BME Design-Spring 2022 - Ben Smith
Complete Notebook

PDF Version generated by

LILY GALLAGHER

on

May 04, 2022 @02:16 PM CDT

Table of Contents

Team contact Information

MADELEINE KREDELL - Mar 01, 2022, 9:05 PM CST

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Thatcher	Graham	Client	graham.thatcher@wisc.edu	(608) 471-330	
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Militello	Giovanni	Communicator	gmilitello@wisc.edu	(262) 955-5201	
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Project description

MADELEINE KREDELL - Mar 01, 2022, 9:03 PM CST

Course Number: BME 301, Lab Section 305

Project Name: VetMed: 3D printed, patient specific incline plane for management of class 2 malocclusion - Improvement in design and workflow

Short Name: VetMed

Project description/problem statement:

To correct Class II Malocclusions in canine patients, client Dr. Graham Thatcher has produced a 3D printed patient-specific incline plane brace to be used on canines. This current process of creating a 3D-printed incline plane begins by taking a CT scan of the canines' jaw. The data from the DICOM file is then used to produce the printable incline plane which would be placed and tested on a model of the canines' jaw. Further adjustments for the next prototype are made with the help of a software engineer. This process is time-consuming and complex. This process does not allow for flexibility between patients, nor take into account the growth of the canine, leading to patient discomfort or breakage. Dr. Graham Thatcher has asked the team to optimize the previous software workflow that will save time and eliminate complications in the current workflow, as well as improve on the current design so that it may be more adjustable and versatile for a wider range of patients.

About the client:

Dr. Graham Thatcher is an veterinary orthodontist trying to find a solution to correct Class 2 Malocclusion. He has a current treatment plan by creating his own incline plane but wants a faster and easier way to create an incline plan for patient specific situations. He has conducted research on Class 2 Malocclusion and other treatment options that are currently out there.

2/8/22 Meeting

Ben Smith - Feb 08, 2022, 7:35 PM CST

Title: First Meeting with Client

Date: 2/8/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Abbie Stertz

Goals: Establish Goals for the Semester

Content:

Questions for Client:

1. How are we expected to be reimbursed for our 3D print jobs; Venmo?
    a. And we need to receive payment now as a budget to start printing in Titanium
2. Do you have any scans of patients with Class 2 Malocclusions that we can 3D print a skull of one and make measurements so that our device could be tested on that patients skull model?
3. Who is the contact you know that can set us up to 3D print in Titanium?
    a. Titanium printing at UW Alloy design and development labs https://thoma.msae.wisc.edu/laboratory/
4. What is the estimated time and cost to print in Titanium?
5. Do you still have access to Solidworks to receive our file of the final design?
6. Does Graham have access to a 3D printer?

Notes:

- Two veterinary dentists at UW he will reach out to about seeing if they have patients
    - Jacob Socup?
    - Chris Snyder?
        - Resident
    - Might also be able to ship to Graham for one of his patients
- Graham will get us a DICOM file for a patient with a malocclusion
- Get in contact with John to see where the 3D titanium printer is at and the timeline and cost for printing our part
- Graham to look if he has any research funds left
    - Can do venmo if needed, otherwise if Vet school can pay for it that works
- Lily to tell Graham exactly what she is owed so he can clear that up asap
- Gio to send old report to Graham

Conclusions/action items:

We had a great first meeting to establish goals and next steps. We need to print in finer plastics now so we can ultimately print in titanium.

1/31/22 Meeting

Ben Smith - Mar 01, 2022, 4:20 PM CST

Title: Advisor Meeting 1

Date: 1/31/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

Goals:

- Have Maddie and Abby try to alter the variables in solidworks
    - Take notes and change depending on feedback
- Print in a finer material
    - Different sizes??
- Print in titanium
    - Try to get it done before preliminary testing
    - Figure out if we can print here at UW
- Print new skull
- Then do some mechanical testing
    - Design own test fixture
        - Subtractive manufacturing of metal block
        - With mouth and teeth?
- Figure out how to make payments this semester

2/7/22 Meeting

Ben Smith - Mar 01, 2022, 4:22 PM CST

Title: Advisor Meeting 2

Date: 2/7/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- Need to figure out titanium printing
- Need another 3D model
- Print in a finer resin
- Can keep most of previous PDS but update it once we speak with Graham

2/14/22 Meeting

Ben Smith - Mar 01, 2022, 4:23 PM CST

Title: Advisor Meeting 3

Date: 2/14/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- Email Dan Toma about 3D printing in titanium in the grainger institute
    - Sector 67?
        - No metal printing
    - The Bodery?
        - No metal printing
    - Subtractive manufacturing?
        - Maybe take 3D printed version to Team labs and see if they can mill our piece out
        - Can get a design consultation on the website
    - If we can’t get in contact by Friday let Dr. P know and he will try to help us out
- Professor Kevin L. Seary runs a lab
- What is the error on titanium printing
- Include range of dimensions on PDS
- Design matrix: maybe write up a testing plan
    - Design matrix for fixtures? Testing processes?

2/21/22 Meeting

Ben Smith - Mar 01, 2022, 4:25 PM CST

Title: Advisor Meeting 4

Date: 2/21/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- Maybe we should print different prototypes with different specs to show its easily replicable
- 1164 ME for presentations
    - Print them based off of additional patient files and their specific measurements to see what sources of error occur while taking measurements and where can our design be edited
- Preliminary Presentation (FRI)
    - Use design matrix with CNC and titanium printing
        - Use paper John shared
- Could the previous team help turn our new scan into an .STL file?
- Design matrix for CNC vs 3D printing?
- Also how to test the design
- Send slides Wednesday by 4pm
    - Background
    - Current treatments
    - Key specs (pds)
    - Previous teams methods
    - Final solution from last semester
    - Briefly what workflow looks like
        - Graphic from poster
    - Final design (3D print in Ti64)
    - Challenges
        - Design Matrix?
    - Key Specs

3/7/22 Meeting

Ben Smith - Apr 21, 2022, 10:21 AM CDT

Title: Advisor Meeting 5

Date: 3/7/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

Updates:

- Have a new model of a skull
- Attempted to print a new prototype to fit the new skull
    - Rings slightly too small
    - Bridge slightly too short
- We want to print another prototype ideally tomorrow 3/8/22 and proceed to order a titanium version so have for show and tell
- Once we order the titanium model, we will do further research into compression testing and how we want to test our prototype
    - Figure out how to mount our prototype in the machine
- Could set up a consultation to see what the margin of error is with titanium 3D printing
- Reach out to TeamLabs and other Test Labs to discuss compression testing
    - https://docs.google.com/document/d/1zUuvHhzvBKnvhgTuz5jSVO8_yC0RkZX55a8I0S8hpgU/edit
    - https://www.engr.wisc.edu/research/centers-consortia-institutes/wisconsin-structures-materials-testing-laboratory/
        - Jacob Zeuske

3/20/22 Meeting

Ben Smith - Apr 21, 2022, 10:27 AM CDT

Title: Advisor Meeting 6

Date: 3/20/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- For show and tell, could have a computer with the workflow and another with solidworks for students to try out the workflow
- Will the titanium material be trusted to withstand the force if the device is much smaller for a smaller dog?
- Can meet with John to look at MTS machines in ECB, contact him if needed
- Do we want to break the piece when we test it, or just test it to the maximum bite force?
    - It is cheap, so maybe, but wouldn’t want to if it isn’t necessary

4/4/22 Meeting

Ben Smith - Apr 21, 2022, 10:30 AM CDT

Title: Advisor Meeting 7

Date: 4/4/22

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- 1080 ECB? Might have scrap metal we can use
- Maybe put PLA piece into fixture first to test how it fits?
- Might not need to 1400N of force into the inclined plane because that would be absolute max bite force at moellers
    - Look at age group of dogs
    - Would need to find numbers at canines to test a different force it would need to withstand
- Reach out to Jacob Zeuske to see if we can get any sort of data printed out with stress analysis
- Include Graham, past students, and John
- In executive summary, include that we talked to WARF
    - Focus on key commercializable aspects
        - Cut costs from x to y
        - Cut time from x to y
    - Talk about business potential
    - Talk about how we have tested the workflow in the show and tell
    - Make Excel sheet to make it easiest

4/11/22 Meeting

GIOVANNI MILITELLO - Apr 27, 2022, 7:54 PM CDT

Title: Advisor Meeting 8

Date: 4/11/22

Content by: Team

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- Go to Team Labs for screws with threads all the way to the head that we can use
- Contact Jacob to set up time so we have a deadline to fabricate plates by
- $100 and certificate for winning Tong award
- Lab Archives
    - Add drafts into lab archives
    - Add research
    - New research
        - How titanium printing works

4/18/22 Meeting

GIOVANNI MILITELLO - Apr 27, 2022, 7:55 PM CDT

Title: Advisor Meeting 9

Date: 4/18/22

Content by: Team

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- Can we take a video of the testing to view possible deformation of the aluminum/bolts?
- Should we look into smaller/thinner bolts?
- Consider staying to watch the testing
- Executive summary comments:
    - Emphasize the work we did with the workflow
    - As it is, it sounds like we are selling us short
    - Mention excel sheet and calculations to show we really shortened the process
    - Went from needing grahams time and a third parties to just grahams time
    - Put client and advisor on just one line
    - Put poster number on it
    - Will be judged based on bullet points in the executive summary directions
        - Make sure we can touch on each bullet point
- Let John know once it’s running/testing in case he is able to stop in and see it

4/25/22 Meeting

GIOVANNI MILITELLO - Apr 27, 2022, 8:07 PM CDT

Title: Advisor Meeting 10

Date: 4/25/22

Content by: Team

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Maddie Kredell, Abbie Stertz

Content:

- Potentiality for starting a company where we are the intermediary between vets and getting this incline plane done
- To sell to the judges, create a business name and throw the idea of starting a company
- Try to calculate strain rate?
- Maybe add market analysis section?
    - Company name
    - Talk on profitability
    - Logo?
    - Potentially let WARF know

PDS 02/11/2022

GIOVANNI MILITELLO - Apr 27, 2022, 12:21 PM CDT

Title: PDS

Date: 02/11/2022

Content by: Team

Present: Team

Goals: Update PDS from last year based on what we need to accomplish this year.

Content:

- Removed portions on software as we eliminated the usage of software in editing CT scans

- Incorporated more workflow as the client needs a CAD program (e.g. Solidworks) to be able to develop and edit our part.

- Material that our client wanted was Ti64 as it was most suitable for our design.

Conclusions/action items:

Below is an attachment of the PDS

GIOVANNI MILITELLO - Mar 02, 2022, 12:05 PM CST


BME Design

VetMed: 3D Printed, Patient Specific Incline Plane

Preliminary Product Design Specifications

BME 200/300

Team Members:
Benjamin Smith, Team Leader
Lily Gallagher, BWIG
Giovanni Militello, Communicator
Madeleine Kriedell, BPAG
Abigail Shartz, BSAC

Client:
Dr. Graham Thatcher

Advisor:
Dr. John Puccinelli

February 11th, 2022

Download

PDS.pdf (206 kB)

Testing Fixture Idea 03/30/2022

GIOVANNI MILITELLO - Apr 27, 2022, 3:31 PM CDT

Title: Testing fixture idea

Date: 03/30/2022

Content by: Team

Present: Team

Goals: Meet with Jacob Zeuske and discuss with him about possible ways to compression test our part.

Content:

- Met with Jacob Zeuske and talked about possible ways to fabricate a testing fixture to compression test our part.

- We mentioned that we want 926 N of force to come in contact with the incline plane portion of the part. Additionally, we asked if it would be possible to do cyclic loading.

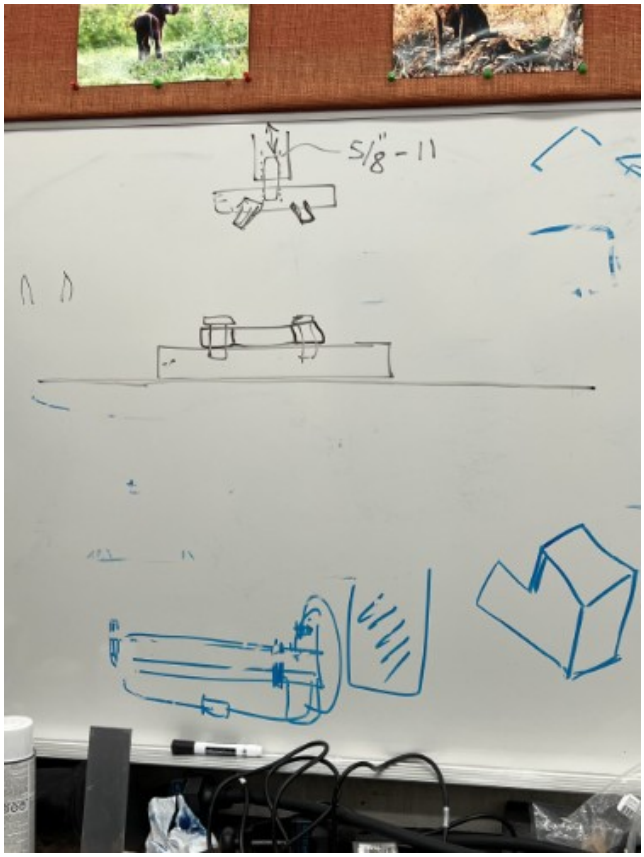


Figure 1: This is a picture Jacob drew for us. He mentioned that our testing fixture needed to include an Aluminum plate with 2 steel screws to hold the Ti-64 incline plane in place. Additionally, the testing fixture needs another Aluminum plate to attach to the MTS machine with two steel screws coming off of it to act as teeth.

Conclusions/action items:

- Go to ECB and Makerspace to collect spare parts to create a testing fixture.

WARF Meeting 4/20/22

LILY GALLAGHER - May 03, 2022, 10:33 PM CDT

Title: Meeting with WARF

Date: 04/20/2022

Content by: The team

Present: The team

Goals: The team met with WARF to talk about our design, proposal and the next steps of the process.

Content:

WARF Meeting 4/20/22

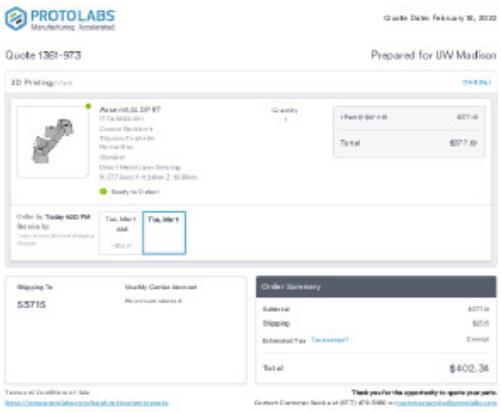
- File for patent protection by dec 6th 2022
- First disclosed to public Dec. 6th 2021 (Fall 2021 Poster Session)
- When did inventing start?
- Consider inventive contributions
    - Who contributed to the invention that is being patented
- When did initial funding start?
- Authorship vs. inventorship (different)
- WARF protects technologies in a way that company pay to use that technology
    - Is this robust?
    - Can we license this technology?
- We are free to patent however we want, whether through WARF, alone, start a company, etc.
- Next meeting May 19th?
    - Send final poster
    - Executive summary
    - Updated workflow (add excel to it)
    - Final Report
    - This is an internal meeting, WARF exchanges thoughts on invention disclosures they have received
        - Discuss thoughts and concerns, discuss whether it's worth the $30,000 fee
        - Will let us know no later than the 20th with an answer
- Give Justin Graham's contact info
- In terms of the expired patent
    - It is very old, 5 million series and now we are on 11 million series
- Different types of patents
    - Workflow
    - Physical Device
    - Process
- Where else can this process be used? Does it have to be medical?
    - All of us will likely have a 3D printer in our house at some point, so how could we leverage this in other areas?

Conclusions/action items:

Wait until May 19th to hear update from WARF.

Protolabs Quote 3D Printing 02/18/2022

ABIGAIL STERTZ - Feb 18, 2022, 1:49 PM CST



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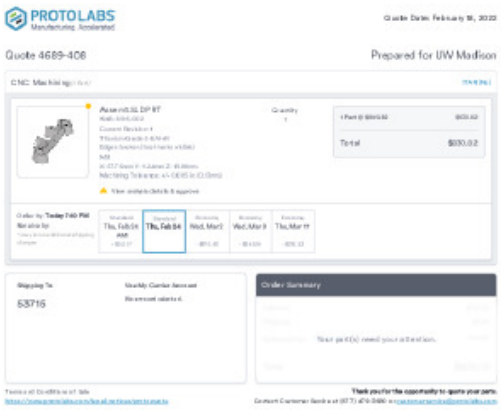
Quote_1361-973.pdf (132 kB)

Protolabs Quote CNC Machining 02/18/2022

ABIGAIL STERTZ - Feb 18, 2022, 1:49 PM CST



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Quote_4689-408.pdf (269 kB)

Expenses Spreadsheet 03/31/2022

GIOVANNI MILITELLO - Apr 27, 2022, 12:28 PM CDT

Title: Expenses Spreadsheet

Date: 03/21/2022

Content by: Ben Smith

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Category 1								
Makerspace Fee	Fee to utilize Makerspsace	Makerspace		2/21/2022	1	$50	$50	
3D- Print	Printing of the Lower Jaw of 3D Model	Makerspace		2/21/2022	1	$6.96	$6.96	
3D- Print	Printing of the Upper Jaw of 3D Model	Makerspace		2/21/2022	1	$25.04	$25.04	
3D- Print	PLA Incline plane	Makerspace		03/11/2022	4	$0.32	$1.28	
3D- Print	Ti-64 Incline plane	i.Materialise		03/31/2022	1	$121.77	$121.77	
						TOTAL:	**$205.05**	

Sculpteo 3D Print Quote 03/04/2022

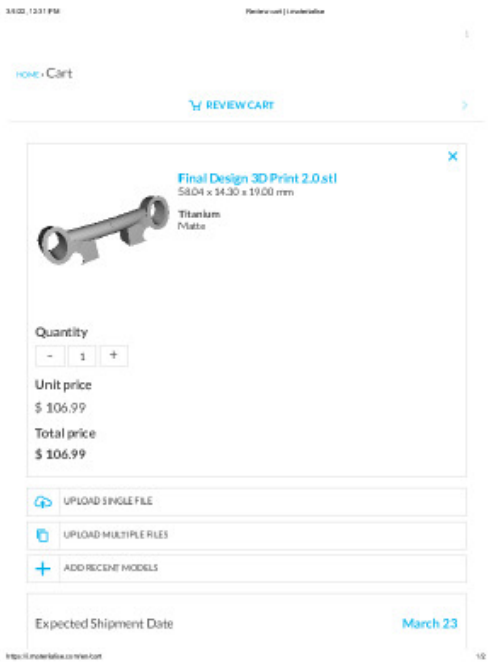
ABIGAIL STERTZ - Mar 04, 2022, 12:36 PM CST

Download

Sculpteo_3D_print_quote.pdf (270 kB)

Materialise 3D Print Quote 03/04/2022

ABIGAIL STERTZ - Mar 04, 2022, 12:36 PM CST



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materialise_3D_print_quote.pdf (119 kB)

Materials for Testing Fixture 04/11/2022

GIOVANNI MILITELLO - Apr 27, 2022, 4:38 PM CDT

Title: Materials for Testing Fixture

Date: 04/07/2022, 04/11/2022

Content by: Giovanni

Present: Ben and Gio

Goals: Collect materials for testing fixture

Content:

- Ben and Gio went to ECB on 04/07/2022 and grabbed a few aluminum plates as well as screws to potentially use for the testing fixture

- On 04/11/2022, Ben and Gio met with Jacob again. We showed Jacob the materials we gathered. Jacob gave us a different aluminum plate to use to connect to the MTS machine that was a bit thicker

Conclusions/action items:

- Fabricate the compression testing fixture for testing

Expenses Spreadsheet 05/02/22

MADELEINE KREDELL - May 02, 2022, 2:16 PM CDT

Title: Expenses Spreadsheet

Date: 05/02/22

Content by: Maddie Kredell

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Makerspace								
Makerspace Fee	Fee to utilize Makerspace	Makerspace		2/21/2022	1	$50.00	$50.00	
Lower Jaw Print	3D printed model of the lower jaw	Makerspace		2/21/2022	1	$6.96	$6.96	
Upper Jaw Print	3D printed model of the upper jaw	Makerspace		2/21/2022	1	$25.04	$25.04	
Incline Plane Prototype	3D printed prototype for patient 0 incline plane	Makerspace		3/4/2022	1	$0.24	$0.24	
Final Design								
Ti-64 Incline Plane	Finalized incline plane 3D printed in Ti-64	Materialise		3/11/2022	1	$121.77	$121.77	
						TOTAL:	**$204.01**	

Solidworks first Model 11/12/21

Ben Smith - Dec 13, 2021, 8:32 PM CST

Title: Solidworks First Model

Date: 11/12/21

Content by: Team

Goals: Create an initial model of our design on Solidworks and print it for show and tell.

Content:

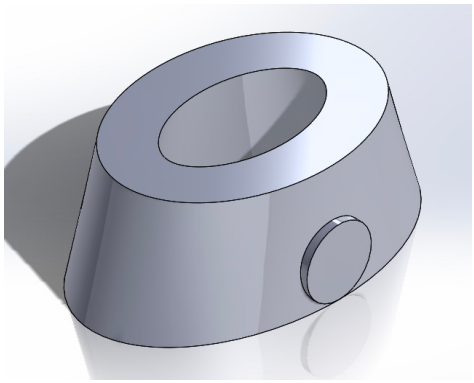


Figure 1: Ring component of the initial model

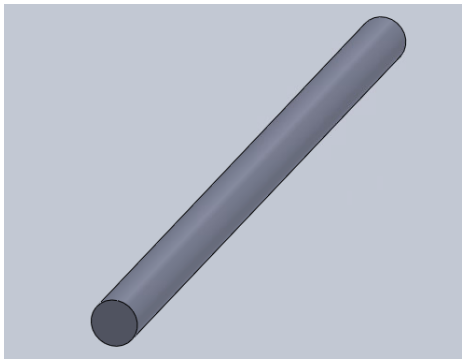


Figure 2: Support bridge component of the initial model.

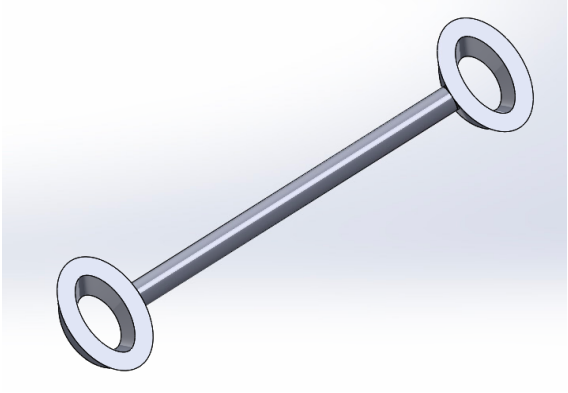


Figure 3: Assembly of the initial ring and support bridge

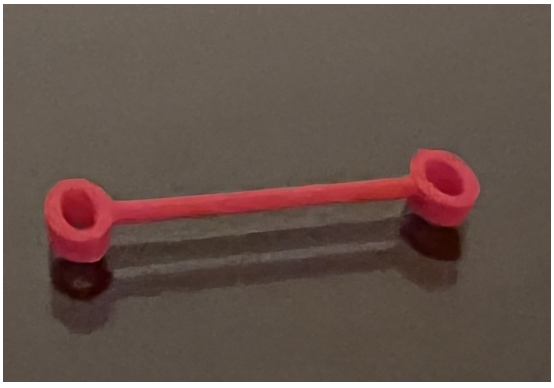


Figure 4: 3D printed PLA version of the initial design of the ring and support bridge.

Conclusions/action items:

These are the first pieces made along with the assembly. The idea is that if we keep the rings separate from the support bridge, we can more easily change the sizes of the individual components and then assemble then after making those changes, allowing an easy way to make the device patient specific. The next step is to model the incline plane and integrate it within the assembly.

