BME Design-Fall 2021 - TARA BOROUMAND
Complete Notebook

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GRACE JOHNSON

on

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Team contact Information

DRAESON MARCOUX (dmarcoux@wisc.edu) - Sep 13, 2021, 12:08 AM CDT

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Project description

GRACE JOHNSON - Dec 14, 2021, 1:36 PM CST

Course Number: BME 400: Capstone Design Course in Biomedical Engineering

Project Name: Approximating Surface Matrix Band for Dentist to Use for Patients

Short Name: Approximating Surface Matrix Band

Project description/problem statement:

Matrix bands are a commonly used dental tool which assist dentists by creating an outside contour of a decayed tooth. This contour maintains the tooth's structure and shape during restorative procedures, such as cavity fillings. During typical filling procedures for cavities on interproximal surfaces, or two adjacent teeth, dentists must fill each tooth separately. This is a tedious procedure as each matrix band must be prepared for each tooth, which includes shaping, placement and securing with dental wedges and rings. This results because two matrix bands cannot fit in the interproximal space as together they are too wide and would create gaps in the restoration. A new dental matrix band design is desired to alleviate the need to repeatedly place bands. The device should employ a dual-band system with a thickness less than or equivalent to current matrix bands throughout such that the fit is secure and the band molds to the appropriate convex/concave contour of each tooth. The finalized product should also maintain the tensile strength, malleability, and space efficiency of current matrix bands. The material used to fabricate the matrix band must not cause any irritation, must be biocompatible, and must be non-reactive to filling materials.

About the client:

Dr. Donald Tipple is a dentist and the sole owner of Nakoma Dental in Madison, WI. He has over 30 years of experience as a dental practitioner, specializing in preventative care and restorative solutions.

2021/09/15 - Client Meeting 1

GRACE JOHNSON - Sep 19, 2021, 7:59 PM CDT

Title: First Client Meeting

Date: Sept. 15, 2021

Content by: Team

Present: Team

Goals: To formally meet and establish/clarify the expectations for the project. We read through much of the previous semesters materials and formed questions that we had regarding our short term goals moving forward.

Content:

Notes from the meeting:

- What about the previous designs would you like improvement upon?
    - Our team noticed the butterfly design seemed straightforward, were there any specific shortcomings of this design
        - Add a component that replaces the ring and ring holder that is used for posterior teeth
        - Put hole so dentist could put floss through to prevent band from falling into the patient's mouth
        - Material should not stick to the filling material
- Dead , soft metal (probably steel - most commonly used)
- Avoid nickel
- Probably single use (if not, must be sterilizable)
- Gum side of fence/matrix band should be slightly convex to encapsulate the entirety of cavity (also makes it easier to insert)
- Potential issues in directionality if one piece of metal is used. 2 directions for 1 piece
- $200-$300 budget, contact if more is needed
- Tofflemire sometimes catches the band when it is being put into place
- Prefers benefits of sectional bands as opposed to circumferential

Conclusions/action items: The client gave the team many useful directions as to how to better design a matrix band. The team will be moving forward in making adjustments to the previous team's "butterfly" design based on his input.

2021/11/21 - Client Meeting 2

DRAESON MARCOUX (dmarcoux@wisc.edu) - Nov 21, 2021, 8:57 PM CST

Title: Client Meeting 2

Date: November 21, 2021

Content by: Team

Present: Team

Goals: Update the client on the status of our proposed final design, receive feedback and discuss our work in the near future.

Content:

(Rescheduled from Oct. 24, 2021)

1. Team Meeting
    1. Wedge must be able to be placed under the band
    2. Must also be space for a ring holder to be used during fillings (specifically rubber dam "butterfly" clamps)
2. Idea for fabrication: Create 2 cuts in a thin piece of metal and fold into form factor
3. Client Meeting Notes:
    1. Based on the CAD design shown, Dr. Tipple would like there to be a gradient gingival depth, increasing towards the center, to provide a greater height which accounts for a greater crown height.
    2. Could include dimensions for a pediatric size as well.
    3. Only one ring tab is needed
    4. Could make the gap shorter (gingival) to allow for a tighter fit with a wedge
    5. The material need to be able to coexist with the filling material without bonding to it. 37% phosphoric acid is also used and a bonding agent/finishing material (high vapor pressure) that is heat blown dry and light cured that must be accounted for.
        1. Check if there are other materials that are commonly used besides "dead-soft" steel.

Conclusions/action items:

2021/09/17 - Advisor Meeting 1

DRAESON MARCOUX (dmarcoux@wisc.edu) - Sep 17, 2021, 1:58 PM CDT

Title: Advisor Meeting 1

Date: Sept. 17, 2021

Content by: Team

Present: Team

Goals: To touch base with Dr. Puccinelli, explain our thoughts on the first week of the project and get some guidance for what we should focus on in the near future.

Content:

1. Don't get tunnel vision focused on the past semesters work. Be open to brainstorming and new ideas
2. Will need a good CAD to ensure precision in prototyping. Also will need to outsource for manufacturing. (resources on the design page)
3. Consider filing for IBR around the time of the preliminary presentation. Begin looking at the requirements asap, like a CAD. (on the WARF webpage)
4. Continue with the standard design matrix for the prelim presentation
5. We can work with other materials in early prototyping. Start to get materials/tools we can start working with.

Conclusions/action items:

Continue researching and brainstorming. Try to get materials, even if they're not very close to the final materials, to play around with and aid in the brainstorming and prelim presentation processes.

2021/09/24 - Advisor Meeting 2

DRAESON MARCOUX (dmarcoux@wisc.edu) - Sep 24, 2021, 2:04 PM CDT

Title: Advisor Meeting 2

Date: Sept. 24, 2021

Content by: Team

Present: Team

Goals: To update our advisor, Dr. Puccinelli, on our accomplishments from the past week, plans to move forward (design matrix), and to receive advise on how we should continue/what we should change.

Content:

1. Coordinate whether or not we will be doing the outreach seminar with Grace this semester.
2. Have rough draft of the preliminary presentation for meeting next week
3. Try to get physical materials any way we can asap, to play around with and use in brainstorming and potentially in early deliverables
4. Preliminary presentations will likely be online, but not pre-recorded

Conclusions/action items:

Continue the typical design process, namely physical materials, design idea specifics and preliminary presentation.

2021/10/01 - Advisor Meeting 3

DRAESON MARCOUX (dmarcoux@wisc.edu) - Oct 19, 2021, 8:23 PM CDT

Title: Advisor Meeting 3

Date: Oct. 1, 2021

Content by: Team

Present: Team

Goals: To update Dr. Puccinelli on our design matrix, and plans for further research, design development, and the preliminary presentation. Receive feedback.

Content:

1.

Conclusions/action items:

2021/10/13 - Advisor Meeting 4

DRAESON MARCOUX (dmarcoux@wisc.edu) - Oct 13, 2021, 1:20 PM CDT

Title: Advisor Meeting 4

Date: October 13, 2021

Content by: Team

Present: Team

Goals: To discuss the preliminary presentation

Content:

1. Make dimensions and annotations to images of designs word processed, not hand written
2. Minimal words on each slide
3. Number designs (1,2,3)
4. Add better descriptors to design criteria and images of the designs
    1. Functionality => Tooth enclosure?
    2. Mirror design specifications in design criteria (testable) and make quantifiable
5. Change color of block diagram
6. Do a few run throughs and practice timing

Conclusions/action items:

2021/10/29 - Advisor Meeting 5

DRAESON MARCOUX (dmarcoux@wisc.edu) - Oct 29, 2021, 2:07 PM CDT

Title: Advisor Meeting 5

Date: October 29, 2021

Content by: Team

Present: Team

Goals: To receive some feedback on the preliminary presentation and report, talk about our recent work and plans moving forward.

Content:

1. Outreach topic to focus on: Joint mobility and motion/kinematics
    1. Make use of this sort of modeling in movies and video games
    2. Utilize visuals to keep interest
    3. Collect as many materials as we can to drop off to the school before the activity (20-30 students). Dr. Puccinelli may have some materials or could acquire them.
    4. Have the activity guide to Dr. Puccinelli by the end of next week. Following approval send it to the teacher, Carmen, as well.
    5. Add a competitive aspect to motivate the students. Find a measurable way to determine the winner.
2. Set up another meeting to discuss outreach next week as there is no advisor meeting next week due to show-and-tell (in person)
3. Show-and-tell is more of a peer-to-peer experience
4. Some good feedback is annotated in pdfs of canvas
5. Focus on getting a materials list together and creating rough prototypes. Modify the existing matrix bands to kind of conform to our design.

Conclusions/action items:

Complete one minute elevator pitch for show and tell next week. Directions are on the course website. Also gather visuals and materials to present.

2021/11/19 - Advisor Meeting 7

DRAESON MARCOUX (dmarcoux@wisc.edu) - Nov 21, 2021, 5:46 PM CST

Title: Advisor Meeting 7

Date: November 19, 2021

Content by: Team

Present: Team

Goals: To discuss

Content:

1. Worked on outreach most of the week
2. Finding materials has been difficult
    1. Potential metal with proper thickness from McMaster-Carr
3. Create a proper fabrication plan
    1. Using aluminum foil
    2. Potentially using the matrix bands we have
    3. Using Dead-soft steel sheet metal for final prototype
4. Contact the team lab
5. CALL metal fabrication companies

Conclusions/action items:

Get materials and a fabrication plan in place before/during thanksgiving break so a model(s) and potentially testing data can be gathered in a timely manner. Only 3 weeks left!

2021/12/03 - Advisor Meeting 8

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 03, 2021, 1:56 PM CST

Title: Advisor Meeting 8

Date: December 3, 2021

Content by: Team

Present: Team

Goals: Final meeting before the poster presentation. Update on our initial prototyping, testing and overall progress towards presenting our work for the semester.

Content:

1. We've produced low fidelity, large scale and small scale models. They aren't of a high quality so we wouldn't really be able to use them in qualitative testing but that is in future plans.
2. We could potentially use the waterjet to create a more dimensionally accurate model. Additionally, there are resources on the course webpage for prototyping companies we might be able to use as well.
3. For the poster presentation we must finish and add testing. Images and data are important in viewer understanding. If we choose to send a an early draft of the poster be sure to send another email describing where to find it or it will be lost in spam.

Conclusions/action items:

9/30/21 Preliminary Designs and Design Matrix

GRACE JOHNSON - Oct 07, 2021, 1:25 PM CDT

Title: Preliminary Designs and Design Matrix

Date: 9/30/21

Content by: All

Present: All

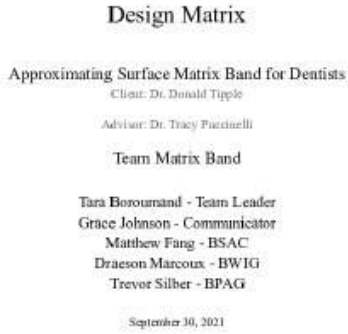
Goals: To meet as a team to decide upon three preliminary designs and design criteria, then score the designs based on the criteria to determine which we will pursue moving forward.

Content:

(see attached pdf)

Conclusions/action items: Based on its scoring in the design matrix, the team has decided to pursue the "Butterfly + U Pinchers" design. Moving forward, we will speak with the advisor and client to receive their feedback on this design and continue brainstorming improvements for the design before fabrication.

GRACE JOHNSON - Oct 07, 2021, 1:25 PM CDT



Design Matrix

Approximating Surface Matrix Band for Dentists

Client: Dr. Donald Tipple

Advisor: Dr. Tracy Puccinelli

Team Matrix Band

Tara Boroumand - Team Leader
Grace Johnson - Communicator
Matthew Fang - BSAC
Draeson Marcoux - BWIG
Trevor Silber - BPAG

September 30, 2021

Matrix_Band_Design_Matrix_1_.pdf(351 KB) - download

2021/12/14 Final Prototype

TREVOR SILBER - Dec 14, 2021, 8:51 PM CST

Title: Final Prototype

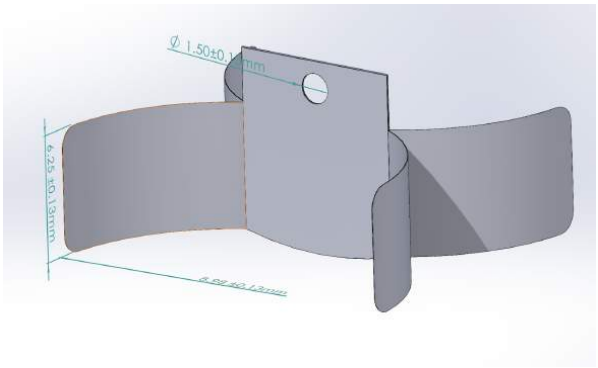
Date: 12/14/2021

Content by: Trevor Silber

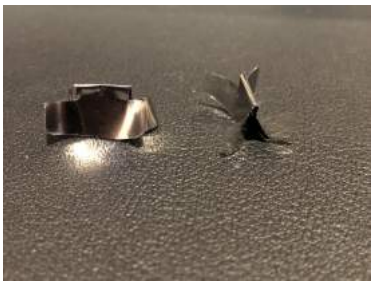
Present: N/A

Goals: Show differences between design matrix and final design

Content:



After concluding that the proposed final design, the Butterfly + U Pinchers Design, would require a tedious and difficult fabrication process due to necessary welding, the team decided to move forward in a different direction. The Butterfly Design was reconsidered, and adjustments were made to the design so that it better satisfied the client's needs and the specified design criteria. The updated design incorporates rounded edges for safety in the patient's mouth, a holed tab to aid in placement and removal of the device, and a convex bottom edge to prevent filling material from entering the gingiva during a procedure. Due to the folded nature of the design, there is space between each band to allow the use of a wedge during a procedure as well.



The final prototype was fabricated out of a 100 inch (2540 mm) long by 6 inch (152.4 mm) wide by 0.001 inch (0.0254 mm) thick shim stock made from 1008-1010 Grade Stainless Steel. Due to the fabrication process and the tiny scale of our prototype some key features were not able to be included in the prototype.

Conclusions/action items:

In the future, a different fabrication plan must be developed to ensure that all features of the design are included in the prototype. After communicating with the TEAM lab on campus, it was conveyed that the team may be able to use a laser cutter or water jet to accurately cut out a to scale prototype with all the key features.

2021/12/15 Final Expense Table

GRACE JOHNSON - Dec 15, 2021, 1:30 PM CST

Title: Final Expense Table

Date: 10/20/21

Content by: Trevor Silber

Present: N/A

Goals: Create an expenses sheet

Content:

Item	Supplier / Brand	UPC	Link	Quantity	Date	Price
Dental Implant Teeth Model Study Teach Standard Model with Removable Teeth	Amazon / Smile1000	601263927587	https://www.amazon.com/dp/B071JVJ1LG/ref=cm_sw_r_sms_api_glt_fabc_BZN7G1DC333NTE4CCJVE	1	10/20/21	$28.42
Steel Shim Stock Roll, 1008-1010 Grade, 0.001 in Thickness, +/-0.0001 in Thickness Tolerance	Grainger	Item Number: 3L432	https://www.grainger.com/product/PRECISION-BRAND-Steel-Shim-Stock-Roll-3L432?opr=PDPRRDSP&analytics=dsrrItems_5EY10	1	11/21/21	$35.96
					Total	$64.38

Conclusions/action items:

This table is a complete expense sheet for the Fall 2021 semester. This table will be forwarded to our client, Dr. Tipple at the end of the semester to collect reimbursement for the teams purchases over the course of the semester. In the Spring semester, this table will either be updated further or a similar table will be constructed to keep track of team expenses throughout the semester.

2021/12/15 Final Materials Justification

GRACE JOHNSON - Dec 15, 2021, 1:40 PM CST

Title: Final Materials Justification

Date: 12/15/21

Content by: Grace

Present: All

Goals: To finalize the description of the material we used in fabrication and the justification for how we got to that decision.

