MSM.890098.

Link: [https://pmc.ncbi.nlm.nih.gov/articles/PMC3999077/#:~:text=It%20was%20shown%20that%20the,Figure%206\)%20%5B23%5D](https://pmc.ncbi.nlm.nih.gov/articles/PMC3999077/#:~:text=It%20was%20shown%20that%20the,Figure%206)%20%5B23%5D).

Content:

Excessive watering of the eye is a common condition in ophthalmological practice. It may be the result of excessive production of tear fluid or obstruction and insufficiency of efferent tear pathways. The differentiation between obstruction and insufficiency of the lacrimal pathways is still clinically questionable. In the diagnostic process it is necessary to perform clinical tests and additional diagnostic imaging is often needed. Dacryocystography, with or without the extension of the dynamic phase or subtraction option, still remains the criterion standard for diagnostic imaging of the lacrimal obstruction. It may help to clarify the cause and exact place of the obstruction and provide information for further management, especially surgical treatment. Increasingly, new techniques are used in diagnostic imaging of the lacrimal tract, such as computed tomography, magnetic resonance, and isotopic methods.

Adequate knowledge of the anatomy and physiology of the lacrimal system and the secretion and outflow of tears is the basis for proper diagnostic imaging. The purpose of this paper is to present the exact anatomy of the lacrimal system, with particular emphasis on the radiological anatomy and the current state of knowledge about the physiology of tear secretion and drainage.

It was shown that the difference in the spatial lacrimal pathways has an impact on the performance of the lacrimal system drainage and can also affect the frequency of obstruction of lacrimal pathways.

The nasolacrimal duct is considered to be an anatomical continuation of the lacrimal sac structures. The duct wall is formed by helical-shaped collagen fibers, spun together with the thick lattice of venous sinus capillaries and tiny arterioles. Similarly to the lacrimal sac, the mucous membrane of the duct is lined with double-layered columnar epithelium. The integrity of the mucous membrane, with numerous vascular plexi in the NLD wall plays, an important role in the tear drainage regulation. Tear fluid components are constantly absorbed by the epithelium during passage through the nasolacrimal duct and are then transported into the thick sinus capillaries plexus, located in the wall of the inferior section of the lacrimal pathways. Excessive build-up of fluid in the vessels leads to edema of the mucous membrane, constriction of the duct lumen, and even to its temporary closure. Due to its specific construction, the NLD wall is compared to the cavernous body structure.

Conclusions/action items:

The nasolacrimal duct is formed through collagen spun fibers, with a thick lattice of venous sinus capillaries. This creates a thick membranous surface which contains viscoelastic like properties and generally typical, yet delicate, soft tissue mechanical status.



04.20.2026 - MRI Image Analysis Methods

CALEB WHITE - Apr 29, 2026, 8:45 PM CDT

Title: MRI image analysis methods

Date: 04.20.2026

Content by: Caleb White

Goals: Discover the methods behind MRI image processing to identify if these same concepts can be applied to the tissue pull testing.

Search Term: MRI Image analysis processing

Citation:

[1 V. Vadmal, G. Junno, C. Badve, W. Huang, K. A. Waite, and J. S. Barnholtz-Sloan, "MRI image analysis methods and applications: an algorithmic] perspective using brain tumors as an exemplar," *Neurooncol Adv*, vol. 2, no. 1, p. vdaa049, Apr. 2020, doi: [10.1093/noajnl/vdaa049](https://doi.org/10.1093/noajnl/vdaa049).

Link: <https://pmc.ncbi.nlm.nih.gov/articles/PMC7236385/>

Content:

The past decade has seen a remarkable change in the availability of powerful, inexpensive computer hardware that has been a major driving force for the progression of machine vision in medical research. This has resulted in advances in digital MRI imaging analysis that ranges from simple tumor identification to the assessment of tumor response and treatments in clinical oncology.¹ Due to the interdisciplinary nature of the field, principles from physics, computer science, and computer graphics are used to address medical imaging informatics problems. With the existence of vast amounts of imaging data procured during standard clinical practice, a primary focus among investigators has been to use image analysis to augment current standards of tumor detection and to gain new insights about the nature of diseases. The stages in a typical workflow are image acquisition, preprocessing, segmentation, and feature extraction. These key terms that define a typical workflow were queried to find current literature in repositories such as Elsevier, IEEE Xplore, Radiology, PubMed, and Google Scholar. This review discusses past and current methods employed in each of these stages as well as the rising popularity of artificial intelligence (AI)-based approaches, using brain tumors as an exemplar. A glossary of key terms is provided in the supplementary materials for ease of reference as these topics are presented.

The first step in any data-driven study is to preprocess the raw images. Preprocessing removes noise by ensuring there is a degree of parity among all the images that in turn make the following segmentation and feature extraction steps more effective.² This involves performing operations to remove artifacts, modify image resolution, and address contrast differences that arise from different acquisition hardware and parameters. One common source of noise is bias fields, which are caused by low-frequency signals emitted from the MRI machine combined with patient anatomy that ultimately leads to inhomogeneities in the magnetic field.³ The resulting images, therefore, have variations in intensity for the same tissue when each tissue should correspond to a specific intensity level.^{4,5} Another source of noise arises from temporal data. During the course of treatment, patients often have a series of pre- and post-images. These imaging series are valuable for analytics, but is almost impossible for the patient to be in the same exact position for the pre- and post-scans. This can make it difficult to discern the status of the tumor not only for imaging software, but also for radiologists. Thus, images taken over a timeframe must be aligned in a process known as image registration.

To address the contrast differences in studies where images are taken from multiple sources and machines, images undergo normalization of color or grayscale values.⁶ Normalization is almost universal in controlled imaging studies and is necessary when employing machine-learning techniques. Normalization effectively defines a new range of color values relative to other images in the data set. Before normalization, it may be necessary to remove noise existing on scans of any modality, including the signal from the patient's skull for patients with brain tumors.

Because accurate segmentation of regions of interest (ROI) is the goal of bias correction, the 2 steps can be combined. The 2 main segmentation-based approaches are both iterative algorithms: expectation maximum (EM) and fuzzy c-means. The EM algorithm is a machine learning-based approach used to iteratively converge a parametric model's parameters based on the maximum likelihood probability. The EM approach can use different criteria to estimate the model's parameters. The fuzzy c-means method also iteratively segments by minimizing a cost function as it steps through a vector of the image's pixel intensities.⁴ EM-based approaches have fallen out of in favor of fuzzy c-means.

Conclusions/action items:

MRI Image analysis typically revolves around using before and after photos and computer algorithms to find differences and therefore discover growth of tumors. Using this same technology on the tissue pull analysis, a tissue pull amount can potentially be quantified helping characterize the impact of graduating the probes.



04.21.2026 - Validation of Region of Interest Measurements for the Objective Assessment of Post-Contrast Enhancement of Renal Lesions on MRI

CALEB WHITE - Apr 29, 2026, 8:53 PM CDT

Title: Validation of Region of Interest Measurements for the Objective Assessment of Post-Contrast Enhancement of Renal Lesions on MRI

Date: 04.21.2026

Content by: Caleb White

Goals: Learn more about the MRI imaging technique and identify the key aspects of region of interest application.

Search Term: MRI ROI application

Citation:

[1 I. S. Al Salmi, J. Halperin, F. Al-Douri, V. Leung, M. Patlas, and A. Alabousi, "Validation of Region of Interest Measurements for the Objective Assessment of Post-Contrast Enhancement of Renal Lesions on MRI," *Br J Radiol*, vol. 92, no. 1103, p. 20190507, Nov. 2019, doi: [10.1259/bjr.20190507](https://doi.org/10.1259/bjr.20190507).

Link: <https://pubmed.ncbi.nlm.nih.gov/articles/PMC6849669/>

Content:

The aim of this study was to validate the use of region of interest (ROI) measurements in MRI to objectively assess for enhancement in suspected solid renal masses and to determine a minimum threshold value for true enhancement.

Contrast-enhanced renal MRI studies performed between January 2015 and December 2017 for patients with a known renal mass who had subsequent biopsy, or partial/radical nephrectomy were included. Two body imaging fellows independently measured the mean ROI values of renal masses, normal renal parenchyma, the ipsilateral psoas muscle and external air on the pre- and post-contrast sequences. The absolute and percentage changes in the mean ROI values were calculated. The readers were blinded to the pathology results.

The aim of this study was to devise an objective tool to allow for assessment of renal mass enhancement on MRI. Our results showed that the use of ROI measurement for renal masses on the pre- and post-contrast MRI images can in fact be a useful objective tool in the assessment of enhancement. It was determined that a minimum threshold of 23% change in the ROI values should be seen in solid renal masses; this will be referred to as the signal intensity index (SII). This threshold includes solid lesions, as well as lesions which are predominantly cystic but have enhancing nodules or thick enhancing septations.

On the other hand, there was a maximum change in the ROI values of 13% or less in pathology-proven renal cysts, which were used as controls. This includes both simple and complicated cysts with hemorrhagic/ proteinaceous content.

These results are not significantly different from the previously published results by Ho et al.³ In their study, they suggested a threshold of 15% to determine enhancement, however, they have addressed that this would result in a small number of false positive cases.³ One should note that they used a timing of 2–4 min for the post contrast examination for the above described threshold, which is different from our study where we used a timing of 30–60 sec post IV contrast administration. Additionally, they had some limitations in their study due to the lack of histopathology for the renal cysts, which were used as controls. Instead, they relied on other imaging modalities like CT and ultrasound to confirm their diagnosis of a renal cyst. This may result in misinterpretation of minimally enhancing renal masses as renal cysts. We were able to overcome this limitation by exclusively limiting our sample to pathology-proven renal cysts.

The objective assessment of renal lesions using the percentage change in the ROI values in pre- and post-contrast T1WI sequences (SII) can be a helpful tool and can supplement the widely used subtraction images. It may potentially be useful in cases where the subtraction images are degraded by misregistration artefact. We suggest a threshold of 20% increase in the ROI values on the post-contrast T1WI sequence compared to the pre-contrast T1WI sequence to establish true enhancement in a suspected solid renal mass.

Conclusions/action items:

ROI application for MRI imaging techniques is a necessary step for pure data acquisition. The ROI, or region of interest, is a region told by the user to the computer to specifically look at. That is, the other portions of the images are unnecessary for the actual change calculation. This is in purpose to reduce noise and create a more accurate representation of change. The decision for ROI placement is very important as excluding regions where growth has occurred for example, would completely invalidate the data being collected.



02/12/2026 - Electroplating Design Idea

CALEB WHITE - Feb 13, 2026, 11:39 AM CST

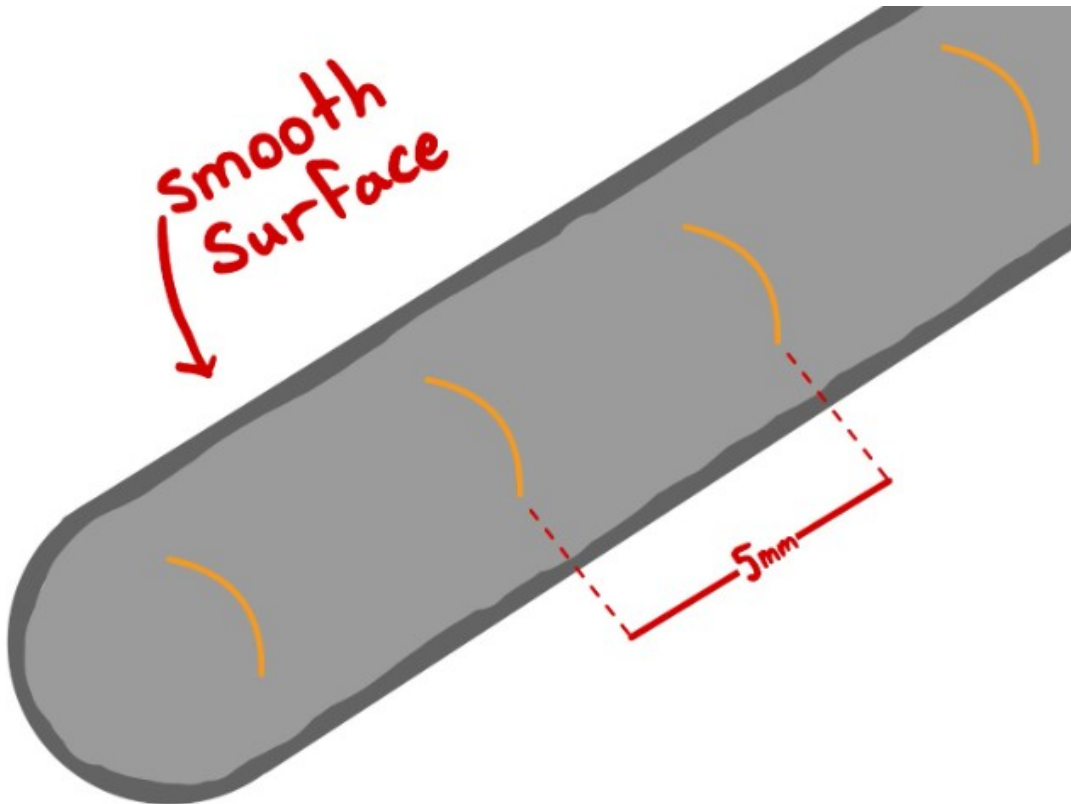
Title: Electroplating Design Idea

Date: 02/12/2026

Content by: Caleb White

Goals: Create a succinct design with the electroplating fabrication method

Content:



Electroplating: The design consideration is electroplating. Electroplating is the process of producing a metal coating on a solid substrate through the reduction of cations of the chosen metal via an electrical current. The two chosen substrates in this case would be the stainless-steel Bowman probe, acting as the anode, and a secondary, separate colored metal, such as a dark titanium, as the cathode. Using electroplating, tiny strips of metal coating would be plated onto the Bowman probe in specific locations through controlled masking with tape or wax. These tiny strips would indicate millimeter measurement markings along the shaft of the probe, providing a visible graduation for live, clinical use during ophthalmological procedure.