Solidworks Final Model 12/06/2021

Ben Smith - Dec 14, 2021, 9:39 PM CST

Title: SolidWorks Final model

Date: 12/06/21

Content by: Team

Present: Team

Goals: 3D print design in makerspace

Content:

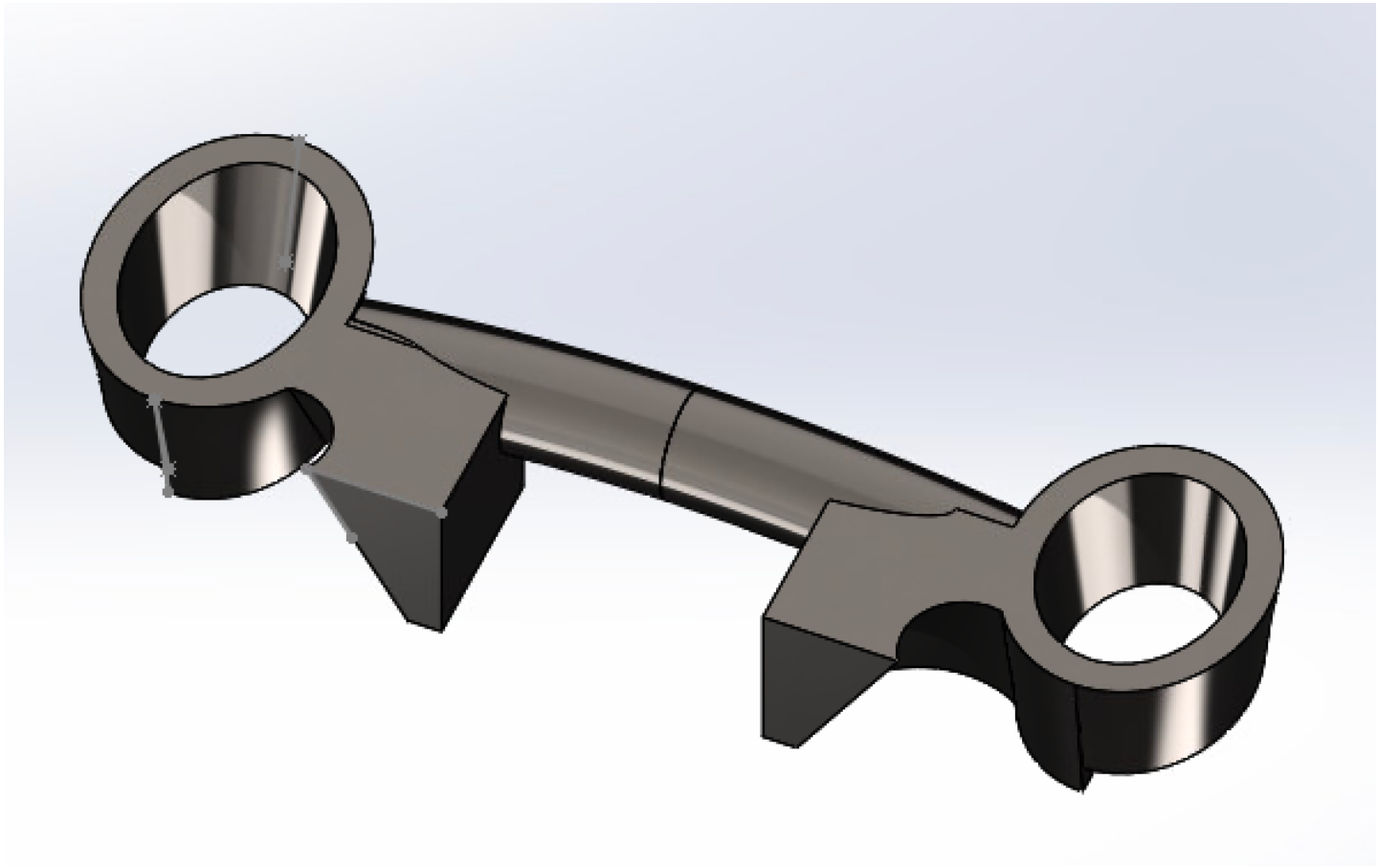


Figure 1: Assembly of our final design in solidworks

- Upper tooth diameter: 15.50 mm x 11.25 mm

- Lower tooth diameter: 13 mm x 8 mm

- Support bridge length: 38 mm

- Degree of incline plane: 60 degrees

- These measurements are subject to change for each specific patient.

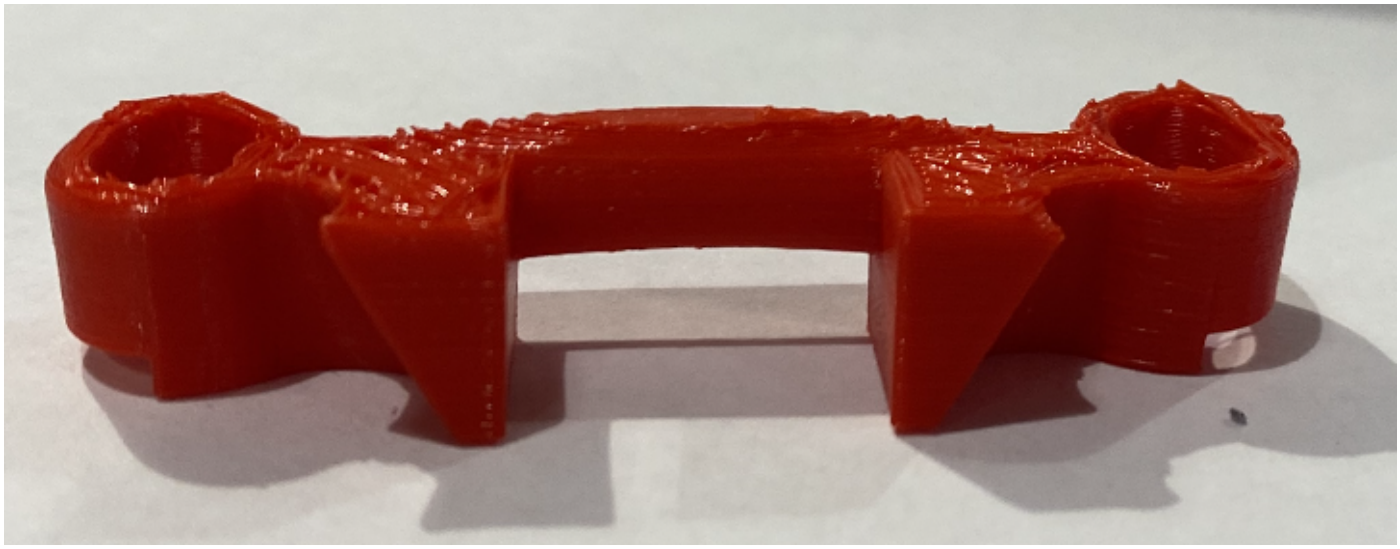


Figure 2: Final design printed in PLA from the makerspace .

Figure 3: Final design in model mouth that we based the measurements off of.

See attached for the final solidworks file of the final model.

Conclusions/action items:

- Use this model as a demonstration during the presentation.

Ben Smith - Dec 14, 2021, 9:38 PM CST

Download

Final_Design_45_degrees_.SLDPRT (329 kB)

Meeting with TEAMLab 02/23/2022

LILY GALLAGHER - Mar 02, 2022, 9:05 AM CST

Title: Meeting with TEAMLab to talk about CNC milling fabrication

Date: 02/23/2022

Content by: Lily Gallagher

Present: Lily Gallagher, Giovanni Militello, Maddie Kredell, Abbie Stertz

Goals: To see if CNC milling at the TEAMLab would be possible for fabrication of our device

Content:

Cannot use the CNC Miling without a green and red permit

- Apply for a green permit
- Complete the green permit quizzes
- Watch the Virtual green permit seminar video/complete the seminar video quiz.
- Successfully complete the test piece (reserve machines through EMU and actually use the machines to make the part in the shop)
    - The test piece is a simple hands-on test for individuals applying for the green permit to prove they have learned what was covered in the quizzes and seminar. There are two versions of the part (alpha and beta) and either may be assigned to individuals when they arrive to make their part. Individuals who do not demonstrate sufficient skill on the equipment with their assigned part will be required to make the other part
- **Training**
- **Experience**

TEAMLAB is not taking any new projects

Look into physics department

Conclusions/action items:

It looks like CNC milling will not be possible- 3D printing in titanium will be easier and cheaper

3D Printed Model Skull 03/02/2022

Ben Smith - Mar 02, 2022, 9:32 AM CST

Title: 3D Printed Model Skull

Date: 3/2/22

Content by: Ben Smith

Goals: Print a 3D Model of a dog's skull so we can model our prints off of it

Content:

Figure 2: Lower jaw print

Conclusions/action items:

We successfully printed out a new model of a dog's skull so we can take accurate measurements of the canines to model future prints off of.

Ti-64 Incline Plane 03/31/2022

GIOVANNI MILITELLO - Apr 27, 2022, 12:57 PM CDT

Title: Ti-64 Incline Plane

Date: 03/31/2022

Content by: Team

Present: Team

Goals: Order and receive Titanium Incline Plane

Content:

- The team ordered the incline plane on March 13th and the part arrived on March 31st.

- Placed the order in i.Materialise

- Part cost $121.77

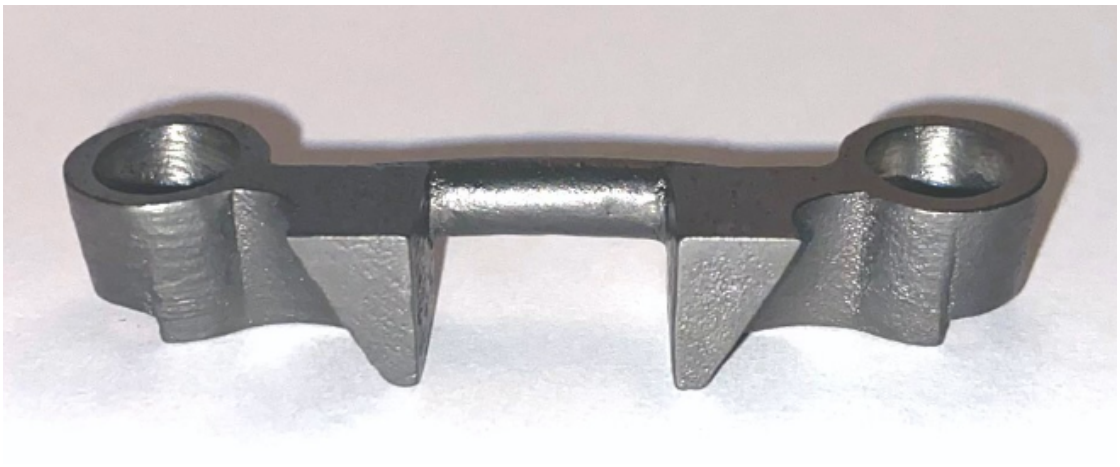


Figure 1: Final Design 3D printed in Ti-64

Conclusions/action items:

- Now we're are looking to compression test our part to verify it would be able to withstand the bite force of a canine.

PLA Incline Planes 03/11/2022

GIOVANNI MILITELLO - Apr 27, 2022, 2:33 PM CDT

Title: PLA Incline Planes

Date: 03/11/2022

Content by: Team

Present: Team

Goals: Get a perfect fitted PLA incline plane for skull model so that we could print in Ti-64

Content:

- Printed out 4 PLA incline planes before we got a print that fit the skull model

- The original measurements were:

- 38 mm for bridge length
- Upper Ring
    - 8.46 mm small ellipse
    - 11.23 mm large ellipse
- Lower Ring
    - 6.535 mm small ellipse
    - 7.875 mm large ellipse

- For the bridge length, we had to subtract 4 mm and then divide by two, as the part is mirrored to make a full part.

- For the Ring dimensions, we added 5 mm to account for the thickness of the ring itself as well as adding a 0.5 mm space between the canine teeth and the ring for easier mobility of moving the rings into the preferred position.

- The next three models printed were adjusted slightly to get the perfect fit on the model skull.

Figure 1: Final 2 models printed. Pink PLA incline plane fit best.

Conclusions/action items:

- We realized that when we took our measurements, we were not as accurate with the placement of where we took the measurements which caused us to print out 4 different models. To fix this, we are going to update our workflow to have a more consistent way of taking measurements.

Fabrication of Testing Fixture 04/15/2022

Ben Smith - May 03, 2022, 10:52 PM CDT

Title: Fabrication of Testing Fixture

Date: 04/07/2022, 04/11/2022, 04/15/2022

Content by: Team

Present: Team

Goals: Collect the required materials for the testing fixture, Meet with Jacob again to confirm our parts would work, and fabricate the testing fixture in MakerSpace

Content:

- On 04/07/2022, Ben and Gio went to ECB and grabbed a few aluminum plates as well as bolts to potentially use for the testing fixture

- On 04/11/2022, Ben and Gio met with Jacob again. We showed Jacob the materials we gathered. Jacob gave us a different aluminum plate to use to connect to the MTS machine that was a bit thicker

- On 04/15/2022, the team met at MakerSpace to fabricate the testing fixture. We talked with a person who worked there and figured out how to put 4 holes into the two plates for our specific bolts. Everyone had a chance to drill the holes. The placement of the hole for the bolts were determined by marking where the rings of the part would be on the bottom aluminum plate and matching where the middle of the incline plane would be for the two holes on the top aluminum plate.

Figure 1: This was the team drilling holes into the aluminum plates

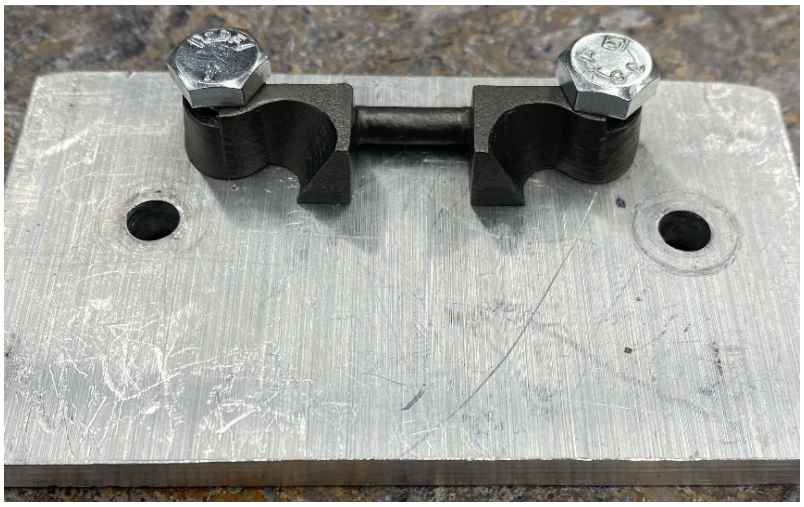


Figure 2: Lower compression plate with 2 1/4 inch-20 bolts to keep the incline plane fastened to the plate

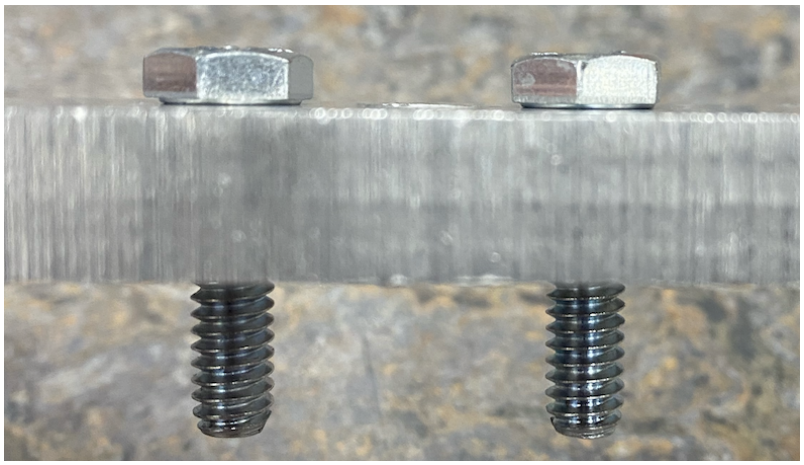


Figure 3: Upper compression plate with two 1/4 inch-20 bolts to act as maxillary canines that will come into contact with the incline plane

Conclusions/action items:

- Meet with Jacob again to preform compression testing

Workflow Document for Client 12/05/2021

Ben Smith - Dec 13, 2021, 8:33 PM CST

Title: Workflow Document for Client

Date: 12/5/21

Content by: Team

Present: Team

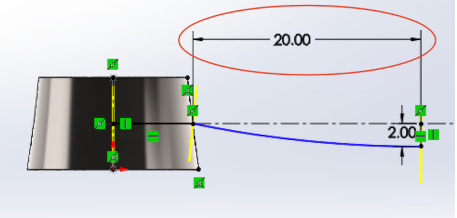
Goals: Create a document where the client will be able to read the directions and make adjustments, depending on his patients, to our final design.

Content:

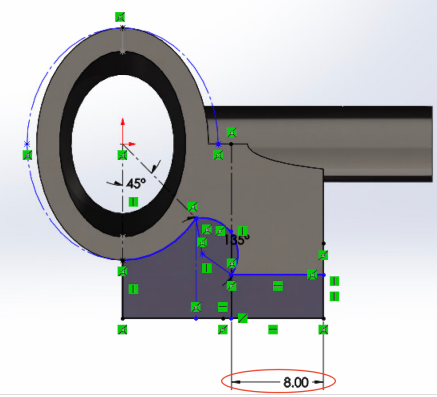
Creation of Patient Specific Part

1. Open up the **Final Design** document
2. Measure the Upper Diameter of the maxillary canine
    1. Double click on the **Upper Tooth Diameter** tab in the feature tree under the tab **Tooth dimension**
    2. Double click on the larger dimension and insert the number in millimeters of the longer width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the base of the tooth
    3. Double click on the smaller dimension and insert the number in millimeters of the smaller width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the base of the tooth
    4. Click exit sketch in top left corner of the screen
3. Measure the Lower Diameter of the maxillary canine
    1. Double click on the **Lower Tooth Diameter** tab in the feature tree under the tab **Tooth dimension**
    2. Double click on the larger dimension and insert the number in millimeters of the longer width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the tip of the tooth
    3. Double click on the smaller dimension and insert the number in millimeters of the smaller width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the tip of the tooth
    4. Click exit sketch in top left corner of the screen
4. At this point, the dimensions of the ring should be all set.
5. Now, edit the length of the support bridge.
6. Measure the distance between the maxillary canine

7. Subtract 4mm, to account for the ring thickness, and divide this value by 2. Remember this value.
8. Click on the **Support Bridge** tab in the feature tree, and double click on **Support Bridge Arc**
9. Double click on the dimension of the arc circled in red, and insert the value in millimeters found in step 7.



10. Now change the angle of the inclined plane.
11. Determine the angle required for desired correction.
12. In the design tree, click on the **Incline Plane** tab and double click on the **Incline Plane Angle** tab
13. In this sketch, double click on the dimension circled in red below



14. To find the desire dimension, solve for x in the equation and add 2, as the bottom of the incline plane stays at 2 mm:

    x= (10)/(tan(desired angle in degrees))

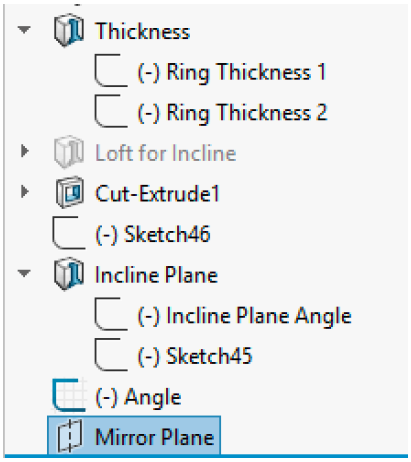
    For example, for a desired angle of 45 degrees, the equation is:

    x= (10)/(tan(45)) , where x=10, and thus x+2 = 12, so enter in 12mm for the circled dimension.

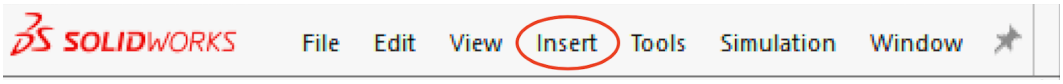
15. To verify the desired angle was obtained, exit this sketch, and click on the **Angle** tab in the design tree. In this sketch, the dimension shown is the angle of tilt for the incline plane.
16. At this point, the part should be fully dimensioned and patient specific. All that's left to do now is mirror the part, and create an assembly to make the piece.

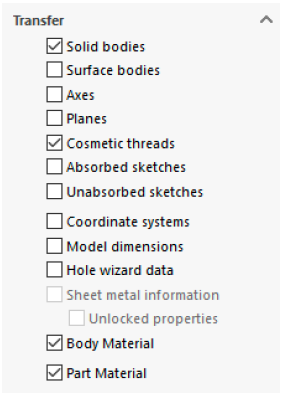
Creation of Mirrored Part

1. Now we want to mirror the part for the assembly.
2. Click on **Mirror Plane** at the very bottom of the feature tree

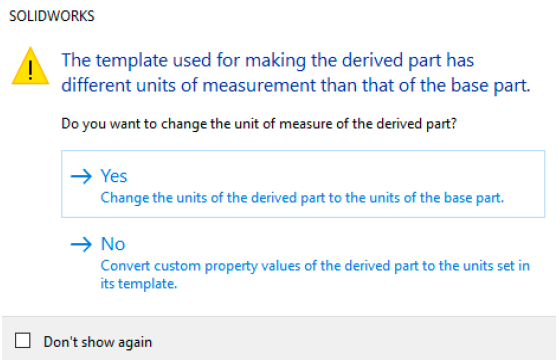


3. Next select **Insert** → **Mirror Part** found at the top of the screen, and make sure the boxes are checked as they are in the following picture





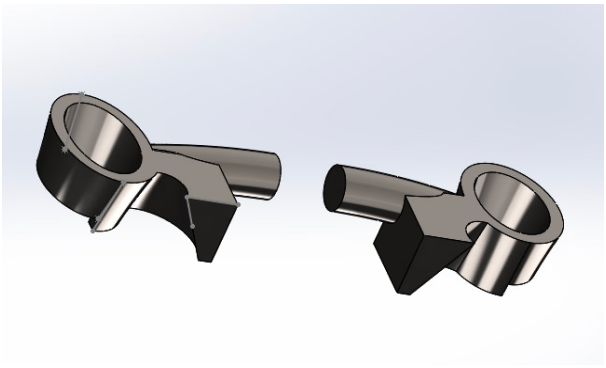
4. If the following message appears, click **yes**



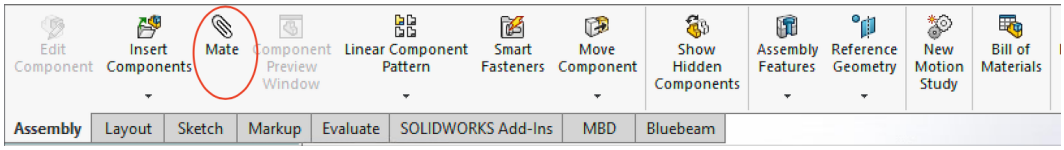
5. The mirrored part will appear, and you should now **Save As** a new part

Creation of Assembly

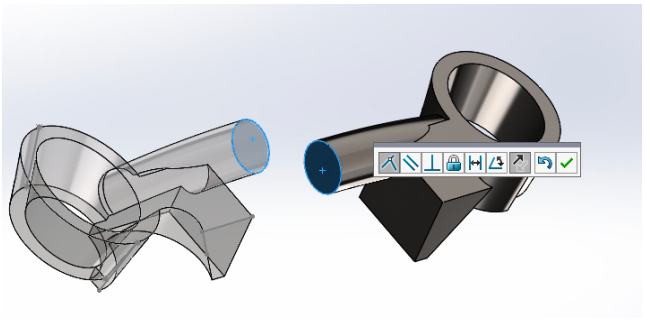
1. Open a new assembly in Solidworks
2. Insert both the initial part and the mirrored part in a similar configuration as shown below



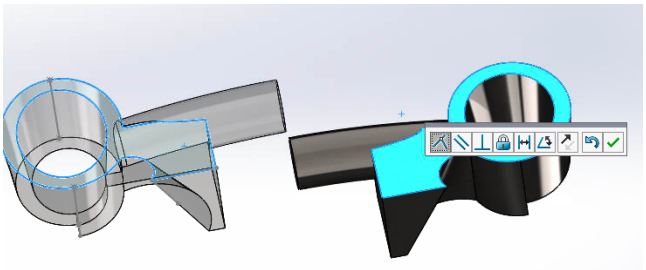
3. In the toolbar, select **Mate**



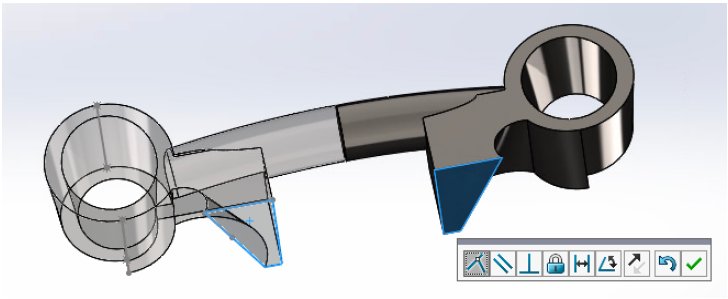
4. In the **Mate** tool, click on the two faces at the end of each support bar as shown below



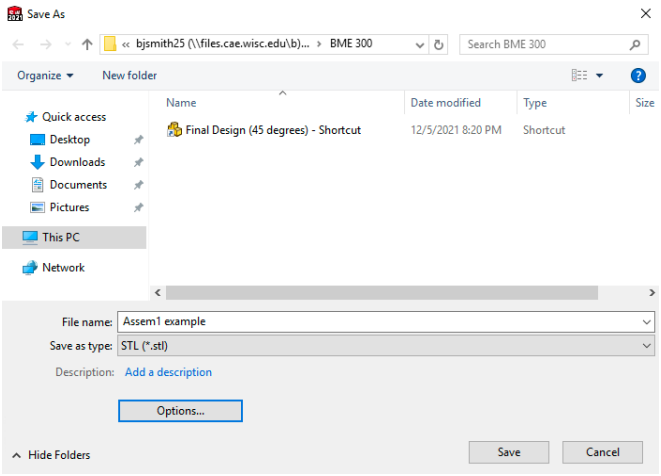
5. With these faces in the same place, click on **Mate** again, and this time click on the two faces in the image shown below.