Content:

The current industry standard for matrix bands is a dead-soft steel primarily due to its mechanical properties and non-toxicity [1]. “Dead-soft” steel refers to a lower carbon and manganese content at less than 0.1% and 0.2-0.5%, respectively [2]. Additionally, it is processed by heating to a critical temperature and cooled more slowly, creating larger grains, making the material less hard, but more ductile. The tensile yield strength is 260-340 MPa, which must be relatively high to withstand tightening around the tooth [2]. The Rockwell B hardness is about 55, which is important for preventing deformations from forming when pressed up against the teeth but is limited due to the method of processing which allows for a lower elastic modulus. The elastic modulus is 200-215 GPa , sufficient for both allowing the thin material to bend around the tooth while maintaining tight contact with the tooth even when withstanding high outward stresses from packing the filling material [3].

In the past, materials such as copper, silver and titanium have been used to fabricate matrix bands but the mechanical characteristics, biocompatibility, and cost of dead-soft steel eliminated them from our considerations [1]. The team decided upon using a shim stock roll of 1008-1010 Grade Stainless Steel, steel containing 0.08 to 0.1% carbon by weight, for fabrication of the matrix band device [4]. The material has a thickness of 0.0254 mm, consistent with the thickness of current matrix bands [5].

sources:

[1] “A historical review of dental matrices from MDJ,” *Scribd*. [Online]. Available: https://www.scribd.com/document/112847146/A-Historical-Review-of-Dental-Matrices-From-MDJ. [Accessed: 20-Oct-2021].

[2] Flyingchimp, “Dead soft steel,” *Falcon Aerospace*, 01-Aug-2013. [Online]. Available: https://www.falconaerospace.com/dead-soft-steel/. [Accessed: 20-Oct-2021].

[3] “ASTM A109 Grade no. 5 dead-soft,” *Matmatch*. [Online]. Available: https://matmatch.com/materials/minfm65939-astm-a109-grade-no-5-dead-soft. [Accessed: 20-Oct-2021].

[4] F. T. C. Ltd, “SAE/Aisi Carbon Steel Naming Conventions,” AZoM.com, 08-Aug-2014. [Online]. Available: https://www.azom.com/article.aspx?ArticleID=6151. [Accessed: 08-Dec-2021].

[5] U. F. O. Themes, “Principles of tooth preparation,” Pocket Dentistry, 12-Feb-2015. [Online]. Available: https://pocketdentistry.com/principles-of-tooth-preparation-2/.

Conclusions/action items: The team is overall satisfied with the stainless steel chosen. It has the necessary carbon content to be named "dead-soft" and thickness to be consistent with current dental matrix bands.

2021/12/01 Initial Band Fabrication

GRACE JOHNSON - Dec 14, 2021, 10:43 PM CST

Title: Initial Band Fabrication

Date: 12/1/21

Content by: Grace

Present: All

Goals: To make an initial prototype with the shimstock material the team ordered.

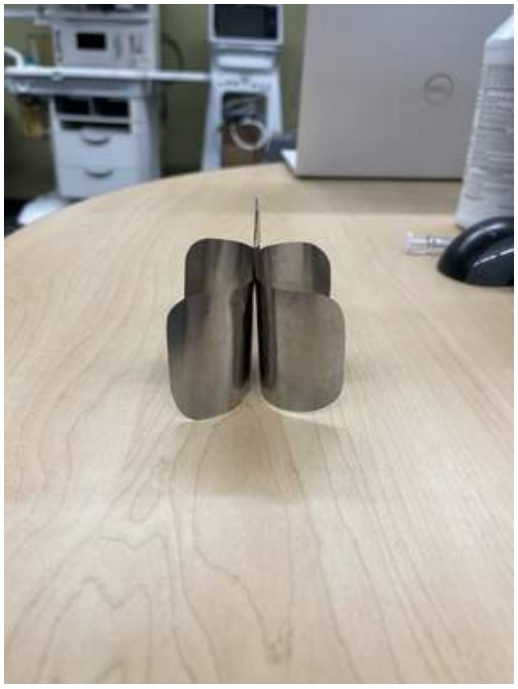
Content:

(see attached images)

- **model is not to scale and is much larger than final prototype would be
  - the team created this as an initial prototype and will have it to show at the final poster presentation
- we first cut a section of the shimstock that was 6" by 5"
- we then folded this in half hamburger style
  - this made two 3" by 5" halves
- cuts were made 2" in on either side of the fold that were 1" deep
  - this made the rectangular top piece of the band
- the band leaflets were then folded to match a tooth contour shape
- a hole was punched in the top rectangular piece through both sheets
- edges of the leaflets and top rectangular piece were rounded for safety purposes

Conclusions/action items: The team is satisfied with how this initial prototype turned out. We will now create a model that is to scale with existing matrix band dimensions following the same fabrication process.

GRACE JOHNSON - Dec 14, 2021, 10:43 PM CST



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GRACE JOHNSON - Dec 14, 2021, 10:43 PM CST

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GRACE JOHNSON - Dec 14, 2021, 10:43 PM CST

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2021/12/01- Team Meeting to Fabricate

TARA BOROUMAND - Dec 01, 2021, 6:48 PM CST

Title: Team Meeting to Fabricate

Date: 12/01/21

Content by: Team

Present: All

Goals: create a large scale prototype for the poster presentation

Content:

The team met to discuss fabricating a prototype. Using the metal that the team ordered, the team fabricated a large size version of the matrix band. This can be seen in the "Initial Fabrication" document. The team also attempted to make an accurate scale prototype.

Some other things the team discussed during this meeting:

-The contour at the gingival should be made convex--> the team will save this as future work and just focus on displaying the overall design at the poster presentation

-The team discussed potential future testing. The team may do a tensile test on the material. Potentially next semester, the team plans on getting prototypes made and creating a survey for dentists to use and report back results

Conclusions/action items:

The team will present the current prototype at the poster session and continue planning testing

2021/12/15 Final Fabrication Methods

GRACE JOHNSON - Dec 15, 2021, 1:15 PM CST

Title: Final Fabrication Methods

Date: 12/15/21

Content by: Grace

Present: All

Goals: To finalize the fabrication method used to create the prototypes from the 1008 shim stock steel.

Content:

The team initially fabricated an enlarged, unscaled prototype to emphasize the details of the design and ensure the 1008 steel could be modified for the design's purposes. A 152 mm x 127 mm rectangular sheet was measured from the 1008 steel shim stock using calipers and was cut with scissors. This sheet was then folded to create two equal 76 mm x 127 mm halves. Cuts were made 25 mm long on both ends of the fold, and 51 mm in from the short edges, to create a rectangular tab. Every sharp corner was then cut to be round in accordance with our final design. The four leaflets of the rectangular base created from these cuts were then shaped outwardly to a curvature of about 90 degrees, with a rounded cylinder, to contour. A hole punch was used through both sides of the folded tab to create the hole.

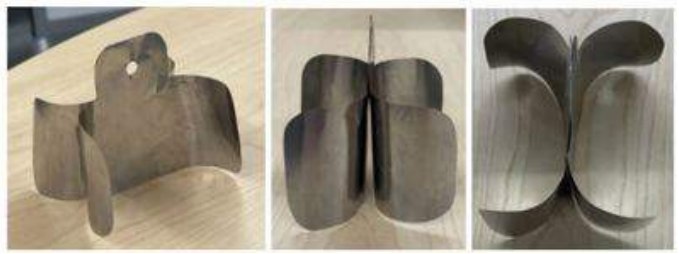
After finishing the enlarged prototype, smaller scaled prototypes were made following the same methods. The team, however, was unable to create smaller details of the design including the hole in the tab and the rounded edges using these methods.

In the future, a different fabrication plan must be developed to ensure that all features of the design, including the convex bottom curve, are included in the prototype. After communicating with the TEAM lab on campus, it was conveyed that the team may be able to use a laser cutter to accurately cut out a to scale prototype with all the key features. However, laser cutters are not able to cut through highly reflective material but are able to cut through some stainless steel. If it turns out that the stainless steel is too reflective, a water jet may be used to fabricate the prototype. Laser cutting has a minimum cutting slit of 0.15 mm and a processing tolerance of 0.05 mm while the water jet has a minimum cutting slit of 0.5 mm and a processing tolerance of 0.2 mm [23]. While laser cutting may provide a more accurate cut, it may also end up melting the steel and leaving deformed edges. It may also be beneficial to outsource the fabrication to a prototyping company. All options will be considered in the upcoming semester.

(see attached images)

Conclusions/action items: Although the team was able to fabricate these models efficiently and in compliance with the steel material, improvements can be made to the process. Looking forward, we hope to refabricate using a laser cutter or water jet for more precise cuts so that we can make a clean, scaled matrix band device and give it to our client for qualitative testing. This will be updated in the final report.

GRACE JOHNSON - Dec 15, 2021, 1:12 PM CST



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GRACE JOHNSON - Dec 15, 2021, 1:13 PM CST

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2021/12/08 - MTS Testing Protocol

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 08, 2021, 2:02 PM CST

Title: MTS Testing Protocol

Date: December 8, 2021

Content by: Team

Present:

Goals: To lay out a full testing protocol for the MTS testing machine

Content:

1. What is the material tested: 1008 Steel
2. Type of testing: Tensile testing (Impact/bending test in the future?)
3. Protocol details: Rate of loading - past semester used 5mm/min and found the samples slipped from the grips. Potentially use a slower loading rate to prevent slipping. However, a faster loading rate is more similar to real applications. Stop the test upon fracture.
4. Fixtures Used: Vice clamps?
5. Number of samples/tests: 3 Tofflemire bands and 3 1008 steel samples
6. Expected load: about 40-70 N for a 0.0254 (0.001") thick x 5 mm wide sample
7. Exported data type: Force vs Displacement
8. Key Outcome Measures: Yield stress

Conclusions/action items:

Add full protocol with materials and procedural steps once testing has actually happened. Some finer details must be decided on once more information is gathered. Thanks to Dr. Christa Wille for her help in the setup and providing access to the MTS machine.

2021/12/06 - SolidWorks Simulink Testing Protocol

MATTHEW FANG (mjfang@wisc.edu) - Dec 14, 2021, 11:45 PM CST

Title: Solidworks Simulink Testing Protocol

Date: December 6, 2021

Content by: Team

Present:

Goals: To lay out a full testing protocol for the Solidworks Testing

Content:

1. Type of testing: Stress Test Simulation
2. Protocol details: Requires premade 3d model of matrix band. User must fix one end of the band and apply loads normal and lateral in separate tests. Then the user must also vary the material between the 1008 and the stainless steel between tests.
3. Number of samples/tests: 4 tests are going to be run based on the force applied and the material of the band
4. Expected load: 100N for normal loading and 10kN for tensile loading
5. Exported data type: Simulation report detailing some of the mechanical properties of the part
6. Key Outcome Measures: Yield stress, von mises stress, displacement

Conclusions/action items:

Run the simulation to compare the material we bought for our prototype and the material that matrix bands are usually made out of

2021/12/08 Team MTS Testing

GRACE JOHNSON - Dec 14, 2021, 10:41 PM CST

Title: Team MTS Testing

Date: 12/8/21

Content by: Grace

Present: Team

Goals: To test both the circumferential matrix bands that the client provided us and our shim stock steel material in the MTS machine to determine and compare mechanical properties.

Content:

- Width of circumferential matrix band measured with calipers to be 6.25 mm, we cut the length in half to ensure two straight samples (thickness of these samples is 0.0381 mm)
- **1:** We cut a straight rectangular sample from our steel to be tested that had a width of 6.44 mm (thickness of 0.0254 mm)
  - length of sample in MTS machine (from clamp to clamp): 33 mm
  - test run #195 - failed at bottom of sample (as seen in attached image)
- **2:** cut sample with width of 6.40 mm in dogbone shape
  - length of sample in MTS machine: 40 mm
  - test run #196 - slipped/incomplete
- **3:** cut sample with width of 7.12 mm in rectangular shape with tape on ends to prevent slippage/create dogbone shape
  - length of sample in MTS machine: 33 mm
  - **test run #197 - first usable test run**
    - slippage occurred towards the end but all data before slippage is usable for analysis
- **4:**cut sample with width of 7.07 mm in rectangular shape with tape on ends
  - length of sample in MTS machine: 49 mm
  - test run #198 - slipped towards the end
- **5:** cut sample with width of 6.45 mm in rectangular shape with tape on ends
  - length of sample in MTS machine: 59 mm
  - test run #199 - slipped towards the end but lasted the longest of all runs so far
- **6:** cut sample with width of 5.90 mm in rectangular shape, no tape
  - length of sample in MTS machine: 50 mm
  - test run #200 - slippage early on
- **loading rate for all previous samples was 5 mm/min, now changed it to 20 mm/min**
- **7:** same sample as previous
  - length of sample in MTS machine: 49 mm
  - test run #201 - slippage early on, loading rate did not help anything
- **8:** cut sample with width of 7.55 mm in rectangular shape with tape on ends
  - length of sample in MTS machine: 60 mm
  - test run #202 - slippage towards the end
- **9:** cut sample with width of 6.14 mm in rectangular shape with tape on ends
  - length of sample in MTS machine: 60 mm
  - test run **#203** - slippage towards the end
- **10:** cut sample with width of 7.34 mm in rectangular shape with tape on ends and new folded/rolled method
  - length of sample in MTS machine: 59 mm

    - test run #204 - slippage towards the end out of the grip
    - **11:** same sample but length in MTS machine of 57 mm
    - test run #205 - slippage out of grip
    - **12:** same sample but length in MTS machine of 61 mm
    - test run #206 - initial slippage then final slippage
- **13:** same sample as run #203
    - length of sample in MTS machine: 62 mm
    - test run **#207** - slippage at the very end
- **14:** cut sample with width of 6.74 mm in dogbone shape to test new method
    - length of sample in MTS machine: 56 mm
    - test run #208 - sample failed at grips
- **15:** cut sample with with of 6.63 mm in rectangular shape with only one layer of tape on each end
    - length of sample in MTS machine: 30 mm
    - test run #209 - slippage right away
- **16:** circumferential band with tape on ends
    - length of sample in MTS machine: 12 mm
    - test run #210 - slippage out of tape after a little bit
- **17:** circumferential band with tape on ends
    - length of sample in MTS machine: 12 mm
    - test run #211 - slippage out of tape after a little bit

Conclusions/action items: The team was not able to get a good testing run with either the circumferential matrix bands or with the shim stock steel material. We ran into a lot of issues with slippage and tried many different methods to reduce this, but no successful method was found. It may be beneficial to research how material like this is tested if there is any existing research. We will still move forward in analyzing the data from a few test runs that had slippage after a longer time of loading. We could possibly get useful modulus and loading data from these runs.

GRACE JOHNSON - Dec 14, 2021, 10:41 PM CST

IMG_5331.jpg(3.3 MB) - download

2021/12/10- MTS Testing Photos

TARA BOROUMAND - Dec 14, 2021, 11:22 AM CST

Title: MTS Testing Photos

Date: 12/10/21

Content by: Tara (photos by Draeson)

Present: team

Goals: To display testing images and show methods in place to avoid slippage

Content:

Figure 1: Samples that were used in the MTS Machine. A variety of methods above are shown that were used in attempts to avoid slippage such as the tape and dog bone cutouts.

Figure 2a-b: Two different fixtures being used during MTS testing. The fixture on the left seemed to lead to much later slippage and was the fixture primarily used.

Slippage was a great issue during testing. Although various factors were tested in attempts of avoiding slippage, such as cutting the material into a dog bone shape, using tape for increased grip, changing the deformation rate of the MTS machine and trying different fixtures, ultimately slippage occurred on every trial.

Conclusions/action items:

Use these photos and discussion in the final paper.