Conclusions/action items:

This design looks to use metal deposition through electroplating to achieve the desired graduation. Selective regions of the probe would be graduated through use of masking. Further help to achieve the technique necessary for precise graduation is needed and should be researched for on campus resources.

03/11/2026 - Bowman Probe Measurement

CALEB WHITE - Mar 12, 2026, 11:20 PM CDT

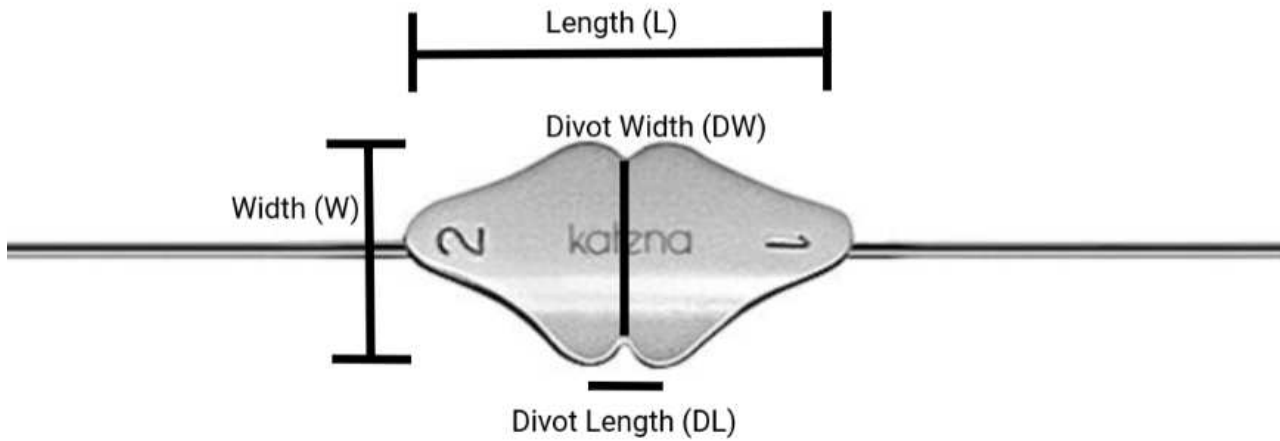
Title: Bowman Probe Measurement

Date: 03/11/2026

Content by: Caleb White

Goals: Measure the bowman probe set with a calibrated caliper in order to know the dimensions required for the CAD holder design.

Content:



Probe #	Probe Size	L (mm)	W (mm)	DL (mm)	DW (mm)
1	3/4	25.630 +/- 0.02	11.343 +/- 0.01	4.867 +/- 0.02 4.690 +/- 0.01	9.503 +/- 0.02
2	7/8	25.356 +/- 0.01	11.233 +/- 0.01	4.270 +/- 0.02 3.865 +/- 0.02	9.410 +/- 0.02
3	7/8	25.467 +/- 0.01	11.220 +/- 0.00	3.983 +/- 0.03 4.457 +/- 0.02	9.473 +/- 0.03
4	3/4	25.450 +/- 0.00	11.360 +/- 0.02	3.910 +/- 0.02 4.72 +/- 0.03	9.447 +/- 0.01

Conclusions/action items:

There is more variability especially in the divot sections than expected. I think based on the variability observed when measuring, a simple box that locks in which allows the probes to be screwed down would be ideal. As long as we can hold it in a repeatable place; the design does not have to be perfect, the fit does not have to be immensely snug. On Monday we will find out the laser bed situation which will provide a lot of clarity on the matter.

 **Biosafety106: Autoclave Use - Training Through the Curriculum**

CALEB WHITE - Apr 04, 2026, 1:45 PM CDT

Title: Biosafety 106: Autoclave Use

Date: 3/18/2026

Content by: Caleb White

OVCR Training Information Lookup Tool **University of Wisconsin-Madison**



This certifies that Caleb White has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/18/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	9/1/2024	9/1/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/3/2024	
Responsible and Ethical Conduct of Research (RECR)	RCR Certification	2/18/2025	No Expiration
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/30/2025	10/30/2028

Data Last Imported: 03/19/2026 12:25 PM

**Biosafety Required Training - Training Through the Curriculum - Copy**

CALEB WHITE - Apr 26, 2026, 7:15 PM CDT

Title: Biosafety Required Training**Date:** 9/1/2024**Content by:** Caleb White**OVCR Training Information Lookup Tool****University of Wisconsin-Madison**

This certifies that Caleb White has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/18/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	9/1/2024	9/1/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/3/2024	
Responsible and Ethical Conduct of Research (RECR)	RCR Certification	2/18/2025	No Expiration
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/30/2025	10/30/2028

Data Last Imported: 04/26/2026 05:26 PM

**Chemical Safety: The OSHA Lab Standard - Training Through the Curriculum - Copy - Copy**

CALEB WHITE - Apr 26, 2026, 7:17 PM CDT

Title: Chemical Safety: The OSHA Lab Standard**Date:** 9/3/2024**Content by:** Caleb White**OVCR Training Information Lookup Tool****University of Wisconsin-Madison**

This certifies that Caleb White has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/18/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	9/1/2024	9/1/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/3/2024	
Responsible and Ethical Conduct of Research (RECR)	RCR Certification	2/18/2025	No Expiration
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/30/2025	10/30/2028

Data Last Imported: 04/26/2026 05:26 PM

Responsible and Ethical Conduct of Research (RECR) - Training Through the Curriculum - Copy - Copy - Copy

CALEB WHITE - Apr 26, 2026, 7:16 PM CDT

Title: Responsible and Ethical Conduct of Research (RECR)

Date: 2/18/2025

Content by: Caleb White

OVCR Training Information Lookup Tool

University of Wisconsin-Madison



This certifies that Caleb White has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/18/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	9/1/2024	9/1/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/3/2024	
Responsible and Ethical Conduct of Research (RECR)	RCR Certification	2/18/2025	No Expiration
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/30/2025	10/30/2028

Data Last Imported: 04/26/2026 05:26 PM



UW Human Subjects Protections Course - Training Through the Curriculum - Copy - Copy - Copy - Copy

CALEB WHITE - Apr 26, 2026, 7:16 PM CDT

Title: UW Human Subjects Protections Course**Date:** 10/30/2025**Content by:** Caleb White

OVCR Training Information Lookup Tool

University of Wisconsin-Madison



This certifies that Caleb White has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/18/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	9/1/2024	9/1/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/3/2024	
Responsible and Ethical Conduct of Research (RECR)	RCR Certification	2/18/2025	No Expiration
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/30/2025	10/30/2028

Data Last Imported: 04/26/2026 05:26 PM



01.28.2026 - Source Evaluation and Source Management

CALEB WHITE - Jan 28, 2026, 1:56 PM CST

Title: Source Evaluation and Source Management

Date: 1/28/26

Content by: Caleb White

Present: All

Goals: Learn how to use library services and databases and how to effectively apply source managers for ease of citation.

Content:

Chat GPT is a predictive text generator, NOT a search engine and they do NOT filter for accuracy and reliability.

- They can generate incorrect statements
- They do not respond to prompts consistently
- They cannot access behind pay walls to databases that we may have access to

Go to library website and filter for just databases

- You can further filter by defining specific areas of interest and specific database libraries ex: Scopus
- You can also further define search by year of publication, additional search terms, and search term delimiters such as AND, OR, and NOT.
- Use FIND IT button to access full text, otherwise you can request a full version, and you will get the full version for free in your email.

Use Zotero as a citation manager for both individual source collection and group citation control on reports and deliverables. It automatically puts source in IEEE.

- Make sure to evaluate the quality of your source by verifying the credibility of the relevance, the author, and in general the content.

Technical reports: The results of a government funded research within a scientific lab. There is a technical reports research guide on the libraries guide. Technical reports have to include everything that happened including things that went well and things that went poorly.

You can also chat with a librarian on the library's website using the ask feature in the upper right-hand corner.

Conclusions/action items:

Citation management is very important and makes the lives of researchers much easier. When researching the project, a group citation folder will help keep everything in order and everything aligned with the project. The library databases help narrow down choices for research entries and finding information.



02.11.2026 - Interview Workshop and Preliminary Presentations

CALEB WHITE - Feb 11, 2026, 2:46 PM CST

Title: Source Evaluation and Source Management

Date: 02/11/26

Content by: Caleb White

Present: All

Goals: Go through the mock interview process and learn about the criteria of preliminary presentations.

Content:

Design matrix draft should be done this Friday with outlines in notebook. The preliminary presentations should follow regular presentation format:

- bullets, limit words
- Good descriptive titles
- Figure captions; should include images, graphs and comparison plots
- Design matrix should be highlighted and highlights should guide the matrix discussion
- As this project is not continuing, don't have to give prior test data and highlights.
- CAD images need just a picture, NOT a design drawing. Just a screenshot with labels and basic dimensions are fine for a report and for the presentations.
- Graphics and sketches should again be nicely labeled, cleanly drawn, with the background removed.
- Results; don't ever show raw data, use graphical results to display themes and trends. Show statistical analysis briefly, ex: p-value
- Visualize and describe the context of use (workflow, interaction with environment) Can do block diagrams and exploded views

Interview guidelines

- bring a portfolio
- Be specific and personal
- Highlight technical skills as well as soft skills (leadership, communication)
- Be prepared to answer common questions that demonstrate you researched them
- Have some questions prepared, red flag if no questions.

1. List your three chosen questions, and the questions picked by others in your group.

Caleb [3, 5, 14] ; Neel [7, 10, 13] ; Cole [2, 11, 13] ; Terese [2, 6, 13]

2. Type your responses to your questions.

Six months from now we are all going to know each other very well. What will everyone here say you do really, really well? And what do you think everyone will know you could do better?

I would hope everyone will be satisfied with my commitment to pursue a high standard, something that myself and others around me can be proud of. If you provide effort and focus on a task, with a desire to come out the other end with a feeling of accomplishment and a feeling that you truly tried the very best you could, with the right intentions, the success of whatever you were trying should follow, and if it hasn't, then it means I am not done. I think I could be better at talking out loud, being vocal with my ideology, and not getting in my own head when getting in the weeds with a project or problem.

Sometimes it is necessary to give other people bad news or criticism in order to achieve a positive goal or to avoid a potentially more serious problem. Describe a time when you communicated something unpleasant or difficult to say to your manager, your professor, or your peers.

I have had to push peers to work harder, and contribute more towards group projects. When there is a common goal at hand, and it feels as though the work is unevenly distributed, not everyone is on task, it is important to question what is the real reason why someone is doing something, what do they want to get out of it. I have found that even when out of my depth, lost and confused, simply attempting to apply myself has returned the greatest outcomes. This is what I told these peers, that they are only inhibiting the learning experience for themselves because regardless of how much work i personally have to do, i will get it done, so it is up to them to evaluate who they are as a worker, and as a person, and what they believe they can achieve.

Talk about a serious mistake or a time when you failed at something pretty important, and explain how you resolved it or dealt with it.

When I was 16 I failed my drivers test the first time. I was devastated, surprised and completely repulsed by the embarrassment I felt. All of my driving hours had gone well but the stress and pressure of the moment cracked my performative confidence. After a day of recovery, I practiced outside with trash cans, over and over again, I practiced the moves, perfected the muscle memory and succeeded on my second attempt.

3. Describe one thing each of your peers did well during their answers, and one thing they can improve.

Neel described circumstances about past project partners and past project experiences. His answers were personal and seemed honest. He answered genuinely and attempted to give insight. He could have provided more detail on how you personally helped others for example in question 7, and been clearer about why these specific anecdotes stand out more than others.

Cole provided very personal stories which help build a strong connection with the interviewer. I think his responses would provide a good amount of insight into who he is and what kind of worker he is. He could present himself more through not necessarily his words but the way in which he presents his words. He could speak louder, be more confident, and put more emotion and intent with his stories.

Terese told personal stories and did very well to provide evidence of specific knowledge and outcomes of the projects she has worked on. Giving a glimpse, showing rather than telling, that you know what you are talking about and the experiences you are describing are real and applicable will provide confidence in the interviewer. In general, though, she could be more specific with her answers. Her answers themselves were specific, but I felt lacked to pertain to the specific questions she was intending to answer.

4. After discussing your answers with your group, how could you improve your answers?

First, I could be more vocal and present my ideas better with my specific tone. The words I am saying are good but similar to Cole, I could add more emotion and more implication to the meaning I am trying to get across to my audience. I could also be more specific. Depending on the question it is hard to be necessarily specific but for question 14 for example, even though it doesn't ask for a specific experience, I could do better to describe experiences that have shaped the view that I described in my answer.

5. How might you improve your interview skills?

To improve my interview skills, I will just need experience. Through my undergraduate degree I have come to realize just as important as meaningful experience is the way in which you sell yourself to the employer. Because so many people have such similar resumes, the employers want to feel that you are dying for the job and that the experiences you have tailor you to be the perfect candidate. I want to get better at selling myself whilst simultaneously building my resume up stronger.

Conclusions/action items:

The lecture today provided a bit of review on what makes a good preliminary presentation but mainly focused on interview practice. I got to answer some mock interview questions and have my peers rate my responses. Overall, I felt it was an effective exercise to identify where my interview strengths and weaknesses are but also get an insight into where other people are at, so I can learn from and teach to those around me.



02.25.2026 - Diversity and Inclusion in Design

CALEB WHITE - Feb 25, 2026, 2:03 PM CST

Title: Diversity and Inclusion in Design

Date: 02/25/26

Content by: Caleb White

Present: All

Goals: Learn about diversity and inclusion in design.

Content:

What does Diversity mean in engineering design:

- Diversity in terms of engineering design means approaching a problem with a broad spectrum of ideas, backgrounds, and potential solutions. Making things widely accessible, making the audience wide and also the producer wide. Open mind to others perspectives, promote differences, learn from others with an open mind. Inclusivity in design considerations, different skill sets. A wide variety of educational experiences. Testing designs with multiple demographics, making sure there is not a one-size-fits-all approach. Cultural differences, Ex: different colored band-aids.

What does Universal design mean:

- It means developing something that can be utilized by all who desire to. It should not be limited to a specific class, race, or religious group but on the purpose of the design itself and its value as a product. This includes considering diversity during the engineering design. Making the design intuitive for use so it does not require a lot of expertise for use.