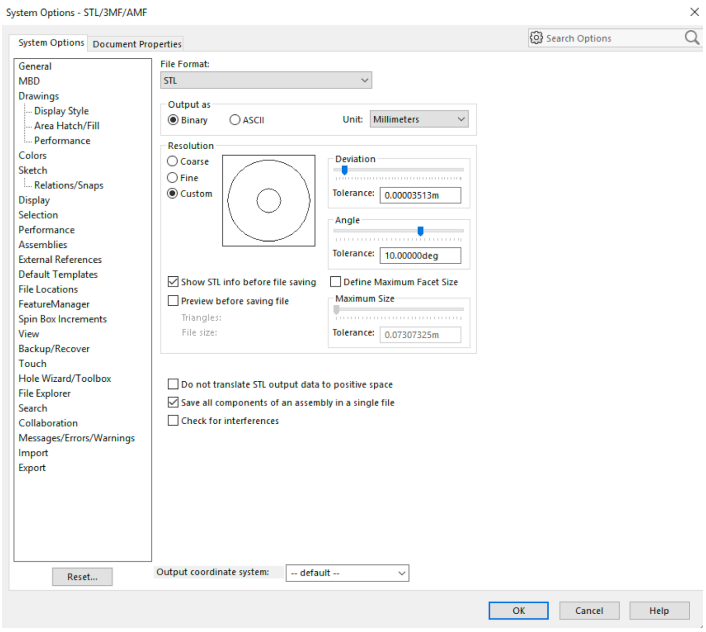


6. Click on **Mate** one more time, and this time, click on the two faces shown in the image below.



7. At this point, the piece is fully configured and ready to be printed.
8. Save the file as a .stl file
    1. Click options
    2. Check **Save all components of an assembly in a single file**





Conclusions/action items:

- Go over this document with our client and see if he is unsure about anything.

- Send workflow document to other students with limited solidworks knowledge for them to try to make a new patient specific part

- Optimize wording and flow of the steps as needed

Updated Workflow 03/01/2022

Ben Smith - Mar 01, 2022, 4:38 PM CST

Title: Updated Solidworks Workflow

Date: 3/1/22

Content by: Ben Smith

Goals: Update the Solidworks workflow to be more in depth for people new to Solidworks.

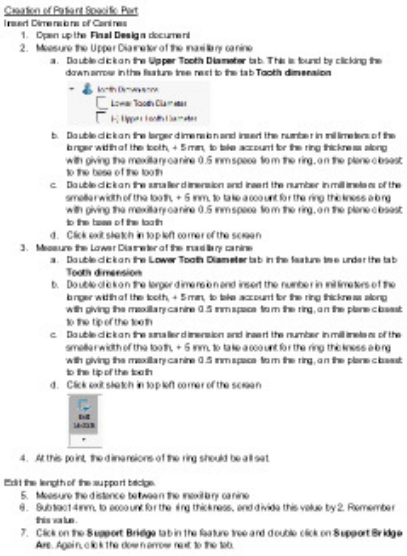
Content:

See attached PDF for updated workflow.

Conclusions/action items:

Abbie and Maddie went through the Solidworks workflow and edited it to make it easier to understand for someone that does not have much Solidworks experience.

Ben Smith - Mar 01, 2022, 4:40 PM CST



Creation of Patient Specific Part

Insert Dimensions of Canines

1. Open up the **Final Design** document
2. Measure the Upper Diameter of the maxillary canine
   a. Double click on the **Upper Tooth Diameter** tab. This is found by clicking the down arrow in the feature tree next to the tab **Tooth dimension**
   b. Double click on the larger dimension and insert the number in millimeters of the longer width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the base of the tooth
   c. Double click on the smaller dimension and insert the number in millimeters of the smaller width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the base of the tooth
   d. Click exit sketch in top left corner of the screen
3. Measure the Lower Diameter of the maxillary canine
   a. Double click on the **Lower Tooth Diameter** tab in the feature tree under the tab **Tooth dimension**
   b. Double click on the larger dimension and insert the number in millimeters of the longer width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the tip of the tooth
   c. Double click on the smaller dimension and insert the number in millimeters of the smaller width of the tooth, + 5 mm, to take account for the ring thickness along with giving the maxillary canine 0.5 mm space from the ring, on the plane closest to the tip of the tooth
   d. Click exit sketch in top left corner of the screen
4. At this point, the dimensions of the ring should be all set.

Edit the length of the support bridge.

5. Measure the distance between the maxillary canine
6. Subtract 4mm, to account for the ring thickness, and divide this value by 2. Remember this value.
7. Click on the **Support Bridge** tab in the feature tree and double click on **Support Bridge Arc**. Again, click the down arrow next to the tab.

Download

WorkFlow_Solidworks_Model.pdf (1.56 MB)

Conversion of DITCOM files to STL 02/11/2022

GIOVANNI MILITELLO - Mar 02, 2022, 11:56 AM CST

Title: Conversion of DITCOM files to STL

Date: 02/11/2022

Content by: Giovanni

Present: All team members

Goals: Mesh the CT scan images (DITCOM files) into a stl model of the canines skull

Content:

1. Upload DITCOM images into Invasales

- Uploaded the DICOM file into Invasales and select option to delete one slide per 2 slides to produce figure 1.

2. Combine all pictures

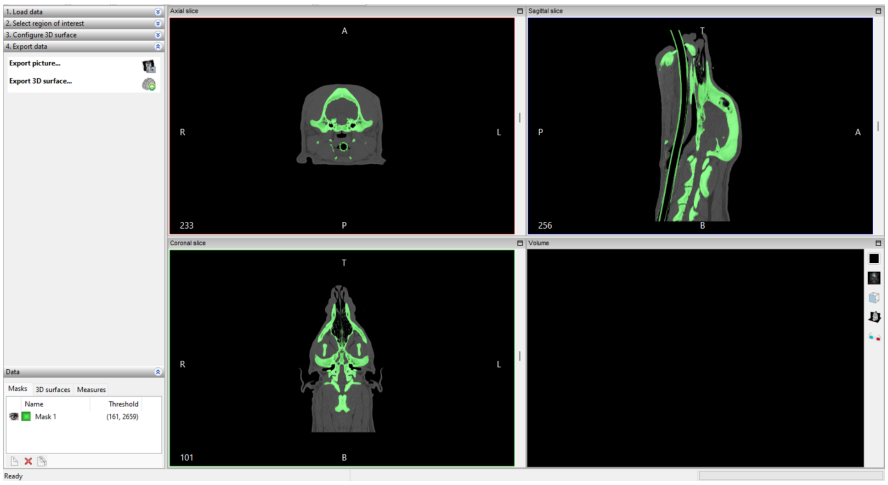


Figure 1: Invasales combines all CT scans into one and then able export as a 3D surface to be put into meshmixer to be edited.

3. Upload to meshmixer and Remove any unwanted pieces

- Cleaned up 3D model by selecting the main skull and removing any additional specs around it

- Cut the back half of the skull to reduce the amount of material needed to print with (only really need the jaws)

- Made the whole piece solid to be able to convert into an STL file for 3D printing

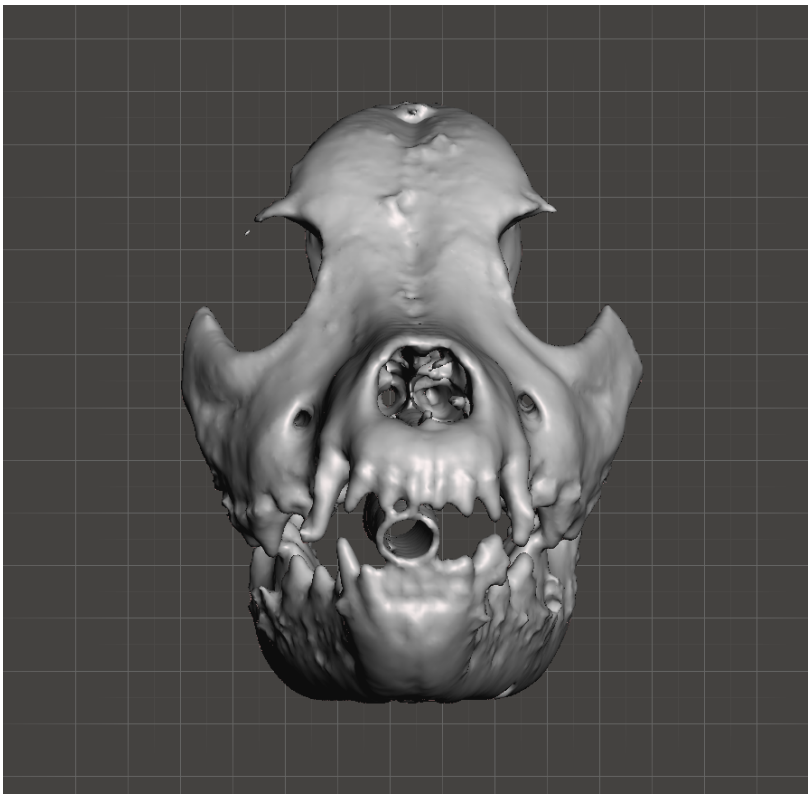


Figure 2: Frontal plane of skull after being modified

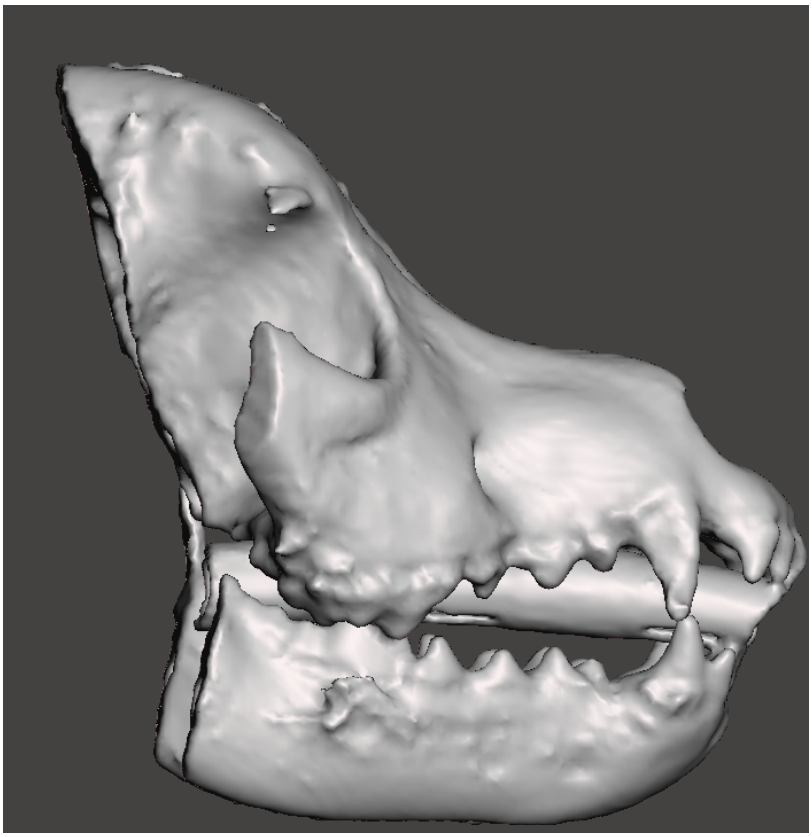


Figure 3: Sagittal plane of skull after being modified

Conclusions/action items:

- Use this model as extra testing to see if our workflow is good enough to be used on multiple different patients.

Finalized Workflow Document 04/24/2022

GIOVANNI MILITELLO - Apr 27, 2022, 7:26 PM CDT

Title: Simplified Workflow Document

Date: 04/24/2022

Content by: Team

Present: Team

Goals: Update workflow document again based on comments and feedback we received from the show and tell presentations

Content:

- Received comments on the workflow to add a portion on how to take measurements to make it more consistent with each persons attempt.

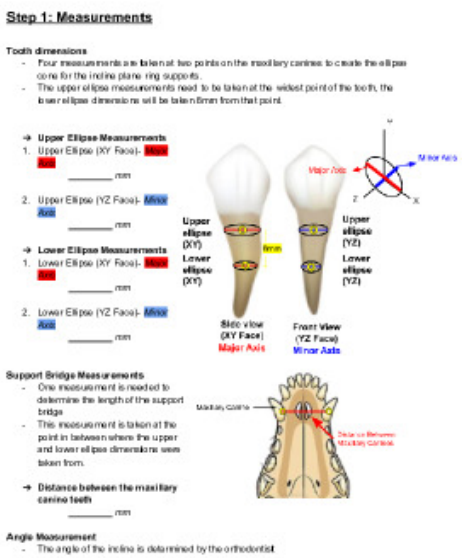
- Also received comments on adding more pictures to make the process simplified even more.

- Additionally, we were told to make the math calculations easier so the veterinarian could simply implement the correct values into solidworks instead of having to do math calculations.

Conclusions/action items:

- More pictures and a more detailed description on how to take measurements were added to the workflow document. Additionally, an excel sheet was made so that the veterinarian can simply input his measurements into the excel sheet and then implement the output values from the excel sheet into solidworks.

GIOVANNI MILITELLO - Apr 27, 2022, 7:16 PM CDT



Download

Simplified_WorkFlow_Solidworks_Model.pdf (2.98 MB)

GIOVANNI MILITELLO - Apr 27, 2022, 7:30 PM CDT

Download

Incline_Plane_Measurement_Conversion_-_Sheet1.pdf (27.4 kB)

Workflow Testing Protocol 4/26/22

Ben Smith - May 03, 2022, 11:05 PM CDT

Title: Workflow Testing Protocol

Date: 4/26/22

Content by: Team

Present: Team

Goals: Have a protocol to test our workflow document to see where improvements can be made

Content:

1. Gather 3 students with varying knowledge of Solidworks: no knowledge, intermediate level, knowledge

2. Have them take measurements of our model skull using the instructions from the workflow document and time them to see how long it takes them

3. Have them follow the workflow document on converting the measurements and implementing them into the Solidworks file and time them to see how long it takes them

4. Have the three students provide feedback on what was unclear on the workflow document

Conclusions/action items:

- Find 3 students with varying knowledge of Solidworks and test the usability of our workflow document

Compression Testing Protocol 4/18/22

Ben Smith - May 03, 2022, 11:05 PM CDT

Title: Compression Testing Protocol

Date: 4/18/22

Content by: Team

Present: Team

Goals: Make a compression testing protocol

Content:

1. Create a testing fixture to simulate mandibular canines coming in contact with the incline plane

- Need: Fixture to hold incline plane, Fixture with screws to act as mandibular canines and come directly in contact with the incline plane.

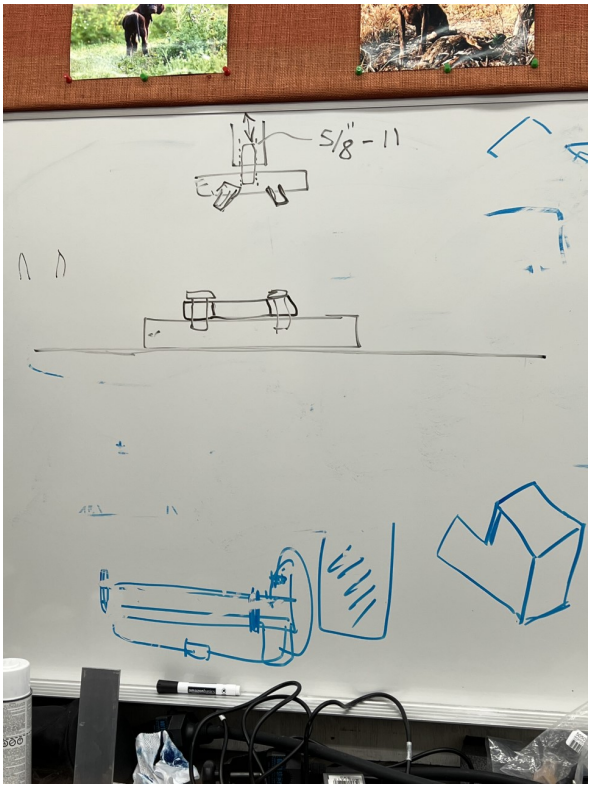


Figure 1: Example of testing fixture

2. Set up MTS machine to perform 926 N of compression force onto the incline plane for 3 cycles at a strain rate of 0.001 s^-1

3. Collect available data provided by the MTS machine and make visual observations on how the part does under the 926 N of force

Conclusions/action items:

- Meet with Jacob and perform compression testing

Solidworks SimulationXpress Analysis Wizard Test 12/05/2021

Ben Smith - Dec 13, 2021, 8:39 PM CST

Title: Solidworks SimulationXpress Analysis Wizard Test

Date: 12/5/21

Content: Team

Present: Team

Goals: Perform stress testing on our final part in Titanium to see how it performs.

Content:

- Performed stress testing on our part on the inline plane as that is where the mandibular canines would come in contact with as the dog bites down

- Used 1400 N of force as that is the maximum bite force of a canine

Property	Value	Units
Elastic Modulus	1.0480031e+11	N/m^2
Poisson's Ratio	0.31	N/A
Tensile Strength	1050000000	N/m^2
Yield Strength	827370880	N/m^2
Tangent Modulus		N/m^2
Thermal Expansion Coefficient	9e-06	/K
Mass Density	4428.784	kg/m^3
Hardening Factor	0.85	N/A

Figure 1: Properties of Ti6Al4V (Ti64) from Solidworks

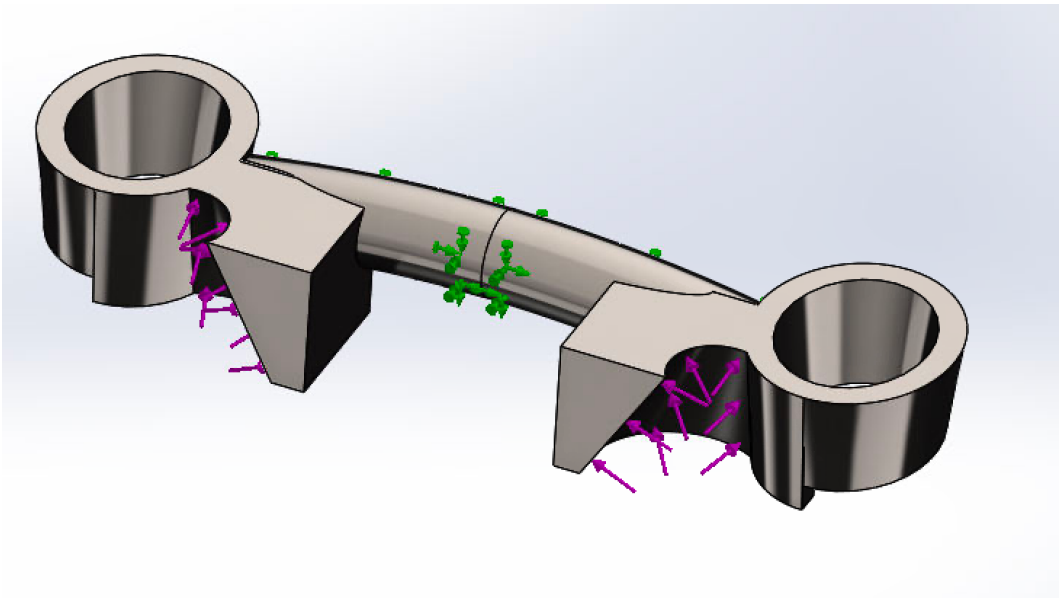


Figure 2: Demonstration of the forces on our device. The purple arrows show the applied force, and the green arrows show what is fixed.

- 1400 N force onto the the incline plane from the mandibular canine

- Bar is fixed in location as the forces of the mandibular canines pusing the incline planes inward which in turn, pushes the bar into each other which is why we can assume that the 2 parts of the bar would be fixed against each other.

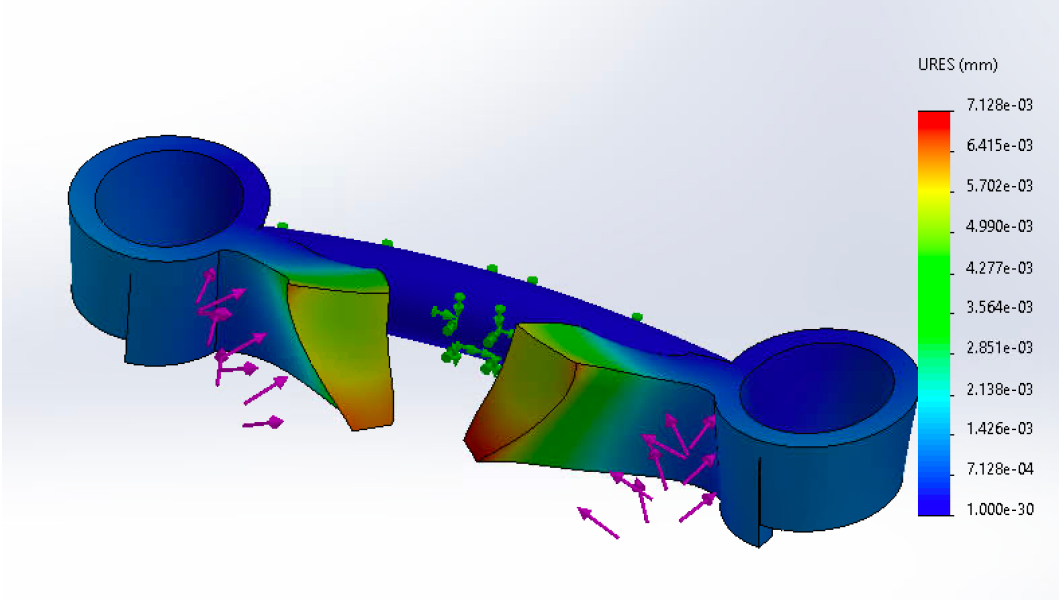


Figure 3: Demonstration of deformation from forces implied on the product during solidworks stress testing.

- This showed the deformation of the part with the stress test. Max deformation can be seen at the smaller end of the incline plane but on the scale it shows that there would only be a 7.13 micrometers which is very little to nothing which shows that our design would withstand a great amount of force from a dog bite without deformation.

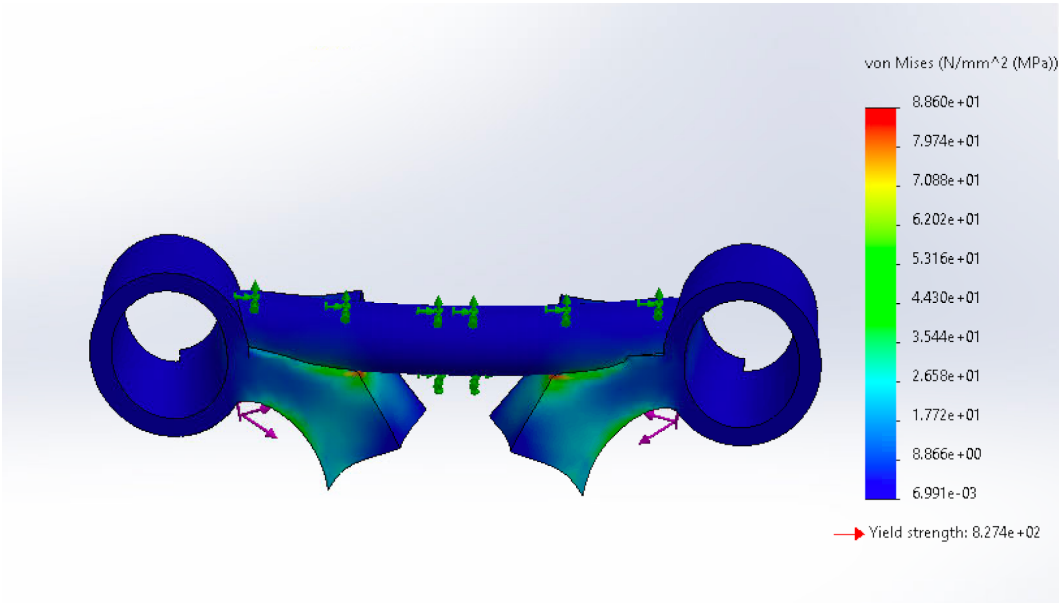


Figure 4: Demonstration of von Mises forces on our part after the force was implied.

- This shows the von Mises stress on our device which is just how likely the part would fracture under stress. In the Solidworks stress test of our part, the most likely place for a fracture would occur near the corners of the incline plane connected to the support bridge with a value of 88.6 MPa. The next highest point of fracture would be near the center of the incline plane as that is

where the 1400 N force from the dog bites would occur. The von Mises stress value here was arounf 44.3 MPa. Overall, Ti64 mechanical properties has a yield strength of about 830 MPa which give our part factor of safety of 9.33.

Conclusions/action items:

Final design made from Ti64 meets desired design criteria of withstanding 1400 N dog bite.

We would like to print our device in this material in the future.

Compression Testing 04/20/2022

GIOVANNI MILITELLO - Apr 27, 2022, 5:43 PM CDT

Title: Compression Testing

Date: 04/20/2022

Content by: Giovanni

Present: Ben and Gio

Goals: Compression Test Ti-64 Incline plane with 926 N of force and see if the part endures any damage

Content:

- Met with Jacob again and situated the testing fixture to the MTS machine. Jacob programmed the machine to compress the incline plane part up to around 926 N (max canine bite force).

- 3 test were performed on the incline plane and the amount of force varied from 926-990 N.

- No visible damage occurred to the incline plane as well as no elastic or plastic deformation of the part. The testing fixture screws shifted when compressed against the part showing how actual maxillary canines would shift outward and be corrected, as the intention of our incline plane part.