2021/12/06 Solidworks Simulink Testing

MATTHEW FANG (mjfang@wisc.edu) - Dec 14, 2021, 11:39 PM CST

Title: Solidworks Simulink Testing

Date: December 6, 2021

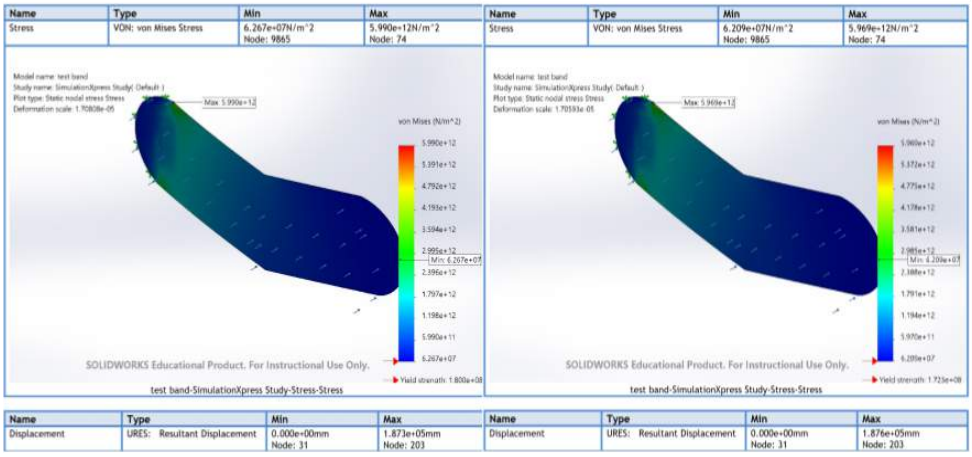
Content by: Team

Present:

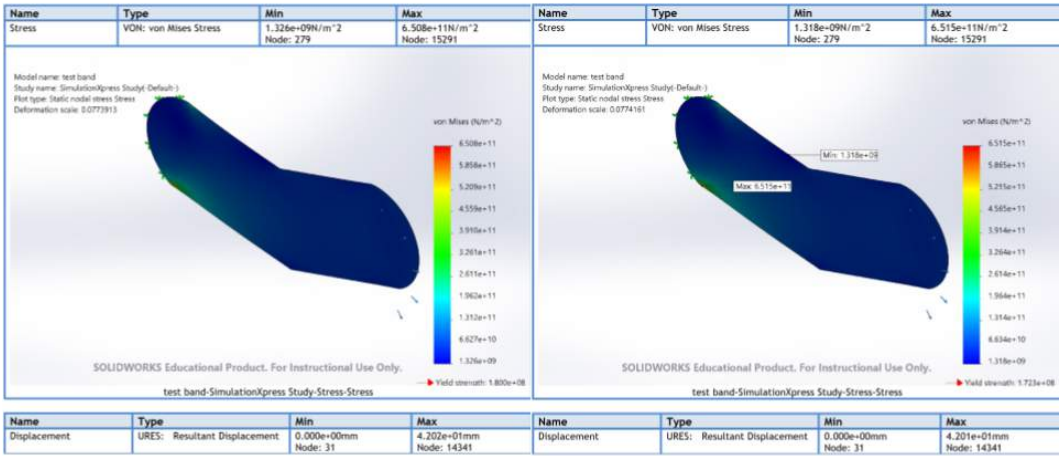
Goals: Run simulation mimicking the

Content:

Protocol details: 4 Tests were performed where loads were applied normal and laterally to band modeled in solidworks in order to get resultant stress and strain calculations for multiple directions of force. In the normal test, at 200N load was applied as the force required to move the band wouldn't need to be super high. Conversely, the load applied laterally was 20kN as the force required to pull the band apart is much higher than the force required to bend the band. The tests varies in the force directions and the material type



Solidworks Simulink stress simulations with load applied normal to the band. Output yields the distribution of Von Mises stresses. 1008-1010 alloy on the left and stainless steel on the right.



Solidworks Simulink stress simulations with load applied normal to the band. Output yields the distribution of Von Mises stresses. 1008-1010 alloy on the left and stainless steel on the right.

Format: Yield Stress, Max Displacement, Max Von Mises Stress

Normal Force:
1008= 180.0 MPa, 1.876 m, 5990 GPa
Stainless Steel = 172.2 MPa, 1.873 m, 5969 GPa

Lateral Force:
1008 = 180.0 MPa, 4.202 mm , 650.8 GPa
Stainless Steel = 172.2 MPa, 4.201 mm , 651.5 GPa

Conclusions/action items:

Conclusion: Material properties appear to be very similar. We will likely be able to use the 1008 in place of the stainless steel if needed. However, more material property testing should be done on the 1008 to confirm

2021/12/13- Statistical Analysis Results

TARA BOROUMAND - Dec 15, 2021, 12:22 PM CST

Title: Statistical Analysis Results

Date: 12/13/21

Content by: Tara Boroumand

Present: N/A

Goals: Present statistical results of MTS Testing

Content:

Table2: Data Summary of the One-Way ANOVA test on the Young's Modulus values of the 1008 steel alloy and the currently used material of the dead-soft stainless steel.

Groups	N	Mean	Standard Deviation	Standard Error
1008 Steel Alloy	2	672700000000	215950410974.3716	152700000000
Dead-Soft Stainless Material	2	162800000000	17536248173.4264	12400000000

Table3: ANOVA Test Summary. The F-statistic value was found to be 11.07739 and the P-value was found to be 0.07964.

Source	Degrees of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F-Statistic	P-Value
Between Groups	1	2.5999800999999998 x 1023	2.5999800999999998 x 1023	11.07739	0.0796
Within Groups	2	4.6942099999999996x 1022	2.3471049999999998 x 1022		
Total	3	3.0694011e+23			

Conclusions/action items:

This ANOVA test was tested with an alpha level of .05 (a standard value). Due to a high P-value of 0.07964, the team failed to reject the null hypothesis and thus, did not have sufficient evidence to conclude a significance difference between the Young's Modulus values of the 1008 alloy and currently used dead-soft stainless steel.

Present this data in the final report. Explain that due to a small sample size these should only be used as preliminary evidence that our material has similar mechanical properties to current dead-soft stainless steel design.

9/23/21 PDS Draft 1

GRACE JOHNSON - Sep 27, 2021, 4:59 PM CDT

Title: PDS Draft 1

Date: 9/23/21

Content by: Team

Present: Team

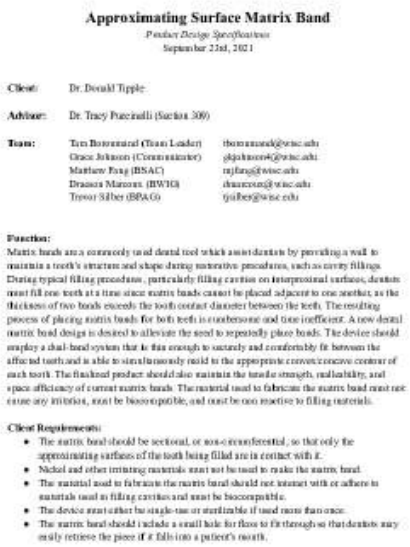
Goals: To complete the first draft of the PDS.

Content:

(see attached pdf)

Conclusions/action items: The team will be updating the PDS as we decide on a final design and our requirements shift.

GRACE JOHNSON - Sep 27, 2021, 5:00 PM CDT



Approximating Surface Matrix Band

Product Design Specifications

September 22nd, 2021

Client: Dr. Donald Tipple

Advisor: Dr. Tracy Puccinelli (Section 309)

Team:

Tara Boisseranel (Team Leader)	tboisseranel@wisc.edu
Grace Johnson (Communicator)	gkjohnson4@wisc.edu
Matthew Fang (BSAC)	mjfang@wisc.edu
Draesen Marcum (BWIG)	dmarcum@wisc.edu
Trevor Silber (BPAG)	tjsilber@wisc.edu

Function:

Matrix bands are a commonly used dental tool which assist dentists by providing a wall to maintain a tooth's structure and shape during restorative procedures, such as cavity fillings. During typical filling procedures, particularly filling cavities on interproximal surfaces, dentists must fill one tooth at a time since matrix bands cannot be placed adjacent to one another, as the thickness of two bands exceeds the tooth contact diameter between the teeth. The resulting process of placing matrix bands for both teeth is cumbersome and time inefficient. A new dental matrix band design is desired to alleviate the need to repeatedly place bands. The device should employ a dual-band system that is thin enough to securely and comfortably fit between the affected tooth and is able to simultaneously mold to the appropriate convex/concave contour of each tooth. The finished product should also maintain the tensile strength, malleability, and space efficiency of current matrix bands. The material used to fabricate the matrix band must not cause any irritation, must be biocompatible, and must be non reactive to filling materials.

Client Requirements:

- The matrix band should be sectional, or non-circumferential, so that only the approximating surfaces of the tooth being filled are in contact with it.
- Nickel and other irritating materials must not be used to make the matrix band.
- The material used to fabricate the matrix band should not interact with or adhere to materials used in filling cavities and must be biocompatible.
- The device must either be single-use or sterilizable if used more than once.
- The matrix band should include a small hole for floss to fit through so that dentists may easily retrieve the piece if it falls into a patient's mouth.

PDS_-_Approximating_Surface_Matrix_Band_5_.pdf(117.7 KB) - download

10/20/21 PDS Draft 2

GRACE JOHNSON - Dec 01, 2021, 7:03 PM CST

Title: PDS Draft 2

Date: 10/20/21

Content by: Team

Present: Team

Goals: To update the PDS based on updates to the design.

Content:

(see attached pdf)

Conclusions/action items: The PDS will need to be updated for the final report to encompass design requirements that have changed due to our final design.

GRACE JOHNSON - Dec 01, 2021, 7:04 PM CST

Approximating Surface Matrix Band

Product Design Specifications

October 20th, 2021

Client: Dr. Donald Tipple

Advisor: Dr. Tracy Puccinelli (Section 309)

Team:

Tara Boisseranad (Team Leader)	tboisseranad@wisc.edu
Grace Johnson (Communicator)	gkjohnson4@wisc.edu
Matthew Fang (BSAC)	mjfang@wisc.edu
Draasen Marcum (BWIG)	dmarcum@wisc.edu
Trevor Silber (BPAG)	tjsilber@wisc.edu

Function:

Matrix bands are a commonly used dental tool which assist dentists by creating an outside contour of a decayed teeth. This contour maintains the teeth's structure and shape during restorative procedures, such as cavity fillings. During typical filling procedures for cavities on interproximal surfaces, dentists must fill each tooth separately. This tedious procedure is due to matrix bands not fitting adjacent to one another in the interproximal space, as the thickness of two bands exceeds the tooth contact diameter between the teeth. The resulting process of placing matrix bands for both teeth is cumbersome and time inefficient. A new dental matrix band design is desired to alleviate the need to repeatedly place bands. The device should employ a dual-band system with a thickness less than or equivalent to current matrix bands, 0.05 mm, throughout such that the fit is secure and the band molds to the appropriate convex/concave contour of each tooth. The finalized product should also maintain the tensile strength, about 400 MPa, malleability, and space efficiency of current matrix bands. The material used to fabricate the matrix band must not cause any irritation, must be biocompatible, and must be non-reactive to filling materials.

Client Requirements:

- The matrix band should be sectional, or non-circumferential, so that only the approximating surfaces of the tooth being filled are in contact with it.
- Nickel and other irritating materials must not be used to make the matrix band.
- The material used to fabricate the matrix band should not interact with or adhere to materials used in filling cavities and must be biocompatible.
- The device must either be single-use or sterilizable if used more than once.

10_20_21_Updated_PDS.pdf(118.2 KB) - download

2021/11/05 - Show and Tell

DRAESON MARCOUX (dmarcoux@wisc.edu) - Nov 05, 2021, 1:44 PM CDT

Title: Show and Tell

Date: November 05, 2021

Content by: Team

Present:

Goals: To explain the main challenge we are trying to solve, what we're trying to do to solve it, and areas of the design that we would most like suggestions/feedback on in about a minute.

Content:

Elevator Pitch:

Our goal is to create a single dental matrix band that allows for adjacent tooth restoration in the common event of interproximal cavities. Currently, the dentist must tediously set and burnish each matrix before each tooth is restored. The Tofflemire band and retainer system is what our client and many other denstists currently use, in conjunction with dental wedges and rings, which is a circumferential band and system. Our model is a double sectional band, tailored for interproximal or mesial (closest to the other tooth) cavities, that fits into the interproximal space in a reflected C shape, allowing for structural support of fillings on adjacent teeth simultaneously. It also incorporates rings and a spring clamp for easier placement and a tighter fit, though it has been advised that traditional wedges and a ring should still be compatible. We've generated a couple of different CAD models that would allow for different means of manufacturing, and we are hopeful to be able to use CNC milling and/or laser cutting to provide the level of accuracy and thinness required for a functional prototype. We hope to be able to test this prototype both mechanically in an MTS machine to ensure at least equivalent structural support and flexibility of the tofflemire band system, and qualitatively on our mouth model and with an evaluation for that will be given to our client, Dr. Tipple, and his colleagues.

Call to Action:

1. Are there any other ideas for how we could more easily manufacture this band and its constitutive parts?
2. Any insights into ways we can bond the 2 sectional bands together while leaving space in the bottom for burnishing and dental wedges?

Feedback:

1. The method that cuts the design from a single sheet of metal and folds it is likely our best option as finding an adequate (thin and strong) bonding material that is also compatible with dentistry will be difficult if not currently impossible.
2. Contact manufacturers/distributors of current matrix bands and ask what they do currently and if they have any ideas/capabilities to manufacture our design, or metal that is thin enough
3. Look on foreign websites as they are often much cheaper and have a much wider range of products available. Be conscious about shipping times and quality but it has been successful in the past.

Conclusions/action items:

Act on feedback by contacting manufacturers and searching on a wider range of websites.

11/12/2021 Outreach Presentation/Activity Notes

GRACE JOHNSON - Nov 18, 2021, 1:06 PM CST

Title: Outreach Presentation/Activity Notes

Date: 11/12/2021

Content by: Team

Present: Team

Goals: To present our outreach knee joint biomechanics presentation and activity and take notes throughout the class.

Content:

Number of Students present: 16

Demographics of students: high school juniors and seniors, multiple backgrounds

What material was well received by the students?

- The students seemed to have a good grasp on the anatomy of the knee and distinguishing the femur from the tibia and the tibial surface during the activity

What material was not well received by the students?

- The students struggled with some of the construction steps in building the knee model
    - this may have been due to them using printer paper rather than paper towel rolls

Common student questions:

- Since they used paper, students asked how big the diameter of the paper roll should be. We said to make your best judgement to size it similar to the diameter of a paper towel roll.
- Students asked how to compress the diagonal slits on the femur bone prior to fitting it into the articulation piece.
- How many cuts on the femur surface are needed?

Conclusions/action items: The students were not able to complete the full activity, partially due to technical issues during the first 10 minutes of class. They were able to get through most of the construction of the tibia and femur, and planned to complete the muscle/ligament construction and reflection questions on the following Monday.

2021/10/01- Cavity Significance

TARA BOROUMAND - Oct 19, 2021, 7:07 PM CDT

Title: Cavity Significance

Date: 10/01/2021

Content by: Tara Boroumand

Present: n/a

Goals: To discuss the motivation for our design

Content:

-92% of adults 20 to 64 have had dental caries in their permanent teeth.

-26% of adults 20 to 64 have untreated decay.

Summary:

It is estimated the average American has three dental fillings. Furthermore, one in four Americans have eleven or more fillings. Although cavities are one of the most common dental procedures, the CDC still estimates that about one-third of adults have untreated dental caries that require fillings. Dental caries are also known as tooth decay which results from enamel breakdown. The goal of a filling is to remove the decayed part of the tooth which is referred to as the cavity. The dentist will then fill the area to prevent any further damage.

Conclusions/action items:

Discuss the significance of these in the motivation of the paper

[1] “What to Expect with Dental Fillings.” Dentist Office in Cincinnati, OH, https://www.blueashdental.com/what-to-expect-with-dental-fillings.

[2] “Is a Dental Filling Always Required for Cavities?” David L. Baker DDS PA Plano Texas, 4 June 2019, https://www.davidbakerdds.com/blog/is-a-dental-filling-always-required-for-cavities/.