7 principles of universal design

- Equitable use: useful and marketable design to people with diverse abilities
- Flexibility in use: the design accommodates a wide range of individual preferences and abilities
- Feedback
- Perceptible information: design communicates necessary information effectively to the user, regardless of ambient conditions
- Tolerance for error: Design minimized hazards and the adverse consequence of accidental or unintended actions
- Low Physical effort: The design can be
- Size and space for approach and use: appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

Relation to ethics:

- Ethics is what is morally correct from a human point of view, how can you help others for the sake of helping them. If you are not designing for the most people possible, specifically excluding groups and demographics, this could be considered ethically incorrect.
- Biomedically engineering code of ethics

In class activity:

- What components of design can be improved

If someone had an allergy to the chromium or nickel alloy coating on the probe, we could create separate probes that have different coatings which would expand user accessibility.

- Which of the 7 principles are being addressed

This is a specific address to equitable use, where the allergy of an individual should not hinder their ability to use the product in its entirety.

- How can you make these improvements? What is your action plan

To make these improvements we can generate other designs with different coatings. There are several other coating types including cobalt which could be applied.

Conclusions/action items:

It is very important during the engineering design process to consider all diversity and universal considerations for the product.

Increasing the demographic of use in any way possibly is monetarily and ethically advantageous for the design team. It is also necessary to reflect on how the Universal design laws apply to the Bowman Probe project.



03.04.2026 - Patents, Standards, and Other Resources for Design

CALEB WHITE - Mar 04, 2026, 2:45 PM CST

Title: Patents, Standards, and Other Resources for Design

Date: 03/04/26

Content by: Caleb White

Present: All

Goals: Learn about patents, standards, and market industry databases.

Content:

UW Library has access to:

- ASTM, ISO, ASABE, IEEE standards
- historical print collection
- In all other cases check TechStreet Enterprise for titles and use the 'Request a Standard' form

Market/Industry Sources

- find information on companies, industries, consumer trends with Business databases
- Library research guides to help you get started with these databases

Specific Recommendations: Datra Axle Reference Solutions, IBISWorld industry Reports, ProQuest One Business

Patents

- Patent examiners evaluate applications against prior art, which includes inventions disclosed in US and foreign patents and patent applications. inventions disclosed in publications, any inventions currently for sale or in public use

The Spungee: packaging US 6,474,260

- can find patent at [Lens.org](https://lens.org)

But design is not only prior art relevant to our invention, need to dig deeper, find more

- Can use the cited page
- Patent evaluation evaluates for: usefulness, novelty, functionality

Claims

- Define legally enforceable aspects of patent
- Every utility

2 types:

- Independent: standalone contain all limitation necessary to define invention
- Dependent: must refer to a previous claim, must further limit the claim

Doing a claim comparison, you can identify what standards are more descriptive to gain an idea of what are deemed as appropriate differences for separate patents

Conclusions/action items:

Using patents for device creation is essential. Identifying not only what exists but also what is legally bound as an idea is core to eventual market placement. If not done correctly there are sever legal issues associated with the matter which makes the matter so intense.



03/06/2026 - Tong Distinguished Lecture - Dr. Williams

CALEB WHITE - Mar 08, 2026, 8:33 PM CDT

Title: Tong Distinguished Lecture - Dr. Williams

Date: 03/06/26

Content by: Caleb White

Present: All

Goals: Learn about patents, standards, and market industry databases.

Content:

Speaker: Dr. Justin Williams

Summary:

The talk discussed Dr. Williams upbringing, his education, and his career contributions and interests, including a deep discussion of his neurostimulation startups. His experiences are copious and he has made significant contributions towards the neurostimulation field both in clinical practice and industry. He has worked on finding better ways to help with various brain diseases including epilepsy, ALS, and parkinsons. His work has garnered appraisal around the scene and he is a well known figure in the the nuerodevice sphere. He came from the farm town of Trenton, South Dakota with a population of 91. He emphasizes the hard lifestyle of farming and his father's wishes for him and his brother to escape the farming scene by going to college. He attended South Dakota State to run track and be a mechanical engineer. He spent a few years working for Daktronics, the main scoreboard manufacturer in the US. He then attended Arizona State University for his graduate school because of their flourishing scene in the new field of bioengineering. He then went to University of Michigan for his postgraduate research where he would commute between Ann Arbor and Madison on the weekends to work on the first couple of his startups. His first startup failed but he kept at is and continued to work on his craft, abiding by his passion to help others. His first main breakthrough was the flexible electronic stimulation pad made for localizing epileptic seizure location. This took away from the invasive nature of the current methods where an entire chunk of the skull had to be removed to place the electrodes appropriately. His patent was taken by the writers of Greys Anatomy for an episode about these flexible electrode pads. His work then transitioned into ALS typing technology where brain electrodes would be paced on the scalp and would detect the letters being thought of. This work lacked a market and was therefore given away for free. He had several other companies following this and continues to work with and do research with neurostimulation devices to this day. His work is inspirational and his contributions to the field are more than meaningful.

Conclusions/action items:

Dr. Williams is a massively accomplished neuro-engineer focused on finding better therapies and work arounds to prevalent brain diseases. His journey has been filled with ups and downs, uncertainty and a lot of perseverance. His story is inspirational and there is so much more that can be taken away from his talk than just an introduction into a new area of interest or research.



03/11/2026 - Protocol Development

CALEB WHITE - Mar 12, 2026, 11:03 PM CDT

Title: Protocol Development

Date: 03/11/26

Content by: Caleb White

Present: N/A

Goals: Learn the steps of protocol development

Content:

Low fidelity prototype fabrication is necessary. Fail and learn fast.

Need to be at the stage of completed low stakes prototype, Circuit diagrams, fittings, simple calculations, Free body diagrams, Mechanics of materials

Materials: Detailed list, match material expense table + more

- Name of the material
- Concentration, amount or starting dimensions
- Manufacturer and part number
- Purpose of the material
- List of equipment needed (manufacturer and model number if known)
- Include references to papers or research in other parts of the notebook.

Methods: Step-by-step plan, list

- Mix - for how long and with what vigor
- Cut - with what tool

Sample Protocol:

1. Follow entry guidelines
2. Materials list at the beginning
3. Step-by-step process run through, detailed enough so that it can be followed

Manufacturing

Consider throughout the process

Can a 3D printed be design be actually professional manufactured

Common professional methods

- Molding: blow, injection, thermoforming
- Machining/Subtractive: mill, lathe, waterjet
- Joining: welding, soldering, screwing, riveting, adhesives

Conclusions/action items:

The team was have a first draft of their fabrication and testing protocols done by next Tuesday, prior to the show and tell on Wednesday. It is important to be as specific as possible and describe the materials and procedure so that an individual with no items and no experience could purchase and complete the supposed task.



03/18/2026 - Brevity in Communication

CALEB WHITE - Mar 18, 2026, 6:13 PM CDT

Title: Brevity in Communication

Date: 03/18/2026

Content by: Caleb White

Present: N/A

Goals: Learn the necessity of brevity in communication

Content:

Elevator Pitches: Succinctly and effectively communicate your ideas

- Seize opportunities

- Use and 'elevator ride' to pitch = short

Goals: Capture attention, generate interest, leave an impression

Know your audience: tailor your pitch to interests and needs to audience

Practice, practice, practice: Rehearse your pitch until it flow naturally and confidently

Be authentic: let your passion and enthusiasm shine through

Keep it simple: avoid complex jargon and technical language

General structure:

- Attention grabber: Immediately let them know what you are looking for

- Introduction: We are working on project X (very concise)

- Value proposition: Target consumer, how the design/product serves a specific problem, emphasize the usefulness

- Benefits: Why is it unique, why is it worth giving time and effort to, why have other devices and ideas failed

- Actionable closer

Tong BME Awards should be selected, pick 1 of 2 awards that the team wants to compete for.

Do's and Don'ts of elevator pitching

- Maintain eye contact and exude confidence

- Keep it concise and focused

- Tailor your pitch to different audiences
- Don't forget to listen to audience
- Don't sound rehearsed or robotic

Executive Summary:

Provide an elevator pitch into a 1-page document

Make sure to know the audience and include

Abstract: Provide a clear concise and specific summary of work done through the semester
Help's reader decides include background, idea, creation, and testing

Reports: Eliminate extraneous text, do not explain the obvious. Only provide the details that are required to actually reproduce the product

Remove redundant pairs ("end results" "important essentials", "basic fundamentals")

Avoid conversational text

Do not include raw data

Remove Redundancies

Make sure to proofread others work not just the things you wrote.

Conclusions/action items:

For show and tell, the team should prepare a detailed elevator pitch so that we can provide as much information in as concise a manner as possible. In order to get the most out of the session, details about current designs, fabrication practices, and difficulties should be provided. Advice on any of these, including the testing of these facets will be helpful and necessary for a successful project.



03/25/2026 - Ethics Discussion

CALEB WHITE - Mar 25, 2026, 2:13 PM CDT

Title: Ethics in Discussion

Date: 03/25/2026

Content by: Caleb White

Present: N/A

Goals: Learn about the ethics associated with the engineering design process

Content:

They come from your own personal experiences, your religion, your parents and your upbringing. Personal ethics is different from professional ethics.

The way in which you structure your approach and define ethical criteria is how professional and personal ethics differ. The decision of professional ethical criteria comes from the group. Biomedical engineering society has a set of ethics they want you to abide by

COE instructors perceive that instructors and students value ethics at different levels.

Solving an ethical dilemma is much like the design process. This involved establishing a need, understanding the problem, generating a solution

Ethical decision making process needs awareness, stakeholders, options, and an analysis of options. Analysis includes Harm test: How many negative consequences, publicity test: If it were to come out in the news how would you feel, reversibility test, and universality test, respect for persons test, utilitarian test: the best for most without attack on a single minority, Social Justice test.

- Type up your answers and add to the case study answers (Q 1-4 above) – upload to Canvas. Copy and paste your design-specific ethics responses into your design notebook.

- What components of your design have ethical dimensions (be specific and list at least 2)?

Possibility of probes breaking during procedure

The laser marking process & creation of oxide layer could lead to sequestration of metal ions from the base layer, causing potential allergic reactions in patients during procedures.

If the probe is ground down, it might not be properly cured or rounded, leading to a rough edge and possibly impacting inner tissues

- How will your team address the ethical dimensions? (What is your action plan?)

Our team will ensure full transparency in releasing testing results, and disclosing these results to the surgeon applying the procedure. Multiple testing procedures will take place to better understand if these concerns could be a reality.

Conclusions/action items:

Ethical considerations are very important for professional product use. As provided in the example case study, companies and lives can be lost because of the failure to be transparent about data.



04/08/2026 - Engineering Judgement

CALEB WHITE - Apr 08, 2026, 3:11 PM CDT

Title: Engineering Judgement

Date: 04/08/2026

Content by: Caleb White

Present: N/A

Goals: Learn about engineering judgment, what it is and how it is used in every form of design

Content:

Engineering judgment is applied in real-world engineering problems, dealing with open ended problems, teamwork and collaboration with others, critical thinking (Evaluating solutions), communication, handling uncertainty including incomplete information, asking questions

Three domains of the model

- Attitudes: what you feel and believe about a specific issue
- Behaviors: How you demonstrate and act upon your knowledge upon a specific issue
- Cognitive (internal and external): What you know about, and are able to do to address a specific issue

Original model

A Model for Engineering Judgement

(Adapted from D. Chadha, Imperial College London)

Attitudes (internal) What you feel and believe about a specific issue.	Behaviours (external) How you demonstrate and act upon your knowledge and attitudes while addressing a specific issue.	Cognitive (internal & external) What you know about, and are able to do, to address a specific issue.
When you consider applying Engineering Judgement to a complex issue, to what extent is it helpful for you to:	When you consider applying Engineering Judgement to a complex issue, to what extent is it helpful for you to:	When you consider applying Engineering Judgement to a complex issue, to what extent is it helpful for you to:
A1. Realize that pure memorization can lead to constraints	B1. Take responsibility for your own learning	C1. Clearly identify a problem
A2. Appreciate that education is a foundation for lifelong learning	B2. Ask questions for clarification and deeper understanding	C2. Apply logic to engineering work
A3. Possess a deep passion for engineering as a discipline	B3. Treat failure as a lesson	C3. Use a sequential thought processes in engineering work
A4. Know that an individual's judgement is a limited perspective and can limit broad application	B4. Document rules, lessons learned, and procedures throughout the design process	C4. Demonstrate competency in a defined content area
A5. Comfortably respond to making mistakes (yours and others)	B5. Value creative contributions from self and others toward the desired objectives	C5. Apply fundamental theoretical knowledge to engineering work
A6. Comfortably celebrate individual and team success	B6. Reflect on how assumptions and biases influenced the outcome	C6. Articulate the context and consequences that go beyond merely a technical solution
A7. Feel a sense of self-confidence in making decisions	B7. Engage in the process of continuous improvement	C7. Use imagination and intuition in engineering work
A8. Value collaboration with others over competition with others	B8. Use past experiences to inform future work	C8. Exercise common sense to draw conclusions and make reasonable recommendations

Conclusions/action items:

Engineering judgment



04/15/2026 - Poster Presentations

CALEB WHITE - Apr 15, 2026, 1:54 PM CDT

Title: Poster Presentation

Date: 04/15/2026

Content by: Caleb White

Present: N/A

Goals: Learn about what makes a good poster and what makes a bad poster

Content:

Good Poster:

- Clear figures
- No overload of info
- No raw data
- Device process demonstration
- Clear text
- Consistent formatting

Bad Poster:

- Blurry, hard to read figures
- Overload of information
- Raw data
- Small poster, no figures
- Device process demonstration
- Bad formatting

Too much text - use diagram

Images need labels and scale

Graphs need labels, titles, legend too small show stats, what is the takeaway

Table with title and clear purpose and direction of focus

Prior to printing, read the requirements and evaluation form

Include relevant and correct contact information (names, emails, websites, affiliations)

Descriptive but succinct title and subtitles

Have a storyline (what are you doing and why do we care, why should we care)

Don't show all results if don't have to. Highlight meaningful results and reference all data.