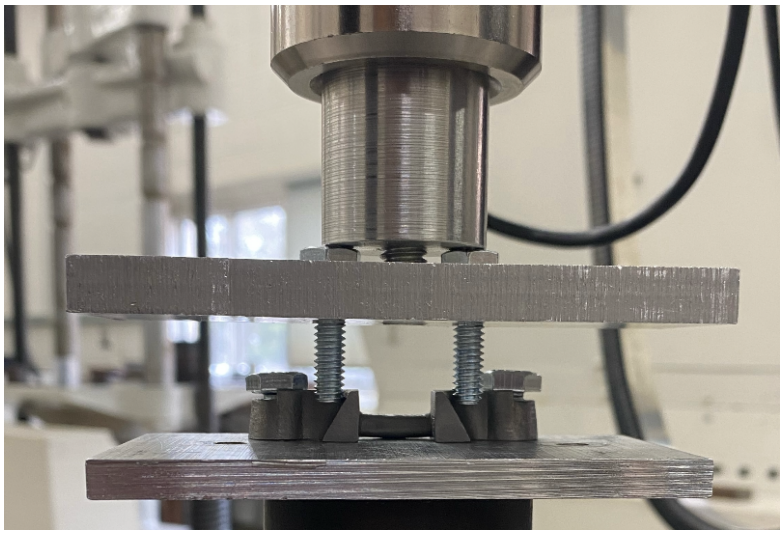


Figure 1: Testing fixture connected to MTS machine. Top plate with the two bolts, acting as maxillary canines, coming in contact with the incline plane ,which is fastened to the bottom plate, and applying compressive force.

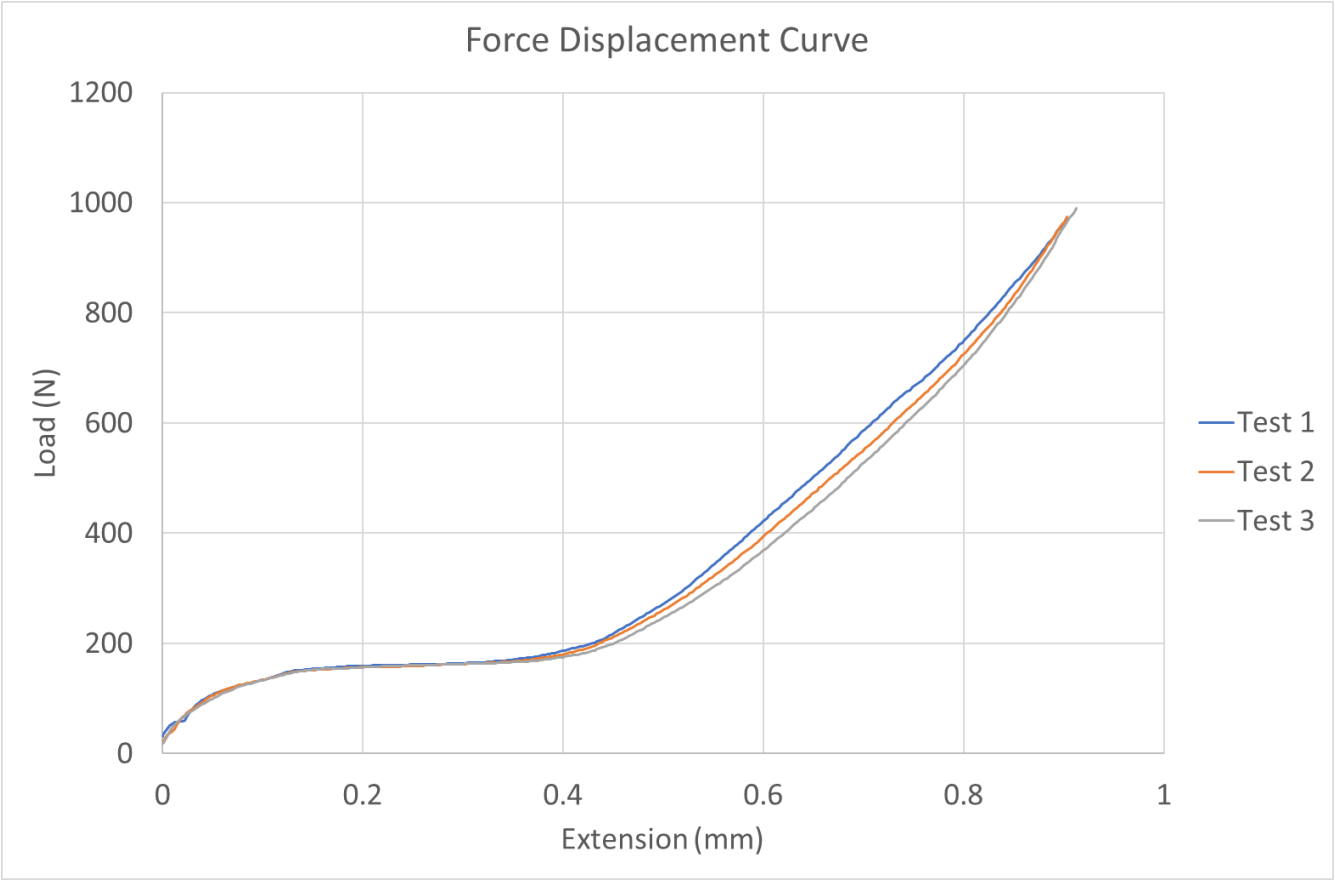


Figure 2: Force Displacement curve of the three tests performed. This graph shows how much force was applied onto the part as the testing fixture moved downward onto the part.

Conclusions/action items:

- Unfortunately, we were not able to conduct cyclic loading since the MTS machine that Jacob was using didn't have the ability to perform that type of test. Additionally, to perform cyclic loading, we needed a better testing fixture as well as multiple hours to set up a specific MTS machine to cyclic compression test. Furthermore, the only data we were able to collect was the Force Displacement curve. But overall, with our part enduring no visible damage as well as no elastic or plastic deformation, it is safe to assume that our part would not fracture in a dogs mouth.

Workflow Testing 5/2/22

Ben Smith - May 03, 2022, 10:54 PM CDT

Title: Workflow Testing

Date: 5/2/22

Content by: Team

Present: Team

Goals: Test our workflow document

Content:

- We gathered 3 students with varying knowledge of Solidworks: no knowledge, intermediate level, knowledgeable

- We had them take measurements of our model skull using the instructions from the workflow document and timed them to see how long it took them. The times for the 3 students were: 15 min and 22 sec, 17 min and 16 sec, 14 min and 49 sec for an **average of 15 minutes and 49 seconds**.

- We had them follow the workflow document on converting the measurements and implementing them into the Solidworks file and time them to see how long it took them. The times for the 3 students were: 18 min and 33 sec, 17 min and 55 sec, 16 min and 4 sec for an **average of 17 minutes and 31 seconds**.

Conclusions/action items:

These times are well in the range our client was looking for in terms of shortening the process of creating patient specific incline planes. Overall, the feedback given was good and all students liked the layout and the clarity of our workflow document. One thing to consider is making a video on walking through how to take the measurements and implement them into the solidworks file for even further clarity.

Compression Testing Results 4/20/22

Ben Smith - May 03, 2022, 11:00 PM CDT

Title: Compression Testing Results

Date: 4/20/22

Content by: Ben Smith

Present: Ben Smith and Giovanni Militello

Content:

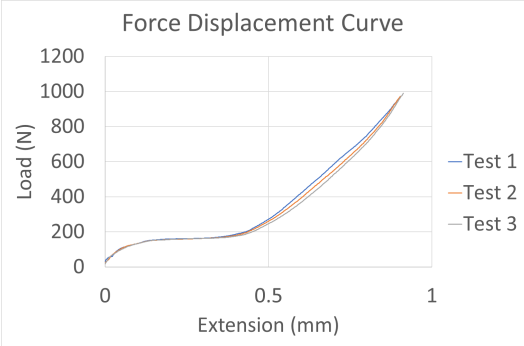
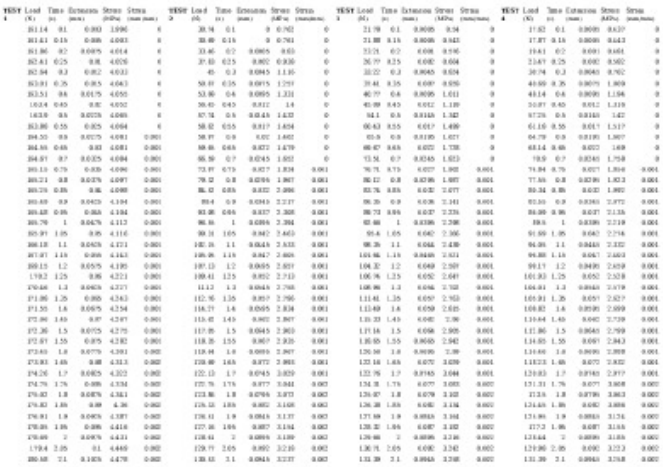


Figure 1: *Force displacement curves for the three compression tests conducted on the incline plane.*

Conclusions/action items:

The team got useful data from testing showing the Force Displacement and how much stress the part experienced over the course of the test.

Ben Smith - May 03, 2022, 11:01 PM CDT



Download

Test_Results.xlsx (54.7 kB)

Final Design 03/01/2022

Ben Smith - Mar 01, 2022, 4:54 PM CST

Title: Final Design

Date: 3/1/2022

Content by: Ben Smith

Content:

Attached is the Solidworks file for our final design.

Ben Smith - Mar 01, 2022, 4:54 PM CST

Download

Final_Design.SLDPRT (299 kB)

Simplified Workflow Document 04/24/2022

GIOVANNI MILITELLO - Apr 27, 2022, 8:18 PM CDT

Title: Simplified Workflow Document

Date: 04/24/2022

Content by: Team

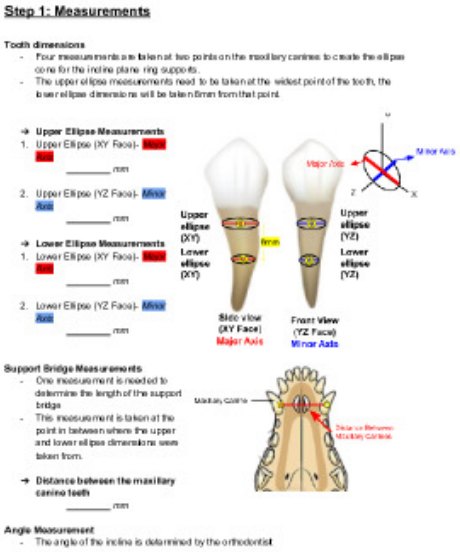
Present: Team

Goals: Update workflow document again based on comments and feedback we received from the show and tell presentations

Content:

Final Simplified Workflow document with Excel Sheet for client usage.

GIOVANNI MILITELLO - Apr 27, 2022, 8:17 PM CDT



Download

Simplified_WorkFlow_Solidworks_Model.pdf (2.98 MB)

GIOVANNI MILITELLO - Apr 27, 2022, 8:17 PM CDT

Download

Incline_Plane_Measurement_Conversion_-_Sheet1.pdf (27.4 kB)

Executive Summary 04/22/2022

LILY GALLAGHER - May 04, 2022, 8:43 AM CDT

Title: Executive Summary for the Tong award

Date: 04/22/2022

Content by: The team

Present: The team

Goals: To summarize our design project, process, future implications and submit for the Tong award

Content:

Class II malocclusions are a common genetic skeletal deformity that affects 10% of purebred dogs. With this condition, the dog's lower jaw is relatively shorter than the upper jaw which diminishes the functionality of the bite. Not only is this painful, but if it is not corrected, it can lead to dental attrition, gum diseases, oronasal fistula, and the destruction of the gum pallet and tissue. To safely correct class II malocclusion, veterinarians use tipping orthodontics. An inclined plane device is used to guide the misaligned teeth to the correct position by utilizing controlled tipping mechanics via the force of a dog's bite. The current procedure to create a patient-specific incline plane requires anesthesia to take a CT scan of the patient's jaw, conversion of DICOM files to produce a 3D printable model of the patient's jaw, and manual carving of an incline plane on this model by the veterinarian which is sent to a software engineer to create a computer model to be 3D printed. This fabrication and workflow is time-consuming and complex, making the procedure expensive and unrealistic for some pet owners. Our new workflow and fabrication process increases the speed of production and reduces costs to create this device, making the treatment more accessible.

The design we developed was inspired by an expired patent, US5151027A. It was created in SolidWorks and the model features two rings that will be secured to the upper maxillary canines of the patient. Attached to these two rings is an incline plane which will be used to tilt the lower mandibular canines into place. Supporting the pressure experienced by the upper maxillary canines from the contact with the lower mandibular canines will be a supporting bridge running along the roof of the patient's mouth, connecting the upper canines. Through the development of a simplified workflow involving the modification of 4 easily measurable dimensions within the patient's mouth taken with a handheld caliper, our SolidWorks model creates a client-specific product. Because of the simplification in design, the design eliminates the need for CT scans and anesthesia, ranging anywhere from $100-500 and $90-200 respectively, and allows the client to simply take measurements in the patient's mouth, alter a base 3D model, and print the device, which in total cuts the cost of fabrication down to only $120 for the device itself. The time required from the veterinarian is cut from 2-3 weeks involving the CT scan, time for the client to carve out a model incline plane (1 week), and time for an external software engineer to develop and print a 3D model incline plane (1-2 weeks), to about 30 minutes with the improved workflow, allowing the client to work independently. The final design will be made out of 3D printable Titanium (Ti64) and sourced from Materialise.

The new workflow process has been tested by other biomedical engineering students. Most students were able to complete the entire workflow in 15 minutes. The device will not break with a dog's bite force. The team compression tested the titanium piece and it repeatedly withstood about 926 N, the maximum force from a canine tooth. The team's workflow was also disclosed to WARF as intellectual property and the team is pursuing a patent. If this design were commercialized, it would be able to help the 4 million dogs affected by Class II malocclusions. Additionally, the profitability of our device can be maximized to 200% by setting the product to cost $500, making it a promising device in the field of veterinary orthodontics.

Conclusions/action items:

Present to the judges at poster presentations

Mechanical Compression Testing 03/01/2022

Ben Smith - Mar 01, 2022, 5:47 PM CST

Title: Mechanical Compression Testing

Date: 3/1/2022

Content by: Ben Smith

Goals: Learn more about compression testing and how we can utilize it with our 3D printed design to test for the properties of Ti64.

Content:

References:

[1] “What is compression testing? ,” *Instron*. [Online]. Available: https://www.instron.com/en/our-company/library/test-types/compression-test. [Accessed: 01-Mar-2022].

[2] “What is a compression test?,” *TestResources*. [Online]. Available: https://www.testresources.net/applications/test-types/compression-test/. [Accessed: 01-Mar-2022].

- Compression testing allows you to apply a compressive force to a material/object to see how it performs under stress [1]
- This type of testing allows you to determine structural and safety properties of a given material
- Compression tests are often performed on finished products
    - This would make sense as we are trying to see if our device can withstand the forces of a dogs bite
- To learn the most about the compressive properties of a material, it would be tested to failure
    - In our case, we do not want to necessarily test our 3D print to failure because it is an expensive piece
    - If we can get a good reading of its compressive strength that is greater than the typical biting force of a dog without testing to failure, that would be ideal
- Tabletop machines like the Instron 6800 series are good for low force testing
    - In the bigger picture, we are testing with low force
- Common types of compression testing [2]:
    - Crush
        - What we will utilize as we try to "squash" the incline plane part of the device
    - Flexure
    - Spring

Things to consider:

- How to translate force from compression platens to the correct point on the incline plane to simulate a dogs bite
    - Do we need to machine a mold that can hold our device in place?
- Are there specific test standards we need to/should follow?

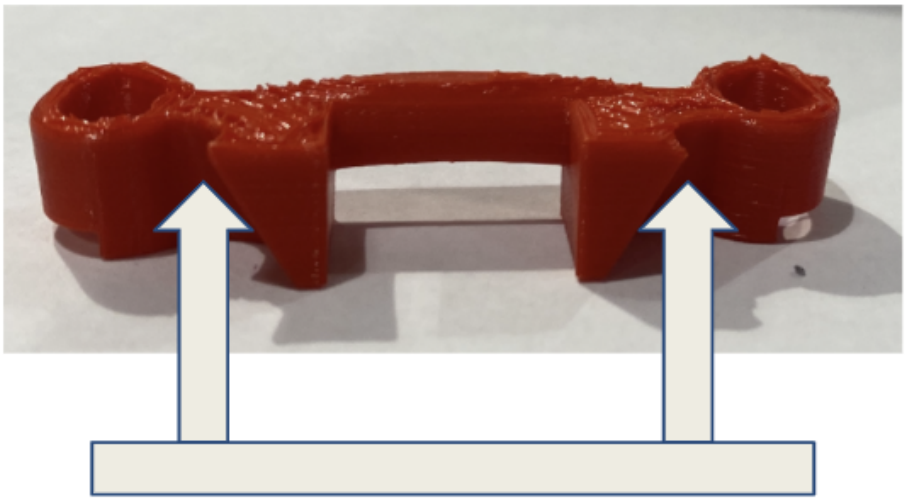


Figure 1: Visualization of how we want to apply force to our incline plane

Conclusions/action items:

Compression testing is necessary to tell us whether our device 3D printed in Ti64 is strong/safe enough for use in a dog. More research is necessary to determine how to exactly use this testing to our benefit (see **things to consider**).

Plate Fabrication Research 4/15/22

Ben Smith - May 03, 2022, 11:32 PM CDT

Title: Plate Fabrication Research

Date: 4/15/22

Content by: Ben Smith

Goals: Research methods of how to work with method to fabricate our compression testing plates

Content:

Reference:

[1] C. L. Rease, “How to drill & tap aluminum,” *It Still Runs*, 10-Jan-2019. [Online]. Available: https://itstillruns.com/drill-tap-aluminum-7524509.html. [Accessed: 15-Apr-2022].

How to tap and thread holes in aluminum:

- Things to consider
  - Aluminum is very light which can cause issues when threading holes
  - When aluminum pieces clog holes that are being drilled, it impedes the drill bit and stops it from drilling properly [1]
- Steps to drilling [1]:
  1. Pick out drill bit size that is a proper fit for the job and mark a spot on the drilling surface to help lock the drill bit into place
  2. Secure the drill bit in place and put a lubricant over the drill bit to help it cut easier
  3. Bring the drill bit to the aluminum, moving up and down once contact is made to free the debris and make it easier for the drill bit to cut. Keep applying lubricant as needed
  4. Once the hole is drilled, it is time to secure the aluminum in the tap with clamps and secure the correct tapping bit size into the machine. Put more lubricant in the hole to help the tap thread easier.
  5. Turn the tap handle clockwise to cut the thread, turning counterclockwise when it gets touch to help break the chips and make it easier to keep threading.
  6. Once the tap is all the way through, remove the tap from the newly threaded aluminum hole. Clean out the chips and grease fro lubricant to reveal threaded hole.

Conclusions/action items:

This is the very basics of how to drill, tap, and thread a hole in a piece of aluminum. The team can take this information to the Makerspace where they can fabricate the platens to be used in compression testing.

WARF Lecture 03/20/2022

Ben Smith - Mar 20, 2022, 10:48 PM CDT

Title: WARF Lecture

Date: 3/20/22

Content by: Ben Smith

Content:

Lecture Notes:

- WARF works on patenting and licensing
  - Manages intellectual property
  - Proceeds support research at UW-Madison
- Cycle of innovation:
  - UW Research and Discovery --> IP Protection --> Licensing and Startups --> Funding to support Research and Discovery
- Protecting Innovation
  - Patents
    - Machines and devices, compounds, processes and methods, improvements
  - Trademarks
    - words and phrases, colors, pictures or logos, sound
  - Copyrights
    - literary works, webpages, software programs
- Prior Art
  - Definition: "references" created before a specific date
- Requirements for Patentability
  - Eligible
  - Useful
  - Enabled
  - Described
  - Novel
  - Non-Obvious
  - Takes about 3-5 years and around $30,000
- Licensing Considerations For New Disclosures
  - Chance of licensing
  - Timeline for licensing
  - Licensing strategy
  - Plan for the next year
  - Revenue Projections
- Licensing Innovation
  - Timeline can vary from months to years
- Factors to Consider in Starting a Company
  - Technology
  - Market
  - Management
  - Capital Requirements
  -

Conclusions/action items:

This was an overall very interesting presentation. I think our project design might intellectual property in the process we created to fix class II malocclusions. I would be very interested in talking to WARF about how we could patent the process we created.

Biocompatibility of TI64 02/11/2022

LILY GALLAGHER - Mar 02, 2022, 7:39 AM CST

Title: Biocompatibility and properties of TI64

Date: 02/11/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To look into the properties and applications of TI64

Content:

Titanium is used in dental implants

Mechanical properties:

- low density (4.5 g/cm^3)

- Good bone contact biocompatibility

Available in 4 grades

- labeled 1 to 4 according to the purity and the processing content
- Ranked on corrosion, resistance, ductility and strength

Ti64Al4V

- - 90% titanium
- -.2% max oxygen
- - .25% Iron
- - UTS/MPa
- -strength/Mpa 850
- -elongation at failure 10%
- -Mircro alpha and beta structure
- -Elastic Modulus/GPa 113
- - Yield strength 795/MPa
- -Density g/cm-3 4.4

Possible surface treatments of titanium alloy implants

Treatment type	Surface Change	Effect
Mechanical		
Machining	Alter surface roughness.	Cleans surface.
Grinding		Improves adhesion
Polishing		
Blasting		
Chemical		
Acid treatment	Modifies oxide layer.	Improves biocompatibility in all cases.
Alkali treatment	Forms sodium titanate gel.	Improves biocompatibility in all cases.
Hydrogen peroxide	Dense inner oxide layer, porous outer layer.	
Anodic oxidation	Increase thickness of TiO_2	
Physical		
Plasma spray	Deposits coating such as hydroxyapatite.	
Flame spray	Deposits coating such as hydroxyapatite.	Improves wear and corrosion resistance.
Ion beam implantation	Modifies surface composition.	Enhances biological properties.

- After fabrication we need to treat the titanium implant to possibly improve the biocompatibility and comfort for the patient
- the surface of the implant is critical for ensuring the necessary osseointegration of dental implants
    - Roughening the surface by some additional processing step has been found to be effective in improving the ability of titanium alloys to undergo osseointegration.
    - This roughening also leads to higher survival rates for dental implants
    - **For example, one study compared the survival rates of implants with rough and smooth surfaces, and showed that the survival rates at 20 to 27 months was 98% for the rough surface but only 81% for the smooth one**
    - **Various studies are described which show that failure rates over considerable time periods are extremely low. Depending on the details of the study and the materials used, at least 89% and typically 97–99% of implants survive for over 10 years.**

Conclusions/action items:

Look into fabrication of device in TI64

J. W. Nicholson, “Titanium Alloys for Dental Implants: A Review,” Prosthesis, vol. 2, no. 2, pp. 100–116, Jun. 2020, doi: 10.3390/prosthesis2020011. http://dx.doi.org/10.3390/prosthesis2020011

3D printed TI644V 02/22/2022

LILY GALLAGHER - Mar 02, 2022, 8:08 AM CST

Title: 3D printed TI64 fabrication specifications

Date: 02/11/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To find out more about 3D printed titanium

Content:

- Titanium (Ti6Al4V) is a workhorse alloy.
- Ti6Al4V are comparable to wrought titanium for tensile strength, elongation, and hardness.
- Final parts built in Ti6Al4V receive vacuum stress relief application.

Primary Benefits

- High stiffness and strength relative to weight
- High temperature and corrosion resistance

Max Part size

- 9.6 in. x 9.6 in. x 13.0 in. (Normal res)
- 3.5 in. x 3.5 in. x 2.7 in. (High res)

Thickness

- 0.0012 in. (Normal res)
- 0.00079 in. (High res)

Minimum feature size

- 0.015 in. (Normal res)
- 0.006 in. (High res)

Tolerance

- Tolerances of ±0.003 in(0.076mm) plus ±0.001 in./in. (0.0254mm/mm) can typically be achieved.

Mechanical Properties:

Resolution	Condition	Ultimate Tensile Strength	Yield Stress	Elongation	Hardness
20 µm	Stress Relieved	153 ksi	138 ksi	15%	35 HRC
30 µm	Stress Relieved	144 ksi	124 ksi	18%	33 HRC

Table [1]: Mechanical Properties of TI64

Applications:

- Compressor blades and discs
- Rings for jet engines

- Airframe and space capsule components
- Surgical instruments
- Medical implants

Conclusions/action items:

Look into the specifications of CNC fabrication

Protolabs "Titanium (Ti6Al4V) 3D Printing" 2022:

https://www.protolabs.com/services/3d-printing/direct-metal-laser-sintering/titanium/

CNC Fabricated Ti64 02/11/2022

LILY GALLAGHER - Mar 02, 2022, 8:23 AM CST

Title: CNC Fabricated Ti64

Date: 02/11/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To understand the mechanical properties of CNC titanium

Content:

Titanium grade 5 (Ti 6Al 4V, Ti 6-4 or 6Al-4V titanium)

- classified into the alpha-beta alloy
- composed of 6% aluminum, 4% vanadium, 0.25% (maximum) iron, 0.2% (maximum) oxygen, and the remainder titanium
- most commonly used titanium in the world.

Grade 5 titanium is significantly stronger than commercially pure titanium

- same stiffness and thermal properties
- can withstand temperatures up to nearly 800°F
- resistant corrosion from seawater
- it also has good fatigue resistance
- high strength-to-weight ratio
- low modulus of elasticity
- low thermal expansion.
- It is typically available in the annealed condition and is readily heat treatable to increase strength.