2021/10/01- Important Definitions and Background Knowledge

TARA BOROUMAND - Oct 19, 2021, 10:59 PM CDT

Title: Important Definitions and Background Knowledge

Date: 10/01/21

Content by: Tara Boroumand

Present: n/a

Goals: To discuss important terminology that should be reviewed in the preliminary report for the readers understanding

Content:

-Dentists can use both sectional and circumferential matrix bands. A circumferential matrix band will need to be placed and tightened with a Tofflemire. A sectional matrix band can be placed with tweezers

One study found:

"Use of the sectional matrix system in two-surface Class II cavities resulted in statistically significantly tighter proximal contacts than the use of the circumferential matrix system" [1]

-The wedge has two purposes:

--"to get a separation between teeth which compensates the matrix thickness for obtaining a strong interproximal contact, and to adapt the matrix intimately to the contour of the tooth all around the cavity floor." [2]

This is the tofflemire which is used for tightening circumferential bands

This is a sectional matrix band being used with a ring (meant to push teeth further apart)

Circumferential matrix band being used with tofflemire.

Conclusions/action items:

Include these explanations in report

[1] D. Richards, “Sectional or circumferential matrix systems for direct composite restorations?,” *National Elf Service*, 30-Sep-2011. [Online]. Available: https://www.nationalelfservice.net/publication-types/randomised-controlled-trial/sectional-or-circumferential-matrix-systems-for-direct-composite-restorations/. [Accessed: 20-Oct-2021].

[2] https://clinicadentalvictoralonso.com/Publicaciones/Sectional%20matrix%20-%20Step-by-step%20directions%20for%20their%20clinical%20use.pdf

2021/10/19- Dimensions

TARA BOROUMAND - Oct 20, 2021, 12:53 PM CDT

Title: Tooth Dimensions

Date: 10/19/21

Content by: Tara Boroumand

Present: n/a

Goals: cite the dimensions teeth and matrix bands

Content:

Average crown height: 8.69mm (upper and lower)

Mesiodistal crown width (diameter from tooth to tooth): 8.20mm

Diameter from cheek to tongue side: 8.71mm

Thickness of current matrix bands: 0.0015 to 0.002 inches, or 0.038 to 0.051 millimeters

Conclusions/action items:

R. I. C. K. N. E. C. SCHEID and G. A. B. R. I. E. L. A. WEISS, Woelfel's dental anatomy. BURLINGTON, MA: JONES & BARTLETT LEARNING, 2020.

2021/10/19- Clinical Explanation

TARA BOROUMAND - Oct 19, 2021, 11:06 PM CDT

Title: Clinical Explanation of Cavities

Date: 10/19/21

Content by: Tara Boroumand

Present: n/a

Goals: To discuss an overview of the procedure and explain important parts of the procedures for the preliminary report.

Content:

Dental care is very important for the overall well being of somebody. One-third of adults have untreated dental caries; if left untreated, these can lead to infection and premanent tooth loss. 175 million people receive at least one dental filling every year [1]. Providing dentists with the proper tools and resources to perform these fillings with both quality and time efficiency is essential in helping the millions of people with untreated cavities. The current process to fill cavities varies depending on the classification and severity of the cavity. Matrix bands are used by dentists to assist in providing the proper contour of the tooth. They are often used along with tooth wedges which serve to tighten the seal and prevent gingival overhang. Class II cavities are those on the interproximal surface of premolars and molars. They are known to be difficult to restore due to the necessity of maintaining a proper and tight tooth contact [2]. Current matrix bands, such as the Sectional and Tofflemire matrix bands have shortcomings when it comes to restoring Class II cavities, because they cannot be used concurrently to fill two adjacent teeth. The dentist must perform one filling, then reposition the matrix band and wedge in order to perform the second filling. This is not only very tedious, but also very time consuming and minimizes the amount of time dentists have to care for other patients.

Conclusions/action items:

Paste and modify this portion for the preliminary report

[1] R. S. King, “A Closer Look at Teeth May Mean More Fillings,” The New York Times, 28-Nov-2011. [Online]. Available: https://www.nytimes.com/2011/11/29/health/a-closer-look-at-teeth-may-mean-more-fillings-by-dentists.html. [Accessed: 19-Oct-2021].

[2] Admin, “Survey results show what is key: Class II fillings - routine but still challenging,” Press & Media, 07-Aug-2017. [Online]. Available: https://news.dentsplysirona.com/en/business-units/restorative/2017/class-ii-fillings--routine-but-still-challenging.html. [Accessed: 19-Oct-2021].

2021/12/01-Terminology Review

TARA BOROUMAND - Dec 15, 2021, 12:50 PM CST

Title: Terminology Review

Date: 12/01/21

Content by: Tara Boroumand

Present: N/A

Goals: To review and cite terminology that will be used throughout the final paper

Content:

Interproximal Space: between the teeth. This is a common space cavities occur where two adjacent teeth have a cavity in the space between them.

Dead soft metal: the softest form of metal, such as a very low carbon steel, which allows them to be malleable and easily shaped to fit a variety of tooth sizes

Circumferential matrix bands- are generally used with a Tofflemire™ retainer, and are wrapped around the whole tooth. The tofflemire is able to tighten the band around the tooth but still requires the use of a wedge for a tight contact, contour, and separation of the teeth.

Dental caries-Tooth decays; result from enamel breakdown

Sectional matrix bands- more suited for proximal cavities and only fit around half of the tooth. They are required to be supported by a ring fit as well as levered by a wedge between two teeth.

Conclusions/action items:

These are terms the advisor mentioned we should explain at the way beginning of the paper. Define these in final deliverables.

“Dental Matrix Systems,” Dentalcompare. [Online]. Available: https://www.dentalcompare.com/Restorative-Dentistry/4630-Dental-Matrices/

2021/12/01- Dental Fillings Chemistry

TARA BOROUMAND - Dec 15, 2021, 12:34 PM CST

Title: Dental Fillings Chemistry

Date: 12/01/21

Content by: Tara Boroumand

Present: n/a

Goals: To research if there is any chemistry the team should consider before creating the final prototype.

Content:

Teeth can be filled with gold, porcelain, silver amalgam, composite resin fillings [1]

-Silver amalgam consists of mercury, silver, tin, zinc and copper

-The (elemental) mercury is liquid and the other metals are a powdered alloy

Steel will not react with any of the above. It is recommended not to use steel along with aluminum, however, that is not used in dental fillings. Corrosion can occur with aluminum and stainless steel contact but this would not occur. Since current dental matrix bands use stainless steel already, the team is confident that the 1008 steel alloy will present very similar chemical properties and will be okay in contact with all the above filling materials [2].

Conclusions/action items:

There seem to be no major chemical considerations the team needs to make. This is mainly due to the fact that the team is using the same metal (extremely similar material) to the currently used dead-soft stainless steel material. Thus, no chemical reactions should occur with the filling material. If the team changes their material at any point, chemistry considerations should be revisited.

[1] “Dental fillings: Gold, amalgam, composite, ceramic and more,” WebMD. [Online]. Available: https://www.webmd.com/oral-health/guide/dental-health-fillings#:~:text=Teeth%20can%20be%20filled%20with,is%20known%20as%20glass%20ionomer. [Accessed: 15-Dec-2021].

[2] “In contact with other metals,” American Galvanizers Association. [Online]. Available: https://galvanizeit.org/hot-dip-galvanizing/how-long-does-hdg-last/in-contact-with-other-metals. [Accessed: 15-Dec-2021].

2021/09/23- Triodent V3 Sectional Matrix

TARA BOROUMAND - Sep 23, 2021, 4:49 PM CDT

Title: Triodent V3 Sectional Matrix

Date: 9/23/21

Content by: Tara Boroumand

Present: N/A

Goals: Research competing designs for PDS

Content:

There are numerous devices and techniques that can be considered competing designs, however, those that relate most to this project are sectional matrix systems. The Triodent V3 Ring used alongside the Triodent Wave-Wedgde are advertised as a sectional matrix system that allows for superior functionality compared to the circumferential band (tofflemire) [1][2][3]. If this Triodent ring is used to separate adjacent teeth with the placement of two matrix bands, the contact between the teeth would not offer optimal contact leading to a larger gap than desired.

Conclusions/action items:

Having two matrix bands used with the current design described would lead to too large of a gap. But this then makes me wonder if this design (the ring and wedge) can be used along with the butterfly design of the previous team. I will meet with the team and discuss this as a possible design.

[1] “Triodent V3 Better outcomes start here,” Triodent V3 | Dentsply Sirona. [Online]. Available: https://www.dentsplysirona.com/en-au/categories/restorative/triodent-v3.html. [Accessed: 23-Sep-2021].

[2] “Dentsply Sirona Launches Ds Primetaper, Announces COMPREHENSIVE Restage of ITS Implant Business,” Dental Products Report, 23-Sep-2021. [Online]. Available: https://www.dentalproductsreport.com/view/dentsply-sirona-launches-ds-primetaper-announces-comprehensive-restage-of-its-implant-business. [Accessed: 23-Sep-2021].

[3] A. E. G. I. S. Communications, “V3 sectional matrix system - triodent: Inside dentistry,” Triodent | Volume 5, Issue 10 | Inside Dentistry. [Online]. Available: https://www.aegisdentalnetwork.com/id/2009/12/v3-sectional-matrix-system-triodent. [Accessed: 23-Sep-2021].

2021/11/20- Current Devices

TARA BOROUMAND - Dec 13, 2021, 11:14 PM CST

Title: Current Devices

Date: 11/20/21

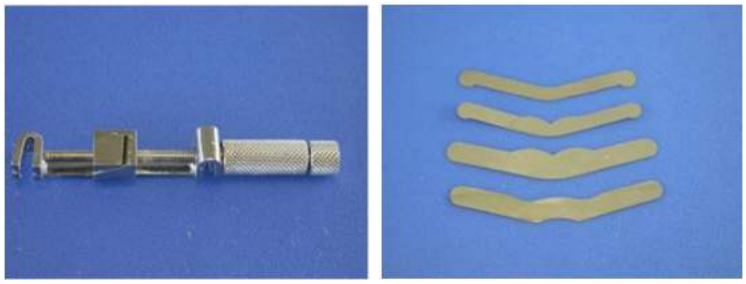
Content by: Tara Boroumand

Present: N/A

Goals: To discuss the current designs that will be used in the final paper

Content:

The Tofflemire Matrix Band system is displayed above. This is a circumferential matrix band system consisting of the retainer on the left and the bands on the right. Dental wedges are also used along with th



[1]

The left image shows the colored switch at the top and colored dial at the bottom. The right image shows how the device would install around a tooth [2][3]

Conclusions/action items:

These are not the sections I am responsible for on the poster and paper, however, I will read over and confirm these are correctly compared to our device.

[1] "A historical review of dental matrices from MDJ," *Scribd*. [Online]. Available: https://www.scribd.com/document/112847146/A-Historical-Review-of-Dental-Matrices-From-MDJ. [Accessed: 20-Oct-2021].

[2] "Pro-matrix | disposable matrix system," Pro-Matrix band disposable matrix system. [Online]. Available: https://www.astekinnovations.co.uk/promatrix.php. [Accessed: 20-Oct-2021].

[3] "Medicos Pro-Matrix Single-Use Matrix Band," YouTube. Dental Product Shopper, 21-Jun-2017.

2021/09/22- FDA Standards

TARA BOROUMAND - Sep 22, 2021, 9:10 PM CDT

Title: FDA Standards

Date: 9/22/21

Content by: Tara Boroumand

Present: n/a

Goals: Research standards and specifications for PDS and future papers. Paste findings into PDS

Content:

FDA approval is necessary for medical devices. Current matrix bands are Class 1 devices as specified in the Codes of Regulations Title 21, Chapter 1, Subchapter H, Part 872 Subpart E. They are identified as low risk devices that present minimal potential for harm. If the new design utilizes the same materials used before 1976 , it would be exempt from premarket notification procedures specified in Subpart E [1]. Otherwise, a premarket notification submission would need to be completed to the Food and Drug Administration at least 90 days prior to the proposed introduction of the product [2]. An Investigational Device Exemption (IDE) would need to be obtained to pursue clinical studies with the device to collect data on safety and effectiveness in support of the Premarket Approval (PMA) application or Premarket Notification 510(k) submission. These studies must be approved by the Institutional Review Board (IRB) before the studies begin [3].

[1] “CFR - code of federal Regulations Title 21,” accessdata.fda.gov. [Online].
Available: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=872.4565. [Accessed: 23-Sep-2021].

[2] “CFR - code of federal Regulations Title 21,” accessdata.fda.gov. [Online].
Available: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?CFRPart=807&showFR=1&subpartNode=21%3A8.0.1.1.5.5. [Accessed: 23-Sep-2021].

[3] Center for Devices and Radiological Health, “Overview of device regulation,” U.S. Food and Drug Administration. [Online].
Available: https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/overview-device-regulation.
[Accessed: 23-Sep-2021].

Conclusions/action items:

Paste above findings in PDS.

2021/09/16- Previous Team Design Review

TARA BOROUMAND - Sep 21, 2021, 8:52 PM CDT

Title: Previous Team Design Review

Date: 9/16/21

Content by: Tara Boroumand

Present: n/a

Goals: To review the previous designs that the prior team had

Content:

The Butterfly Design: This has one matrix band with two sections on both sides that peel apart while the middle of the design stays together. The middle would still remain the thickness of one band. A wedge can be inserted between the teeth to ensure further separation.

Overall, I thought this design seemed very straightforward and effective. I think this would be a good design to improve upon, however, I wonder how it would be placed in the teeth? I wonder if a tofflemire would be used and if so, what type of modifications would need to be made to it. The other concern is using a ring with this design is being able to use a ring along with this butterfly design. I am not sure if rings can be placed vertically to allow for work space on both sides of the tooth.

The DoubleHug (Doug): This includes two tightening mechanisms on two independent bands within the same device. The previous team had mentioned the only issue with this is the width of the two matrix bands during the filling process makes the junction between the teeth two weak after the filling is done.

This design seems complex to me. It seems a new tofflemire would need to be designed in order to use this sort of tightening mechanisms. This would mean redesigning the tofflemire which I think is much more of a difficult task than redesigning a band that may not need the design of a new tofflemire in addition.

The Potato Wedge: This design includes slit inserts on the sides where matrix bands can be inserted and fitted to the curvature of the teeth. This would help maintain the natural spacing while inserting two bands

I do not think I fully understand this design. My follow up question would be how would this solve the issue of maintaining a close contact? Wouldn't two bands still have double the required distance? I also imagine this design would be hard to use for the dentist

Conclusions/action items:

Overall the butterfly design makes the most sense to me. I think the team should either pursue this design or brainstorm a new one

2021/10/15- Proposed Solutions of Butterfly shortcomings

TARA BOROUMAND - Oct 19, 2021, 10:35 PM CDT

Title: Proposed Solutions of Butterfly shortcomings

Date: 10/15/21

Content by: Tara Boroumand

Present: n/a

Goals: Discuss solutions that were considered in design matrix evaluation

Content:

Copy and Pasted below are the shortcomings evaluated in my previous entry- in bold are proposed solutions

-The team is unsure whether the design would fit various tooth sizes. Of course there would need to be separate bands for adults and kids like similar designs today, however, would this design be able to fit a wide variety of tooth sizes? The ends of the band would need to peel back and fit around the tooth, however, if someone had very small teeth would the fit be loose?

This can be addressed with the pinchers component the team has on the Butterfly + U Pinchers design. The Pinchers would create inward force that would be exerted on the matrix band. This would hopefully cause the matrix band to be tightly placed along the tooth surface. If someone had smaller teeth, the pinchers would still cause the band to wrap around the tooth tightly.

-How would the dentist place and remove this? It seems to be a really hard band to place because it would also need to be peeled back at each end. I am not sure if tweezers would be able to be used since there is no tab or anything to hold on to.

The Pinchers would allow for the dentist to place and remove the band simply via holding onto the pinchers. However, current matrix bands have tabs that have holes sticking out of the sectional band. Tweezers can be used to place these bands with the use of holes. Both The Butterfly and The Butterfly + U Pinchers design could benefit from a component like this.

-Fabrication of this design would be really hard. It would be two separate matrix bands that are welded together in the middle. This would be difficult to do with the thing metal we plan on using

This is still an issue that the team is working on addressing. Fabrication would be hard and this currently remains a future work for the team.

Conclusions/action items:

It is important to note that even though The Butterfly + U Pinchers design offers solutions to some of the issues the team has experienced with The Butterfly Design, it still has its own shortcomings. One of the largest ones is that the pinchers would likely obstruct the view of the dentist. This needs to be assessed by the team. This is why all three of our designs must be evenly evaluated in the design matrix, as all current designs have proposed potential issues.