Captions, all figures and graphics must have captions

Fonts; style must be easy to read

Colors; use for ease of reading, to separate sections and to highlight important point

- avoid harsh colors
- avoid using too many colors
- generally, light background, dark text

Formatting:

- must be able to read text from 3ft, use 'view' at 100%, usually 24-28 font
- References in relatively small font

Context of use and workflow

- Start with the user and setting (who, where)
- Show workflow (before->during->after, and/or inputs-outputs)
- Place in a larger system (app, clinic, decision)
- Use color/grouping to organize/show what belongs together
- Use labels with minimal text
- Keep it high-level and understandable

Flow charts should be easy to read, have a clear start, direction and ending point which makes sense. The flow chart should be inherently easy to follow because of the logic associated with it.

Conclusions/action items:

Engineering judgment



2026/1/30- Congenital Nasolacrimal Duct Obstruction

Cole Miller - Jan 30, 2026, 12:00 PM CST

Title: Congenital Nasolacrimal Duct Obstruction

Date: 1/30/26

Content by: Cole M.

Search Term: Nasolacrimal

Citation: J. Heichel, "Congenital Nasolacrimal Duct Obstruction - Early Diagnosis and Graded Therapeutic Approach as Key Points for Successful Management," *Seminars in Ophthalmology*, pp. 1-11, May 2024, doi: <https://doi.org/10.1080/08820538.2024.2358328>.

Link: <https://pubmed.ncbi.nlm.nih.gov/38794810/>

Goals: Learn about Nasolacrimal Duct Obstruction, diagnosis, and treatment

Content:

Definition & Clinical Context

- Epiphora in children = common presenting symptom.
- Most commonly caused by Congenital Nasolacrimal Duct Obstruction (CNLDO).

Differential Diagnosis

- Not all pediatric epiphora is due to CNLDO.
- Important alternatives to consider:
 - Inflammatory ocular surface diseases
 - Intraocular inflammatory conditions
 - Congenital glaucoma

Therapeutic Concept for CNLDO

- Staged (stepwise) management strategy is recommended.
- Goal:
 - Achieve resolution with minimal invasiveness
 - Preserve lacrimal system anatomy
 - Allow individualized treatment based on response

Success Rate

- Approximately 95% cure rate

- ~~Approximately 95% cure rate~~
- Achieved using conservative or minimally invasive interventions

Conclusions/action items:

This article provides a good background on Nasolacrimal Duct Obstruction, which can inform the design of our Bowman Probes



2026/1/30-Probing for Congenital Nasolacrimal Duct Obstruction in Older Children

Cole Miller - Jan 30, 2026, 1:11 PM CST

Title:

Date: 1/30/26

Content by: Cole M.

Search Term: Bowman Probe

Citation: M. Fard, B. Eshragi, B. Masomian, and M. Akbari, "Probing for congenital nasolacrimal duct obstruction in older children," *Middle East African Journal of Ophthalmology*, vol. 20, no. 4, p. 349, 2013, doi: <https://doi.org/10.4103/0974-9233.120018>.

Link: <https://pmc.ncbi.nlm.nih.gov/articles/PMC3841956/>

Goals: Learn about the bowman probing process

Content:

Study Overview (Context)

- Condition: Congenital Nasolacrimal Duct Obstruction (CNLDO)
- Population: Children \geq 24 months (2-5 years)
- Purpose:
 - Evaluate effectiveness of primary probing in older children
 - Identify factors predicting probing outcome
- Key Finding:
 - Probing remains effective without age-related decline
 - Bilateral CNLDO is the main predictor of failure

Bowman Probe Procedure – Step-by-Step Notes

Preparation

- Procedure performed under general anesthesia
- Conducted by a single oculoplastic surgeon
- Upper punctum selected for entry
- Bowman probes size 0 and 00 used

Step 1: Punctal Dilatation

- Upper punctum is gently dilated
- Ensures smooth introduction of the Bowman probe

Step 2: Vertical Insertion

- Bowman probe introduced vertically into:
 - Punctum
 - Ampulla
- Maintains alignment with natural anatomy

Step 3: Horizontal Rotation into Canaliculus

- Probe rotated 90° horizontally
- Advanced into the canaliculus
- Lateral tension applied to eyelid to straighten canaliculus and reduce trauma

Step 4: Advancement to Lacrimal Sac

- Probe advanced until bony resistance is felt
- Bony firmness indicates entry into the lacrimal sac

Step 5: Rotation and Entry into Nasolacrimal Duct

- Probe rotated upward 90°
- Advanced downward through the nasolacrimal duct
- Resistance at distal end usually membranous (Valve of Hasner)

Step 6: Perforation of Membranous Obstruction

- Gentle pressure applied until probe passes through membranous resistance
- Entry into nasal cavity confirmed

Step 7: Confirmation of Nasal Entry

- Second probe used intranasally to confirm metal-to-metal contact
- Contact detected below the inferior turbinate

Step 8: Irrigation to Confirm Patency

- Saline irrigated through superior punctum
- Successful probing confirmed by:

- Saline flow into nasal cavity
- Detection using pediatric suction catheter below inferior meatus

Step 9: Postoperative Care

- Topical medications prescribed for 2 weeks
- Follow-up at 1 month and 6 months

Conclusions/action items:

Becoming familiar with the bowman probe process will allow us to best improve upon its design, keeping in mind its usage.



2026/1/30- Anatomy, Head and Neck: Eye Lacrimal Gland

Cole Miller - Jan 30, 2026, 1:07 PM CST

Title: Anatomy, Head and Neck: Eye Lacrimal Gland

Date: 1/30/26

Content by: Cole M.

Search Term: Nasolacrimal Anatomy

Citation: R. Machiele, M. J. Lopez, and C. N. Czyz, "Anatomy, Head and Neck, Eye Lacrimal Gland," PubMed, 2020. <https://www.ncbi.nlm.nih.gov/books/NBK532914/>

Link: <https://www.ncbi.nlm.nih.gov/books/NBK532914/>

Goals: Learn about Nasolacrimal System anatomy

Content:

1. Lacrimal Gland

- Shape & Structure:
 - Bilobed, tear-shaped exocrine gland
 - Divided by the levator palpebrae superioris tendon into:
 - Orbital lobe (larger, in lacrimal fossa of frontal bone)
 - Palpebral lobe (smaller, extends into upper eyelid)
- Location:
 - Anterior, superotemporal orbit
- Histology:
 - Predominantly serous acini
 - Also contains mucinous acini, myoepithelial cells, and ductules

2. Tear Film Components

- Three layers:
 1. Mucin layer (inner) – from conjunctival goblet cells; allows tear adhesion to cornea
 2. Aqueous layer (middle) – from lacrimal gland; bulk of tear volume
 3. Lipid layer (outer) – reduces evaporation
- Function:

- Protects ocular surface
- Provides smooth optical interface
- Removes debris

3. Lacrimal Duct System (Secretion Pathway)

- Interlobular ducts connect orbital and palpebral lobes
- Excretory ducts:
 - Both lobes drain into upper conjunctival fornix
 - 2-5 ducts from palpebral lobe drain into lower conjunctival fornix

4. Lacrimal Drainage System

- Tears drain sequentially through:
 1. Lacrimal puncta
 2. Canaliculi
 3. Lacrimal sac
 4. Nasolacrimal duct
 5. Valve of Hasner
 6. Nasal cavity
- Provides tear clearance into the nose

Conclusions/action items:

- The anatomy of the Lacrimal system will be important to keep in mind throughout the project, and this article will provide an excellent reference.



2026/2/6-Guidelines for the cleaning and sterilization of intraocular surgical instruments

Cole Miller - Feb 06, 2026, 11:40 AM CST

Title: Guidelines for the cleaning and sterilization of intraocular surgical instruments

Date: 2/6/26

Content by: Cole M.

Goals: Research typical sterilization procedures of intraocular instruments to inform life in service and operating environments in PDS

Search Term: Sterilization + Bowman Probe

Citation: D. F. Chang, N. Mamalis, and Ophthalmic Instrument Cleaning and Sterilization Task Force, "Guidelines for the cleaning and sterilization of intraocular surgical instruments," *Journal of Cataract and Refractive Surgery*, vol. 44, no. 6, pp. 765-773, Jun. 2018, doi: <https://doi.org/10.1016/j.jcrs.2018.05.001>.

Link: <https://doi.org/10.1016/j.jcrs.2018.05.001>.

Content:

Life in Service:

- Intended Use Duration:
 - Individual clinical uses are brief
 - Typically seconds to under one minute per procedure
 - Despite short use times, probes are reused frequently over many years
- Reusability & Longevity:
 - Ophthalmic instruments are commonly reused for many years (5-10+ years) when properly maintained
 - Repeated reuse is considered safe provided structural integrity and surface condition are maintained
 - Functional degradation (e.g., bending, surface wear, loss of markings) is a primary end-of-life concern
- Material Implications:
 - Instruments exposed to frequent sterilization must be made from:
 - Corrosion-resistant metals (e.g., stainless steel)
 - Materials that resist:
 - Surface pitting
 - Oxidation
 - Microstructural fatigue
 - Studies of reusable ophthalmic tools show no significant structural damage after dozens of autoclave cycles, supporting long service life when appropriate materials are used
- Sterilization Frequency:
 - Reusable ophthalmic instruments are routinely subjected to hundreds of sterilization cycles over their lifetime

- Steam sterilization (autoclaving) is the standard method
- **Cleaning Considerations:**
 - Instruments must tolerate:
 - Repeated manual cleaning
 - Flushing and rinsing with purified (“critical”) water
 - Smooth surfaces are preferred to:
 - Minimize debris retention
 - Reduce cleaning difficulty
 - Excessive surface roughness increases risk of residue retention and inflammation (TASS)

Conclusions/action items:

This information will be important to keep in mind throughout our project, as ensuring our graduated probes, along with the graduated markings/engravings, are durable enough to withstand sterilizations procedures without degrading.



2026/2/6-Tool-tissue forces in surgery: A systematic review

Cole Miller - Feb 06, 2026, 11:54 AM CST

Title: Tool-tissue forces in surgery: A systematic review

Date: 2/6/26

Content by: Cole M.

Goals: Research typical forces required of the Bowman probe to complete ergonomics section of PDS and detail the required strength of our Bowman probe.

Search Term: Ophthalmology instruments + Forces

Citation: A. K. Golahmadi, D. Z. Khan, G. P. Mylonas, and H. J. Marcus, "Tool-tissue forces in surgery: A systematic review," *Annals of Medicine and Surgery*, vol. 65, p. 102268, May 2021, doi: <https://doi.org/10.1016/j.amsu.2021.102268>.

Link: <https://doi.org/10.1016/j.amsu.2021.102268>

Content:

1. Required Insertion Force

- Force Magnitude in Ophthalmology:
 - Ophthalmology procedures require the lowest applied forces of all surgical specialties
 - Mean of average forces: ~0.04 N
 - Maximum forces typically < 0.1 N
 - Retinal and other delicate ocular tissues are manipulated at forces well below 1 N, often orders of magnitude lower
- Relevance to Bowman Probes:
 - Lacrimal probing involves delicate epithelial and canalicular tissue
 - Design limit of ≤ 1 N insertion force is conservative and safely above typical forces used in ophthalmic manipulation
 - Probe stiffness must allow controlled advancement without requiring excess force

2. Torsional and Twisting Forces

- Observed Surgical Practice:
 - Excessive torsion during tool-tissue interaction is associated with increased tissue damage
 - Ophthalmic instruments rely on:
 - Minimal twisting
 - Fine rotational adjustments rather than sustained torque
 - No high torsional loads are reported in ophthalmology compared to other specialties
- Implications for Bowman Probes:
 - Probe must tolerate minimal torsion forces generated by gentle rotational guidance
 - Design should prioritize:
 - Dimensional
 - Resistance to permanent bending rather than torsional fatigue

- No requirement for high torque resistance

Conclusions/action items:

As Ophthalmological instruments typically are exposed to very low forces during use, a limit of 1 N is a conservative guideline to ensure that our probe is significantly durable for intended use. Additionally, the information on forces, torque, and fatigue will need to be referenced throughout the project to ensure durability for prolonged use.



2026/2/6-The Effects of Laser Marking and Symbol Etching on the Fatigue Life of Medical Devices

Cole Miller - Feb 06, 2026, 12:43 PM CST

Title: The Effects of Laser Marking and Symbol Etching on the Fatigue Life of Medical Devices

Date: 2/6/26

Content by: Cole M.

Goals: Determine how we could use laser markings to make graduated markings on our probe, and the effects it would have

Search Term: Laser Engraving

Citation: P. J. Ogrodnik, C. I. Moorcroft, and P. Wardle, "The Effects of Laser Marking and Symbol Etching on the Fatigue Life of Medical Devices," *Journal of Medical Engineering*, vol. 2013, pp. 1-6, 2013, doi: <https://doi.org/10.1155/2013/570354>.

Link: <https://doi.org/10.1155/2013/570354>

Content:

1. Laser Marking Mechanism

- Process Characteristics:
 - Laser marking modifies metallic surfaces through:
 - Localized heating
 - Material removal or microstructural alteration
 - The depth and geometry of the mark depend on:
 - Laser power
 - Pulse duration
 - Number of passes
 - On stainless steel, laser marking commonly produces:
 - Visible contrast via surface oxidation or texture change

2. Surface Defects & Geometry

- Defect Formation:
 - Laser markings create localized surface discontinuities that behave as:
 - Micro-notches
 - Stress concentrators
 - Measured marking depths of ~25 μm or greater are readily achievable, even under typical processing conditions
 - Unlike machined engravings, laser marks:
 - Lack controlled radii at edges
 - Often contain sharp transitions that amplify local stress
- Surface Texture Effects:
 - Laser-etched regions exhibit:
 - Raised ridges

- Roughened edges relative to the surrounding polished surface
- These features disrupt the otherwise smooth finish expected for atraumatic ophthalmic instruments

3. Design Implications for Bowman Probe Markings

- Marking Strategy:
 - Markings should:
 - Minimize depth and width to preserve cross-sectional strength
 - Avoid creating pronounced ridges or sharp transitions
 - Thin, shallow laser markings reduce the likelihood of:
 - Localized weakening
 - Surface roughness that could damage lacrimal tissue
- Laser Parameters:
 - Lower-energy laser settings that rely on:
 - Surface discoloration
 - Minimal material removal are preferable for small-diameter probes
 - This approach maintains legibility while limiting mechanical compromise

Conclusions/action items:

As laser engraving continues to be a viable option for creating the markings of our graduated probes, we must pay attention to how it will affect the strength of our probe. Additionally, this is a helpful starting source for planning how we plan to apply laser engraving to our project.