Properties:

- Density: 4420 kg/m3.
- Young’s modulus: 120 GPa
- Tensile strength: 1000 MPa

Machining titanium grade 5

- heat treated
- welded
- fabricated
- machined

PROPERTIES	TI 6AL-4V (UNS R56400)	TITANIUM GRADE 2 (UNS R50400)
METALLURGY	895 MPa	345 MPa
ULTIMATE TENSILE STRENGTH	827 MPa	276 MPa
0.2% OFFSET YIELD STRENGTH	827 MPa	276 MPa
% ELONGATION (DUCTILITY)	10	20
CORROSION RESISTANCE	Very good	Outstanding
CREEP AND STRESS-RUPTURE	High	NA
FATIGUE	High	NA
SERVICE TEMPERATURE	-210°C – 400°C for reliable structural integrity	Depends on environments e.g. up to 316°C for steam and seawater
WELDABILITY	Weldable	

Table[1]: Mechanical properties of grade 5 titanium verses grade 2 titanium

Guide to CNC Milling Titanium:

- Compared with other metal, titanium machining is not only more demanding, but also has more restrictions.
- it has an excellent strength-weight ratio and density is 60% of that of steel, lower coefficient of elasticity than steel, higher hardness, better deflection, higher corrosion resistance and low in thermal conductivity.
    - All of these make it generate higher and more concentrated cutting force in the machining process
    - easy to causes vibration and milling chatter
        - if the material react with cutting tools, the crater wear will be aggravated.
        - Poor thermal conductivity, the cutting heat may concentrate in the cutting area
            - choose a titanium cutting tool with high thermal hardness is important.
- In the actual titanium alloy milling process, it's not easy to meet all the requirements, because the optimal conditions and machining stability are not always available
    - in fact, the shape or geometry of lots of titanium machined parts is complex and custom
        - it may contain fine or deep cavities, thin walls, bevels, curves, thin brackets or other features, to machine titanium with these details, large overhanging milling cutters with small diameters should be applied, but it will affect the stability of tools, other potential problems are also likely to occur in the cutting process.
- Generally, the tool and speed used in machining of cast iron or low alloy steel are not suitable for machining titanium.
- Even make comparison with stainless steel CNC machining, the titanium processing is still more challenging.
    - Different cutting speed, feed rate and precautions are needed to be taken to process titanium, as long as there are stable workpiece and machine tool, right cutting tool and setup, firm clamping, appropriate cutting force, good working condition, and ISO50 spindle with short tool overhang is equipped

Conclusions/action items:

Compare to specifications of titanium 3D printing

"CNClating: Guide to CNC Milling Titanium." https://www.cnclathing.com/guide/guide-to-cnc-milling-titanium-tips-methods-for-milling-machining-titanium-alloy-cnclathing

Past Project Research 09/17/2021

LILY GALLAGHER - Dec 14, 2021, 2:58 PM CST

Title: Past Project Research

Date: 09/17/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain and understanding of the past groups work

Content:

Parker Callender et. al, “VETMED: 3D Printed, Patient Specific Incline Plane for Management of Class 2 Malocclusion - Improvement in Design and Workflow Final Report,” unpublished.

Past Project Summary

Problem Statement:

- 3D printed patient-specific incline plane brace for canine patients
    - To create 3D printed incline plane:
        - CT scan of the patient's jaw
        - Prototype inclined plane is placed and tested on a model of the patient's jaw, then Data from the DICOM file is used to produce the printable incline plane with the help of a software engineer
        - Time consuming and complex
    - Issues:
        - Time consuming and complex
        - Adjust to dogs growth
        - Design a workflow to save time
        - Versatile

Current Methods & Devices:

- Self curing bis acryl composite material directly to the teeth
    - Inflammation can occur, generate too much heat and burn the dogs mouth
- Mann Incline plane
    - Telescoping
    - Size of inclined plane changes with growth of the patients maxillae (upper jaw)
    - Contact with only hard tissue
    - Requires models of the patients teeth to be made -- COSTLY
    - Not easy to adjust
- Metal rods combined with composite resin
    - Built intraorally with anesthesia
    - Allows from growth of the maxillae (upper jaw)
    - Can result in gingivitis

Motivation

- Cause issues for dogs and cats if not treated.
- Current treatment involves visits for adjustments, applying and removing the orthodontics and anesthesia (timely, costly)
- Current creation process of the 3D printed incline plane is inefficient (timely and costly)
    - Alleviates safety complications, such as burns
- Inclined planes involves possible complications and gingivitis is a common side effect

Improve treatment for canine patients but also streamline the process for veterinarians and veterinary orthodontists

Physiology and Biology

- Normal Occlusion in a Canine
- Class II Malocclusion

Existing Treatment/Device

Extraction:

- Used to remove the specific canine
- Brings up more lifestyle complications for the dog
    - Need canines to eat food

Shortening:

- Shorten the tooth so it does not irritate the palette
- Distorts the canine and is not able to function properly

Incline plane:

- Designed by Dr. Graham Thatcher
- Dental orthodistry treatment for the dog
- 3D printed
- Combination of two ramps on either side
- Tilted, so over time the dogs teeth will shift into the correct alignment
- FDA approved dental material
- Retainer attached to the mandibular jaw through hole attachments
- Breakage

Existing Development Process of the Incline Plane

- Inefficient and complicated
- CT scan
- 3D prints the skull/mouth
- Uses dental material to mold a potential design
- Sends the CT scans and model to a software engineer
- Software engineer builds an stl file of the inclined plane
- Dr.Thatcher and engineer work together to adjustments and trials

Client Information

- Dr. Graham Thatcher is a veterinary dental surgeon working at the University of Wisconsin- Madison Veterinary Hospital and the School of Veterinary Medicine.
- Currently working on this project to refine his current designs

Design Specifications

- Incline Plane
    - Withstand pressure of 400 lbs
    - Adjust to the angle of the mandibular canines by about 30 degrees
- Software/Interface
    - Simple enough where a veterinary orthodontist can easily utilize
    - Compatible with common computers
    - Manipulate cross sections of a DICOM file

Preliminary Designs

Incline Plane:

- Adjustable Bridge
    - Expander like mechanism to adjust the width of the incline plane
- Separate
    - Two separate pieces
- Rubber incline plane
    - Similar design but rubber material

Software:

- 3D Slicer
    - Able to slice cross sections
- Osiris X
    - Very mathematically based software
- GeoMagic
- Software that works with solidworks

Conclusion:

Go into more in depth and pick flaws/ places of improvement

Class II Malocclusions 09/17/2021

LILY GALLAGHER - Dec 14, 2021, 3:00 PM CST

Title: Past Project Research

Date: 09/17/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain and understanding of what the problem we are needing to solve is

Content:

G. Thatcher, “Diagnosis and management of Class II malocclusion,” *Can Vet J*, vol. 60, no. 7, pp. 791–795, Jul. 2019.

Project:

VETMED: 3D PRINTED, PATIENT SPECIFIC INCLINE PLANE FOR MANAGEMENT OF CLASS 2 MALOCCLUSION – IMPROVEMENT IN DESIGN AND WORKFLOW

Class 2 Malocclusion:

- Identification of skull type (brachycephalic, mesocephalic, dolichocephalic)
- Facial symmetry (maxillomandibular relationship)
    - Cats and dogs: Anisognathism jaws
        - Maxillae, upper jaw are wider and longer (in relation to mandibles, lower jaw)
        - Specifically the interlock between the teeth and jaws should be a triad interlock with the maxillary 3rd incisors (upper, smaller), mandibular canines(lower), and the maxillary canines(upper)
            - V look, top points are the top teeth and bottom of the v is bottom canines
        - Class II Malocclusions
            - Mandibular distoclusion: abnormal rostro-caudal relationship
            - Overbite and overjet
            - Diagnosed in many breeds
                - Mixed breed dogs and cats
                - Golden retriever, labrador retriever, standard poodle, bull terrier, German shepherd, and more mixed breeds involving poodles
        - Treatment Options
            - Removing traumatic malocclusion --- to provide a comfortable occlusion
                - Removing painful contact
                - Multiple anesthesia events
            - Tipping movement
                - Light force applied to the incisive tip of the tooth
            - Inclined plane
                - Common passive force method of directing mandibular canine teeth into atraumatic occlusion with mandibular distocclusion
                - Designed and applied directly to the maxillary arches using a self suring temporary crown.
                - Used to guide the mandibular canine teeth into their normal position
                - Custom formed to provide
                - Requires adjustments throughout the tooth movement process (require anesthesia)

        - Mann incline plane: Cast metal telescoping inclined plane
        - Adjustments cannot be made
    - Crown Extensions
        - Caps to go on the lower teeth
        - Guide the canines into the correct space
        - Mouth often does not close immediately after crown extensions
- Removing these pets from the breeding population

Title: Class II Maloclussion in Canines

Date: 09/22/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain and understanding of what the problem we are needing to solve is

Content:

“Lingually Displaced Canines,” www.dentalvets.co.uk. https://www.dentalvets.co.uk/common-cases/lingually-displaced-canines

Displaced Mandibular Canines & Hard Palate Trauma

Identifying...

Class II malocclusion

Class II Malocclusion is more common in mesocephalic or doliocephallic rather than brachycephalic skull types.

The trauma can be significant and painful producing obvious signs of oral pain and dysfunction and associated inappetence and morbidity. Left untreated this malocclusion can lead to oronasal fistula formation in severe cases.

- First spotted between 6-8 months old as the adult teeth emerge (canines erupt from 22-26 weeks of age)

- Lower canines occlude into the soft tissue of the roof

-causing discomfort and inflammation

Causes...

Inherited Condition (autosomal recessive mutation)

- both parents may look normal but carry recessive genes for the condition.

- approx 1 in 4 pups will be affected, appear abnormal and can pass the information if bred

-approx 2 in 4 will carry abnormal gene from one parent and normal gene from the other (will look normal but pass the problem on if bred)

-approx 1 in 4 will not be a carrier of abnormal genes (will be unaffected and cannot pass the trait on to future generations)

Preventing...

if this condition appears in the litter ==== not to breed from the parents again

- no test to identify this gene

- all the normal looking sibling pups are likely to carry the recessive genes

Removal

- Young puppies are advised to have their lower canines removed as soon as possible

why?

1. Sharp teeth, cannot close mouth without pain

2. negatively affect the growth on the mandible

- can cause deviation of the skull laterally or ventral bowing of the lower jaws

3. affect ligands in the mouth

- crown extensions

ADLUT DOGS

- Ball therapy

- can push tooth inward even more resulting in worsening the condition

- size and type of ball is critical

- should be the distance between the tips of the two lower canine + 50%

- too large of a ball can intrude the lower canines back into their sockets

- ball should "give" when puppy bites down == semi-hollow rubber ball is best, tennis balls are too abrasive

- encourage to play with the ball several times a day (6-8)

SURGICAL OPTIONS

- CROWN AMPUTATION partial coronal pulpectomy

- reduces height of the lower canines

This is a very delicate procedure and carries very high success rate (in our hands) since the availability of Mineral Trioxide Aggregate (MTA). We have used it as the material of choice since 2005. The previous agent (calcium hydroxide) was much more caustic and tended to "burn" the pulp. The success rate of MTA treated cases is quoted as 92% in a seminal ten year study based in vet dental clinics in Finland. This compares with 67% when caclium hydroxide was previously the agent. Luotonen N et al, JAVMA, Vol 244, No. 4, February 15, 2014 Vital pulp therapy in dogs: 190 cases (2001–2011).

- SURGICAL EXTRACTION

-tooth loss weakens the lower jaw (compounded if both lower canines are removed)

- not an easy extraction

-CROWN EXTENSION

- bond composite resin extensions on the lower canines to increase the crown length by 30%.

- this allows the lower canines to occupy the correct position and provides more leverage to tip the crowns

- remain in place for 2 months

- downside: if dog breaks them off, you need to return for repairs, cannot play with sticks and other hard options.

ORTHODONTIC TIPPING

composite resin bute plane is bonded onto the upper teeth with an incline

lower canine makes contact with the incline when the mouth closes and over time, the force tips the tooth.

4-8 weeks

Bites need to be cleaned and adjusted from time to time.

Conclusion:

It is relevant to look into more about the heredity of malocclusions to find the impact.

Material Research 09/28/2021

LILY GALLAGHER - Dec 14, 2021, 3:03 PM CST

Title: Orthodontic Material Research

Date: 09/28/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: to brainstorm materials

Content:

R. Eftekhar Ashtiani, M. Alam, S. Tavakolizadeh, and K. Abbasi, “The Role of Biomaterials and Biocompatible Materials in Implant-Supported Dental Prosthesis,” *Evid Based Complement Alternat Med*, vol. 2021, p. 3349433, Aug. 2021, doi: 10.1155/2021/3349433.

BPA FREE

polyurethane resins

Man made Polymeric materials

Biofunction:Biofunctionality deals with those mechanical and physical properties that enable the implanted device to perform its function under the stresses imposed in the oral cavity.

Biocompatability: Biocompatibility refers to the interactions between materials and the recipient tissues of the body and is one of the most important factors involved with the material selection.

Availability: Availability refers to the handiness of the fabrication and sterilization techniques of the implants

New process technology for Zirconia: powder injection molding (PIM)

An alternative to classical machining for preparing Zirconia and other ceramics is the Powder injection molding (PIM), also called ceramic injection molding (CIM). PIM is a combination of powder technology and injection molding.

Titanium- metallic implants are sterile and strong

Conclusions/action items:

pick materials for design matrix

Title: Orthodontic Material used as attachments for orthodontics

Date: 09/28/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: to brainstorm materials

C.-T. Ho, Y.-T. Huang, C.-W. Chao, T.-H. Huang, and C.-T. Kao, “Effects of different aligner materials and attachments on orthodontic behavior,” Journal of Dental Sciences, vol. 16, no. 3, pp. 1001–1009, Jul. 2021, doi: 10.1016/j.jds.2021.01.011.

Three types of attachments (thick and thin) ellipsoid shape were attached to a canine crown surface

1. Polyethylene Terephthalate enhanced with glycol (BIOSTAR) Polyethylene Terephthalate (BenQ)

2,3.Thermoplastic polyurethanes (TPU) were used to fabricate different aligners.

polyethylene terephthalate glycol-modified (PET-G), polypropylene, polycarbonate (PC), thermoplastic polyurethanes (TPU), ethylene vinyl acetate,

Low degree of hardness, good elasticity, high resilience

Most important aspects: comfort and aesthetics

Thickness: .5mm to 1.5mm

Thicker deliver higher forces than thin

Difficult to correct tooth torque and rotation with aligners

- need attachments

Process:

Conclusion:

Attachment shape or size had little influence on the movement of the tooth

A high modulus material may be suitable for clinical applications.

Conclusion:

This study did not have results that could be utilized in our prototype, it was found that aligners do not work to to correct tooth torque and rotation, thus rank our thermoplastic retainer lower as it does not function how we would like to.

Ethics/Standards 10/04/21

LILY GALLAGHER - Dec 14, 2021, 3:06 PM CST

Title: Orthodontic Implants Insertion

Date: 10/04/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To get a better understanding of materials/ethics used in orthodontics

Content:

“ISO 13504:2012(en), Dentistry — General requirements for instruments and related accessories used in dental implant placement and treatment.” https://www.iso.org/obp/ui/#iso:std:iso:13504:ed-1:v1:en

Material

- Typically orthodontic implants are made of titanium alloy ASTM grade 5 (Ti-6Al-4V) (not subjected to surface treatment)
- The machined orthodontic implants without surface treatment have tool marks and grooves.

Surface roughness:

- The surface of the dental implant is treated (WITH ACID), which increases its roughness and osseointegration.
- The implant surface roughness governs cell interactions, allowing adhesion, proliferation, and differentiation.
- An adequate implant surface increases the bone-implant contact (BIC) and makes the orthodontic implants most suitable for immediately loading (harder to get off)

Clinical Procedure:

- Determination of the height of the installation site with a probe, taking into account the position of adjacent tooth roots and other anatomical structures such as inferior alveolar nerves, arteries, veins, mental foramen, and nasal cavity
- Soft tissue anesthesia
- Drilling with a lance
- Insertion

Dimensions

Orthodontic implants may be placed under an angulation between 10° and 20° and maybe up to 45°. In maxilla, particularly, a 30° to 40° angulation to the long axes of adjacent teeth and a 10° to 20° angulation in the mandible are recommended to avoid dental injuries. Besides, this angle increases the area of bone contact and ensures greater primary stability.

Hygiene control

- It helps to prevent peri-implantitis or the inflammation of the tissues around the orthodontic implant. It is recommended that the implant site be cleaned with an interdental brush dipped in 0.12% chlorhexidine

Conclusions/action items:

Look more in depth on what materials are safe in the mouth

Title: Veterinary orthodontics

Date: 10/20/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To get a better understanding of ethics used in veterinary orthodontics

Content:

Ethical Standard of Orthodontics

[1] “AAHA-AVMA canine preventive healthcare guidelines,” *American Veterinary Medical Association*. https://www.avma.org/resources-tools/avma-policies/aaha-avma-canine-preventive-healthcare-guidelines

[2] U. F. O. Themes, “Occlusion and Orthodontics,” *Veterian Key*, Aug. 15, 2020. https://veteriankey.com/occlusion-and-orthodontics/).

- Every animal deserves and has the medical right to an occlusion that is functional and free from discomfort, as can be reasonably provided by therapy.

"The American Veterinary Dental College(AVDC) has a position statement: “The goal of orthodontic procedures in companion animals is to provide pets with a healthy and functional occlusion. The AVDC supports the AVMA policy regarding cosmetic procedures that enhance the appearance of show or breeding animals” [1].

DENTAL ORTHODONTICS SHOULD NOT BE PREFORMED IF NOT NECESSARY (no cosmetic reasons):

"The Principles of Veterinary Medical Ethics of the AVMA (Section I.e.) states: “Performance of surgical or other procedures in all species for the purpose of concealing genetic defects in animals to be shown, raced, bred, or sold, as breeding animals is unethical. However, should the health or welfare of the individual patient require correction of such genetic defects, it is recommended that the patient be rendered incapable of reproduction” (Section VII, Genetic Defect)" [1].

WHEN GENETICS ARE INVOLVED... [2]

When there are reasonable indications of hereditary involvement the owner should be informed as to the possibility and, should treatment be considered, the owner or agent should acknowledge their responsibilities prior to treatment and genetic counseling should be advised.

- LACK of information to distinguish hereditary and systemic

- Primary objective of veterinary orthodontics is to provide a comfortable bite for companion animals

- Orthodontics are never provided for sole cosmetic purposes.

- Ethical priority is to provide genetic counseling to avoid future problems associated with malocclusions

Normal occlusion take in an account of..

Head dimension or shape

- mesaticephalic (medium length)

- brachiocephalic (short, wide head)

- dolichocephalic (long narrow)

and symmetry

conclusion:

take these points into account when diagnosing treatment plans

Teeth angles and forces 10/17/2021

LILY GALLAGHER - Oct 20, 2021, 12:47 PM CDT

Title: Teeth angles and forces

Date: 10/17/2021

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: Provide data on the tooth angles in dog size weights

Content:

- External forces are managed by by the practitioner

- Want to provide the least amount of force needed, to ensure safety for the patient

-avoids discomfort and complications

Estimation of the root surface area is important in determining anchorage and force application.

- In the dog there are variations within breeds and from individual to individual.

- While these values(in the table) are just approximations, they correlate with the two studies that showed a mean root surface area for a maxillary fourth premolar was 562.8 ± 124.9 mm2 and for the mandibular first molar was 497.1 ± 116.2 mm2 which are similar to the values for a dog up to 50 pounds in the table.

- with this in mind, when a light to mild force is applied, stimulates and initiates cellular activity resorption and deposition of bone(physiologic movement)

-When these pressures are exceeded with a heavy force there will be necrosis of periodontal tissues on the pressure side and poor to no deposition of bone on the traction side, which is labeled pathologic movement. BAD!!!!!

	<10 lb	<25 lb	<50 lb	<90 lb
Maxillary				
First incisor	0.7	1.0	1.3	1.7
Second incisor	0.8	1.2	1.5	1.9
Third incisor	1.2	1.6	2.25	2.6
Canine	3.4	5.4	7.8	9.5
Fourth premolar	2.5	4.15	5.25	6.75
First molar	1.5	2.25	3.25	4.25
Mandibular				
First incisor	0.6	0.9	1.2	1.6
Second incisor	0.7	1.2	1.5	1.8
Third incisor	0.9	1.4	1.7	2.0
Canine	3.3	5.25	7.65	9.25
Fourth premolar	1.3	1.9	3.25	3.75

	<10 lb	<25 lb	<50 lb	<90 lb
Maxillary				
First incisor	0.7	1.0	1.3	1.7
Second incisor	0.8	1.2	1.5	1.9
Third incisor	1.2	1.6	2.25	2.6
Canine	3.4	5.4	7.8	9.5
Fourth premolar	2.5	4.15	5.25	6.75
First molar	1.5	2.25	3.25	4.25
Mandibular				
First incisor	0.6	0.9	1.2	1.6
Second incisor	0.7	1.2	1.5	1.8
Third incisor	0.9	1.4	1.7	2.0
Canine	3.3	5.25	7.65	9.25
Fourth premolar	1.3	1.9	3.25	3.75

Table[1]:Approximate tooth root surfaces of the dog in square centimeters in relation to the relevant weight of dog.

U. F. O. Themes, “Occlusion and Orthodontics,” Veterian Key, Aug. 15, 2020. https://veteriankey.com/occlusion-and-orthodontics/

Conclusions/action items:

Continue research

Title: Teeth angles and forces

Date: 10/17/2021

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: Provide data on the tooth angles in dog size weights

Content:

The collum angle (the crown root angulation) of the maxillary teeth were compared

60 subjects were categorized into 4 groups

A variation in collum angle was observed between the maxillary and mandibular teeth and malocclusions.

The effect of these variations of the collum angle in the torque expression is important to biomechanics when treating class ii malocclusion.

in this study...

class ii malocclusion is defined as

> Group 2 – Class II division 1 malocclusion (ANB > 4°, Class II molar, proclined upper anteriors, increased overjet, AO ahead of BO by > 0.8 mm)
>
> The angle was measured using CS 3D imagining software (carestream3D)
>
> - allowed for oblique slicing
>
> When straight wire technique is used, the shape of the labial surface of teeth is important, in addition to the collum angle which is critical in torque expression.
>
> conclusion:
>
> "No statistically significant difference in mean collum angle was observed between the right and left side of maxillary and mandibular anterior teeth in different types of malocclusions."
>
> B. Elangovan, B. Srinivasan, V. Kailasam, and S. Padmanabhan, “Comparison of the collum angle of incisors and canines in skeletal malocclusions – A CBCT study,” *International Orthodontics*, vol. 18, no. 3, pp. 468–479, Sep. 2020, doi: 10.1016/j.ortho.2020.06.006.

Conclusion:

Does not show useful data

LILY GALLAGHER - Oct 20, 2021, 12:19 PM CDT

Title: Teeth angles and forces to move teeth

Date: 10/17/2021

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: Provide data on the forces needed to move teeth

Content:

Excessive forces may cause root eruption, damage to the gum tissue, or root

- causing pain

insufficient forces will have no effect

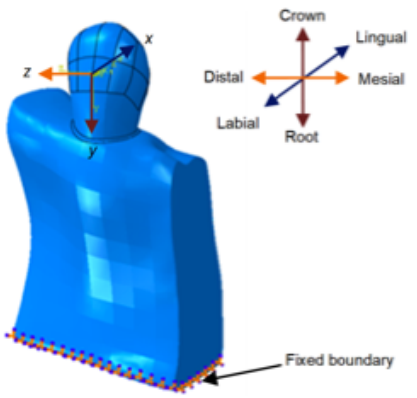
Study was to investigate the optimal orthodontic forces on a maxillary canine

- using hydrostatic stress and logarithmic strain

Types of forces:

Distal translation/tipping forces

labial translation/tipping forces



figure[1] showing the different tipping forces on a canine[1]

Movement	Optimal force/moment
Distal-direction translational	130–137 g
Distal-direction tipping	40–44 g
Labial-direction translational	110–124 g
Labial-direction tipping	28–32 g
Extrusion	38–40 g
Rotation around long axis	170–210 g·mm

Table[1] Optimal Force/moment on a canine

Results:

"Based on the findings, the optimal orthodontic forces for canine distal-direction translational and tipping movements were 130–137 and 40–44 g, respectively, the optimal forces for labial-direction translation and tipping were 110–124 and 28–32 g, respectively, the optimal force for extrusion was 38–40 g, and the optimal force moment for canine rotation around the long axis was 170–210 g·mm."[1]

[1] J. Wu, Y. Liu, W. Peng, H. Dong, and J. Zhang, “A biomechanical case study on the optimal orthodontic force on the maxillary canine tooth based on finite element analysis,” *J Zhejiang Univ Sci B*, vol. 19, no. 7, pp. 535–546, Jul. 2018, doi: 10.1631/jzus.B1700195.