2021/11/01- Design Idea with Nitinol

TARA BOROUMAND - Dec 13, 2021, 11:04 PM CST

Title: Design Idea with Nitinol

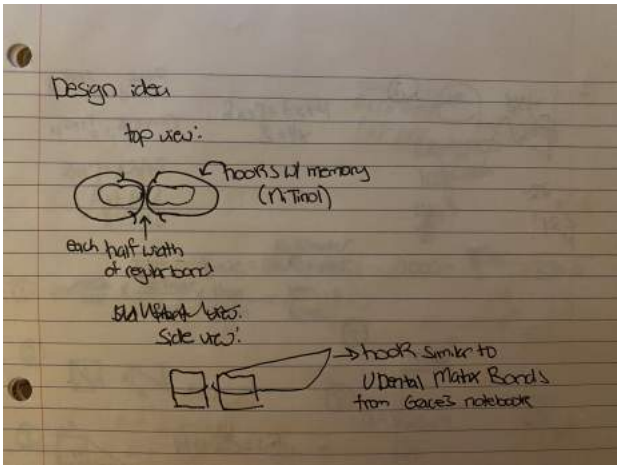
Date: 11/01/21

Content by: Tara Boroumand

Present: N/A

Goals: To document a design idea I had in my notebook from earlier in the semester

Content:



-This was an idea I had in my notebook from around the time we were adjusting the Butterfly design. This design is similar to the butterfly design with hooks, however, it using nitinol for the U-Pinchers. Nitinol is used as the material for rings that are used to separate the teeth during cavity fillings. These hooks are similar to the UDental Matrix bands from Grace's design notebook. This idea was not pursued because I nickel is a very common allergen. Although it is used as the ring material for cavity fillings, I was unsure on the limitations of its use. Additionally, we modified a new design a short time later so this was never pursued.

Conclusions/action items:

Discuss the advantages of our current design over ideas such as this one and others.

2021/12/10- Final Design and Fabrication

TARA BOROUMAND - Dec 15, 2021, 12:59 PM CST

Title: Final Design and Fabrication

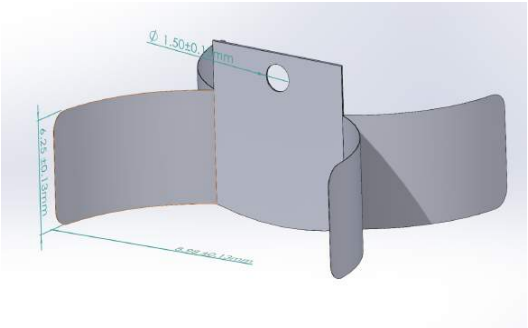
Date: 12/10/21

Content by: Tara Boroumand

Present: N/A

Goals: Discuss final design and changes from the previous designs.

Content:



With the use of calipers a 152 mm x 127 mm rectangular sheet was measured from the 1008 steel shim stock and was cut with scissors. This sheet was then folded to create two equal 76 mm x 127 mm halves. Cuts were made 25 mm long on both ends of the fold, and 51 mm in from the short edges, to create a rectangular tab. Since sharp corners were a concern on the earlier designs, the corners were rounded. The four leaflets of the rectangular base created from these cuts were then shaped outwardly to a curvature of about 90 degrees, with a rounded cylinder, to contour . A hole punch was used through both sides of the folded tab to create the hole. This hole will aid in removal and placement of the band.

The TEAM Lab suggested that the team may be able to use a laser cutter to accurately cut out a to scale prototype with all the key features. Upon further research, the team realized laser cutters are not able to cut through highly reflective material but are able to cut stainless steel. If this does not work due to reflection, a water jet can be used to fabricate the prototype.

Laser cutting has a minimum cutting slit of 0.15 mm and a processing tolerance of 0.05 mm while the water jet has a minimum cutting slit of 0.5 mm and a processing tolerance of 0.2 mm [1].

A concern with laser cutting is whether it will melt the steel which would lead to undesirable edges. A third party manufacturer may be considered if both the laser cutter and the water jet are an issue.

Conclusions/action items:

Discuss above in final deliverables.

[1] Sculpteo, “Laser Cutter vs Waterjet Cutting: 5 points to set them apart,” Laser Cutting or Water Jet Cutting: Which is Best for Your Application? [Online]. Available: https://www.sculpteo.com/en/3d-learning-hub/laser-cutting/laser-cutting-vs-water-jet-cutting/. [Accessed: 15-Dec-2021].

2021/09/23- Patient/Customer Concerns

TARA BOROUMAND - Sep 23, 2021, 4:54 PM CDT

Title: Patient/Customer concerns

Date: 9/23/21

Content by: Tara Boroumand

Present: N/A

Goals: Reflect on patient/customer concerns for PDS

Content:

Customer

-Dentist/dental suppliers

-Dentist would probably want ease of use for their own comfort

-Dentist would also likely want decreased procedure time to do more treatments in less time

-Suppliers would want the most profitable item. Easy to manufacture and should be around the same price to manufacture as current designs

Patient

-ideally should not add extra pain since many patients already have a lot of discomfort with fillings

-no allergens for the matrix band (such as nickel)

-Sterilization not an issue since this should be single use

Written for PDS:

a. Customer:

i. This design should mainly appeal to dentists. Thus, the design needs to be optimized to fit the user's comfort and ease of use while decreasing procedural time. Dental suppliers would also be target customers, so the design must outcompete others on the market. The client specifications should be closely followed, as the client has the perspective of a dentist and, thus, potential customer.

b. Patient Related Concerns:

i. The device will be in direct contact with the patient's oral cavity, so the materials must be non-toxic and non-allergenic. Common metal allergies include: nickel, cobalt, copper and chromium [1]. This design should also be one-time use, similar to the current matrix band used. Thus, sterilization would not be a concern. Ideally, the device would not add any additional discomfort during the filling process.

Conclusions/action items:

Put in PDS for submission

[12] Y. Yoshihisa and T. Shimizu, “Metal allergy and systemic contact dermatitis: An overview,” Dermatology research and practice, 2012. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3369403/. [Accessed: 23-Sep-2021].

2021/10/01- Shortcomings of The Butterfly design

TARA BOROUMAND - Oct 19, 2021, 10:23 PM CDT

Title: Shortcomings of The Butterfly design

Date: 10/01/21

Content by: Tara Boroumand

Present: n/a

Goals: Talk about the shortcomings the team has tried to improve upon

Content:

Shortcomings:

-The team is unsure whether the design would fit various tooth sizes. Of course there would need to be separate bands for adults and kids like similar designs today, however, would this design be able to fit a wide variety of tooth sizes? The ends of the band would need to peel back and fit around the tooth, however, if someone had very small teeth would the fit be loose?

-How would the dentist place and remove this? It seems to be a really hard band to place because it would also need to be peeled back at each end. I am not sure if tweezers would be able to be used since there is no tab or anything to hold on to.

-Fabrication of this design would be really hard. It would be two separate matrix bands that are welded together in the middle. This would be difficult to do with the thing metal we plan on using

Conclusions/action items:

Use these shortcomings in the design matrix evaluation

2021/10/19- Discussion of Designs

TARA BOROUMAND - Oct 19, 2021, 11:02 PM CDT

Title: Discussion of Designs

Date: 10/19/21

Content by: Tara Boroumand

Present: n/a

Goals: To discuss some of the significant progress and decisions the team has made. This should be pasted and modified into the preliminary report.

Content:

The team was tasked with designing a device that would allow concurrent restoration of two adjacent interproximal cavities. When initially reviewing this problem, the team discussed the designs of the previous team. One of the previous teams' designs, The Butterfly, stood out to the team. It seemed to offer an easy solution to the current issue at hand. The Butterfly allowed the proper tooth contact to be restored due to its two matrix bands consisting of half the thickness of a regular sectional band. However, the team anticipated some issues with this design upon further consideration. The placement and removal would be difficult without an additional tool to aid the dentists. The team was also unsure whether the contact of the band would be tight along the surface of the tooth without an additional force to keep it in place. Based on these considerations, the team came up with two additional designs to evaluate in the design matrix. The Handcuff design took a fully different approach by being a circumferential matrix band that relies on its own openings to anchor and tighten the band around the tooth. The Butterfly + U Pinchers design includes pinchers that improve some of the shortcomings of The Butterfly design, but comes with its own shortcomings (such as potentially obstructing the view of the dentist). These three designs were evaluated in a design matrix, and ultimately, The Butterfly + U Pinchers design was the winner. This mainly won for the inward force the pinchers exert on the matrix band, ensuring a tight and proper tooth contact, while allowing for easy removal and placement with the pinchers. The team will, thus, be moving forward with The Butterfly + U Pinchers design.

There are various considerations that must be made prior to fabrication of this design. The team must perform some sort of assessment to determine whether the U Pinchers would block the view of the dentist. This can be done by quantitative assessments of the shape of the device with a prototype that can be used on a tooth model. Additionally, the team has discussed including a tab with a hole for further ease of placement and removal via tweezers. Current sectional matrix bands have a tab with a hole on the occlusal edge and wing ends for this exact purpose. Incorporating a tab may further increase the ease of use of this design.

Conclusions/action items:

Overall, all three of the designs have potential shortcomings. It is important to weigh these factors and determine a design based on criteria. This is what the team used the design matrix for. A separate entry will be made discussing the significance of the design matrix.

2021/10/19- Design Matrix Evaluation/Discussion

TARA BOROUMAND - Oct 19, 2021, 11:45 PM CDT

Title: Design Matrix Evaluation/Discussion

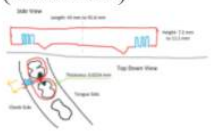
Date: 10/19/21

Content by: Tara Boroumand

Present: n/a

Goals: To discuss the significance of the design matrix for future considerations

Content:

Dental Matrix Band Design Matrix						
Design Criteria (Weight)	Design 1 (Handcuff) 		Design 2 (Butterfly) 		Design 3 (Butterfly + U pinchers) 	
Functionality (30)*	3/5	18	2/5	12	5/5	30
Ease of Use (20)	2/5	8	4/5	16	4/5	16
Fabrication (15)	4/5	12	3/5	9	3/5	9
Ease of Sterilization (15)	3/5	9	3/5	9	3/5	9
Safety (10)	4/5	8	5/5	10	5/5	10
Cost (10)	4/5	8	3/5	6	2/5	4
Total (100)	63		62		**78**	

*The functionality criteria was based on the design's ability to allow the dentist to complete the procedure with both quality and time efficiency.

The design matrix revealed a few things that I think are important to discuss. The Butterfly + U Pinchers won the functionality section under an assumption that the pinchers will truly aid in the placement and removal of the matrix band. If the team finds it difficult to use, then the Butterfly + U Pinchers design may need modifications such as a tab with a hole that allows the dentist to place the matrix band (similar to current sectional matrix bands used today). This is because a large part of the functionality criteria is time efficiency. The motivation for the current process is that removing and repositioning matrix bands and wedges is a tedious task. If our proposed design did not improve upon this issue, it would defeat the purpose of the design. However in regard to quality of procedure, I think the pinchers would be very beneficial to have since it creates such a close contact with the tooth's surface. Similarly, the pinchers is why it scored so high in ease of use. It did not receive a 5/5 because the team considered the possibility of the pinchers obstructing the dentist's view. Overall, some of the rankings it received are under the condition the device works how the team intended it to.

Conclusions/action items:

Discuss this evaluation in the conclusion of the preliminary report.

2021/10/19- Overview/Abstract

TARA BOROUMAND - Oct 20, 2021, 12:56 PM CDT

Title: Overview/Abstract

Date: 10/19/21

Content by: Tara Boroumand

Present: n/a

Goals: To summarize the progress of the project thus far for preliminary deliverables

Content:

Dental cavities are one of the most prevalent diseases in both children and adults. In fact, dental caries (decay) is the most common disease in children. Fifty-three million people live with untreated tooth decay, labelling cavities as a silent epidemic. This issue disproportionately affects disadvantaged communities, and unfortunately, cavities become more difficult to repair the longer it is left untreated [1]. Untreated tooth decay not only can lead to severe tooth pain and discomfort, but also can lead to tooth loss. Dental fillings remain the most common method of combating tooth decay, thus, it is essential filling procedures are optimized to decrease procedural times while increasing the accuracy of the filling. Current matrix bands being used such as the Sectional and Tofflemire bands fail to allow concurrent restoration of adjacent interproximal cavities. The team is tasked with designing a matrix band that can support the concurrent filling of two adjacent teeth with interproximal cavities while maintaining the proper tooth contact. A design has been proposed that utilizes two matrix bands attached at the interproximal region, each having half the thickness of a regular matrix band to support the proper and flossable tooth contact. This design incorporates a metal piece coming out from the band that would aid in the placement and removal of the band while exerting inward force to maintain a tight contact with the tooth surface. The viability of the device will be determined by functionality tests that determine whether the design allows for the proper tooth contact that current matrix bands create. This functionality testing will reveal further accommodations the team will need to make to confirm the device is able to support two adjacent interproximal cavities undergoing repair, while maintaining a flossable tooth contact with a reduced procedure time.

Conclusions/action items:

Modify the above with team members and paste into report for the abstract section

[1] R. M. Benjamin, “Oral Health: The silent epidemic,” Public health reports (Washington, D.C. : 1974), 2010. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2821841/. [Accessed: 20-Oct-2021].

2021/12/08- MATLAB Code to Analyze MTS Machine Results

TARA BOROUMAND - Dec 12, 2021, 11:13 PM CST

Title: MATLAB Code to Analyze MTS Machine Results

Date: 12/08/21

Content by: Tara Boroumand

Present: N/A

Goals: To use MATLAB in order to graph and calculate stress-strain curve values

Content:

```
close all;
clear all;
data=load("bme400207.txt"); %import the correct data (different for each run)
disp=data(:,1);
force=data(:,2);
time=data(:,3);
dispMain= disp-disp(1,1); %subract initial values (initial values should be 0 regardless)
%Below is a force vs. frame plot to determine where the linear region is.
%This plot is used to select the frame where linear region begins and ends
figure(1);
plot(force);
xlabel('Frame (point)')
ylabel('Force (kN)')
title('Force Measured Using an MTS Machine over Many Frames');
j1=input('Enter first frame of the linear region of loading curve');
j2=input('Enter last frame of the linear region of the loading curve');
Lo=input('Enter the gauge length');
A=input('Enter the cross-sectional area of your specimen');
stress = (force*1000)/A;
strain = dispMain/Lo;
figure(2)
plot(strain,stress,'.',strain(j1:j2),stress(j1:j2),'o')
xlabel('Strain (mm/mm)')
ylabel('Stress (MPa)')
title('Stress vs. Strain Plot for Current Dental Matrix Band (20mm/min)')
%Change title as appropriate for trials
```

Once this data was graphed, an equation for the linear region of the graph was made using basic plotting tools in MATLAB (from region J1 to J2)

Conclusions/action items:

Use this code to graph the stress-strain curves and calculate the equations to find the young's modulus

2021/12/08- Stress-Strain Curve of 1008 Alloy Steel Material

TARA BOROUMAND - Dec 12, 2021, 11:10 PM CST

Title: Stress-Strain Curve of 1008 Alloy Steel Material

Date: 12/08/21

Content by: Tara Boroumand

Present: N/A

Goals: To graph the stress-strain curves of the team's material in order to analyze the young's modulus of the linear region

Content:

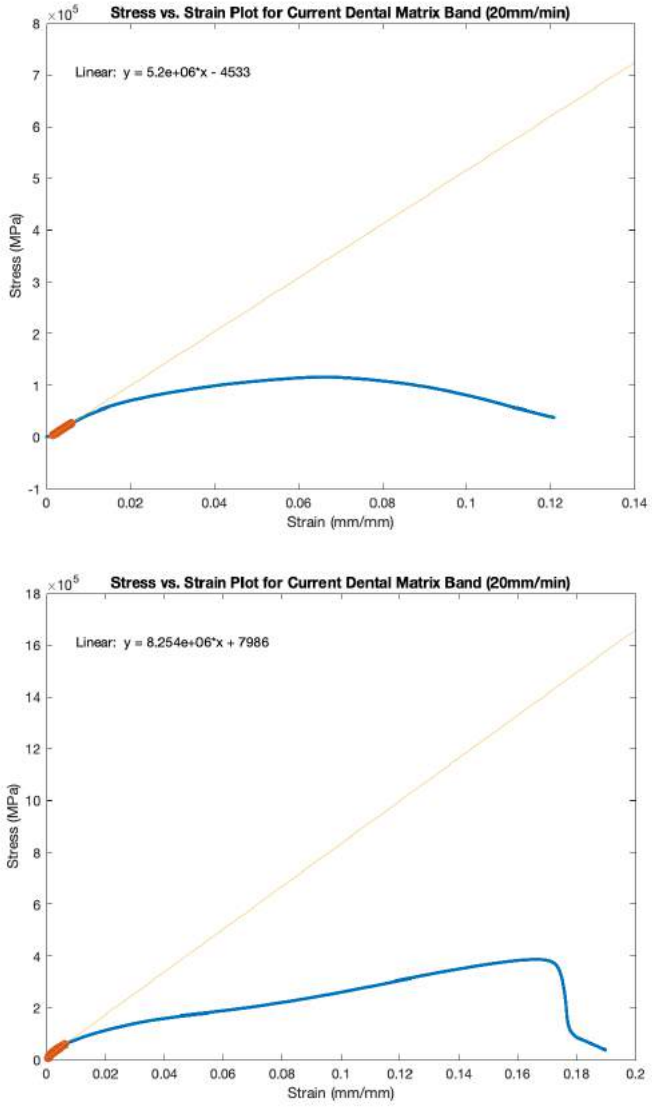


Figure 1: Plotted Stress-Strain curves from tensile testing on an MTS machine to determine Young's Modulus. Both runs above are with the 1008 steel alloy

Conclusions/action items:

Compare the Young's Modulus values of the above graphs to those of the currently used dental matrix band stainless steel material.