2026/2/12-Electropolishing and Shaping of Micro-Scale Metallic Features

Cole Miller - Feb 13, 2026, 12:31 PM CST

Title: Electropolishing and Shaping of Micro-Scale Metallic Features

Date: 2/12/26

Content by: Cole M.

Goals: Research methods of improving laser engraving

Search Term: Electropolishing

Citation: S. Zaki, N. Zhang, and M. D. Gilchrist, "Electropolishing and Shaping of Micro-Scale Metallic Features," *Micromachines*, vol. 13, no. 3, p. 468, Mar. 2022, doi: <https://doi.org/10.3390/mi13030468>.

Link: <https://doi.org/10.3390/mi13030468>

Content:

How Electropolishing Works

- Electrochemical material removal process (reverse of electroplating).
- The steel part acts as the anode in an electrolytic bath (commonly phosphoric/sulfuric acid mixture).
- A DC current passes between the part (anode) and a cathode.
- High points (microscopic surface peaks) dissolve faster than low points.
- This results in surface leveling and smoothing at a micro-scale.
- A thin layer of material (typically 5–50 μm) is uniformly removed.

Why Electropolishing Is Used

- Improves corrosion resistance
- Reduces surface roughness
- Improves cleanability and sterilization
- Removes burrs and micro-defects
- Improves aesthetic finish
- Enhances fatigue life

Laser engraving (or mechanical engraving) creates:

- Surface grooves and cavities
- Heat-affected zones (in laser engraving)
- Micro-cracks or burrs
- Disrupted passive layer

Electropolishing can help restore the surface by:

- Smoothing engraved edges
- Reducing surface roughness in engraved areas
- Improve biocompatibility

Conclusions/action items:

Electropolishing serves as a potential means to improve upon some of the less favorable aspects of laser engraving, namely smoothing out the roughness of the engravings. Though this is a promising solution, it removes an additional amount of material from the probe, which could make it weaker.



2026/2/12-Laser Annealing

Cole Miller - Feb 13, 2026, 12:01 PM CST

Title: Laser Annealing

Date: 2/12/26

Content by: Cole M.

Goals: Learn about laser annealing, an alternative to laser engraving

Search Term:

Citation: Laserax, "How Does Laser Annealing Work?," Laserax, Mar. 19, 2019.

<https://www.laserax.com/blog/how-does-laser-annealing-work?> (accessed Feb. 13, 2026).

Link: <https://www.laserax.com/blog/how-does-laser-annealing-work>

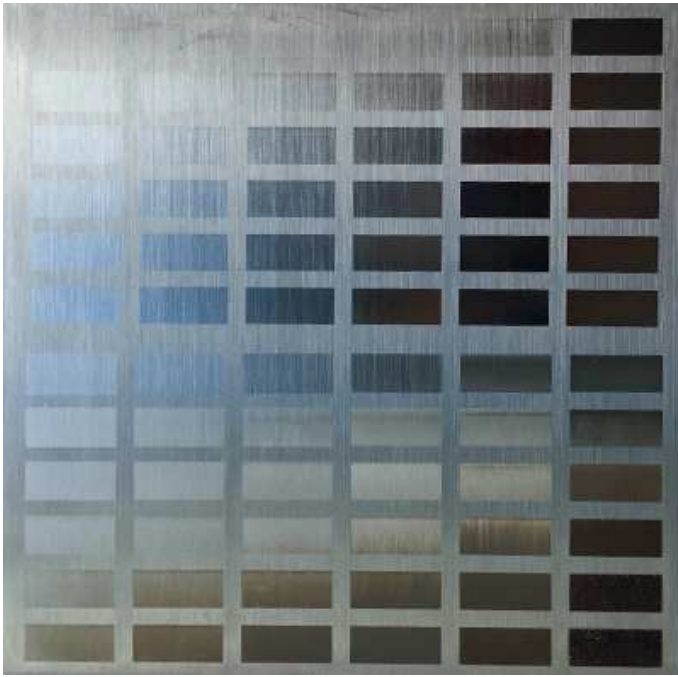
Content:

Laser Annealing Process

- Localized laser heating:
 - A laser beam slowly heats the metal surface without removing material. The process increases temperature until oxygen diffuses into the surface, causing internal oxidation rather than ablation.
- Oxide layer formation:
 - The laser-induced heat creates a thin oxide layer (typically < ~300 nm thick) beneath the surface. As light reflects off this oxide film and the substrate, thin-film interference produces visible color changes (e.g., blues, browns, blacks).
- Color change without surface roughness:
 - Because annealing doesn't remove material, the surface texture remains smooth, which is important for preventing debris retention and easing sterilization on medical instruments
- No material removal or cavities:
 - Unlike engraving, annealing does not etch grooves or create physical notches — no ablation occurs, so there are fewer places for contaminants or bacteria to lodge

Comparison to Laser Engraving

- Preserves surface smoothness
- Maintains material integrity
- Slower marking process
- Less contrast

**Conclusions/action items:**

Laser annealing is a promising alternative to laser engraving that addresses some of our concerns of engraving. Primarily, using annealing instead of engraving would allow us to preserve the mechanical strength of the probe, and preserve the smooth surface.



2026/2/13-Electroplating in the Medical Device Industry: Surface Treatment

Cole Miller - Feb 13, 2026, 12:35 PM CST

Title:Electroplating in the Medical Device Industry: Surface Treatment

Date: 2/13/26

Content by:Cole M.

Goals:Learn about the process of electroplating, what it is used for, and how we could apply it to our project

Search Term: Electroplating

Citation:C. Katchmark, "Electroplating in the Medical Device Industry-Surface Treatment," ProPlate®. Accessed: Feb. 11, 2026. [Online]. Available:

<https://www.proplate.com/medical-product-outsourcing/>

Link:<https://www.proplate.com/medical-product-outsourcing/>

Content:

Process Characteristics:

Electroplating modifies medical device surfaces through:

- Electrochemical deposition of a thin metallic layer onto a conductive substrate
- Controlled ion transfer in an electrolyte solution under applied current
- Surface bonding between the deposited coating and base material

The thickness, uniformity, and functional properties of the plated layer depend on:

- Current density
- Plating time
- Bath chemistry and temperature
- Substrate preparation and cleanliness

On stainless steel and other common medical alloys, electroplating commonly provides:

- Improved corrosion resistance
- Enhanced electrical conductivity
- Increased charge storage capacity (for electrodes)
- Antimicrobial functionality (e.g., silver-based coatings)
- Improved lubricity or dielectric performance when paired with engineered surface treatments

Electroplating is frequently used in cardiovascular, orthopedic, dental, and neuromodulation devices where electrical performance and biocompatibility are critical.

The paper did not identify any uses of Electroplating to create visible markings, instead being used to improve durability or electrical conductivity in devices. Though it is not currently used this way, it may still be possible to use electroplating to make marks on the probe.

Conclusions/action items:

This article explains the process of Electroplating, which is a possible method of creating the graduations of our bowman probe by altering the surface with a coating. Although this process has not been used to create visible measurements so far, it is still a possibility for this project.



2026/1/30- Calibrated Bowman's lacrimal probe

Cole Miller - Jan 30, 2026, 11:42 AM CST

Title: Calibrated Bowman's lacrimal probe

Date: 1/30/26

Content by: Cole M.

Search Term: Bowman's Probe

Citation: A. Pujari, M. S. Bajaj, and P. Sharma, "Calibrated Bowman's lacrimal probe," *Indian journal of ophthalmology*, vol. 66, no. 3, p. 478, Mar. 2018, doi: https://doi.org/10.4103/ijo.IJO_1063_17.

Link: <https://pubmed.ncbi.nlm.nih.gov/29480277/>

Goals: Learn about an alternative solution to this problem

Content:

Background / Clinical Problem

-
- Epiphora (excessive tearing) caused by nasolacrimal duct or canalicular obstruction is a common issue in ophthalmology.
- Traditional lacrimal probing methods:
 - Do not provide precise intraoperative feedback on how far the probe has advanced.
 - Can lead to incorrect localization of the obstruction.
 - Are often time-consuming and less accurate, especially in pediatric cases.

Existing Solutions

-
- "Smart lacrimal probes" have been previously described.
 - These include distance markings every 10 mm from the punctum.
 - Help estimate probe depth but still have limited precision.

Innovation Introduced

-
- The authors developed a calibrated Bowman's lacrimal probe with:

- Laser-engraved millimeter markings (permanent and precise).
- Calibration on both ends of the probe:
 - One side: markings every 2 mm (2-20 mm).
 - Other side: markings every 5 mm (5-20 mm).
- Laser engraving ensures:
 - Durability
 - Clear visibility
 - Accurate measurement during procedures

Clinical Advantages

- Allows precise measurement of the obstruction site from the lacrimal punctum.
- Can detect obstruction levels with accuracy as fine as 1 mm.
- Particularly useful for:
 - Pediatric therapeutic probing
 - Canalicular obstruction assessment before canalicular trephination
- Reduces:
 - Procedural time
 - Risk of false localization of blockage

Conclusions/action items:

This development creates a more accurate and efficient bowman probe that improves the functionality of the probe. This will be a helpful source of inspiration for our project.



2026/3/12-Laser Classes

Cole Miller - Mar 13, 2026, 12:30 PM CDT

Title:Laser Classes

Date: 3/12/26

Content by:Cole M.

Goals: Learn about the different classes and hazards of lasers, and compare to Pfefforkorn's lab

Link:<https://www.lasersafetyfacts.com/laserclasses.html>

Content:

- Class 1
 - Considered safe under normal operating conditions.
 - The emitted radiation is below levels that could damage eyes or skin.
 - Often enclosed inside devices so the beam is not accessible (e.g., laser printers, CD players).
- Class 1M
 - Safe for unaided viewing, but can become hazardous if viewed through optical instruments like microscopes or telescopes.
 - Hazard increases because optics can focus the beam and increase intensity.
- Class 2
 - Low-power visible lasers (<1 mW).
 - Normally safe because the blink/aversion reflex (~0.25 s) limits exposure.
 - Direct staring into the beam should still be avoided.
- Class 2M
 - Similar to Class 2 but may be hazardous when viewed with optical aids that concentrate the beam.
- Class 3R
 - Low risk but potentially hazardous if viewed directly.
 - Typical visible output power 1–5 mW.
 - Momentary accidental exposure is usually not harmful, but deliberate viewing should be avoided.
- Class 3B
 - Moderate-power lasers (5–500 mW).
 - Direct beam or specular reflections can cause serious eye injury.
 - Usually not a fire hazard and diffuse reflections are generally safe.
- Class 4
 - High-power lasers (>500 mW).
 - Dangerous to eyes and skin, and can also create fire hazards and hazardous reflections.
 - Requires strict safety controls and protective equipment
- Major Hazards
 - Eye damage
 - Even diffuse reflections (e.g., from a wall) can be hazardous at close range.
 - Skin burns
 - Fire hazards

- **Hazardous reflections**
 - Reflections from mirrors, glass, or shiny surfaces can redirect dangerous beams.
- Air contaminants and plasma
 - High-power lasers may generate laser-generated air contaminants or plasma radiation during material processing

Required Safety Practices

- Laser protective eyewear
- Controlled access:
 - Use in restricted areas with trained operators only.
- Beam awareness
 - Always know the location and path of the beam to prevent accidental exposure.
- Avoid reflective surfaces
 - Minimize mirrors or shiny materials that could reflect the beam unpredictably

Conclusions/action items:

Pfefforkorn's lab uses a 200 W laser, so we must be very careful and follow the above safety practices during use. Specifically, we must be careful to use non-reflective materials to create our fixture, and create a very in-depth fabrication plan, ensuring each step is safe.



2026/3/12-How Cermark works and Process

Cole Miller - Mar 13, 2026, 12:46 PM CDT

Title:How Cermark works and Process

Date: 3/12/26

Content by:Cole M.

Goals:Learn more about how Cermark works chemically and the application process

Link:<https://www.jpplus.com/blogs/unleashing-creativity-exploring-the-magic-of-cermark-metal-marking-spray?>

Content:

How Cermark Marks Are Created (Chemical/Physical Process)

- Cermark contains metal oxides and glass-forming compounds suspended in a liquid carrier.
- When a laser heats the coated area, the temperature rises enough to melt the compound.
- The heat causes the glass matrix and metal oxides to fuse with the metal surface.
- This creates a thin, durable ceramic-like layer chemically bonded to the substrate.
- Only the laser-exposed areas bond permanently, producing a dark, high-contrast mark.

Basic Use Steps for Cermark

1. Clean the surface of the material to remove oils or contaminants.
2. Apply a thin layer of Cermark (spray, paste, or liquid) to the area to be marked.
3. Allow the coating to dry before laser processing.
4. Run the laser marking process, which bonds the compound to the surface where the beam hits.
5. Wash or wipe away excess coating, leaving only the permanent laser-bonded markings.

Conclusions/action items:

This provides a better understanding of how Cermark works with the laser to chemically create a ceramic-like layer on the stainless steel probe. Understanding this, along with the steps needed to use Cermark effectively puts us in a good place to begin fabrication.