Conclusion:

See if we can use these forces in physics calculations for the angle

Tipping orthodontics 04/20/2022

LILY GALLAGHER - May 04, 2022, 1:14 PM CDT

Title: Tipping orthodontics

Date: 04/20/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding of the forces and rotation involved in tooth tipping so that we can make a free body diagram

Content:

Space closure is one of the most challenging processes in Orthodontics

- requires a solid comprehension of biomechanics in order to avoid undesirable side effects.
    - Without- results in failure to achieve an ideal occlusion
- Regulation of space closure is ultimately determined by the biomechanical forces applied to the teeth
    - variation in force
    - variation in moment magnitude
    - moment-to-force ratio (M/F)
    - force-to-deflection rate
    - anchor unit
- Need an evaluation to make a selection of the most appropriate model for each case.
- Friction mechanics/sliding mechanics
    - simplicity
        - the space site is closed by means of elastics or coil springs to provide force
        - brackets slide on the orthodontic archwire.

frictionless mechanics

- uses loop bends to generate force to close the space site
- allowing differential moments in the active and reactive units
- leading to a less or more anchorage control

Tipping mechanics physics

- Center of mass/gravity
    - Each body has a point in its mass, which behaves as if the whole mass is concentrated at that single point, which we call the center of mass/gravity
- Couple
    - If the same body is acted upon by two forces one above and one below the center of mass, which are equal in magnitude and opposite in direction, it will spin the body around the center of mass and this situation is called a **COUPLE**, which may be clockwise or anticlockwise.
- Bodily movement/translation
    - If the force is passing through the center of mass, the whole body moves in a straight line, in a parallel fashion. Here all the points of the body get displaced equally from

the initial position.

- Center of rotation
  - The point around which a tooth rotates when a force is applied
    - Center of rotation can be at the Cres, apical to it, at the root apex or at infinity.
- Moment
  - The force applied acts at a distance from the Cres. This is termed the **MOMENT** and is the product of force times the perpendicular distance from the point of application of force to the Cres, measured in gm-mm.
  -
- Moment to force ratio
  - The ratio of moment produced to force applied
  - determines the type of tooth movement.
  - < 5:1 uncontrolled tipping
  - 5 to 8:1 controlled tipping
  - 10:1 translation
  - 12:1 torque

Uncontrolled tipping

- Crot at Cres, crown and root move is opposite directions.

Controlled tipping

- Crot at the tooth apex, crown moves in the direction of applied force but root gets minimally displaced.

Figure 1: Types of tooth movement. A) Uncontrolled tipping B) Controlled tipping C) Bodily movement D) Root movement

Ribeiro, Gerson & Jacob, Helder. (2016). Understanding the basis of space closure in Orthodontics for a more efficient orthodontic treatment. Dental Press Journal of Orthodontics. 21. 115-125. 10.1590/2177-6709.21.2.115-125.sar.

Conclusions/action items:

Create a free body diagram explaining this tipping orthodontics involved in using an incline plane device

Title: FBD of tooth tipping mechanics with an incline plane

Date: 04/20/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To draw a free body diagram showing the mechanics of tipping

Content:

Controlled tipping orthodontics, utilizing the mechanics where the root gets minimally displaced.

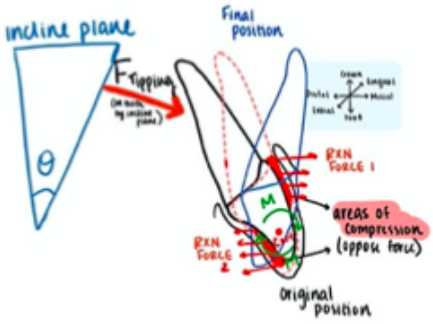


Figure 1: FBD of the tipping mechanics

Tipping orthodontics uses an incline plane to guide the misaligned teeth to the correct position by utilizing controlled tipping mechanics. When the dog closes its mouth, the teeth will hit the incline plane with the force of a bite. Due to Newton's 3rd law, this force moves the crown in one direction, while the root of the tooth resists motion. A moment force is created at the apex of the root, and over time repeated motion will slowly guide the canines into the desired position. In the free body diagram, the root of the tooth stays in the same place so there is no damage done to the buccal bony plate.

Conclusions/action items:

Visualize these mechanics with the dog skull and our printed device.

How TI64 printing works 04/20/2022

LILY GALLAGHER - May 04, 2022, 1:30 PM CDT

Title: Lily Gallagher

Date: 04/20/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain a better understanding on how 3D printing titanium is done

Content:

3 common metal 3D printing methods used to create titanium parts

- Direct Energy Deposition (DED)
- Electron Beam Melting (EBM)
- Selective Laser Melting (SLM)

Direct Energy Deposition (DED)

- a high-intensity energy source such as a laser or a beam is used to melt the titanium powder (or wire) as it is deposited through a nozzle onto the substrate
  - ability to create large parts at a relatively high material deposition rate (up to 320 cc/h)
- Many variations of DED technology, including Sciaky's Electron Beam Additive Manufacturing (EBAM) and Wire Arc Additive Manufacturing (WAAM).

Electron Beam Melting (EBM)

- an electron beam is applied to a layer of metal powder, melting and fusing it with the previous layer.
  - considered to be more accurate than DED, and suitable for smaller, complex parts.
- takes place in a vacuum and at a high temperature.
  - This results in minimal residual stresses in 3D-printed parts
  - *parts don't require subsequent heat treatment*
- In 2013, Arcam released two AM machines, Arcam Q10 and Arcam Q20
  - Targeting the orthopaedic implant and aerospace industries respectively.
  - The Arcam Q20 is particularly designed to work with the Ti6Al4V alloy.
- Arcam has also released the Arcam Spectra H 3D printer
  - Capable of printing new crack-prone titanium alloys such as titanium aluminide.

Selective Laser Melting (SLM)

- powder bed fusion process
  - uses a laser beam instead of an electron beam to melt and fuse the layers of metal powder.
  - The thickness of one layer in the SLM process can be as thin as 20 microns,
  - more accurate when compared to DED and EBM

"A guide to 3D printing with titanium," *AMFG*, 18-Jun-2019. https://amfg.ai/2019/06/18/titanium-3d-printing-guide/

Conclusions/action items:

Continue with titanium printing

Incline Plane 04/23/2022

LILY GALLAGHER - May 02, 2022, 8:27 PM CDT

Title: Updated research on Incline plane applications/designs to correct class II malocclusion

Date: 04/23/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To check new designs/applications of incline plane orthodontics for the treatment of class II malocclusion

Content:

Published October 18th, 2021

In patients where there is concurrent mesioversion of the maxillary canine teeth resulting in narrowing of the interdental spaces, combined orthodontic therapy of teeth 104 and 204 with elastic chain appliances and placement of single tooth inclined planes has been described.

Traditionally, a flowable self-curing bis-acryl composite material has been used.[10] The method described here uses a light-cured acrylic denture base material utilizing multiple customized segments to construct the appliance to the desired shape and size necessary to achieve a functional incline plane. Advantages of this application include ease of use, placement accuracy, and minimization of material usage.

The incline plane is created while being attached directly to the affected canines.

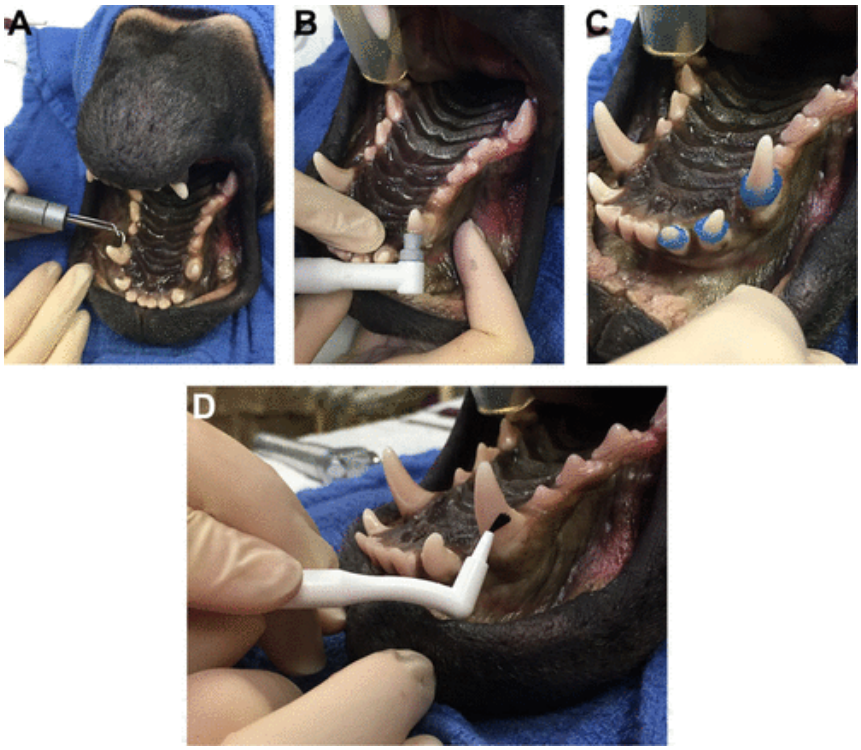


Figure 1: These teeth are ultrasonically scaled (A) and polished (B) with a fluoride-free coarse pumice to remove plaque and saliva. Etching (C) is performed with a 38% phosphoric acid gel. The cusps of each tooth are left unetched to facilitate removal of the acrylic and to avoid cusp fracture during appliance removal. The acid gel is rinsed from the teeth and gently dried with an air-water syringe. Bonding agent is applied (D) to the etched enamel on buccal and palatal aspects of the teeth, thinned with air and light cured according to manufacturer recommendations.

.

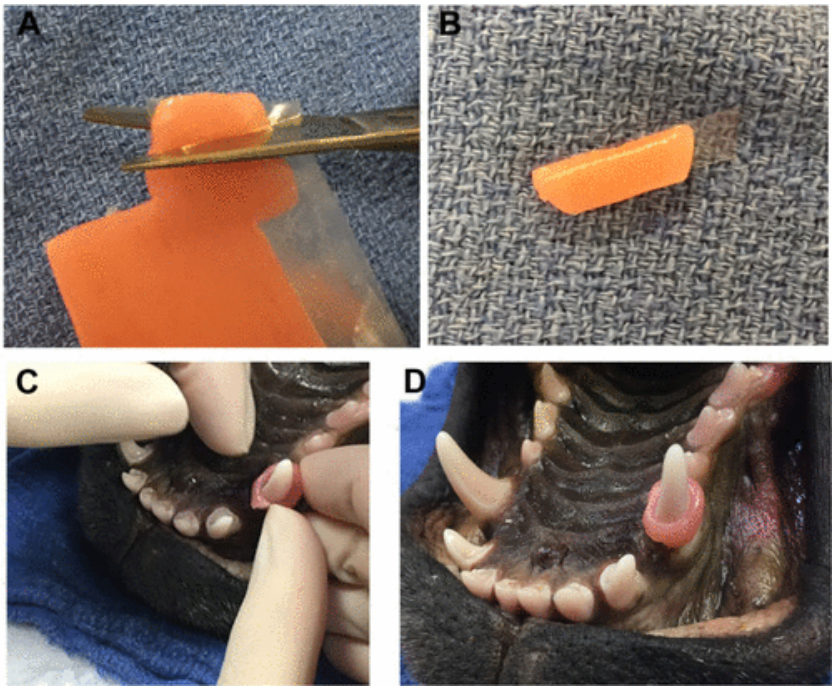


Figure 2: Showing how the material is cut and shaped around the canines tooth

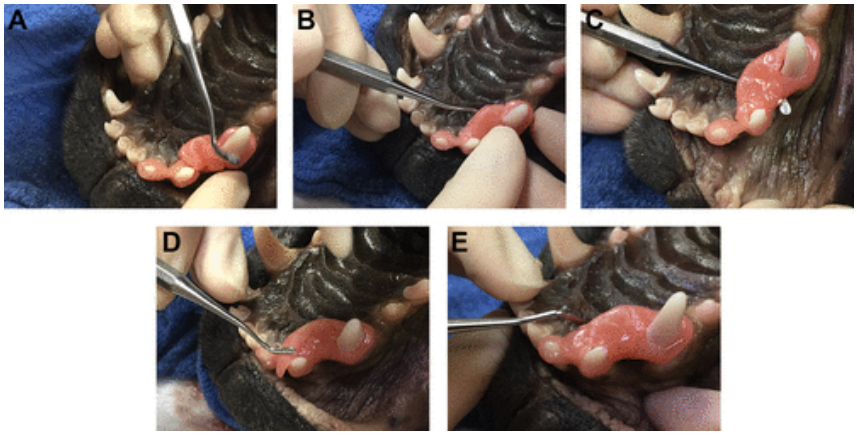


Figure 3: The incline plane is attached to the two teeth as well as the affected canine.

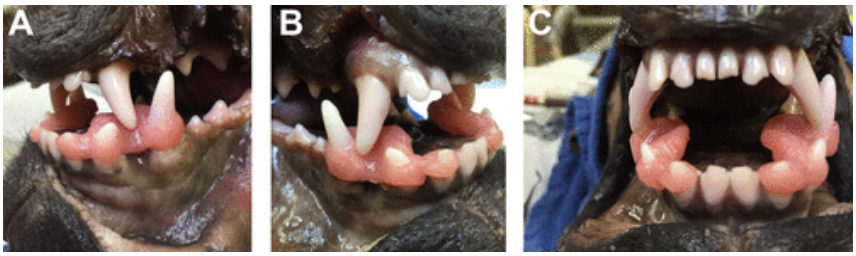


Figure 4: The final result. There are individual inclines on each side of the mouth.

Conclusion/action items:

Overall, there is a different approach to creating this incline plane, however, anesthesia is still needed. The process is still tedious and needs to be restarted with every new patient. There was no information about the testing of this material and if it can withstand the bite force of the dog.

This design does not change anything about our current design, I still believe our editable solid works file can be manipulated easier and more accurate, allowing for a more efficient and inexpensive solution to class II malocclusion.

K. Haggerty, K. Block, and J. Battig, “Orthodontic Inclined Plane Application Using a Visible Light Cure Acrylic Material for Treatment of Linguoverted Mandibular Canine Teeth,” *J Vet Dent*, vol. 38, no. 2, pp. 99–104, Jun. 2021, doi: 10.1177/08987564211026747.

Testing Protocols for Mechanical Testing 02/20/2022

LILY GALLAGHER - Mar 02, 2022, 10:50 AM CST

Title: Mechanical testing protocol for dental mouthguard

Date: 02/20/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To get a better understanding of mechanical testing set up of dental applications

Content:

The experiment employs a pendulum striker that impacts the mouthguard covering a specially designed device outfitted with strain gauges and an accelerometer. It is not stated in the paper what the maxillary surrogate is, it appears to be tooth- shaped.

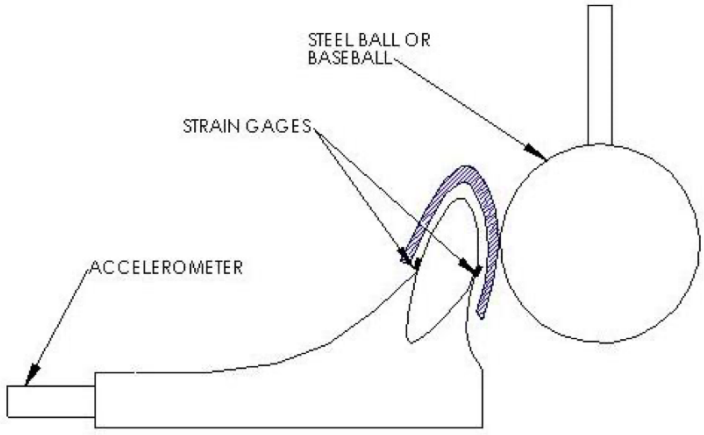


Figure 2 - Takeda testing apparatus

This researcher used both a steel ball and a baseball as the impacting object and measured both distortion of the tooth and acceleration of the maxillary device.

- All of the mouthguards tested were approximately 3.0 mm thick at the point of contact.
- For both measurements, acceleration and distortion, peak values during impact were used as the metric for performance.
- The results were presented as a percent reduction in either peak acceleration or distortion (strain) as compared to the control (no mouthguard).
- All mouthguards tested showed a significant reduction in acceleration and distortion with both impact objects.
- The impact energy was not noted in this paper for either the case of the steel ball or the baseball, and at high impact energies, the buffer room given by the insert plus hard space might be depleted resulting in failure of this type of guard to protect the teeth to the degree reported in the study.
- The author contends that in higher energy impacts, the hard insert would break down and absorb much of the energy of the impact\

"Mouthguard materials: their physical and mechanical properties." Robert E Going, Ronald E. Loehman, Ming Sam Chan. Volume 89 Issue 1, P132-138 July 01,1974 https://doi.org/10.14219/jada.archive.1974.0354

Conclusions/action items:

Begin to create a testing set up

Testing Protocols for Mechanical Testing of Dental implants 02/20/2022

LILY GALLAGHER - Mar 02, 2022, 11:13 AM CST

Title: Mechanical testing strategies for dental implants

Date: 02/20/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To get a better understanding of how we are going to preform mechanical testing of our device by looking at the mechanical testing of dental implants

Content:

In medical device manufacturing, mechanical testing is a critical step in both the product development program and the FDA approval process.

WHAT PARAMETERS SHOULD BE TESTED?

Device-Related Potential Failure Modes	
Structural Failure	**Membrane Leak**
Durability/fatigue	Permeability
Migration	**Vascular Trauma**
Pull test for modular components	Radial force Recoil
Attachment Site Leak	**Occlusion or Stenosis**
Radial force Conformability	Radial force Simulated use
Delivery System Potential Failure Modes	
Inability to access	**Balloon-related failures**
Wire pushability Bond strength Flex/kink Torsion Trackability Simulated use	Burst strength Inflation times **Inability to withdraw** Balloon deflation Tensile strength Bond strength

Table I. Partial list of potential failure modes and tests identified by AAMI/ISO TG150, SC2, WG31 committee in developing a working document for endovascular devices.

HOW MANY TEST CYCLES SHOULD BE RUN?

The number of cycles required for testing depends on the expected service life of the product and what could happen as a result of a structural failure.

WHAT SHOULD TEST FREQUENCY BE?

Material properties. Nonmetallic materials such as ultra-high-molecular-weight polyethylene (UHMWPE) tend to heat up after repeated loading or have viscoelastic properties and damping. For metals this is not an issue.

Device natural frequency. Sometimes the device simply cannot follow the applied load profile because it cannot rebound between each load cycle (prosthetic feet, for example).

Test system limitations. This could be due to the actuators used, transducers employed, system resonance, or control issues. Test equipment builders are always looking for ways to increase and verify the performance of new test instrument designs.

COMPARISON OF STATIC TO DYNAMIC FORCE/DEFLECTION MEASUREMENTS

Frequency (Hz)	Phase (degrees)	Stress (N/mm^2)	Strain (mm/mm)	E* measured (N/mm^2)	E′ real (N/mm^2)	E″ imaginary (N/mm^2)
1	0.1	0.1254	0.2698	0.465	0.464	0.033
3	0.89	0.1272	0.2648	0.480	0.479	0.041
5	1.25	0.1272	0.2642	0.482	0.480	0.044
10	2.43	0.1366	0.2762	0.495	0.491	0.055
12	2.54	0.1393	0.2862	0.487	0.484	0.055
15	2.87	0.1387	0.2747	0.505	0.501	0.060
20	1.98	0.1535	0.3060	0.502	0.499	0.052
25	2.81	0.1423	0.2825	0.504	0.500	0.060
30	2.84	0.1423	0.2781	0.512	0.508	0.061
40	2.08	0.1423	0.2784	0.511	0.508	0.054
50	2.77	0.1357	0.2631	0.516	0.512	0.061

Figure 1: *The response of a viscoelastic material subjected to sinusoidal loading at different frequencies.*

Conclusion:

Use this information to create a test protocol

MCDI, "Mechanical Testing: Accelerated Protocol Development and Advanced System Design." Kent S. Vilendrer. March, 2000

https://www.mddionline.com/news/mechanical-testing-accelerated-protocol-development-and-advanced-system-design

Testing Protocols for Mechanical testing 02/20/2022

LILY GALLAGHER - Mar 02, 2022, 11:03 AM CST

Title: Mechanical testing strategies for dental implants

Date: 02/20/2022

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To get a better understanding of how we are going to preform mechanical testing of our device

Content:

- Dental implant is a type of biomaterial, which that have been appealed in clinical applications frequently for more than 40 years
- Stress represents the resulting force distribution inside a solid body when an external force acts.
    - force per unit of area over which the force acts
- Mechanical stress is tensor quantity instead of a vector quantity.
    - Tensors are generalized vectors having more than one directions, which indicates a force into anatomically relevant axes
- Strain is the measure of the deformation of a material created by an external load
- The primary reason for stress is an external force, but strain of permimplant bone area could also results in bone stress
- Dental implants are exposed to static and dynamic loads continuously.
    - Long term success of dental implants these measurements are utilized.

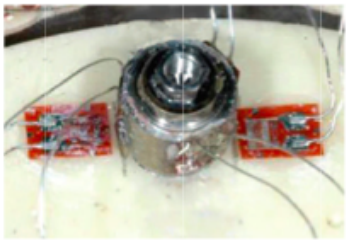


Fig. 1. Strain gauges on dental implant in the study

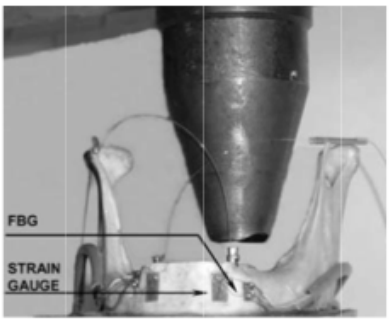


Fig. 2. Static loading measurement set-up in the study

Fig. 3. Dynamic loading measurement set-up in the study

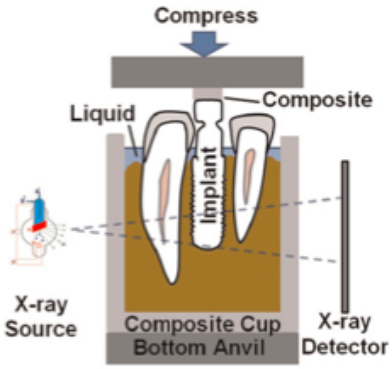


Fig. 5. Schematic of in-situ testing system in the study

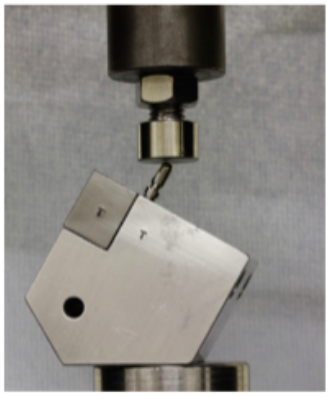


Fig. 6. Experimental set up

Conclusions/action items:

TATLISOZ M.M., CANPOLAT C. (2017) MECHANICAL TESTING STRATEGIES FOR DENTAL IMPLANTS. In: Badnjevic A. (eds) CMBEBIH 2017. IFMBE Proceedings, vol 62. Springer, Singapore. https://doi.org/10.1007/978-981-10-4166-2_29

WARF IP Lecture 03/20/2022

LILY GALLAGHER - May 03, 2022, 9:46 PM CDT

Title: Warf IP Lecture
Date: 03/20/22
Content by: Lily Gallagher
Present: Lily Gallagher
Goals: Learn more about patents and intellectual property
Content:

Warf Intro

- Wisconsin Alumni research foundation
  - Independent board of alumni
- Supports research at the University of Wisconsin Madison
  - Students (graduate and undergraduate), professors
  - Licensing, startups, funding to support research
- IP protection
  - Patents, trademarks, copyrights
    - Machines and devices
    - processes and methods
    - pictures or logos
    - literary works
    - webpages
    - software programs
- 350-400 invention disclosures each year
- 50 licenses each year

Prior art

- "references" created before a specific date
- by the inventor: > 1 year before the filing date of the patent application
- By another: before filling date of patent application
- Examples of public disclosure: journal publication, presentation, poster

Requirements for patentability

- Eligible
- Useful
- Enabled
- Described
- Novel (is there a problem because based on an expired patent?)
- Non-obvious
- US patent takes 3-5 years and takes thousands of dollars $$$

New disclosures

- Chance of licensing: Potential applications
- Timeline for licensing: Stage of tech
- Licensing strategy: Companies, public?
- Plan for the next year: Further tech development, does anything need to be done additionally?
- Revenue Projections: Early revenue, how much money could this bring in?

Licensing

- WARF provides exclusive rights
- Licensee provides commercialization
- Timeline can vary from months to years

Factors to start a company

- Technology
- market
- management
- capital requirements

Conclusion/action items:

Overall I enjoyed this lecture, it was very informational and interesting. It is defiantly something that we could try with our design project. We could look into getting our workflow patented.

Class 2 Malocclusion 09/23/2021

GIOVANNI MILITELLO - Dec 13, 2021, 3:03 AM CST

Title: Class 2 Malocclusions

Date: 9/23/21

Content by: Giovanni Militello

Present:

Goals: Learn about Class 2 Malocclusions

Content:

Malocclusions in Dogs - When Teeth Are Malaligned, Lorraine Hiscox DVM FAVD Dip. AVDC; Jan Bellows, and Contributors: Lorraine Hiscox DVM FAVD Dip. AVDC; Jan Bellows, “Malocclusions in dogs - when teeth are malaligned,” *vca_corporate*. [Online]. Available: https://vcahospitals.com/know-your-pet/malocclusions-in-dogs-when-teeth-dont-align. [Accessed: 23-Sep-2021].

Class 2 Malocclusions:

Puppies normally have twenty-eight deciduous (primary or baby) teeth, which erupt during the first six months of life, and adult dogs have forty-two permanent teeth. Dogs have four types of teeth:

1. **Incisors** are the teeth located between the canines on the upper and lower jaws. They are used for grasping food and they, along with the lower canines, help keep the tongue within the mouth.
2. **Canine** teeth are located on the sides of the incisors and are used to grasp food and other objects. The lower canines help retain the tongue within the mouth.
3. **Premolars** are located behind the canines in both the upper and lower jaws and work together to shear or cut food.
4. **Molars** are behind the premolars and are the teeth found at the back of the mouth. They are used for grinding food to prepare it for swallowing.