2021/12/08- Stress-Strain Curve of Currently used Stainless Steel Material

TARA BOROUMAND - Dec 12, 2021, 11:17 PM CST

Title: Stress-Strain Curve of Currently used Stainless Steel Material

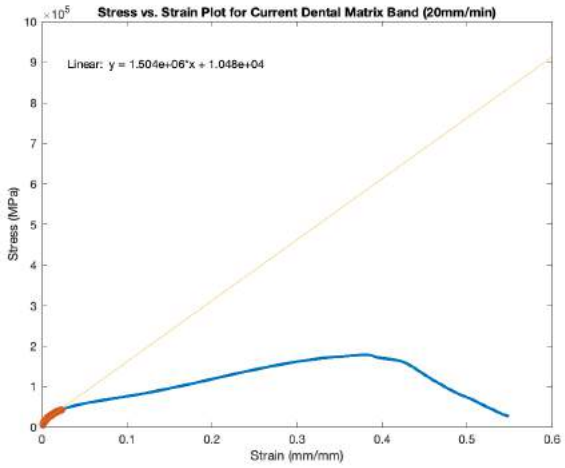
Date: 12/08/21

Content by: Tara Boroumand

Present: N/A

Goals: To graph the stress-strain curves of the team's material in order to analyze the young's modulus of the linear region

Content:



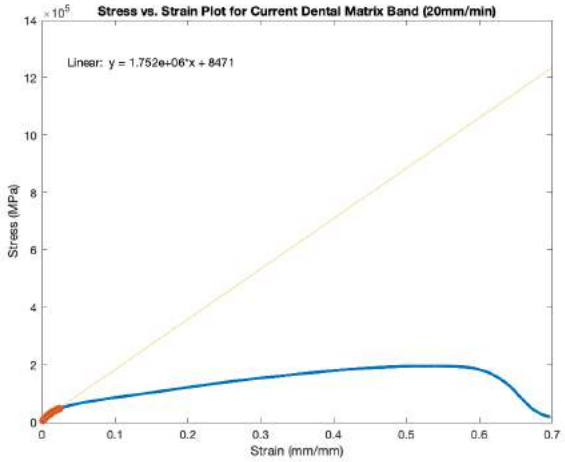


Figure 1: Plotted Stress-Strain curves from tensile testing on an MTS machine to determine Young's Modulus. Both runs above are with stainless steel

Conclusions/action items:

Compare the Young's Modulus values of the above graphs to those of the currently used dental matrix band stainless steel material.

2021/12/08- Statistical Analysis of MTS Machine Testing

TARA BOROUMAND - Dec 12, 2021, 11:04 PM CST

Title: Statistical Analysis of MTS Machine Testing

Date: 12/08/21

Content by: Tara Boroumand

Present: n/a

Goals: To determine whether MTS Machine testing yielded significant data on youngs modulus difference

Content:

F-statistic value = 11.07739

P-value = 0.07964

Data Summary				
Groups	N	Mean	Std. Dev.	Std. Error
Group 1	2	672700000000	215950410974.3716	152700000000
Group 2	2	162800000000	17536248173.4264	12400000000

ANOVA Summary					
Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	1	2.5999800999999998e+23	2.5999800999999998e+23	11.0774	0.0796
Within Groups	2	4.6942099999999996e+22	2.3471049999999998e+22		
Total:	3	3.0694011e+23			

Null hypothesis: There is no difference between the Young's Modulus of the team's material (1008 alloy) and currently used material (stainless steel)

Alternative hypothesis: There is a difference between the Young's Modulus of the team's material (1008 alloy) and currently used material (stainless steel)

A one-way ANOVA test was performed at an alpha value of .05. Due to a high P-value, the team was not able to conclude that there was a significant difference (fail to reject the null hypothesis)

This was actually what the team was hoping, however, further quantitative testing should be done in the future (this is further explained in future works discussion).

Conclusions/action items:

Discuss the implications of this statistical test in the results section of the final paper.

2021/12/10- Results of MTS Testing Explained

TARA BOROUMAND - Dec 13, 2021, 11:59 PM CST

Title: Results of MTS Testing Explained

Date: 12/10/21

Content by: Tara Boroumand

Present: N/A

Goals: To explain the results of the MTS Testing

Content:

Although the Solidworks testing revealed fairly similar results for the stress at 200N and the yield stress between the two materials, MTS testing data revealed a difference in Young's Modulus values between the two materials. The entry called (Stress-Strain Curve of 1008 Alloy Steel Material) under the Discussion/Analysis folder shows the stress-strain curve for the two best trials (defined as the trials with the least slippage) performed on the 1008 steel alloy (the team's ordered material). The linear region of the curve was approximated, and a line of best fit was created for only the linear region. The slope of this linear region is the Young's Modulus, which was an average of 627.7 GPa for the 1008 steel alloy. This value was higher than the Young's Modulus obtained for the currently used stainless steel material. The entry called "Stress-Strain Curve of Currently used Stainless Steel Material" under the Discussion/Analysis folder shows the stress-strain curves of the two best trials (again defined as the trials with the least slippage) performed on the currently used dental matrix band material (stainless steel). The slope of the linear region for these graphs was 162.8 GPa.

Since the difference in Young's Modulus values between the two materials appeared drastically different at first, the team conducted a One-Way ANOVA test on the results with the null hypothesis that there is no difference in the Young's Modulus means. The entry called "Statistical Analysis of MTS Machine Testing" summarizes the results of the ANOVA test.

The ANOVA test was tested with an alpha level of .05 (a standard value). Due to a high P-value of 0.07964, the team failed to reject the null hypothesis and thus, did not have sufficient evidence to conclude a significance difference between the Young's Modulus values of the 1008 alloy and currently used stainless steel.

Conclusions/action items:

Discuss these in the final paper, except incorporate the other 3 entries mentioned above and their figures with this one to create the results section of the final paper.

2021/12/10- Semester Discussion/Analysis

TARA BOROUMAND - Dec 14, 2021, 11:31 AM CST

Title: Semester Discussion/Analysis

Date: 12/10/21

Content by: Tara Boroumand

Present: N/A

Goals: Discuss the implications of the results that were presented in this folder

Content:

The below section will directly be placed into the final paper:

The results found in the mechanical testing of the materials were similar to those in the literature. The Elastic Modulus of the “dead soft” steel used in dental matrix bands was reported at 200-215GPa, as discussed previously in the materials section while the team’s MTS testing found an average Young’s Modulus of 162.8GPa [1]. Although slightly low, the team felt confident that that MTS machine could be used on the team’s ordered material to compare its mechanical properties with those of the current dental matrix bands.

Favorable testing results would mean there was no difference found between the mechanical properties of the team’s material, the 1008 steel alloy, and the currently used dental matrix band stainless steel material. Although the statistical analysis from the ANOVA test yielded these favorable results with a high P-value concluding that no significant difference in the Young’s Modulus can be concluded, there are a few considerations to be made here. First, although a One-Way ANOVA test is commonly done with three groups and a greater sample size, the conditions of this test are still valid [2]. However, there are many limitations with a sample size this low and thus, this statistical analysis should moreso be used as preliminary evidence that the team’s material exhibits appropriate mechanical properties and further testing should be performed.

In addition to the analysis above, slippage should also be discussed in the final paper. Although various factors were tested in attempts of avoiding slippage, such as cutting the material into a dog bone shape, using tape for increased grip, changing the deformation rate of the MTS machine and trying different fixtures, ultimately slippage occurred on every trial.

Conclusions/action items:

[1] “ASTM A109 Grade no. 5 dead-soft,” Matmatch. [Online]. Available: https://matmatch.com/materials/minfm65939-astm-a109-grade-no-5-dead-soft. [Accessed: 20-Oct-2021].

[2] https://statistics.laerd.com/spss-tutorials/one-way-anova-using-spss-statistics.php

2021/12/10- Future Work

TARA BOROUMAND - Dec 14, 2021, 11:35 AM CST

Title: Future Work

Date: 12/10/21

Content by: Tara Boroumand

Present: n/a

Goals: To discuss final work which is one of my sections in the final paper.

Content:

It would be beneficial to repeat quantitative testing moving forward for a few reasons. First, it would be beneficial to analyze other mechanical properties beyond the Young's Modulus. For example, since the team has data on the ultimate tensile strength of the currently used dental matrix band material, testing for the ultimate stress and strain values could be done and analyzed in the future. It would be beneficial to compare other mechanical properties such as ultimate tensile strength and strain that could not be compared in the above testing due to slippage occurring well before these values were reached. The team found some methods for preventing slippage were more effective than others, and by combining methods and creating a new testing protocol, the team believes they will be able to prevent slippage in the future to yield both more property values and a greater sample size.

The team is very satisfied with the evolution of the design through the semester, however, much remains to be done. In addition to redoing quantitative testing in hopes of analyzing other mechanical properties such as ultimate stress and strain and increasing sample size, the team must also pursue creating a better prototype and performing qualitative testing. Fabrication was successfully completed by the team this semester, however, a better model should be made that can be used in qualitative testing. After meeting with the team lab, suggestions were made to use the laser cutter or water jet on the 1008 steel alloy to create a more precise model. Both these fabrication methods will be looked into and tested. If the team is unsuccessful in using both these methods for a higher grade prototype, third party manufacturers will need to be researched into.

The team's most important goal for next semester is completing qualitative testing. This would consist of creating a survey for Dr. Tipple and his colleagues to fill out in order to determine the functionality of our design in its application. This qualitative testing will determine if the new design is more easily and quickly installed and removed, without impeding on the efficacy or speed of the tooth restoration. Likely, the survey should be a questionnaire that allows the dentist to evaluate our design based on its effectiveness in aiding concurrent fillings at once, its ease of use in both its placement and removal and its time effectiveness. Although quantitative testing was important to ensure the team's material behaves similarly to the standard, qualitative testing is ultimately much more important as the success of the design is dependent on a dentist's desire to use it over the current model that has been the standard for years.

Split up the above sections- half in discussion half in conclusion. The quantitative testing portion will likely be most applicable in the discussion section--> explaining why more testing would be beneficial. The rest of text should go in the conclusion section.

Conclusions/action items:

Use the above text and paste in parts of the above into the final paper to explain future work.

2021/12/14- Justification for small sample size in ANOVA

TARA BOROUMAND - Dec 14, 2021, 11:59 AM CST

Title: Justification for small sample size in ANOVA test

Date: 12/14/21

Content by: Tara Boroumand

Present: N/A

Goals: To justify why the team only used 2 trials of each material out of many for the stats analysis

Content:

Originally, the team performed a One-Way ANOVA test with many more trials for both materials. However, the team quickly questioned the accuracy of the results due to the early slippage that occurred in the majority of the trials. In most of the trials, slippage was occurring during the linear region of the stress-strain curve which would drastically impact the Young's Modulus value. Although it would mean a much smaller sample size, the team decided to analyze all the data and only analyze the samples where slippage did not occur until well after the linear region. Fortunately, there were two trials of each material that had slippage occur after the linear region of the stress-strain curve. This is what allowed the team to analyze the Young's Modulus of the stress-strain curve with confidence in the data.

Conclusions/action items:

Paste this explanation into the final paper and modify it to flow with the rest of the discussion.

9/15/21 Review of Previous Team's Work

GRACE JOHNSON - Sep 17, 2021, 4:54 PM CDT

Title: Review of Previous Team's Work

Date: 9/15/21

Content by: Grace

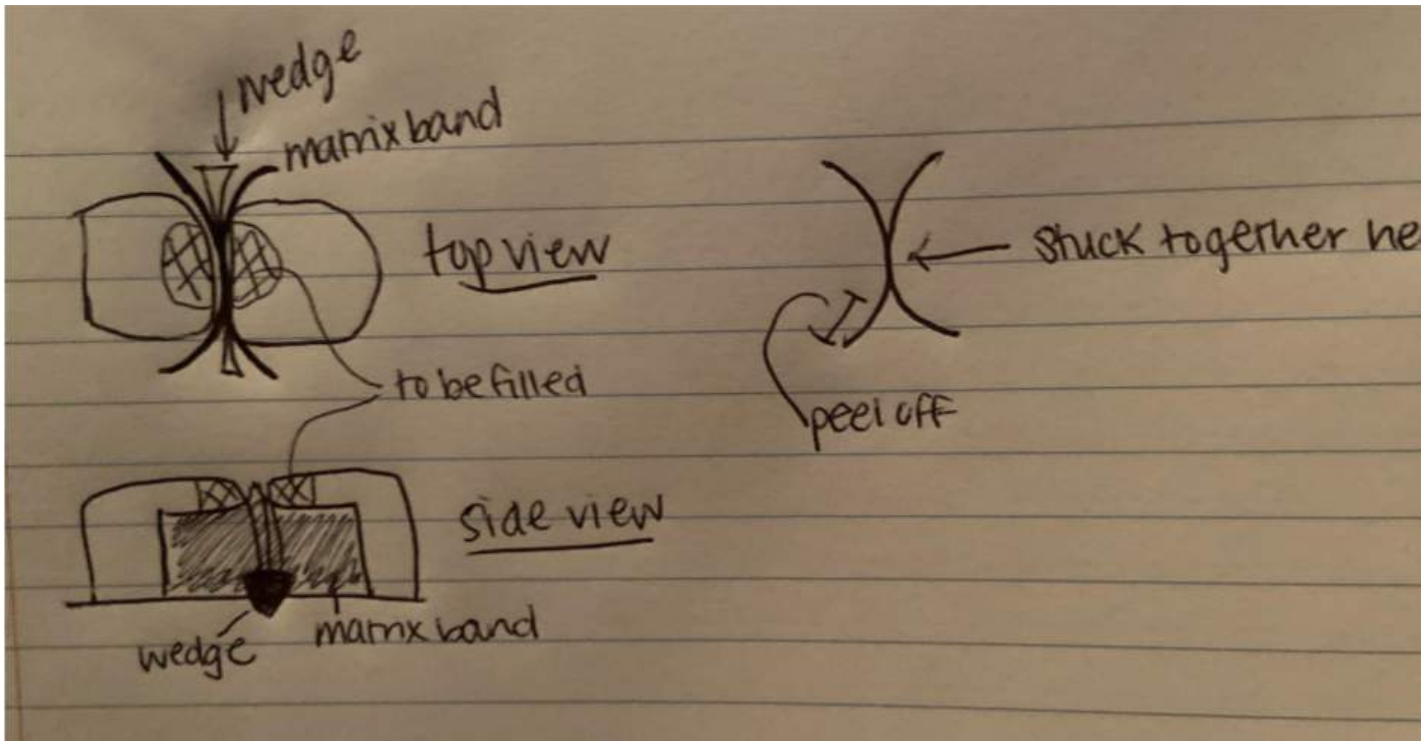
Present: Grace

Goals: To review the previous design team's deliverables to get a better understanding of where the project is at before we meet with the client.