**Title:****Date:** 3/12/26**Content by:** Cole M.**Goals:** Investigate how the marking process works and how specific parameters effect results**Content:**

- Laser color marking on stainless steel creates durable colored markings without chemicals or inks, making it environmentally friendly and suitable for automated manufacturing.
- The main mechanism for color formation is oxidation caused by laser heating, which forms thin oxide layers on the metal surface. These layers interact with light and produce different colors.
- Two main color-generation mechanisms were observed:
 - At low energy input, yellow colors form mainly from chromium oxide (Cr_2O_3) on the surface.
 - At higher energy input, multilayer oxide films form, producing stronger and more varied colors through thin-film interference.
- Processing parameters strongly affect the resulting colors, especially scanning speed, pulse frequency, pulse energy, and heat accumulation between laser pulses
- Thermal effects are the dominant factor: higher average temperatures during processing lead to stronger oxidation and more intense coloration.
- Optimal conditions for uniform colors include high pulse frequencies, moderate pulse energies, moderate scan speeds, and small hatch distances.
- Experiments also showed that single high-energy laser pulses alone do not produce visible color, indicating that heat accumulation from multiple pulses is necessary for color formation.

Conclusions/action items:

Since the color and appearance of the markings depend strongly on laser parameters and heat accumulation, careful control of factors such as scan speed, pulse frequency, and energy input would be necessary to produce consistent and clearly visible graduations. Additionally, the results indicate that multiple pulses and proper thermal conditions are required to generate visible marks, meaning the manufacturing process would need to be optimized to ensure uniform and repeatable markings on the stainless steel probes

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Laser color marking of stainless steel – Investigation of the fluence-dependent and thermal mechanisms in generating laser induced surface modifications

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Abstract

Laser color marking is an attractive process to generate functional, aesthetic and durable colorants on various suitable materials such as stainless steel or titanium. The color generation is usually based on interference effects on thin oxide layers, usually formed by an anodized pulsed laser treatment. Due to the large number of mutually influencing processing parameters and different thermal, chemical, electrostatic and photophysical aspects of the color generation, the process is still not fully understood. This review, the reproducibility of the marking and the processing times, also do not meet the requirements of industrial manufacturing processes. To improve the understanding of the underlying phenomena responsible for the color generation using different parameters sets, spectroscopic, microscopic and SEM/EDS analyses are carried out to investigate the effects of the surface morphology, oxide layer properties, chemical composition and heat accumulation on the marking results.

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Keywords: Laser color marking; anodic film processing; oxide layers; thin film interference.

1. Introduction

In laser color marking processes, the generation of functional blocks at marking like serial numbers, production dates, quick response (QR) codes, logos or other product information can be combined with aesthetic, decorative features, and design elements [1, 2]. The process involves electrochromic, dyes or ions and is therefore electrochemically (usually) usually done of maintenance and offers high potential for an automated and fully digital workflow. The color generation is usually generated by pulsed laser processing of suitable metal surfaces from oxides containing chromophores, leading to localized modifications of the structural, morphological and chemical properties of the surface in the irradiated areas. A combination of multiple factors contributes to the visual appearance of the markings. For non-anodized pulsed laser marking processes, the main influences on the

generated colors are the kinetic of oxide growth, the effects of the oxide layer, the colors of the generated oxides themselves and the surface morphology [3]. Although most authors analyze the greatest significance is the thin film interference effect, there are still discrepancies between theoretical calculations and experimental observations. While experimentally measured oxide layer thicknesses are found to be in the range of several hundred nanometers [4, 5] in a few nanometers [6]. Thin oxide interference colors are expected to appear at layer thicknesses below 100 nm [2, 6, 7]. Despite that experimental results usually only show a single pass through a limited color scale [2, 8]. Indicating that the color generation mechanisms are not fully understood.

Numerous studies investigated the process of laser color marking and the major influencing processing parameters in the generated colors have been identified. In most of these studies two or more of the main influencing process parameters

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1-s2.0-S221282712400550X-main.pdf (1.27 MB)



2026/3/20-Probe Holder W/ Ruler

Cole Miller - Apr 29, 2026, 9:23 PM CDT

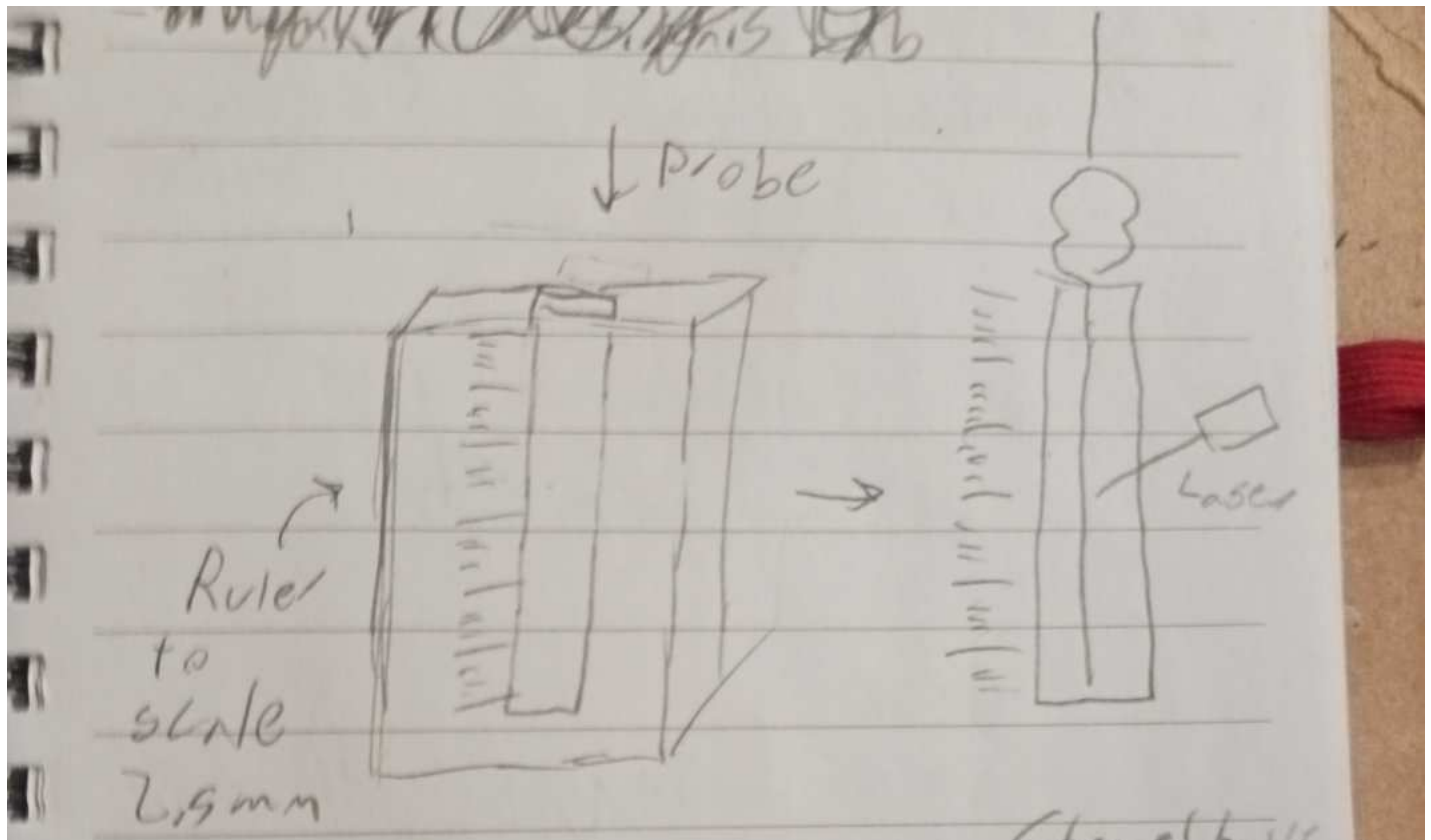
Title: Probe Holder W/ Ruler

Date: 3/20/26

Content by: Cole M.

Goals: Design a probe holder with a way to make consistent markings

Content:



- Probe inserted into probe holder
- Probe holder has a ruler to guide laser markings



2026/3/20-Sliding Probe Holder W/ Ruler

Cole Miller - Apr 29, 2026, 9:27 PM CDT

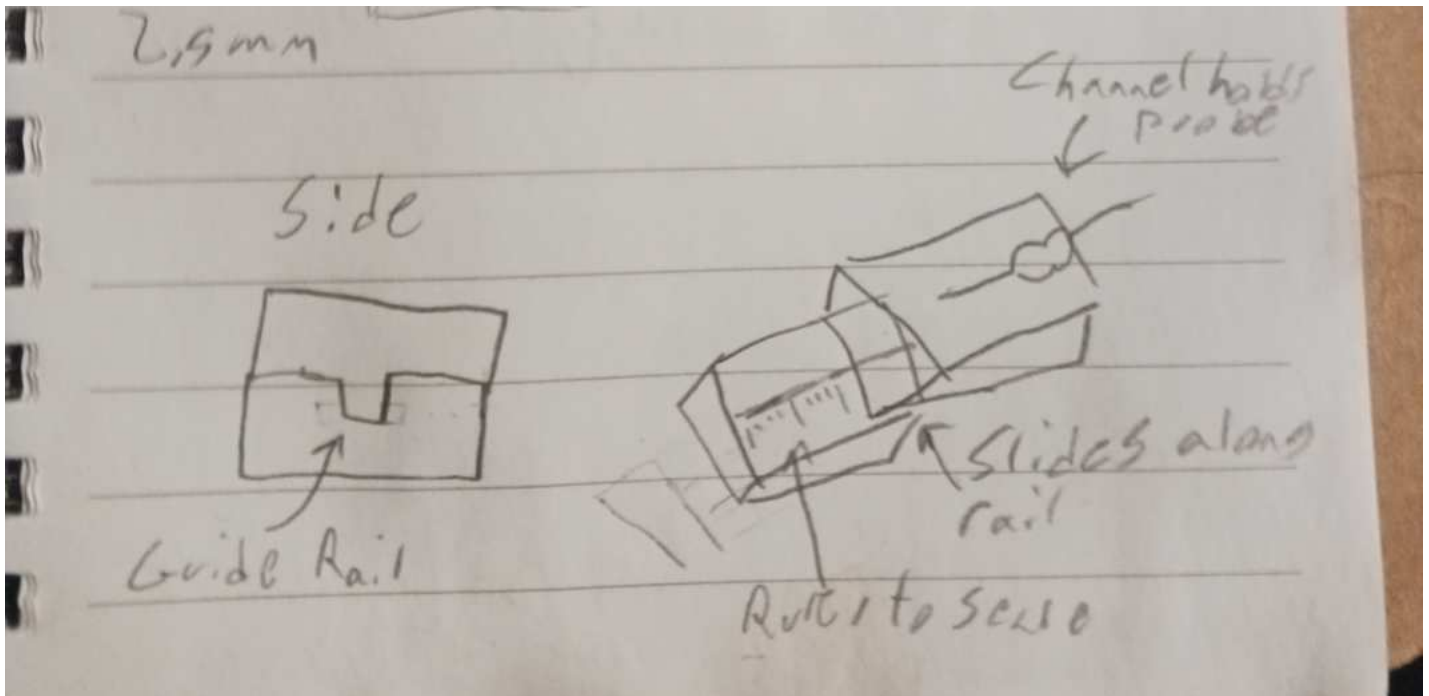
Title: Probe Holder W/ Ruler

Date: 3/20/26

Content by: Cole M.

Goals: Design a probe holder with a way to make consistent markings

Content:



- Probe inserted into indent and stays still
- Probe holder made of 2 pieces with guiderail to ensure alignment
- Top piece slides along the rail to facilitate moving probe
- Bottom piece has ruler to guide laser to make consistent markings
- Probe holder has a ruler to guide laser markings



2025/03/12-Biosafety and Chemical Safety Training

Cole Miller - Apr 30, 2025, 4:48 PM CDT

Title: Biosafety and Chemical Safety Training

Date: 3/12/25

Content by: Cole M

Goals: Complete Biosafety and Chemical safety training to work in the wetlab to produce our biomaterial.

Content:

VCRGE Training Information Lookup Tool

University of Wisconsin-Madison



This certifies that Cole Miller has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	1/24/2025	1/24/2030
Chemical Safety: The OSHA Lab Standard	Final Quiz	1/23/2025	

Data Last Imported: 03/13/2025 12:57 PM

Figure[1]: This image is a screenshot of the VCRGE Training Information Lookup Tool, depicting the completion of Biosafety Required Training and Chemical Safety: The OSHA Lab Standard by Cole Miller.

Conclusions/action items:

Completing this training will allow me to assist my team in producing our biomaterial



Cole Miller - Nov 05, 2025, 2:50 PM CST



Cole Miller
ID Number: 997611110
Eligible: C&E
Industry

My Memberships				
Membership Type	Start Date	Expiry Date	Renew	Card Info
Shop Tools	Tue, Mar 6 2024	Permanent	Not Renewable	N/A
Machining	Tue, Aug 20 2024	Permanent	Not Renewable	N/A
Shop Tools - Training Eligible	Tue, Aug 20 2024	Wed, Dec 31 2026	Not Renewable	N/A
Machining - Training Eligible	Tue, Aug 20 2024	Wed, Dec 31 2026	Not Renewable	N/A
Lab Orientation	Tue, Aug 20 2024	Wed, Dec 31 2026	Not Renewable	N/A

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1741889100335.png (61.1 kB)

General Training + Human Subjects Training

Cole Miller - Nov 05, 2025, 2:44 PM CST



The screenshot displays the 'OVCR Training Information Lookup Tool' interface from the University of Wisconsin-Madison. It features the university's logo and a confirmation message: 'This certifies that Cole Miller has completed training for the following course(s)'. Below this, a table lists three training courses with their respective assignments, completion dates, and expiration dates.