Malocclusion refers to abnormal tooth alignment. There are two types of malocclusion: skeletal and dental. A skeletal malocclusion results when an abnormal jaw length creates a malalignment of the teeth. A dental malocclusion, or malposition, occurs when the upper and lower jaw lengths are considered normal but there may be one or more teeth that are out of normal alignment (malpositioned tooth/teeth). When a dental or skeletal malocclusion causes trauma to other teeth or to the oral soft tissues, the condition is termed non-functional or traumatic and treatment is needed. Therapy options include:

- extraction,
- moving the offending or offended tooth/teeth, or
- surgically creating additional space for the malpositioned tooth to occupy.

Mandibular distoclusion or Class 2 Malocclusion (MAL2). Also known as an overbite, overjet, overshot, and mandibular brachygnathism, it occurs when the lower jaw is shorter relative to the length of the upper jaw. When the mouth is closed, the teeth of the lower jaw do not occlude (align normally) with their corresponding teeth in the upper jaw. There is a space between the upper and lower incisors when the mouth is closed and the lower incisors may traumatically contact the roof of the mouth behind the upper incisors. The upper premolars are aligned too far toward the nose compared to their counterparts in the lower jaws.

Conclusions/action items:

There are many different skeletal and dental malocclusions but the one we are focused on is Class 2 Malocclusion which is explained above.

Last Year Report 09/14/2021

GIOVANNI MILITELLO - Dec 13, 2021, 3:20 AM CST

Title: Last Year's Report

Date: 9/14/21

Content by: Giovanni Militello

Present:

Goals: See what last year's team did for the project

Content:

Parker Callender et. al, “VETMED: 3D Printed, Patient Specific Incline Plane for Management of Class 2 Malocclusion - Improvement in Design and Workflow Final Report,” unpublished.

VETMED: 3D PRINTED, PATIENT SPECIFIC INCLINE PLANE FOR MANAGEMENT OF CLASS 2 MALOCCLUSION – IMPROVEMENT IN DESIGN AND WORKFLOW

- Work with dogs that have Class 2 malocclusion
    - Class 2 malocclusion is also known as an overbite, overjet, overshot, and mandibular brachygnathism, it occurs when the lower jaw is shorter relative to the length of the he upper jaw
- Different types of treatments
    - Extraction: removal of misaligned teeth
    - Shortening: making misaligned teeth smaller
    - Incline plane: retainer for dog to push out misaligned teeth
- Incline plane is what Dr. Thatcher wants as the other two methods impair the dogs function to eat
- Dr. Thatcher takes a CT scan of the dogs and then 3D print the incline plane specific for the dog
- “The product must be able to withstand constant pressure of up to 400 lbs over the course of 3-8 weeks of treatment due to the dog’s natural eating and lifestyle habits. In addition, the incline plane must be able to adjust the angle of the mandibular canines by about 30 degrees of tilt. This angle will vary by each dog’s unique anatomy”
    - Dr. Thatcher wants us to continue with the previous project and fix any failures to the incline plane
- Dr. Thatcher wants us to use software that will be easy for orthodontist to use to scan the dogs mouth and create the incline plane
- The design for the incline plane they used was the separate design that is two separate pieces for each side of the dog's mouth to push the affected teeth outward.
- The software used was Blender which allows easy adjustments from the CT scan
- Used MeshMixer software to split the incline plane into two separate pieces and take in the CT scan and adjust the model with SolidWorks
- The incline plane has weak points on it where there are high stress points and would break after usage

Conclusions/action items:

Dr. Thatcher wants us to take what was made last year and make it better.

Ti64 Fatigue limit 05/02/2022

GIOVANNI MILITELLO - May 04, 2022, 2:52 AM CDT

Title: Ti 64 Fatigue limit

Date: 5-2-22

Content by: Giovanni

Present: Giovanni

Goals: Research fatigue limit for Ti64

Content:

- Fatigue limit: the highest stress that a material can withstand for an infinite number of cycles without breaking

- Ti–6Al–4V alloy exhibits a fatigue limit of approximately 410 MPa

- Since the max bite force of mandibular canines of dogs is 926 N, the load is well below the fatigue limit showing that our part would not break during clinical trials

Conclusions/action items:

Source : R. J. Morrissey and T. Nicholas, "Fatigue Strength of Ti–6Al–4V at Very Long Lives," *International Journal of Fatigue,* vol. 27, no. 10-12, pp. 1608-1612, 2005.

Workflow/Software design 10/03/2021

GIOVANNI MILITELLO - Dec 13, 2021, 3:12 AM CST

Title: Software/Workflow

Date: 10-03-21

Content by: Giovanni Militello

Present: Giovanni

Goals: Research software and workflow designs

Content:

“3D printing splints with Formlabs SLA 3D printers,” *Formlabs*. [Online]. Available: https://dental.formlabs.com/indications/splints-and-occlusal-guards/guide-v2/. [Accessed: 04-Oct-2021].

Workflow for material Dental LT Resin (V2) from Formlab

Dental LT Clear Resin (V2) is Formlabs’ second-generation, long-term biocompatible material for directly 3D printing affordable, high-quality splints and occlusal guards. Highly durable and resistant to fracture, this color-corrected material prints clear, polishes to high optical transparency and resists discoloration over time for a finished appliance you’ll be proud to deliver.

This application guide demonstrates each step for making 3D printed splints on Formlabs SLA 3D printers. Use the following workflow to ensure precise results. If you're using our legacy Dental LT Clear Resin, please follow the workflow guidelines here.

Essentials

Needed From the Dentist

- A physical or digital impression of the patient's dentition

Required Hardware and Materials

Made by Formlabs:

- Form 2 or Form 3B SLA 3D Printer: Printer needed to 3D print
- Form 2 Resin Tank LT or Form 3 Resin Tank V2 or higher: Type of compartment/tank to hold the 3D printable material
- Dental LT Clear Resin (V2): 3D printable material
- Form Wash: Solution to clean up the 3D printed product
- Form Cure: Teamperature to finalize the product
- Build Platform: Building platform to have the product created in the printer
- Finishing kit or secondary wash station: Further clean and cure the product

Made by Third Parties:

- Desktop scanner (if physical impression or model)
- Dental design software
- Dental handpiece with cutting and finishing wheels
- Polishing equipment and materials
- Isopropyl alcohol (IPA) ≥ 99%

Required Software

Made by Formlabs:

- PreForm Software (free) 3.6.1 or higher
- Firmware 1.7.3 or higher

Made by Third Parties:

- Dental design software or outsourcing to a dental design provider

1. Scan

Dental design software requires a digital impression of the patient's anatomy in order to design a splint or occlusal guard. To acquire this data, scan the patient directly with a 3D intraoral scanner or scan a physical impression or a poured model with a desktop 3D scanner.

2. Design

2.1 Design the Appliance

There are several dental software options for digitally designing occlusal splints. In this application guide, we will be outlining parameters for 3Shape Dental System and ExoCAD.

There are also outsourced dental CAD providers where you can send a digitized impression for creating the design.

2.2 Export the STL File

Once the case has been designed to specification manufacturing can begin. The majority of dental design software generates a manufacturing file in .stl format. Locate the file and move it into the print preparation software, PreForm.

3. Print

3.1 Import the File(s)

Import or open the design file(s) by dragging them into Preform or opening them using the "File" menu and locating them on your computer or network.

3.2 Material Selection

Select the material for printing by clicking the printer box in the "Job Info" menu on the right hand side.

Select Dental LT Clear (V2) in the material pull down.

3.3 Orientation

Proper part orientation is critical to ensure part accuracy and fitment.

Always position the splint horizontal to the built platform with the intaglio surface facing away from the build platform.

To rotate a splint, click on the part and "click and drag" the sphere.

3.4 Generate Supports

3.4.1 Automatic Support Generation

While having the part(s) selected, click the "Supports" button on the left toolbar.

Under "Basic Settings" confirm that "Support Density" is 1.00 and "Touch Tips" is 0.30 mm.

Once the settings are confirmed, click "Auto-Generate" to add the required supports.

3.4.2 Manual Support Editing

If a support point is not in an ideal location, it can be moved after automatic generation by clicking the "Edit…" button in the Supports menu.

Be sure not to reduce the number of supports and always properly support the parts of the splint closest to the build plate.

Perform will indicate in red what areas might require additional support.

Confirm under the "Job Info" menu bar on the right side of the window that "Printability" has green thumbs-up.

3.5 Printing Layout

For normal printing, it is best to place parts toward the middle of the build plate.

Tip: When printing multiple cases, overlapping rafts can optimize the use of the build volume and save material.

3.6 Transferring Job to the Printer

Send the job to the printer by clicking the orange printer icon on the left.

The “Print” dialog box will open to select the printer.

Click the orange “Upload Job” button to begin the transfer of the job to the printer.

3.7 Set up the Printer

Shake the Dental LT Clear Resin (V2) cartridge and then insert the cartridge, a build platform, and a compatible resin tank into the Form 2 or Form 3B printer.

- Begin printing by selecting the print job from the printer’s touch screen
- Follow any prompts or dialogs shown on the printer screen
- The printer will automatically complete the print

4. Post Processing

Always use gloves when handling uncured resin and parts.

4.1 Part Removal

Remove printed parts from the build platform by wedging the part removal or scraping tool under the part raft and rotating the tool.

4.2 Washing

Precautions

- When washing the printed part with solvent, it should be in a properly ventilated environment with proper protective masks and gloves.
- Expired or unused Dental LT Clear Resin (V2) shall be disposed in accordance with local regulations.
- IPA shall be disposed of in accordance with local regulations.

Place the printed parts in a Form Wash filled with isopropyl alcohol (IPA, ≥99%) and wash them for 15 minutes.

Make sure the parts are fully submerged in IPA when washing.

Exceeding wash duration may affect dimensional accuracy and performance of printed parts over time.

Remove parts from the Form Wash and soak them in fresh isopropyl alcohol (IPA, ≥99%) for an additional 5 minutes.

Note: Using a squeeze bottle of fresh IPA and compressed air can help make parts clean, especially in deep parts of the intaglio anatomy.

4.3 Drying

Remove parts from the IPA and leave to air dry at room temperature for at least 30 minutes.

Inspect printed parts to ensure that they are clean and dry.

No residual alcohol, excess liquid resin or residue particles may remain on surface before proceeding to subsequent steps.

Note: If any residual resin remains (it will look shiny) reference the previous section for an additional rinse in clean IPA.

4.4 Post Curing

Place the dried printed parts in a Form Cure and post cure at 60°C for 60 minutes.

Allow Form Cure to cool down to room temperature between cure cycles.

Note: Leaving the Form Cure door open will help the unit cool between cycles quicker.

4.5 Support Removal

Remove supports using a cutting disk and handpiece, or other part removal tool.

Note: While ripping the supports from the part might be quicker, it can leave divots in the part. We recommend cutting the supports off individually.

Removing supports should leave a small positive feature.

As sections of the supports are removed, the raft can be cut to give more room for the next area of the part to be cut.

Inspect the appliance. Discard and reprint the part if any cracks are detected.

4.6 Finishing and Polishing

Smooth down the support surfaces with a carbide or wheel rotary and handpiece.

Note: Depending on what tools are used for finishing, it might be necessary to have a second finishing step with a “scotch-brite” type rotary.

Once the surface is finished to satisfaction, polish and smooth the outside of the splint for patient comfort.

A high gloss shine can be achieved with traditional polishing tools and materials commonly used for dental acrylics.

Note: Lathes with rag or felt wheels, pumice, and high shine compound make the process quick and easy.

5. Cleaning and Disinfecting

5.1 Cleaning the Parts

Fully post processed parts can be cleaned using a dedicated soft toothbrush with neutral soap and room temperature water.

Do not use toothpaste or any other abrasive cleaning products on parts printed with Dental LT Clear Resin (V2). Abrasive cleaning products may affect surface finish and patient comfort.

After cleaning, always inspect the part and discard it if any damage or cracks are detected.

5.2 Disinfection

A tested method of disinfection includes soaking the finished part in fresh 70% IPA for 5 minutes.

Conclusions/action items:

Can look at Formlabs for other workflow methods for different types of materials for 3D printing

Materials design 10/03/2021

GIOVANNI MILITELLO - Dec 13, 2021, 3:14 AM CST

Title: List of Materials

Date: 10-03-2021

Content by: Giovanni Militello

Present: Giovanni

Goals: Gather types of materials to use for our project

Content:

From Stratasys.com

> "Professional 3D printing materials for Digital Dentistry," *Formlabs*. [Online]. Available: https://dental.formlabs.com/materials/. [Accessed: 04-Oct-2021].

> **NEW Biocompatible MED625FLX** is a flexible, transparent biocompatible material certified for temporary in-mouth placement, ideal for orthodontic indirect bonding trays and implant gingival masks.

Biocompatible MED610 is a rigid, transparent material certified for temporary in-mouth placement. It is frequently used for surgical guides and cast partial frames.

Biocompatible VeroGlaze MED620 is a rigid, opaque material that is ideal for a broad range of biocompatible applications such as denture try-ins, diagnostic wax-ups and custom trays. VeroGlaze is certified for temporary in-mouth placement of up to 24 hours.

VeroDent MED670 offers high-quality detail, strength and durability in a peach tone - ideal for orthodontic labs and clear aligner manufacturers.

VeroDentPlus MED690 creates fine features and finishes with strength, accuracy and durability. Available in dark beige, ideal for crown and bridge work.

> "Dental 3D printing materials for Digital Dentistry," *Stratasys*. [Online]. Available: https://www.stratasys.com/materials/search/dental-materials#imageCarousel. [Accessed: 04-Oct-2021].

From Formlabs

Model Resin

An accurate material for dental modelmaking and clear aligner production

Model Resin was developed specifically to meet the high precision, accuracy, and throughput requirements of dental professionals. Print removable dies with crisp margins and contacts within ±35 microns.

Draft Resin

A cutting-edge material designed to print accurate orthodontic models – fast

Draft Resin is our fastest printing material, capable of printing a dental model in under 20 minutes. This highly accurate resin prints with a smooth surface finish, making Draft Resin the ideal material for aligner and retainer production. Use 200 micron settings for fastest print speeds and same day appliances, or use 100 micron settings for more detailed models.

Surgical Guide Resin

A next generation 3D printing material for premium-quality surgical implant guides

Surgical Guide Resin is an autoclavable, biocompatible resin for applications including 3D printing dental surgical guides for implant placement. Developed specifically for Formlabs printers and rigorously tested with autoclaves, solvents, and implant systems, this material was designed from the ground up to exceed dental demands in part quality, accuracy, and performance.

Dental LT Clear Resin (V2)

Our second-generation, long-term biocompatible material for splints and occlusal guards

Directly print affordable, high-quality occlusal splints in-house with Dental LT Clear Resin (V2). Highly durable and resistant to fracture, this color-corrected material prints clear, polishes to high optical transparency, and resists discoloration over time for a finished appliance you'll be proud to deliver.

Castable Wax Resin

A highly accurate material for casting and pressing crowns, bridges, and RPDs

Tested at length by dental technicians, Castable Wax Resin provides accurate, sealed margins and contains 20% wax for reliable casting with clean burnout. Printed patterns are strong enough to handle with no post-cure required, allowing for a faster, simpler workflow.

Digital Dentures

Truly accessible direct printed dental prosthetics

Bring your removables department digital now. Formlabs is expanding access to digital dentures with an efficient, cost-effective manufacturing solution. Class II long-term biocompatible Digital Denture Resins enable dental professionals to produce 3D printed full dentures accurately and reliably.

- Use Denture Base Resin for denture bases and try-ins
- Use Denture Teeth Resin for denture teeth

Custom Tray Resin

A fast-printing biocompatible material for custom impression trays

Use Custom Tray Resin to directly print impression trays for implants, dentures, crowns and bridges, and other comprehensive cases. Digitally manufactured impression trays provide consistent, accurate impressions for high-quality dentistry. Custom Tray Resin prints full impression trays quickly using 200 micron layer heights, reducing labor time and enabling higher throughput.

Temporary CB Resin

A tooth-colored resin for 3D printing of temporary crown and bridge restorations, inlays, onlays and veneers

Indicated for up to seven-unit bridges and available in four VITA shades, Temporary CB Resin provides excellent marginal adaptation, strength, and aesthetics. Use traditional temporary cements to fix restorations produced with Temporary CB Resin. Restorations made with Temporary CB Resin may remain up to 12 months in the mouth. Digitally created restorations enable a quick, collaborative process between dentist, technician, and patient.

Permanent Crown Resin

A tooth-colored, ceramic-filled resin for 3D printing permanent single crowns, inlays, onlays, and veneers

Permanent Crown Resin produces high strength, long term restorations with an accurate and precise fit, available in four VITA Classical* shades. Low water absorption and a smooth finish ensure restorations made from Permanent Crown Resin have a low tendency to age, discolor, or accumulate plaque.

IBT Resin

A flexible biocompatible material for efficient, accurate dental bracket placement

3D printed indirect bonding trays reduce chair time and increase patient comfort by placing all of the brackets at once.

Class I compliant IBT Resin offers optimized tear strength, translucency, and flexibility, for appliances that are easy to plan, easy to use, and easy to remove.

Soft Tissue Starter Pack

Expand your digital capabilities with 3D printed gingiva masks and implant models

Create flexible gingival masks for use in combination with rigid dental models. Confidently check implant prosthetics by adding removable soft tissue components to your model production. Use the Soft Tissue Starter Pack to create your own Soft Tissue Resin in customizable dark, medium, and light pink shades.

Conclusions/action items:

Look at other materials not used in 3D printing for other design/workflow ideas.

Incline plane design 10/07/2021

GIOVANNI MILITELLO - Dec 13, 2021, 3:20 AM CST

Title: Incline plane design

Date: 10/07/21

Content by: Giovanni Militello

Present: Giovanni

Goals: Come up with design of incline plane

Content:

G. Thatcher, “Diagnosis and management of class II malocclusion,” *The Canadian veterinary journal = La revue veterinaire canadienne*, Jul-2019. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563895/#b1-cvj_07_791. [Accessed: 07-Oct-2021].

Parker Callender et. al, “VETMED: 3D Printed, Patient Specific Incline Plane for Management of Class 2 Malocclusion - Improvement in Design and Workflow Final Report,” unpublished.

What the incline plane should do from Dr. Thatcher's paper:

- main goal should be removing the trauma to provide the animal with a comfortable occlusion
- Esthetics should not be a consideration during treatment planning
- The purpose of the patient should also be considered and treatment should result in a functional occlusion
- passive force method of directing mandibular canine teeth into atraumatic occlusion with mandibular distocclusion
- Material used to create direct incline planes must not produce exothermic reactions in the dog's mouth during the curing process
- incline plane is now designed and applied directly to the maxillary arches using self-curing temporary crown material (bisacryl composite)
    - can be used to guide the mandibular canine teeth into their normal position mesial to the maxillary canine teeth or distal to the maxillary canine teeth if the mandibular distocclusion is more severe and the shorter distance to an atraumatic occlusion is distal to the maxillary canine teeth
- composite based appliances are bonded to the maxillary canine teeth, incisors, and/or the premolars and carefully shaped with acrylic burrs
- incline plane is custom formed to provide a trough in which the mandibular canine tooth will be guided into an atraumatic position
- alternative to the bisacryl composite incline plane is a cast metal telescoping incline plane that is fabricated by a dental laboratory and known as a Mann incline plane
- telescoping bridge between the maxillary arches is designed to allow for unimpeded growth of the maxillae
- Mann incline plane requires detailed dental impressions to produce articulating stone models, which increases costs
- adjustments cannot easily be made to a fixed metal incline plane if the inclination angle needs to be changed

Designs that were disscused with the team that I mentioned with the team during a team meeting:

Design 1:

- Incline plane on just the upper canine of the dogs mouth that would push the lower mandibular canine away from the mouth and tip the tooth outward

- Similar to the patten that Ben Smith found

Design 2:

- Incline plane with individual components (last years design)
- Collected from last years design project

Design 3:

- Incline plane like last years but with a bridge in the middle connecting the two pieces
- Collected from last years design project

Conclusions/action items:

Talk with team and pick a design to go with.

WARF Lecture 03/29/2022

GIOVANNI MILITELLO - Mar 29, 2022, 12:28 PM CDT

Title: WARF Lecture

Date: 3/29/2022

Content by: Giovanni Militello

Content:

Lecture Notes:

- WARF is an organization that works in patenting and licensing
  - Started in 1925 to manages intellectual property
  - Organized as a non-profit and proceeds support research at UW-Madison
- Cycle of innovation:
  - Starts with UW Research and Discovery
  - WARF IP Protection (Patents)
  - Commercialize by Licensing and Startups
  - Annual Grant for Funding to support Research and Discovery
- Protecting Innovation
  - Patents
    - Machines and devices
    - Compounds
    - Processes and methods
    - Improvements
  - Trademarks
    - Words and phrases
    - Colors
    - Pictures or logos
    - Sound
  - Copyrights
    - Literary works
    - Webpages
    - Software programs
- Prior Art
  - Definition: "references" created before a specific date
  - By inventor: >1 year before filling date of patent application
  - By another: before filling date of patent application
- Examples of typical public disclosure of an invention
  - Journal publication
  - Meeting, presentation, seminar
- Requirements for Patentability
  - Eligible: ability to patent
  - Useful
  - Enabled
  - Described
  - Novel: New concept
  - Non-Obvious: Can combine multiple references to go against your idea
  - (Takes about 3-5 years and around $30,000)

- IP Management Process
  - Disclose invention
  - Monthly meeting
  - Patent application drafting
  - Technology marketing
  - Licensing
- Licensing Considerations For New Disclosures
  - Chance of licensing: Potential applications
  - Timeline for licensing: Stage of tech
  - Licensing strategy: Companies
  - Plan for the next year: Further tech development
  - Revenue Projections: Early revenue
- Licensing Innovation
  - WARF provides exclusive rights
  - Licensee provides commercialization
  - Timeline can vary from months to years
- Finding a License
  - Internal: Meetings, inventor contacts
  - External: Publications
- Factors to Consider in Starting a Company
  - Technology: What needs to be developed
  - Market: What is the market
  - Management: Who will fill management roles
  - Capital Requirements: Funding needed

Conclusions/action items:

This was an interesting presentation. I think our project design intellectual property could be in the process/workflow we created to correct class II malocclusions. It would be interesting to see what WARF would say about our process/workflow.

Previous PDS Notes 02/04/22

MADELEINE KREDELL - May 02, 2022, 3:32 PM CDT

Title: Previous PDS Notes

Date: 02/04/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Find out what our client asked the previous team to work on and the design specifications.

Content:

- Further develop Dr. Thatcher's current incline plane and design a more efficient workflow
- Requirements:
  - Incline plant device
  - Modified based on specific patient using CT scan
  - User friendly software
  - Can be worn in patients mouth
- Incline placed is placed on the upper jaw of the patient's mouth for 6-8 weeks
- Device material must follow "ISO 13504"
- Withstand bite force of 147-926 N
- Develop DICOM or stl files that are easy to manipulate

Conclusions/action items: Read over the final report from the previous semester to understand how they addressed these specifications and learn what work still needs to be done. Research class 2 malocclusions.

Class II Malocclusions 02/04/22

MADELEINE KREDELL - May 02, 2022, 3:57 PM CDT

Title: Class II Malocclusions

Date: 02/04/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Learn what a class II malocclusion is and how it affects a dog.

Content:

- American Veterinary Dental College. defines Class II Malocclusion as mandibular distocclusion
  - abnormal rostro-caudal relationship between the dental arches.
    - rostral - structures that are in the most forward position in the mouth
    - caudal - teeth that are in the back position of the mouth
  - The mandibular arch occludes caudal to its normal position relative to maxillary arch
    - occludes - comes in contact with another tooth in the opposite jaw
    - Mandibular - lower jaw
    - Maxillary - upper jaw
  - Associated with overbite and overjet
- Diagnosed in many breeds
- Concerns
  - Sharp bottom teeth come in contact with the palate of the dog = oral pain, non-vital teeth, dental attrition, periodontal diseases, oronasal fistula
- Possible treatments
  - extraction of the teeth
  - crown extensions
  - crown reduction with vital pulp therapy
- Tipping movement - requires multiple general anesthesia events
  - light force applied to the incisive tip of the tooth
  - causes crown and root to move in opposite directions about a fulcrum
  - needs a retention period of 2 months
- Incline plane - common passive force method that direct mandibular canine teeth

Conclusions/action items: Continue researching the past project, materials, and testing options.

MADELEINE KREDELL - May 02, 2022, 3:36 PM CDT

G. Thatcher, “Diagnosis and management of Class II malocclusion,” Can Vet J, vol. 60, no. 7, pp. 791–795, Jul. 2019. [Online] Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563895/

Dog Bite Forces 03/10/22

MADELEINE KREDELL - May 02, 2022, 5:15 PM CDT

Title: Dog Bite Forces

Date: 03/10/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Determine the average amount of force in a dog bite to make sure our device can withstand this force.

Content:

- Study considered multiple variables that could affect the bite force of dogs
  - skull size
  - skill shape
  - sex
  - body weight
- Bite force was calculated using observed values from maximally stimulated sedated dogs
  - the values may represent maximum bite force value instead of average bite force value
- Bite force for males and females
  - At the canine
    - Male = 486 ± 42 N
    - Female = 375 ± 23 N
  - At the molar
    - Male = 1606 ± 170 N
    - Female = 1217 ± 95 N

Conclusions/action items: Use these values while conducting mechanical tests on our incline plane.