Content:

- The team outsourced fabrication to produce a dual matrix band
- Mechanical testing was conducted on a similar material and thickness, which revealed no useful results due to slippage out of the MTS machine
- Functionality testing on the prototype resulted in a failing score
- Many improvements are necessary in order for the matrix band to be used for its purpose

Looking at the team's preliminary designs, the "butterfly" design, although it scored lower than the team's final prototype in their design matrix, seems to have potential.



- sectional rather than circumferential
- would be easier to use in the mouth considering no Tofflemire tool is needed
- needs something like the wedges to hold it in place

Conclusions/action items: The previous design team was able to make a physical matrix band, but it did not meet specifications. Moving forward, our team will meet with the client to understand his requirements and desired improvements of the band.

12/14/21 Finalized Abstract w/ Motivation

GRACE JOHNSON - Dec 14, 2021, 11:22 PM CST

Title: Finalized Abstract w/ Motivation

Date: 12/14/21

Content by: Grace

Present: Grace

Goals: To edit the preliminary abstract to better represent the team's current standing with the project including our final design, testing we've conducted, and future work.

Content:

Fifty-three million people live with untreated tooth decay, labelling cavities as a silent epidemic. This issue disproportionately affects disadvantaged communities, and unfortunately, cavities become more difficult to repair the longer they are left untreated [1]. Untreated tooth decay can lead to severe tooth pain and discomfort, and in some cases, tooth loss. Dental fillings remain the most common method of combating tooth decay, thus, it is essential that filling procedures are optimized. Current matrix bands used in these procedures, such as sectional and circumferential bands, fail to allow concurrent restoration of adjacent interproximal cavities. The team was tasked with designing a matrix band that can support this simultaneous filling of two adjacent teeth while maintaining proper tooth contact. The final design mimics two adjacent sectional matrix bands, but is designed with half the thickness of a regular matrix band to support the proper, flossable tooth contact within the interproximal space. The device incorporates a holed tab for easy placement and removal as well as a space between each band side to allow the use of a wedge. Preliminary mechanical testing indicates that the 1008 steel used to fabricate early prototypes provides similar structural support when compared to the stainless steel widely used in existing matrix bands. Improved fabrication methods, such as using a water jet, are necessary in order to develop a more precise model. Following this, qualitative testing can be conducted to determine whether the design is both effective and favorable for dentists to use in filling procedures.

[1] R. M. Benjamin, “Oral Health: The silent epidemic,” Public health reports (Washington, D.C. : 1974), 2010. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2821841/. [Accessed: 20-Oct-2021].

Conclusions/action items: It is interesting to me how prevalent tooth decay is and how often it goes untreated. Now that this abstract is finalized, I will add it in the final report.

10/12/21 Review of Team Members Research

GRACE JOHNSON - Oct 12, 2021, 11:44 AM CDT

Title: Review of Team Members Research

Date: 10/12/21

Content by: Grace

Present: Grace

Goals: To review the previous research conducted by my teammates to get a good summary for the background section of the preliminary presentation.

Content:

- the purpose of a dental matrix band is to restore contact areas within teeth
  - Matrix - "a mould in which something is cast or shaped"
  - matrix band is a "thin strip adapted around the tooth to supply missing walls and contours against which restorative materials may be placed and condensed"
- good matrix bands have the following properties
  - are rigid against the existing tooth structure
  - establish proper anatomic contour
  - restore correct proximal contact relation
  - prevent gingival overhang
  - are easily removable
  - must have significant rigidity and integrity
- wedges are used to compress matrix bands to get a tighter seal on the teeth
  - help angle the matrix band correctly
    - shape and size of wedge changes this angle
  - wedge height effects restored contact point
- matrix bands should extend 1.5 - 2.0 mm above the marginal ridge of the adjacent tooth and 0.5 mm below the cavosurface margin

sources:

Matrix Placement for Class II Amalgam Restoration. [Online]. Available: http://www.columbia.edu/itc/hs/dental/operative/matrixband.html.

M. Ahmad, “A Historical Review of Dental Matrices,” *Malaysian Dental Journal*, vol. 33, no. 2, pp. 1–7, 2011.

Conclusions/action items: My teammates have found some useful background material on dental matrix bands that will be helpful as I condense the background section of the preliminary presentation.

10/13/21 Preliminary Background

GRACE JOHNSON - Oct 17, 2021, 7:58 PM CDT

Title: Preliminary Background

Date: 10/13/21

Content by: Grace

Present: Grace

Goals: To write out a background paragraph so that I may practice it and present the information during the preliminary presentation.

Content:

- Matrix bands are a commonly used dental tool that assist dentists by creating an outside contour of a decayed tooth. This contour maintains the tooth's structure and shape during restorative procedures such as cavity fillings.
- Most dental matrix bands are made from a dead, soft metal, such as stainless steel, that is malleable, or easily shaped (show matrix band).
- The bands typically display a thickness between 1.5 to 2 thousandths of an inch, which allows them to fit in the interproximal space between adjacent teeth.
- Effective dental matrix bands are rigid against the existing tooth structure and maximize matrix-tooth contact.
- Dental matrices often require the use of retainers, such as a Tofflemire (show), or they require the use of clips, rings, or wedges to hold the band in place and widen the interproximal space.
    - These tools, however, make the patient's mouth crowded and the filling procedure more difficult for the dentist.
- There are currently no dental matrix band devices that allow for the filling of two cavities on interproximal surfaces simultaneously.
    - Instead, dentists must fill each cavity separately since placing two matrix bands in the interproximal space would exceed the allowable tooth contact diameter.

Conclusions/action items: I will practice speaking these points along with showing our team's matrix bands and Tofflemire for the preliminary presentation.

10/18/21 Tooth Size Research

GRACE JOHNSON - Oct 18, 2021, 6:51 PM CDT

Title: Tooth Size Research

Date: 10/18/21

Content by: Grace

Present: Grace

Goals: To research average tooth diameter to add to the PDS and background of the preliminary presentation.

Content:

- Summarizing Trevor's findings on tooth size:
  - Measurements were taken on both maxillary (upper) and mandibular (lower) teeth from central incisors to third molars
  - On average, maxillary teeth have a crown height of 8.77 mm, ranging from 7.2 to 11.2 mm, and mandibular teeth have a crown height of 8.62 mm, ranging from 7.5 to 11.0 mm
  - The mesiodistal (MD) crown width indicates the diameter of the tooth in the mediodistal direction, or in the direction from front teeth to back teeth
    - These values ranged from 5.3 to 11.4 mm with an average of 8.20 mm
  - The faciolingual (FL) crown width indicates the diameter of the tooth in the faciolingual direction, or in the direction from cheek to tongue
    - These values ranged from 5.7 to 11.5 mm with an average of 8.71 mm
  - The MD and FL crown widths were approximated as lengths of a rectangle to approximate the average tooth perimeter as 33.82 mm, with a range of 22 to 45.8 mm
    - Since teeth are round and not rectangular, it can be presumed that this approximation overvalues what the actual average tooth perimeter is
      - This is beneficial - if we design a matrix band that will fit for larger tooth perimeters we are designing to fit the most teeth

Source: R. I. C. K. N. E. C. SCHEID and G. A. B. R. I. E. L. A. WEISS, Woelfel's dental anatomy. BURLINGTON, MA: JONES & BARTLETT LEARNING, 2020.

Conclusions/action items: After extensive research I was not able to find circumferential molar size data, however, after reviewing Trevor's research and approximations, I concluded that they may be better. His rectangular perimeter approximations most likely overestimate the actual circumference of teeth, leaving us with some wiggle room for our matrix band design.

9/20/21 Existing Surface Matrix Bands Research

GRACE JOHNSON - Sep 20, 2021, 2:18 PM CDT

Title: Existing Surface Matrix Bands Research

Date: 9/20/21

Content by: Grace

Present: Grace

Goals: To research existing sectional dental matrix bands to get some inspiration for modifications and design ideas for the butterfly design.

Content:

"Used to form the interproximal surfaces when fabricating a direct restoration, dental matrices have grown in importance along with advances in dental composites. There are a number of different matrix types including sectional matrix systems, matrix bands and other configurations, but they are all designed to be placed between the tooth being restored and the adjacent tooth to help create the outside contour of the restorative material."

- most matrix bands are made out of stainless steel, a few plastic
- an important characteristic when choosing matrix bands is the consistency of contact areas with the tooth
- some come in rolls of matrix material to be shaped in office, others come in a pre-contoured shape
- matrix bands come in different sizes and widths
- some are completely disposable, some multi-use bands
- most often, matrix bands require the additional use of retainers, clips, or rings to hold the band in place and increase the width of the gap between teeth
    - this makes the mouth more crowded and influences patient comfort

- This photo shows a sectional matrix band held by a ring

- This photo shows an innovative design that utilizes a stainless steel sectional matrix band connected with a separating plastic wedge
    - eliminates the need for a bulky ring

Reference: “Dental Matrix Systems,” *Dentalcompare*. [Online]. Available: https://www.dentalcompare.com/Restorative-Dentistry/4630-Dental-Matrices/. [Accessed: 20-Sep-2021].

Conclusions/action items: There are many sectional matrix band designs out there that the team could modify so that approximating teeth can have matrices in contact with them at the same time.

9/27/21 U Dental Matrix Bands

GRACE JOHNSON - Sep 27, 2021, 5:54 PM CDT

Title: U Dental Matrix Bands

Date: 9/27/21

Content by: Grace

Present: Grace

Goals: To look into the innovative U Dental Matrix Bands to understand how they allow for approximating cavities to be filled simultaneously.

Content:

- invented by a dentist
- eliminates the need for Tofflemires, forceps, or rings
  - held by an integrated spring clip handle, creates a natural curve
  - wedge used for added stability
- adjacent restorations
  - place bands back to back as seen in photo
  - large metal piece is the spring clamp holding the bands in place
- premolar bands are 1/4 or 3/16 inch wide and 0.0015 inches thin
- not much information on any website

- looks as though the matrix bands do not maximize tooth-band contact
- stainless steel
- made by Maryland Dental Bands

References: “U Dental Matrix Bands Premolar Kit 48/Kit,” *Practicon Dental Supplies*. [Online]. Available: https://www.practicon.com/u-dental-matrix-bands-premolar-kit/p/7120914. [Accessed: 27-Sep-2021].

“U Dental Matrix Bands Intro Kit,” *Supply Clinic*. [Online]. Available: https://www.supplyclinic.com/items/u-dental-matrix-bands-intro-kit-maryland-dental-bands-intro-kit. [Accessed: 27-Sep-2021].

“01-Assorted U Dental Bands Kit,” *Maryland dental bands*. [Online]. Available: https://marylanddentalbands-com.3dcartstores.com/Assorted-U-Dental-Bands-Kit_p_13.html. [Accessed: 27-Sep-2021].

YouTube video explaining use of bands: https://www.youtube.com/watch?v=KO6UHoPCOvo

Conclusions/action items: This design seems to allow the dentist to simultaneously fill approximating cavities. There are no reviews and little information about the product though, so it is unclear whether it is currently in use by dentists. A new design inspired by this one with improvements could be detailed and produced by the team.

12/8/21 Matrix Band Procedural Time Research

GRACE JOHNSON - Dec 08, 2021, 5:41 PM CST

Title: Matrix Band Procedural Time Research

Date: 12/8/21

Content by: Grace

Present: Grace

Goals: To figure out how long the procedural time is for using matrix bands in fillings.

Content:

- I was not able to find any information regarding how long a filling procedure using a matrix band takes
- I could only find vague information about how long it takes to fill a cavity
    - cavity fillings can take anywhere from 10 minutes to an hour

source: "How Long Does a Cavity Filling Take?," *South High Dental*, 28-Jan-2021. [Online]. Available: https://www.southhighdental.com/dental-blog/how-long-does-a-cavity-filling-take-2/. [Accessed: 08-Dec-2021].

Conclusions/action items: It is still unknown exactly how long the filling procedure is when using a dental matrix band. We can move forward in just assuring that our device is not any more complicated to place/remove than current bands and assume that it will shorten the procedural time by allowing two teeth to be restored in one procedure.

9/27/21 Approximating Surface Matrix Band Design

GRACE JOHNSON - Oct 18, 2021, 5:27 PM CDT

Title: Approximating Surface Matrix Band Design

Date: 9/27/21

Content by: Grace

Present: Team

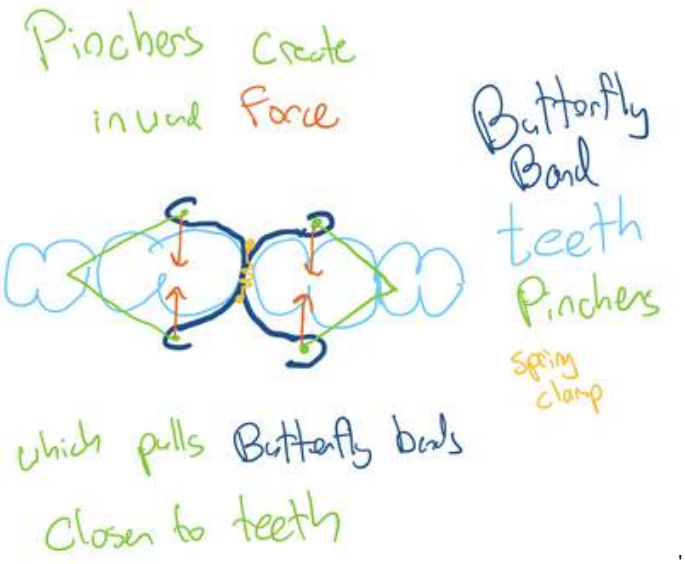
Goals: To present to the team my U Dental Matrix Band research and collectively come up with a design to evaluate in the design matrix.

Content:

- The team agreed with my research conclusions that the existing U Dental Matrix Bands could somehow be combined into a dual-band system in order to allow for approximating cavities to be restored.
- Trevor drew up a sketch of the team's design idea (attached)
    - The design is similar to the butterfly design in that the portion of the band that fits in between adjacent teeth must be the thickness of a single matrix band, not two bands.
        - The rest of the design is also a single matrix band thickness (</= 0.05 mm)
    - The design differs from the butterfly design in that there are "pinchers" which should create an inward force for maximal matrix-band contact
        - The design also incorporates a "spring clamp" which would function the same as a typical wedge
    - The design does not require the use of a Tofflemire or ring

Conclusions/action items: The team sees potential in this design and will move forward in evaluating it against the "handcuff" and "butterfly" designs in the design matrix.

GRACE JOHNSON - Oct 18, 2021, 5:18 PM CDT



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10/28/21 Butterfly + U Pinchers Design Feedback/Update

GRACE JOHNSON - Oct 28, 2021, 12:52 PM CDT

Title: Butterfly + U Pinchers Design Feedback/Update

Date: 10/28/21

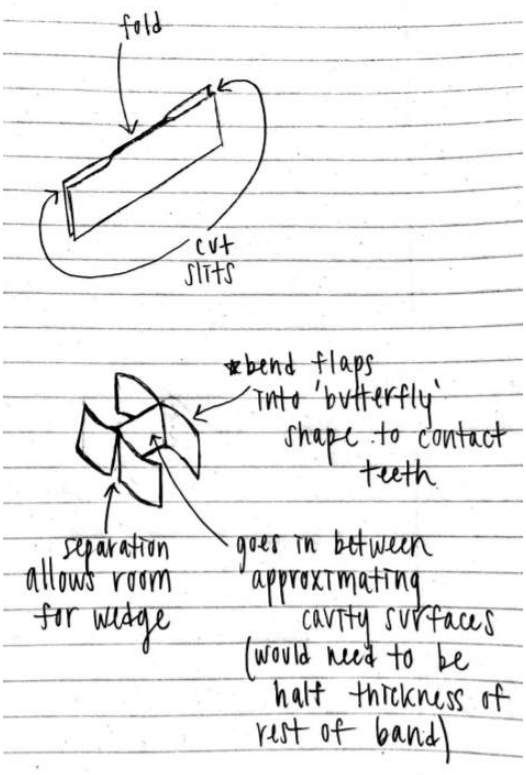
Content by: Grace

Present: Grace

Goals: To review with Tara the feedback that she received from a current dentist with a background in BME on our Butterfly + U Pinchers design and suggest possible updates for the design.