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	07/14/2025	07/14/2026
Chemical Safety: The OSHA Lab Standard	Final Quiz	07/15/2025	
IWM Human Subjects Protection Course	Basic/Behavioral Course - Human Subjects Research	10/16/2025	10/16/2028

Data Last Imported: 10/04/2025 02:24 PM

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compliance-research-wisc-edu-TILT-Details-8988676-11-05-2025_02_44_PM.png (140 kB)

 **2026/3/20- Autoclave Training**

Cole Miller - Mar 20, 2026, 11:15 AM CDT

Title: Autoclave Training

Date: 3/20/26

Content by: Cole M

Present: N/A

Goals: Learn how to use autoclaves safely

Content:



This certifies that Cole Miller has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	3/20/2026	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	1/24/2025	1/24/2030
Chemical Safety: The OSHA Lab Standard	Final Quiz	1/23/2025	
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	10/30/2025	10/30/2028

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2026/1/28-Lecture #1

Cole Miller - Jan 28, 2026, 1:52 PM CST

Title: Lecture #1

Date: 1/28/26

Content by: Cole M

Present: All

Goals: Learn how to use library services and databases

Content:

- Technology
 - Online Search Engines
 - Index information, produces results lists
 - Chatbots
 - Trained on internet data, produce text based on input
 - Do not evaluate accuracy or bias, can make up sources or make incorrect statements
 - May not be current
 - Databases
 - Separated by category and department
 - Can be searched and organized by relevancy, time, and other subcategories
 - Can use findit at UW button to gain access
 - Key words are important words to search for to find the right articles
 - Can use AND, OR, as well as () and "" to search keywords
 - Citation Managers
 - Can save articles in Zotero, automatically saving citation information
 - Can be used to automatically format bibliographies
 - Should be checked as they can make mistakes
- Evaluating Sources
 - Relevancy
 - Authority
 - Quality
 - Currency(When was it made)
- Librarian
 - Are available by appointment to help with searches
- Technical Reports
 - Publish the results of scientific or technical research
 - Often use federal funds
 - Made by companies, universities and government labs

- Must publish mistakes and progress
- Not Peer-Reviewed
- Search Process
 - During the search process, it is common to experience confusion and doubt during the exploration of your topic

Conclusions/action items:

I can use this information to inform the research process of my design project, as well as assist me in my research throughout my career. By following these guidelines, I know how to best search databases and the internet for the most relevant, current, and accurate articles to gather information for this and future projects.



2026/2/11- Lecture 4

Cole Miller - Feb 11, 2026, 2:07 PM CST

Title: Lecture 4

Date: 2/11/26

Content by: Cole M.

Present: All

Goals: Learn how to create and give better presentations

Content:

- Keep format uniform throughout presentations
- Keep your audience interested
 - Focus on impact
 - Attitude
 - Presence, excited
 - Mannerism: talk to the audience
- Cannot cover all information: Highlight important information
 - Highlight winning categories in design matrix
- Keep short bullet points without too much hierarchy
- Figure captions:
 - Figure X with description, citation
 - Explain graphs, plots, etc
 - Properly label CAD drawings, sketches, add dimensions
 - Use 3D model
- Results
 - Never show raw data, graph it
 - Comparable axis values
 - Use statistical analysis
- Use figures to effectively explain how design works
 - Exploded view, block diagrams

Interviews

- Bring small portfolio: Design Projects, Resume, etc
- How to stand out amongst BMEs
 - Design projects, leadership
 - Be specific, personal
 - Technical skills
 - Soft skills: Communication, leadership

Conclusions/action items:

Using this information will help me to present information well and give professional presentations. Additionally, the information and practice on interviews will be helpful as I pursue roles throughout my career.



2026/2/25-Diversity and Inclusion in Design

Cole Miller - Mar 06, 2026, 12:02 PM CST

Title: Diversity and Inclusion in Design

Date: 2/25/26

Content by: Cole M.

Present: All

Goals: Learn about diversity and inclusion in design

Content:

What Diversity Means in Engineering Design:

- In engineering design, diversity means looking at a problem from many different perspectives and backgrounds.
- It involves including people with different skills, experiences, and ideas in the design process.
- Designers should keep an open mind and learn from others' viewpoints.
- Products should be tested with different groups of people instead of assuming one design works for everyone.
- Diversity also includes considering cultural differences. For example, bandages are made in different skin tones so they work better for more people.

What Universal Design Means

- Universal design means creating products that can be used by as many people as possible.
- A design should not be limited to a certain group based on race, class, or religion.
- Instead, it should focus on the purpose of the product and how useful it is to everyone.
- Universal design also means making products easy to understand and use without requiring special training.

Seven Principles of Universal Design:

- Equitable Use: The design is useful for people with many different abilities.
- Flexibility in Use: The design works for different preferences and abilities.
- Simple and Intuitive Use: The design is easy to understand.
- Perceptible Information: The design clearly communicates important information to the user.
- Tolerance for Error: The design reduces risks and negative effects from mistakes.
- Low Physical Effort: The design can be used comfortably without too much effort.
- Size and Space for Approach and Use: The design provides enough space for people of different body sizes, postures, or mobility levels.

In-Class Activity

- What component of the design could be improved?
 - If someone is allergic to chromium or nickel coatings on the probe, alternative coatings could be used.
 - Creating probes with different coatings would allow more people to safely use the product.
- Which universal design principle does this address?

- This relates to Equitable Use, because a user's allergy should not prevent them from being able to use the device.
- How could these improvements be made? (Action Plan)
 - Develop additional versions of the probe with different coating materials
 - Research and test alternative coatings, such as cobalt or other hypoallergenic materials, to make the device safer and more accessible.

Conclusions/action items:

This will be helpful to designing ethical and universal designs in my current and future design projects.



2026/3/4- Patents and Standards

Cole Miller - Mar 06, 2026, 12:15 PM CST

Title: Patents and Standards

Date: 3/4/26

Content by: Cole M.

Present: All

Goals: Learn about how patents and standards are used in the industry and how to research and compare them

Content:

UW Library Resources

- The UW Library provides access to many engineering standards, including ASTM, ISO, ASABE, and IEEE.
- It also has a historical print collection of standards.
- If a standard is not available, search for it in TechStreet Enterprise and submit a "Request a Standard" form.

Market and Industry Sources

- Business databases help you find information about companies, industries, and consumer trends.
- The library also provides research guides to help you learn how to use these databases.
- Recommended databases include Data Axle Reference Solutions, IBISWorld Industry Reports, and ProQuest One Business.

Patents

- Patent examiners review new applications by comparing them to prior art.
- Prior art includes:
 - Existing patents and patent applications (U.S. and international)
 - Published research or articles
 - Products already being sold or publicly used
- However, one patent alone is not enough for research.
- You should also review related and cited patents to better understand previous designs.
- Patent evaluations consider usefulness, novelty, and functionality.

Patent Claims

- Claims define the parts of an invention that are legally protected by the patent.
- Two Types of Claims
 - Independent Claims: Standalone claims that fully describe the invention.
 - Dependent Claims: Refer back to another claim and add more specific details or limitations.

Claim Comparison

- Comparing claims from different patents helps identify key differences between inventions.
- This process can show how new designs are distinct enough to qualify for a separate patents

Conclusions/action items:

This provides an excellent background into patents and standards, as well as how to search for them and research them, which will be useful throughout this design project and future projects in my career.



2026/3/6- Tong Lecture

Cole Miller - Mar 13, 2026, 11:47 AM CDT

Title: Tong Lecture

Date: 3/6/26

Content by: Cole M

Present: All

Goals: Learn from Justin William's story, and hear his advice

Reflection:

Justin had a long and diverse entrepreneurial career, starting out in a small town of only 90 people. I was inspired by many parts of his story, but I was largely inspired by how many times he changed directions in his career, and how many companies/ ideas of his did not work out. It was helpful to hear that you can always move on from ideas that didn't work out. Additionally, Williams gave helpful advice about thinking smaller, and how less can sometimes be more when creating something. Justin's work in neuroengineering was very interesting, and his stories and words gave much inspiration and advice.



2026/3/11- Lecture #8

Cole Miller - Mar 13, 2026, 11:52 AM CDT

Title: Lecture 8

Date: 3/11/26

Content by: Cole M.

Present: All

Goals: Summarize lecture 8 material

Content:

- Build low-fidelity prototypes early to test ideas quickly and learn from failures. Include basic circuit diagrams, fittings, simple calculations, free-body diagrams, and mechanics of materials considerations.
- Create a detailed materials list that matches the material expense table. For each material include:
 - Name of the material
 - Concentration, amount, or starting dimensions
 - Manufacturer and part number
 - Purpose of the material
- List all required equipment, including manufacturer and model number when known.
- Reference supporting research or papers elsewhere in the notebook when relevant.
- Write a clear step-by-step methods section that someone else could follow exactly. Specify details such as mixing time and intensity, cutting tools used, and other process conditions
- Structure the protocol clearly: follow notebook entry guidelines, place the materials list at the beginning, then provide the detailed step-by-step procedure.
- Consider manufacturability throughout the design, ensuring prototypes could eventually be professionally produced using methods such as molding (blow, injection, thermoforming), machining/subtractive processes (mill, lathe, waterjet), or joining techniques (welding, soldering, screws, rivets, adhesives).

Conclusions/action items:

We will have our first fabrication and testing protocols done by next Tuesday. We must be as specific and clear as possible so that someone with no experience could follow along.



2026/3/18-Lecture #9

Cole Miller - Apr 29, 2026, 8:10 PM CDT

Title: Brevity in Communication

Date: 3/18/26

Content by: Cole M.

Goals: Learn why and how to talk briefly

Content:

Elevator Pitch

- Deliver ideas quickly and clearly in a short time window
- Take advantage of spontaneous opportunities to present
- Aim to grab attention, spark interest, and be memorable

Key Principles

- Adapt your message to your specific audience
- Rehearse until delivery feels natural and confident
- Show genuine enthusiasm and belief in your work
- Use simple, clear language—avoid technical complexity

Basic Pitch Structure

- Hook: Immediately state your purpose or goal
- Intro: Briefly describe your project
- Value Proposition: Define the target user and the problem being solved
- Benefits: Highlight what makes your solution effective or different
- Close: End with a clear call to action

Presentation Tips

- Maintain eye contact and project confidence
- Stay concise and focused
- Adjust messaging based on audience feedback
- Avoid sounding overly scripted

Tong BME Awards

- Choose one of the two award categories to target strategically

Executive Summary Guidelines

- Convert your pitch into a one-page written format
- Tailor content to the intended audience
- Clearly communicate the project's purpose and impact

Abstract Writing

- Provide a brief, specific overview of the project
- Include background, concept, development, and testing
- Help readers quickly understand the significance of the work

Technical Report Best Practices

- Include only necessary details for reproducibility
- Remove unnecessary explanations and filler content
- Avoid redundant phrasing (e.g., “final outcome,” “basic fundamentals”)
- Use formal, non-conversational language
- Exclude raw data unless essential
- Eliminate repetition and redundancy
- Thoroughly proofread the entire document, not just your own sections

Conclusions/action items:

Our team can use the lessons taught in this lesson to streamline communication and be more professionally appealing. We should prepare a Elevator pitch for Show and Tell to quickly explain our project, so we can get feedback



2026/3/25-Lecture #10

Cole Miller - Apr 29, 2026, 8:26 PM CDT

Title: Ethics Discussion

Date: 3/25/26

Content by: Cole M.

Goals: Discuss ethics in engineering

Content:

Personal vs. Professional Ethics

- Personal ethics are shaped by individual influences such as upbringing, culture, religion, and life experiences
- Professional ethics are defined by collective standards set by organizations or fields
- Differences arise from how ethical principles are structured and applied in each context
- Professional groups (e.g., biomedical engineering societies) establish formal codes of conduct

Ethical Problem-Solving Approach

- Addressing ethical dilemmas follows a process similar to engineering design
 - Identify the need or issue
 - Clearly define the problem
 - Develop and evaluate possible solutions

Ethical Decision-Making Framework


- Awareness: Recognize that an ethical issue exists
- Stakeholders: Identify all individuals or groups affected
- Options: Generate possible courses of action
- Analysis: Evaluate each option using structured criteria

Ethical Analysis Tests

- Harm Test: Assess the extent and severity of potential negative consequences
- Publicity Test: Consider how the decision would be perceived if made public
- Reversibility Test: Evaluate whether the decision would feel fair if roles were reversed
- Universality Test: Determine if the action would be acceptable if everyone did it
- Respect for Persons Test: Ensure individuals are treated with dignity and autonomy
- Utilitarian Test: Maximize overall benefit while avoiding harm to vulnerable groups
- Social Justice Test: Consider fairness and equitable distribution of benefits and burdens

Conclusions/action items:

We must continue to consider these ethical principles throughout our project and future projects to ensure equitable designs.



2026/4/8-Lecture #11

Cole Miller - Apr 29, 2026, 8:34 PM CDT

Title: Engineering Judgement

Date: 4/8/26

Content by: Cole M.

Goals: Learn about engineering judgment and how it applies to design

Content:

Engineering Judgment

- Applied to real-world, open-ended problems
- Involves collaboration and teamwork
- Requires critical evaluation of potential solutions
- Depends on effective communication
- Includes managing uncertainty and incomplete information
- Emphasizes asking relevant questions

Three Domains of the Model

- Attitudes: Personal beliefs and perspectives about an issue
- Behaviors: Actions taken to apply knowledge in practice
- Cognitive (Internal & External): Understanding and skills used to address an issue

A Model for Engineering Judgement

(Adapted from D. Chadha, Imperial College London)

Attitudes (internal) What you feel and believe about a specific issue.	Behaviours (external) How you demonstrate and act upon your knowledge and attitudes while addressing a specific issue.	Cognitive (internal & external) What you know about, and are able to do, to address a specific issue.
When you consider applying Engineering Judgement to a complex issue, to what extent is it helpful for you to:	When you consider applying Engineering Judgement to a complex issue, to what extent is it helpful for you to:	When you consider applying Engineering Judgement to a complex issue, to what extent is it helpful for you to:
A1. Realize that pure memorization can lead to constraints	B1. Take responsibility for your own learning	C1. Clearly identify a problem
A2. Appreciate that education is a foundation for lifelong learning	B2. Ask questions for clarification and deeper understanding	C2. Apply logic to engineering work
A3. Possess a deep passion for engineering as a discipline	B3. Treat failure as a lesson	C3. Use a sequential thought processes in engineering work
A4. Know that an individual's judgement is a limited perspective and can limit broad application	B4. Document rules, lessons learned, and procedures throughout the design process	C4. Demonstrate competency in a defined content area
A5. Comfortably respond to making mistakes (yours and others)	B5. Value creative contributions from self and others toward the desired objectives	C5. Apply fundamental theoretical knowledge to engineering work
A6. Comfortably celebrate individual and team success	B6. Reflect on how assumptions and biases influenced the outcome	C6. Articulate the context and consequences that go beyond merely a technical solution
A7. Feel a sense of self-confidence in making decisions	B7. Engage in the process of continuous improvement	C7. Use imagination and intuition in engineering work
A8. Value collaboration with others over competition with others	B8. Use past experiences to inform future work	C8. Exercise common sense to draw conclusions and make reasonable recommendations

Conclusions/action items:

We should continue to apply engineering judgement to our current and future projects, collaborating to evaluate ideas and identify the best solutions



2026/4/15-Lecture #12

Cole Miller - Apr 29, 2026, 8:48 PM CDT

Title: Poster Presentations

Date: 4/15/26

Content by: Cole M.