MADELEINE KREDELL - May 02, 2022, 5:16 PM CDT

J. L. Ellis, J. Thomason, E. Kebreab, K. Zubair, and J. France, “Cranial dimensions and forces of biting in the domestic dog,” *Journal of Anatomy*, vol. 214, no. 3, pp. 362–373, 2009.

Ti-64 Notes 03/10/22

MADELEINE KREDELL - May 02, 2022, 4:49 PM CDT

Title: Ti-64 Notes

Date: 03/10/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Understand why Ti-64 was chosen as the best material for our device.

Content:

[1]

- Applications: blades, discs, rings. Biomedical implants
- Biocompatibility: excellent, especially when direct contact with tissue or bone is required
- Undesirable for bone screws or plates because it has poor shear strength
- Modulus of elasticity = 113.8 GPa
- Ultimate bearing strength = 1860 MPa

[2]

- Ions integrated on the titanium surface have been useful against the formation of bacterial biofilms
- Ti6414V has better mechanical features and more advantages than other titanium alloys
- High strength and low density
- Ti is becoming the best material for dental implants because of its biocompatible properties

Conclusions/action items: Research the process of 3D printing Ti-64 and find the best place to print our design.

MADELEINE KREDELL - May 02, 2022, 4:43 PM CDT

[1] “Titanium Ti-6Al-4V (Grade 5), Annealed,” *ASM material data sheet*. http://asm.matweb.com/search/SpecificMaterial.asp?bassnum=mtp641.

[2] R. Eftekhar Ashtiani, M. Alam, S. Tavakolizadeh, and K. Abbasi, “The role of biomaterials and biocompatible materials in implant-supported dental prosthesis,” *Evidence-Based Complementary and Alternative Medicine*, 05-Aug-2021. [Online]. Available: https://www.hindawi.com/journals/ecam/2021/3349433/.

Ti-64 3D Printing Process 03/11/22

MADELEINE KREDELL - May 02, 2022, 5:00 PM CDT

Title: Ti-64 3D Printing Process

Date: 03/11/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Understand the standards and process of 3D printing Ti-64.

Content:

Materialise - Titanium (Ti6Al4V)

- Technical Specifications
  - Standard time - minimum of 10 working days
  - Standard accuracy - DTTG 6 for dimensions below 30 mm
  - Layer thickness - 0.03 - 0.06 mm
  - Minimum wall thickness - 1 mm (standard), 0.5 mm (performance)
  - Minimum detail - 0.5 mm
  - No interlocking or enclosed parts
  - Surface structure - unfinished parts typically have a rough surface but various finishing degrees can achieve smooth surfaces
- Datasheet
  - Density > 4.36 g/cm^3
  - Tensile strength > 900 MPa
  - Yield strength > 830 MPa
  - E-modulus = 110 GPa
- Process
  - Laser melts the titanium particles together
  - Successive layers of metal powder are spread on top, while a laser selectively binds particles to form the part and its supports
  - The loose powder is removed
  - The part undergoes heat treatment
  - The support is removed
  - The part is finished

Conclusions/action items: Print our design in titanium and complete testing on it.

MADELEINE KREDELL - May 02, 2022, 5:02 PM CDT

"Titanium (Ti6Al4V)." Materialise. Retrieved from: https://www.materialise.com/en/manufacturing/materials/titanium.

Mechanical Testing 03/22/22

MADELEINE KREDELL - May 02, 2022, 5:26 PM CDT

Title: Mechanical Testing

Date: 03/22/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: To determine the best way to test our incline plane and what results we will.

Content:

- Compressive test: the specimen would be compressed by an applied strain rate (displacement) and the force will be measured by the load cell
    - Compute Young's modulus and ultimate strength
- Load cell values: 50 N, 250 N, 1kN, 10 kN
    - Would need 10 kN to ensure that we don't exceed the maximum load

Conclusions/action items: Meet with Jacob Zueske to discuss how to test our incline plane and design a testing apparatus.

Previous Semester Final Report 02/04/22

MADELEINE KREDELL - May 02, 2022, 4:12 PM CDT

Title: Previous Semester Final Report

Date: 02/04/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Learn what the team did last semester and what the goals of this semester should be.

Content:

- Affects 10% of purebred dogs
- Existing treatments
    - intrusive orthodontic procedures
        - extracting or shaving down the problematic tooth
        - both decrease functionality
    - tipping orthodontics
        - teeth hit incline plane when the dog closes its mouth with the force of its bite
        - force moves crown in one direction while the root resists
        - moment of force created and will slowly move the teeth into place
- Dr. Thatcher's process
    - Takes a CT scan of the jaw - saved in DICOM file
    - DICOM file used to print 3D model of jaw
    - He hand carved an incline plane in model
    - Sent incline plane to software engineer that produced a printable incline plane
- Expired patent (US5151027A) used an incline plane to correct displacement of mandibular teeth
- Design 1: Ring design
- Material: titanium - used in human braces as wires.
- Ring design was made in solid works
- Solidworks file had measurements that can be changed and a workflow that explained how to manipulate the file
- SolidWorks SimulationXpress testing done showed that titanium would be strong enough
    - Need to print the design in titanium and perform mechanical tests

Conclusions/action items: Work through the SolidWorks workflow document and see if any changes need to be made in order to make it more user friendly.

Expired Patent 02/04/22

MADELEINE KREDELL - May 02, 2022, 4:32 PM CDT

Title: Expired Patent (US5151027A)

Date: 02/04/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: To look at the expired patent that the final design was based on and see what was changed.

Content:

- Application events
  - Application filed in 1989
  - Application approved in 1992
  - Publication in 1992
  - Expired in 2009
- Useful in correcting lingual displacement of the mandibular canine teeth
  - inclined biting planes coupled to the maxillary canines to move the mandibular canines into their normal position
- Telescoping rod bridges the fixtures from tooth to tooth
  - prevents undue stress
  - no inhibiting restraints on the animal's normal growth development
- Expired due to failure to pay maintenance fee

Conclusions/action items: Continue work on our design and the workflow.

MADELEINE KREDELL - May 02, 2022, 4:15 PM CDT

Orthodontic device for small animals, by Lloyd J. Mann. (1992, Sept. 29).US5151027A.

Updated Search for Patents 04/20/22

MADELEINE KREDELL - May 02, 2022, 5:34 PM CDT

Title: Updated Search for Patents

Date: 04/20/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: See if any new patents or research has been done that would be competition to our device.

Content:

"Class II Malocclusion treatment"

- No new results appeared that contained a design similar to ours
- Included human braces patent

"Incline plane dog patents"

- No new patents or treatments

"Class II malocclusion dog patents"

- No new patents or treatment plans

Conclusions/action items: Continue to research new patents and designs every few months.

Demographics and Marketability 04/21/22

MADELEINE KREDELL - May 02, 2022, 5:46 PM CDT

Title: Demographics and Marketability

Date: 04/21/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Determine the demographics and the marketability of our design.

Content:

- Percentage of purebred dogs with a class II malocclusion = 10.8%
- Percentage of mixed breed dogs with a class II malocclusion = 16.5%
- When considering AKC breed standard, there were significantly more purebred dogs that presented with malocclusions than mixed breed dogs
- In litter dogs, there are more mixed breed dogs but these are not AKC breed standard
- This would mean a large demographic and good marketability

Conclusions/action items: Create a predication of the marketability and share it with WARF and include it in the executive summary.

MADELEINE KREDELL - May 02, 2022, 5:47 PM CDT

J. E. R. Naomi K. Hoyer, “Prevalence of malocclusion of deciduous dentition in dogs: An evaluation of 297 puppies - Naomi K. Hoyer, Jennifer E. Rawlinson, 2019,” *SAGE Journals*.

Notes on Current Workflow 02/11/22

MADELEINE KREDELL - May 02, 2022, 5:51 PM CDT

Title: Notes on Current Workflow

Date: 02/11/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Work through the current workflow to find areas where it can be made more user friendly.

Content:

Comments left on the shared google doc to be revised

1. Add more pictures for each measurement that needs to be entered
2. Put all the measurements needed and their adjustments at the top of the page before even talking about the solidworks document
3. make the pictures bigger or get rid of the numbers on the screen that don't need to be changed
4. A lot of trouble with the mating part, maybe we can make that clearer.

Conclusions/action items: Update the workflow. Have other people look at the workflow to see how else it can be improved.

WARF Lecture

MADELEINE KREDELL - May 02, 2022, 2:54 PM CDT

Title: WARF Lecture

Date: 03/20/22

Content by: Maddie Kredell

Present: Maddie Kredell

Goals: Learn more about patents and intellectual property to understand how they may apply to our design.

Content:

Warf Overview

- Manages intellectual property
- Governed by an independent board of UW-Madison alumni
- Supports scientific research within the UW community
- Cycle of innovation:
  - UW research and discovery -> IP protection -> licensing and startups -> funding to support research and discovery
- 350-400 invention disclosures each year and 50 licenses each year

Protecting innovation

- Patents (Most likely our design falls here)
  - Machines and devices
  - Compounds
  - Processes and methods
  - Improvements
- Trademarks
  - Words and phrases
  - Colors
  - Pictures or logos
  - Sound
- Copyrights
  - Literary works
  - Webpages
  - Software programs
- Prior art - "references" created before a specific date
  - by the inventor: > 1 year before the filing date of the patent application
    - A year after last year's final presentation
  - by another: before the filing of the patent application
- Public disclosure: journal publication, talk or poster, non-confidential department seminar, open thesis defense, cataloged dissertation
- Requirements for patentability
  - Eligible
  - Useful
  - Enabled
  - Described

    - Novel (is there a problem because based on an expired patent?)
    - Non-obvious
- US patent takes 3-5 years and take thousands of dollars
- IP Management Process
    - disclose your innovation to WARF
        - submit an invention disclosure report and meet with WARF IP staff
    - disclosure committee meets monthly to review new disclosures
    - patent application drafting, filing, and prosecution
        - meet with WARF IP staff and outside patent counsel
    - technology marketing
        - technology summary
        - outreach to company contracts
    - licensing
        - negotiate license agreement
        - commercialization partners
        - maintain business relationship with licensers

Commercializing innovation

- Licensing Innovation
    - WARF provides exclusive or non-exclusive rights to make, use, sell, or import
    - License provides developing and commercialize, reasonable fees
    - Timeline varies from months to years
- WARF's accelerator program is validation funding to speed promising technologies to a commercial license
- Funding a license
    - internal: inventor contacts, meetings, sponsored research
    - external: technology descriptions in website, publications, technology portals, targeted outreach
    - Inventor startup fund

Conclusions/action items: Discuss with the team and Dr. Puccinelli about weather our design and workflow should be submitted to WARF. If we decide we should, submit an invention disclosure report and meet with someone eon the WARF IP staff.

MTS Machine Testing 03/24/2022

ABIGAIL STERTZ - Mar 24, 2022, 8:41 PM CDT

Title: MTS Machine Testing

Date: 3/24/2022

Content by: Abbie

Goals: Learn about using an MTS machine and look into possible ways to test our titanium piece once it arrives

Content:

- Multiple different types of MTS machines have force up to 500 kN which is more than we need

- The vertical test space is up to 83 inches which is also more than we should need since it is a small piece

- Has specific clamps to hold material in place

    - Probably need to create bracket which works with the clamps and the piece

Conclusions/action items:

Create a testing plan and test Ti piece

Link: https://www.upc.edu/sct/documents_equipament/d_77_id-412.pdf

Bite Force 04/04/2022

ABIGAIL STERTZ - Apr 16, 2022, 10:16 AM CDT

Title: Bite Forces in Dogs

Date: 4/4/2022

Content by: Abbie

Goals: Determine whether 1400 N of force is actually needed to test titanium piece, or if a smaller amount is needed due to which teeth are used

Content:

- Bite force measurements can vary significantly based on the measuring technique and how cooperative the dog is.

- Different measurements for bite force can be taken in vivo, in vitro, or in silico.

- Jaw adductors are primarily responsible for determining bite force. These include the temporal, masseter, and medial and lateral pterygoid.

- In addition to class II malocclusion applications, bite force can be used in plates and screws, restorative materials, and many more veterinary applications.

Table 1

Studies on the bite force measurement/estimation in dogs and cats.

Animal	Measured/estimated location	Bite force (Newton, N)	Measurement/estimation method
Dog	Not specified	13–1,394	Measured by chewing transducer rolled with the rawhide (22)
	Canine teeth Molar teeth	147–926 574–3,417	Maximum bite force measurement by electronic stimulations (26)
	Canine teeth	300* 340* 571* 588*	Bite force estimation using equations of Kiltie (27) Thomason (28) Kiltie (26) (adjusted) Thomason (26) (adjusted)
	Molar teeth	755* 849* 1,949* 2,036*	Kiltie (27) Thomason (28) Kiltie (26) (adjusted) Thomason (26) (adjusted)
	Canine teeth Carnassial teeth	351.5* 549.8*	Bite force estimation using Thomason's equation (29)
	Canine teeth Carnassial teeth	231.99–511.80[a] 620.33–1,091.1[b]	Bite force estimation using finite element analysis (35)

Conclusions/action items:

- Look at what teeth are used in a class II malocclusion and determine maximum possible bite force

- Determine whether other factors such as tooth size affect bite force

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5932386/

3D Printing in Titanium 04/16/2022

ABIGAIL STERTZ - Apr 16, 2022, 10:33 AM CDT

Title: 3D Printing in Titanium

Date: 4/16/2022

Content by: Abbie

Goals: Learn more about the Ti printing process and applications

Content:

- Titanium is strongest material that can currently be used in 3D print.

- Minimum size of part: 0.25 mm layers and 0.4 mm wall thickness.

- Typically created using direct metal laser sintering technique.

- The printed titanium parts are not shiny due to the printer using unpolished raw materials. In some cases, you might also be able to see each individual layer.

Conclusions/action items:

Continue learning about 3D printing technology.

Link: https://3dprint.com/111142/3d-printing-with-titanium/

Dog Teeth Strength 04/19/2022

ABIGAIL STERTZ - Apr 19, 2022, 9:00 PM CDT

Title: Fracture Limits of Maxillary Fourth Premolar Teeth in Domestic Dogs Under Applied Forces

Date: 4/19/2022

Content by: Abbie

Goals: learn more about the strength of dog teeth

Content:

- Study is based around maxillary fourth premolar teeth which may be stronger than the canine teeth which are affected by our device.

- Enamel of dogs' teeth are thicker than human teeth. However, damage due to chewing is still very common.

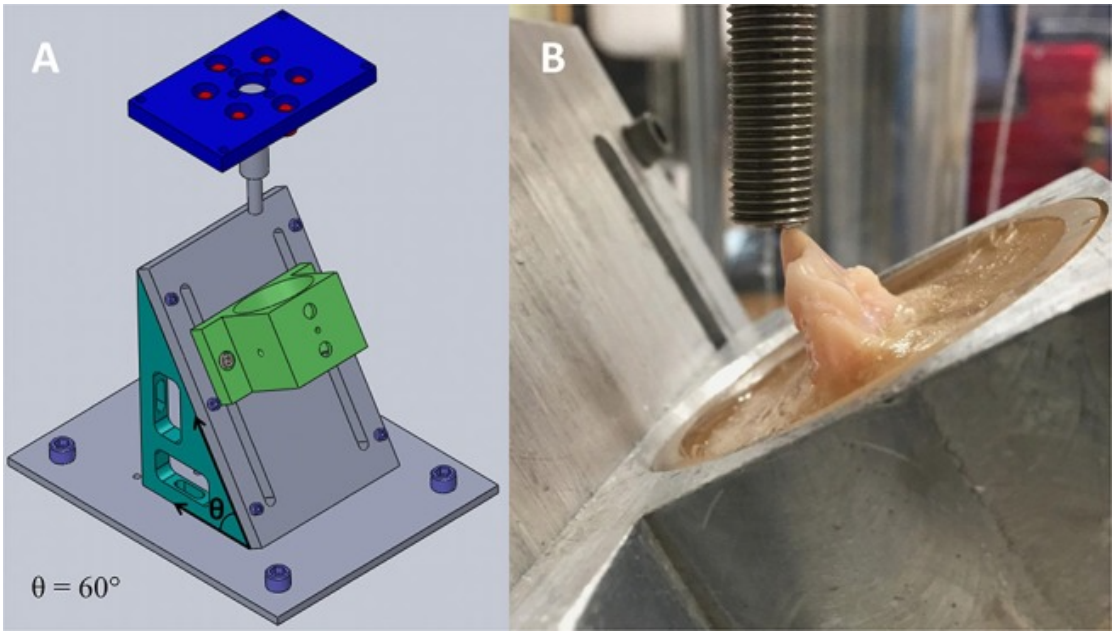
- Pulling force from dog teeth can be up to 1200 N.

- An axial compression test was performed at a 60° angle.

- Most common damage was seen on the crown of the tooth.

- Most teeth sustained a force of up to about 1200 N.

- This study impacted the dog teeth at an angle



Conclusions/action items:

- Look at the testing plan in this study and see if the forces at an angle and see if this would be a better way to test our device.

- Confirm that these force measurements are compatible with our titanium piece.

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6364561/

Titanium Implants 04/26/2022

ABIGAIL STERTZ - Apr 26, 2022, 9:53 AM CDT

Title: Titanium Implant Safety

Date: 4/26/2022

Content by: Abbie

Goals: Confirm biocompatibility of titanium in the body

Content:

- Struggled to find specific information about biocompatibility in dogs so I'm assuming typically materials that are safe in humans are safe in dogs as well

- Titanium can cause an allergic reaction, especially if the patient has a history of metal allergies

- Rarely, titanium can be toxic which can cause bone problems

- Titanium implants may not heal properly if the patient has certain other health conditions including cancer, diabetes, or others.

Conclusions/action items: Continue researching safety concerns regarding the titanium piece

Link: https://www.healthline.com/health/dental-and-oral-health/titanium-implants#potential-side-effects

3D Printing Ti Medical Devices 05/02/2022

ABIGAIL STERTZ - May 02, 2022, 9:21 PM CDT

Title: 3D Printing Titanium Medical Devices

Date: 5/2/2022

Content by: Abbie

Goals: learn more about how titanium 3D printing is used in the medical industry

Content:

- Titanium has good properties for an implant including biocompatibility, low weight, and corrosion resistance

- Titanium 3D printing minimizes material waste

- Implants can be customized to each individual patient's needs

Conclusions/action items: Continue researching uses for Ti 3D printing in medical field

Link: https://www.med-technews.com/medtech-insights/latest-medtech-insights/titanium-and-3d-printing-the-future-of-medical-implants/

Previous Semester Research 02/04/2022

ABIGAIL STERTZ - Apr 16, 2022, 12:05 PM CDT

Title: Research Reports and Data During Previous Semesters

Date: 2/4/2022

Content by: Abbie

Goals: Understand what has been done in previous semesters and what is needed going forward

Content:

Reviewed final reports and final presentations from previous semesters.

- Class II malocclusions affect 10% of purebred dogs

- A class II malocclusion is when the lower jaw is shorter than the upper jaw resulting in an under bite

- This condition can cause pain for the dog and/or health issues later in life

- Current treatment methods are lengthy and expensive. They involve taking a scan of the dog's mouth which involves anesthesia, the veterinarian making a mold, and then sending this to a software engineer to process and 3D print.

- The team's new design makes this process more efficient by eliminating the need for a scan and instead using only measurements of the dog's mouth.

- The process is based on existing patent US5151027A, but it is expired

- Titanium is used because it is strong and not toxic

- Previous pieces 3D printed in plastic broke

Conclusions/action items:

Continue researching and get working on the project

Updated Search for Patents 04/16/2022

MADELEINE KREDELL - May 02, 2022, 5:28 PM CDT

Title: Continue research to determine whether any additional patents/research have emerged for treatment of class II malocclusions

Date: 4/16/2022

Content by: Abbie

Goals: Continue researching to determine whether additional patents have emerged to treat class II malocclusions

Content:

No additional information came up with these google searches

- treatment class 2 malocclusion canines
    - the first thing that came up was an article by the client
    - all other search results were case studies of dogs without any additional information or human malocclusions

-treatment class 2 malocclusion canines patent
    - all results returned human treatments

Conclusions/action items: Continue updating research and checking for patents

For WARF Presentation- Potential Licensing 04/16/2022

ABIGAIL STERTZ - Apr 16, 2022, 11:03 AM CDT

Title: Look at Licensing Ideas to Present to WARF

Date: 4/16/2022

Content by: Abbie

Goals: Get an idea of where our device could be marketable if it is patentable

Content:

- Every year, more than 4 million canines are impacted by class II malocclusions [1] [2]

- In 2013, pet owners spent more than $11.2 million on dental procedures which covers more than 500,000 dogs and this has likely increased since then

- Applicable for several small veterinary dental practices similar to the client's, especially since it is a patient specific device.

Conclusions/action items:

Continue researching and preparing for meeting with WARF

Sources:

- https://humanepro.org/page/pets-by-the-numbers [1]

    - Percentage of dogs owned in the United States that are purebred

- https://www.avma.org/resources-tools/reports-statistics/us-pet-ownership-statistics [2]

    - Number of dogs in the United States

- https://www.veterinarypracticenews.com/americans-spent-billion-veterinary-care-2018/#:~:text=According%20to%20the%20association's%20annual,percent%20over%20last%20year's%20figures. [3]

WARF Patent Process 04/16/2022

ABIGAIL STERTZ - Apr 16, 2022, 11:54 AM CDT

Title: WARF Patenting Process

Date: 4/16/2022

Content by: Abbie

Goals: Learn more about what to expect when meeting with WARF

Content:

Steps for WARF Patent Process

1. Submit an Innovation Disclosure (Completed)

2. Disclosure Meeting (This week)

    - Informal meeting about applications and potential for innovation

3. WARF decision committee makes determination

    - Committee typically meets monthly

    - Decision is based on several factors including patentability, licensing potential, etc.

4. Disclosure goes through equity review

    - Office of Vice Chancellor for Research and Graduate Education reviews funding.

5. Innovators enter memorandum agreement with WARF

    - Agree to give ownership to WARF in exchange for assistance and funding during patenting process

6. WARF applies for patent

Conclusions/action items:

Continue researching existing patents and prepare for innovation disclosure meeting

Link: https://www.warf.org/invent/patenting-process/

USPTO Patent Process 04/16/2022

ABIGAIL STERTZ - Apr 16, 2022, 11:58 AM CDT

Title: USPTO Patent Process

Date: 4/16/2022

Content by: Abbie

Goals: Learn about patent process

Content:

Steps 1-5 completed with assistance of WARF

6. Work with patent examiner

    - Examiner looks over contents of application and determines if it meets requirements

7. Receive approval or rejection

8. Maintain patent

Conclusions/action items:

Work with WARF to move through patent process

Link: https://www.uspto.gov/patents/basics/patent-process-overview#step6

Innovation Disclosure Form 03/28/2022

ABIGAIL STERTZ - Mar 28, 2022, 2:50 PM CDT

Innovation Disclosure Confirmation

Wisconsin Alumni Research Foundation <no-reply@formassembly.com>

Thank you for your Innovation Disclosure submission. PLEASE FORWARD this Innovation Disclosure confirmation email to all innovators listed below so that they have a copy of the submission for their records.

Our team will reach out to you shortly to schedule an informal and confidential discussion about your submission.

In the meantime, please direct any questions or corrections to your submission to your IP Manager at jandersen@warf.org.

Please see the below information that was submitted to WARF.

Response Id: **2631**

Who is your IP Manager at WARF?
Justin Andersen

Innovators

First Name
Abigail

Last Name
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Student

Innovators

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Download

Innovation_Disclosure_Form.pdf (115 kB)

WARF IP Lecture 03/13/2022

ABIGAIL STERTZ - Mar 13, 2022, 5:49 PM CDT

- WARF background/purpose
  - WARF supports research at UW Madison- professors, undergraduate, and graduate levels
  - Use technology/inventions to bring innovations to the real world
  - IP protection, licensing and startups, funding to support research
    - Patents, trademarks, and copyrights
    - Trade secrets in industry- weakest protection
- Process
  - Prior art: what invention is evaluated against, what has been done before
    - Used to determine whether you can be patented
    - You can also create your own prior art
  - Examples of public disclosure: journal publication, poster, seminar or other types of public speaking
  - Requirements for patenting: eligible, useful, enabled, described, novel, non-obvious
  - Disclose to WARF, disclosure committee meets, patent application, technology marketing, licensing
- Licensing Considerations
  - Change of licensing
  - Timeline
  - Strategy and plan
  - Revenue projections
  - A license allows a company or multiple companies to use a patent in return for money/benefits
  - Can find a license internally or externally
- Resources
  - D2P: mentors and training to help you grow into the market
  - Entrepeneurons: WARF series on different startups
  - UpStart and Innovation Roadmap: weekly programs to learn about product development
  - Law and Business clinics: legal advice from law students

This applies to my project because we developed a new process to make a product faster. This is a new process which is unlike anything else we know of so it likely is eligible for a patent.

BME Design-Fall 22-notebook

Ben Smith - Jan 31, 2022, 12:57 PM CST


BME Design-Fall 2021 - Ben Smith
Complete Notebook
PDF Version generated by
Ben Smith
on
Jan 31, 2022 @ 12:47 PM CST

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BME_Design-Fall_2021_Complete_Notebook.pdf (17.4 MB)

2014/11/03-Template

LILY GALLAGHER - May 04, 2022, 8:33 AM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

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.