Goals: Learn how to create better posters

Content:

Effective posters use clear, high-quality figures, consistent formatting, and concise text while avoiding information overload and raw data. Visuals should dominate over text, with diagrams used when possible. All images, graphs, and tables must be clearly labeled, include titles, and communicate a clear takeaway. Graphs need readable axes, legends, and key statistics, while tables should have a defined purpose.

Posters should be planned according to evaluation criteria and include accurate contact information, a clear title, and a structured narrative explaining what the project is and why it matters. Only key results should be shown, with supporting data referenced rather than fully displayed. Captions are required for all visuals.

Design should prioritize readability from ~3 feet away using 24–28 pt fonts, consistent formatting, and simple, accessible color schemes (light background, dark text, minimal and non-harsh colors). References should be small and unobtrusive.

A strong poster also shows context and workflow by identifying the user, setting, and system placement, and by presenting processes clearly (input → output or before → during → after). Organization should rely on grouping, minimal labels, and high-level clarity.

Flowcharts must have a clear start, logical progression, and defined end, making the process easy to follow through simple structure and visual logic.

Conclusions/action items:

We must apply this advice as we design our poster to make sure it is appealing and conveys information well.



2026/4/22- Lecture # 13

Cole Miller - Apr 29, 2026, 8:40 PM CDT

Title: Poster Feedback

Date: 4/22/26

Content by: Cole M.

Goals: Present our poster for feedback and give comments to others

Content:

Flexing Prosthetic Finger Potentiated By Adjacent Finger

Team Members: Jack Zemlock, Emma Hellberg, Yair Ben Shaul, Sydney Smith
Department of Biomedical Engineering - University of Wisconsin Madison
Client: Mr. Greg Olson Advisor: Prof. Justin Williams
BME301, April 24th 2026

Problem Statement

Upper extremities require hand dexterity and repetitive motion. While most prosthetics, fingers provide constant resistance with limited movement, many adaptive designs lack natural articulation. This results in stiff, cumbersome motion and minimal grip contribution, while also placing a full load on the prosthesis, increasing energy or electromyography expenditure. Medical Air Prosthetics synthesizes motion, highlighting the need to integrate function without working against it. This project develops a rigid proximal finger (use with an adjacent finger) that mechanically links to an adjacent finger, enabling passive, mechanical motion. The design maintains natural hand function while providing a realistic external appearance, and improves eligibility for prosthetic retention concepts.

Background

Prosthetics & Retention

- Fingers consist of three phalanges (proximal, middle, distal) connected by MCP, PIP, and DIP joints [1]
- Flexion and extension are driven by coordinated muscle contractions
- Electromyography (EMG) indicates functional performance

Mechanics & Global Impact

- ~180,000 upper limb amputees in the US (1-300,000 by 2050) [2]
- Proximal and finger requirements under the majority of upper limb loss [2]
- Only ~10% of people globally who need prosthetic devices receive them [2]

Challenges & Practical Need

- Stiffness: prosthetic fingers are often limited to constant, limiting sensory concepts
- Adding mechanical functionality enables identification as a functional prosthesis
- Addressing need for both realistic appearance and functional movement



Figure 1: Proximal finger location



Figure 2: Prosthetic finger attached

Design Criteria

- The device must provide passive flexion and extension at the PIP and DIP joints
- The device must be able to be scanned by an adjacent finger
- The prosthesis body must provide structural support
- The device must fit inside a silicone finger sleeve and be able to receive tactile input
- The device must attach to the patient's residual finger

Final Design Features

- Accounting for a 11-12 PIP articulation angle
- 3D printed PLA proximal body
- Integer motion representing PIP and DIP joints
- Asymmetrical channels for attachment to residual finger



Figure 3: Prosthetic finger assembly

Final Design & Fabrication

Fabrication Methods

- PIA part printed on Bambu Lab printer at the MakerSpace
- 15% infill
- Blowtorch edge cleanup
- 0.8mm Extra Fine layer height
- Hardware
 - 1/8" 316 stainless steel screws and nuts for hinge joints
 - 1/4" 316 stainless steel thread-forming screws to secure the metal linkage
 - 1/4" 316 stainless steel thread-forming screws to secure bearing components
 - The metal linkage was cut out using the Waterjet at the MakerSpace



Figure 4: Prosthetic finger design components



Figure 5: Prosthetic finger assembly



Figure 6: Prosthetic finger assembly

Testing & Results

Joint Angle Testing

- Used a linear actuator, actuator, and an LISBN motor driver to automate cycle
- Tracked cycles using the software EEMCON and 11-12 PIP Simulation Seed
- All fixtures were the source of fabric and fixed in the same spot
- All PIA pieces experienced minimal displacement over 15,000 cycles



Figure 7: Testing apparatus



Figure 8: Number of cycles with significant displacement



Figure 9: Prosthetic finger assembly



Figure 10: Number of cycles with significant displacement



Figure 11: Prosthetic finger assembly



Figure 12: Number of cycles with significant displacement



Figure 13: Prosthetic finger assembly

Discussion

- Design Advancements:**
- Created a functional prosthetic finger that can fit into provided silicone sleeve
 - 0.800" (11-12 PIP) fixed had a life span of 4,000 cycles, longer than the other models tested and has customer's prototype
 - Designed and constructed a testing mechanism to simulate accelerated life testing (2x faster than real life)
 - Surpassed DIP joint angle with PIP joint angle within 10% of goal
- Design Drawbacks:**
- Unable to reach intended duration of 10,000 cycles a month due to metal tendon binding. (Only achieved around 11 days of usage before failure)
 - Lack of back hand part had testing due to limited size and customer with patient

Future Work

- Future Design Changes**
- Test different options for wiring the tendon system
 - Test new materials to be used as the tendon
 - Make changes to the attached structure to decrease the stress applied at the point of failure
 - Add low density foam to fill space between prosthetic and adjacent device
 - Essential design is easily reproducible for client
 - Material production for client every 2-3 years [15]
 - Ability to change size for different clients
 - Design enable vendor to make adjacent finger excisions without additional finger fabrication
- Future Testing**
- Complete accelerated life testing to simulate failure points
 - Complete with lower price life testing using the Autodyn/Ansys/ Solid/Ansys/Pro/Ansys (ANSYS)
 - Range of motion and load-bearing capacity testing during wear
 - Test the finger required to achieve the production form for adjacent finger

Acknowledgments

The team would like to thank our client, Mr. Greg Olson, the team at Medical Air Prosthetics, Jane Dierks, our TA, Charles Mitchell, and our advisor Dr. Justin Williams for their guidance and support on this design project throughout the semester.

References

1. "Prosthetic Fingers." *Prosthetic Fingers*. n.d. Web. 10 Oct. 2026. <https://www.prostheticfingers.com/>
2. "Prosthetic Fingers." *Prosthetic Fingers*. n.d. Web. 10 Oct. 2026. <https://www.prostheticfingers.com/>
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lots of pictures! Overall there is a lot of text. Testing section looks cluttered.

Conclusions/action items:

We will incorporate our peers suggestions into our poster, and continue to improve our presentation



Title: Uniformity Testing

Content by: Cole Miller

Present: Neel, Cole

Goals: Determine accuracy of probe markings and reproducibility of fabrication

Content:

In order to ensure the accuracy of probe markings and reproducibility of the graduated Bowman's probe's fabrication process, Uniformity testing was performed. 28 graduated probes of sizes ra to 7 were captured using a Leica MZ95 stereomicroscope. The position and magnification of the microscope were not changed in between images, allowing probes to be measured on the same was used to determine the interval length in between markings and marking widths. The distance from the end of the probe to the first marking was of particular importance, as it affects the accu subsequent markings. After analyzing each probe, the average interval length was found to be 2.59 mm, corresponding to an average error of 3.71% from the target length of 2.5 mm, indicating consistency in spacing between markings. The average marking width was measured at 0.15 mm, with a higher average error of 15.35%; however, this variation is not practically significant, as i meaningfully affect the visibility of the markings. The average distance from the probe tip to the first marking was 2.78 mm. While this highlights an area where the fabrication process could be r substantially impact the overall functionality of the probe. Collectively, these results demonstrate that the fabrication method produces probes with a high degree of reproducibility and sufficient a reliable clinical application.

	First Mark Length	Avg. Mark Length	Std Mark Length	Avg Mark Width	Std Mark Width	Mark 1 L	Mark 2 L	Mark 3 L	Mark 4 L	Mark 1 W	Mark 2 W	Mark 3 W	M
Probe 0000	2.921	2.6155	0.204581687	0.119	0.02	2.921	2.5	2.541	2.5	0.149	0.109	0.109	
Probe 000	2.84	2.57925	0.1755170932	0.15925	0.0205	2.84	2.459	2.516	2.502	0.149	0.149	0.19	
Probe 00	2.99	2.63625	0.2380019258	0.1665	0.03882009789	2.99	2.473	2.541	2.541	0.19	0.19	0.109	
Probe 0	2.733	2.5685	0.111356784	0.126	0.01978214683	2.733	2.5	2.541	2.5	0.149	0.109	0.11	
Probe 1A	2.948	2.6255	0.2160455199	0.2035	0.0369278576	2.948	2.502	2.504	2.548	0.149	0.217	0.217	
Probe 1B	2.964	2.648	0.2106735231	0.129	0.02309401077	2.964	2.542	2.541	2.545	0.109	0.149	0.109	
Probe 2A	2.69	2.56775	0.09900138888	0.16625	0.0206135069	2.69	2.5	2.581	2.5	0.19	0.149	0.177	
Probe 2B	2.841	2.60775	0.1567575091	0.156	0.014	2.841	2.545	2.502	2.543	0.149	0.177	0.149	
Probe 3A	2.881	2.61625	0.1775300444	0.13225	0.02005617112	2.881	2.501	2.542	2.541	0.149	0.122	0.109	
Probe 3B	2.732	2.56275	0.1180095335	0.1695	0.02367136104	2.732	2.46	2.543	2.516	0.149	0.149	0.19	
Probe 3C	2.692	2.569	0.08419421991	0.12225	0.01885691739	2.692	2.501	2.542	2.541	0.122	0.109	0.149	
Probe 3D	2.717	2.569	0.1001199281	0.1695	0.02367136104	2.717	2.513	2.503	2.543	0.19	0.19	0.149	
Probe 4A	3.057	2.653	0.2698703392	0.129	0.02309401077	3.057	2.514	2.541	2.5	0.109	0.109	0.149	
Probe 4B	2.541	2.51425	0.03307944981	0.146	0.02797618034	2.541	2.473	2.541	2.502	0.149	0.177	0.149	
Probe 4C	2.364	2.496	0.088	0.139	0.02	2.364	2.54	2.54	2.54	0.109	0.109	0.149	
Probe 4D	2.583	2.54225	0.033480099359	0.14925	0.03306937153	2.583	2.501	2.543	2.542	0.149	0.109	0.149	
Probe 5A	2.758	2.578	0.1212133106	0.15925	0.0205	2.758	2.5	2.541	2.513	0.19	0.149	0.149	
Probe 5B	2.948	2.62225	0.2180250368	0.1525	0.02805352028	2.948	2.5	2.5	2.541	0.122	0.149	0.149	
Probe 6A	2.759	2.579	0.1212133106	0.109	0	2.759	2.501	2.542	2.514	0.109	0.109	0.109	
Probe 6B	2.907	2.612	0.1987947015	0.146	0.006	2.907	2.5	2.554	2.487	0.149	0.137	0.149	
Probe 7A	2.65	2.56175	0.06009645026	0.1695	0.02367136104	2.65	2.541	2.515	2.541	0.149	0.149	0.19	
Probe 7B	2.542	2.5245	0.02033879708	0.1595	0.03882009789	2.542	2.514	2.541	2.501	0.19	0.149	0.109	
Probe 7C	2.649	2.558	0.0635295207	0.16625	0.0206135069	2.649	2.541	2.541	2.501	0.149	0.149	0.19	
Probe 7D	2.541	2.53575	0.01459166429	0.1595	0.03882009789	2.541	2.514	2.543	2.545	0.109	0.149	0.19	
Probe 8A	2.691	0.4220527259	0.09201947258	0.16625	0.0206135069	2.691	2.473	2.541	2.542	0.149	0.149	0.19	
Probe 8B	2.88	2.612	0.1821629307	0.14925	0.03306937153	2.88	2.473	2.554	2.541	0.149	0.109	0.149	
Probe 8C	2.921	2.636	0.1928574603	0.1695	0.02367136104	2.921	2.501	2.582	2.54	0.149	0.19	0.19	
Probe 8D	3.099	2.6745	0.2832872512	0.1865	0.02805352028	3.099	2.515	2.541	2.543	0.19	0.19	0.149	
Avg	2.779964286	2.510242954	0.1384053195	0.1526875	0.02378640489	Avg no First:	2.52222619						
Std	0.1770426779	0.4116095374		0.02136314022		Std no First:	0.02562818064						

Conclusions/faction items:

Collectively, these results demonstrate that the fabrication method produces probes with a high degree of reproducibility and sufficient accuracy for reliable clinical applicati



2026//- Best Template

Cole Miller - Jan 28, 2026, 1:16 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:



2026//-Research Template

Cole Miller - Feb 06, 2026, 12:26 PM CST

Title:

Date: //26

Content by: Cole M.

Goals:

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2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.



2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

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New Page