Content:

- The dentist suggested some modifications to our design and necessary components that she believes will make it functional based on her dental experience
  - The device will still need to use a wedge and a ring
    - These tools are necessary for separating the teeth and stabilizing the band
  - In order to allow for a wedge, the bands in between the teeth must not be connected on the gum side
    - Wedge will fit in this separation of bands, while the tops of the bands are still connected
    - Trevor had an idea for how we could fabricate the thin metal we use to have this upper attachment but lower separation to allow for the wedge, as seen in my drawing below



- The band would additionally need a piece coming off the top of the fold that had a hole for easy placement and removal of the device

- The most difficult part of fabricating this would be incorporating the half thickness between approximating cavity surfaces

Conclusions/action items: Tara plans to talk to the dentist again to reiterate all of her suggestions, but the feedback we currently have from her is very helpful in improving our design. I think the fabrication suggestions as outlined in the drawing could work - the team needs to get started with making a prototype and adjusting as necessary.

11/12/21 Updated CAD Design

GRACE JOHNSON - Dec 14, 2021, 11:13 PM CST

Title: Updated CAD Design

Date: 11/12/21

Content by: Grace

Present: Grace

Goals: To review the updated design that the team was able to make a CAD model for.

Content:

- Matt made a CAD model of our initial folded design idea (as seen in attached images)
- The model would follow similar fabrication steps as first thought with the initial folded design but now has the desired tab with the hole incorporated
- a wedge and a ring could also still be used
- the thickness of material used to fabricate this design would need to be half the thickness of a standard matrix band
    - when the material is folded, the two sheets would come together at the center part to be the thickness of a single band

Conclusions/action items: Now that we have the CAD model for this design and we believe it will be much easier to fabricate than our original Butterfly + U Pinchers design, we will run it by Dr. Tipple. After receiving his feedback, we may make some design updates before finalizing the design for fabrication.

GRACE JOHNSON - Dec 14, 2021, 11:12 PM CST

image_4_.png(281.3 KB) - download

GRACE JOHNSON - Dec 14, 2021, 11:12 PM CST

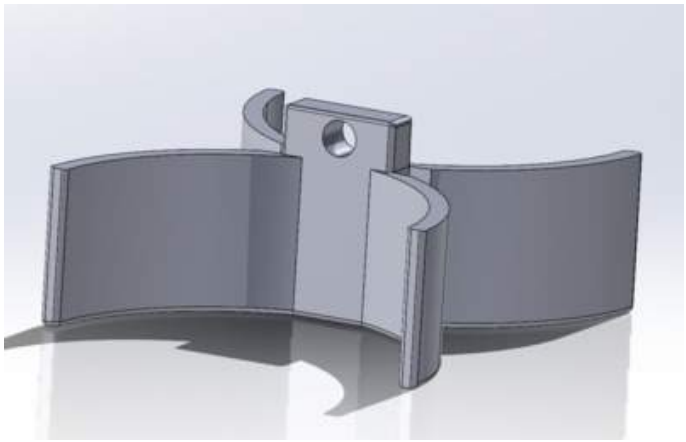


image_5_.png(281 KB) - download

GRACE JOHNSON - Dec 14, 2021, 11:12 PM CST

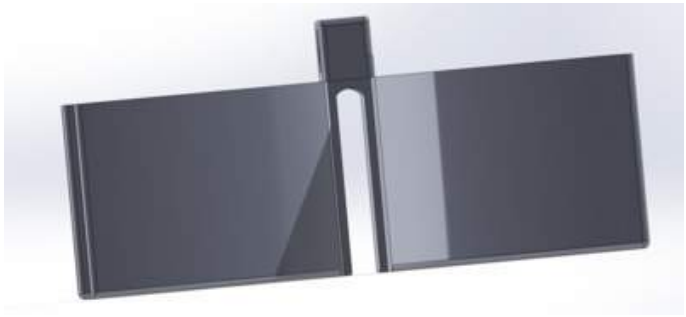


image_6_.png(855.5 KB) - download

11/18/21 Client Design Feedback

GRACE JOHNSON - Dec 14, 2021, 10:57 PM CST

Title: Client Design Feedback

Date: 11/18/21

Content by: Grace

Present: Grace

Goals: After reaching out to Dr. Tipple with our current design idea, he provided us with some feedback and advice. The goal is to review that and apply it to our design.

Content:

(see attached images)

Dr. Tipple's ideas were:

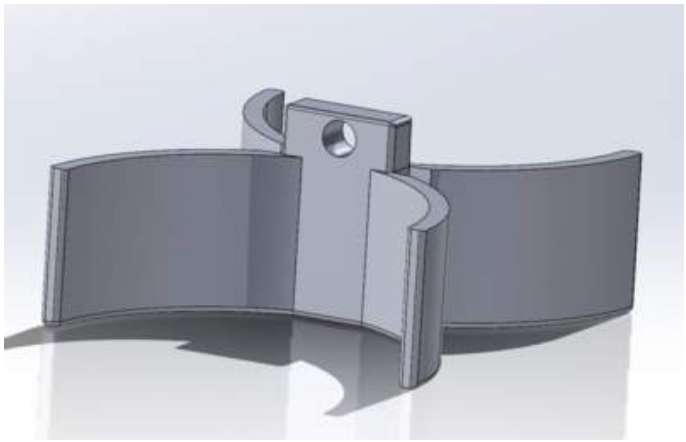
- To add a convex contour to the gingival
  - This just means make the bottom edge of the band that contacts the gums convex for stability purposes and to prevent gingival overhang during filling procedures
- Because the gap only serves purpose for fitting a wedge, to only make it 2 mm high at the gingival
  - This means make the gap shorter so that it only raises 2 mm up from the bottom edge of the band
- To consider making the cross section of the tab with the hole in it flower out towards the distal and mesial so that the fillings are naturally contoured away from each other
  - contact point of teeth from the biting surface flowers out like this because the surfaces are convex, mimic that shape for fillings
  - this requires the tab to be split into two sheets rather than be one piece
    - the two sheets could then be contoured away from each other after placement

Conclusions/action items: These recommendations are all very easy to incorporate into our design and will make it more functional in dental use. We will move forward in updating our CAD model with these changes so that we can fabricate ASAP.

GRACE JOHNSON - Dec 14, 2021, 10:58 PM CST

image_4_.png(281.3 KB) - download

GRACE JOHNSON - Dec 14, 2021, 10:58 PM CST



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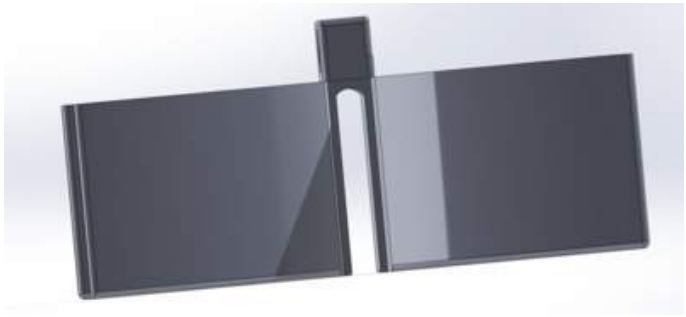
GRACE JOHNSON - Dec 14, 2021, 10:58 PM CST



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12/1/21 Initial Fabrication Idea

GRACE JOHNSON - Dec 14, 2021, 10:44 PM CST

Title: Initial Fabrication Idea

Date: 12/1/21

Content by: Grace

Present: Grace

Goals: To make a first, rough draft, not to scale prototype of our matrix band with the shim stock material we ordered.

Content:

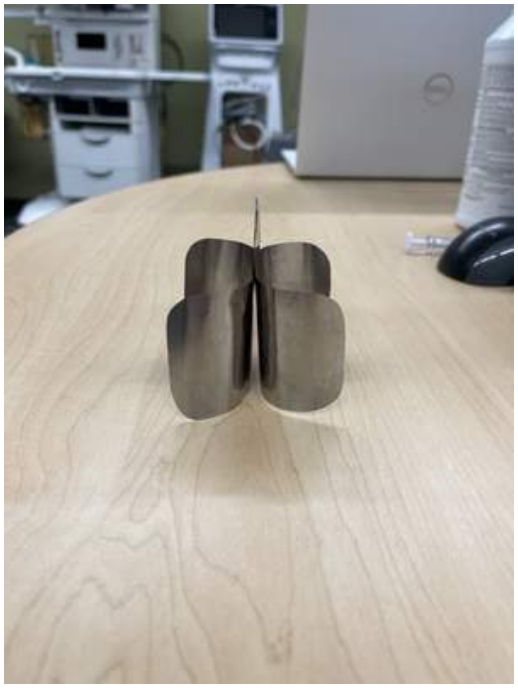
- We decided to create a larger version of our matrix band design to figure out how to best use the shim stock material and enlarge details of the prototype

(see attached images)

- We used scissors, a calipers, and a hole punch to create this initial design
- We wanted to focus on the details of curved edges for safety, the hole at the top for placement of the band in a patient's mouth, and minimizing the space where the two bands touch
- a difficulty we ran into in our fabrication process was folding the shim stock
    - if we creased it too hard, the material would snap at the crease
    - if we did not crease it enough, the two sheets would not be folded together close enough
    - this may cause problems when we fabricate a smaller, to scale model

Conclusions/action items: This initial fabricated design will be great to showcase at the poster presentation. The team now has to decide if fabricating a smaller, to scale matrix band using the same methods is effective enough. We may need to look into using a more precise cutting method and a different way to create the hole.

GRACE JOHNSON - Dec 14, 2021, 10:44 PM CST



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GRACE JOHNSON - Dec 14, 2021, 10:45 PM CST

IMG_5227_1_.jpg(1.9 MB) - download

GRACE JOHNSON - Dec 14, 2021, 10:45 PM CST

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IMG_5229_1_.jpg(2.2 MB) - download

12/9/21 Final Poster Design Criteria

GRACE JOHNSON - Dec 12, 2021, 3:28 PM CST

Title: Final Poster Design Criteria

Date: 12/9/21

Content by: Grace

Present: Grace

Goals: To finalize the design criteria section of the final poster presentation to detail the specifications our matrix band device must satisfy.

Content:

In terms of size, matrix bands come in thicknesses between 0.0254 and 0.0508 mm, which is between 1 and 2 thousandths of an inch [1]. They must be this thin to create the proper tooth contact during the procedure. The bands also typically come in heights of up to about 10 mm. This is to accommodate varying tooth crown heights, which can range between 7.2 and 11.2 mm. Matrix bands must be able to shape around varying tooth sizes, which can vary widely in perimeter from 22 to 45.8 mm [2].

In terms of the material used to make the matrix band, it must be malleable and easy to shape. Additionally, it must be non-toxic and cause no harm to patients during the procedure. The matrix band material must not react with any filling materials either. The mechanical properties of the material used to fabricate the matrix band device must be similar to those of existing band materials. Existing bands are typically made from a dead-soft stainless steel, which exhibits a tensile strength between 260 and 340 MPa and an elastic modulus between 200 and 215 GPa [3].

In terms of performance, the band must be single-use and disposable. It must function in providing a rigid contour for the filling material so that the shape of the pre-existing tooth may be held. The device must be convex at its bottom edge to prevent any filling material from entering the gingiva and causing infection. The matrix band must be as easy to place and remove from the teeth as current bands are. Overall, the designed device must allow for a shorter procedural time. Current restoration procedures using matrix bands can take up to 30 minutes per tooth, so the team's device must shorten this by allow simultaneous filling of two teeth.

[1] “JR Rand Tofflemire,” Net32. [Online]. Available: https://www.net32.com/search?q=JR%2BRand%2BTofflemire%2Btype. [Accessed: 22-Sep-2021].

[2] R. SCHEID and G. WEISS, Woelfel's dental anatomy. BURLINGTON, MA: JONES & BARTLETT LEARNING, 2020.

[3] “ASTM A109 Grade no. 5 dead-soft,” *Matmatch*. [Online]. Available: https://matmatch.com/materials/minfm65939-astm-a109-grade-no-5-dead-soft. [Accessed: 20-Oct-2021].

Conclusions/action items: I will practice this part of the presentation before tomorrow's poster session. I will also use this to rewrite our design specifications section of the final report, since it was far too lengthy in the preliminary report.

12/14/21 Final Design & Fabrication Methods

GRACE JOHNSON - Dec 14, 2021, 1:20 PM CST

Title: Fabrication Methods

Date: 12/14/21

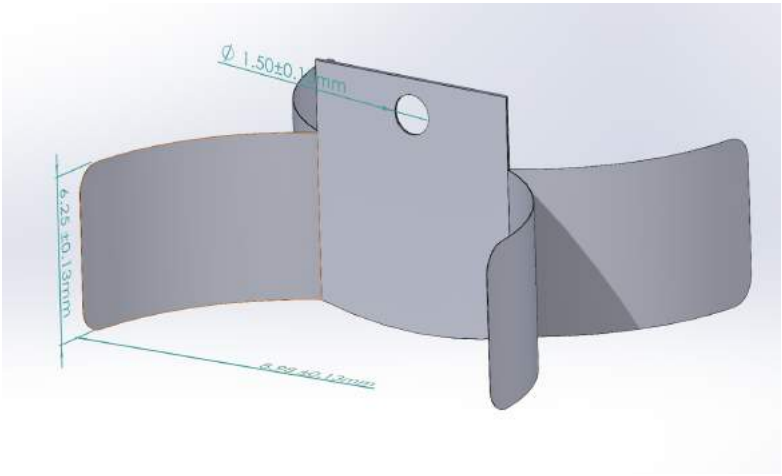
Content by: Grace

Present: Grace

Goals: To describe how the team transitioned from the proposed final design to the final design and the exact methods the team used to create the prototype so that they may be added into the final report.

Content:

After concluding that the proposed final design, the Butterfly + U Pinchers Design, would require a tedious and difficult fabrication process due to necessary welding, the team decided to move forward in a different direction. The Butterfly Design was reconsidered, and adjustments were made to the design so that it better satisfied the client's needs and the specified design criteria. The updated Butterfly Design, as seen in the figure below, can be made from a single sheet of material, decidedly the 1008 steel, to make the fabrication process more feasible for the team and for possible mass production. The design has a band thickness throughout of 0.0254 mm, except at the center portion where the thickness is twice that, 0.0508 mm, due to folding of the steel sheet. Its height is 6.25 mm, consistent with the height of the circumferential matrix bands given to the team by the client. The updated design incorporates rounded edges for safety in the patient's mouth, a holed tab to aid in placement and removal of the device, and a convex bottom edge to prevent filling material from entering the gingiva during a procedure. Due to the folded nature of the design, there is space between each band to allow the use of a wedge during a procedure as well.



Updated Butterfly Design. Dimensions of the device include a height of 6.25 mm, a band radius of 8.98 mm, a hole diameter of 1.5 mm, and a material thickness of 0.0254 mm. Key features include rounded edges for safety, a holed tab for placement/removal, and a convex bottom edge for preventing the escapement of filling material.

The team initially fabricated an enlarged, unscaled prototype to emphasize the details of the design and ensure the 1008 steel could be modified for the design's purposes. A six inch by five inch rectangular sheet was measured from the 1008 steel using calipers and was cut with scissors. This sheet was then folded to create two equal three inch by five inch halves. One inch deep cuts were made on both ends of the fold, two inches in from the short edges. These were then cut towards the short edges to remove the entire top corners of the fold to create the tab. The four leaflets created from these cuts were then shaped with a rounded cylinder to create the outward facing bands that contour the teeth. A hole punch was used through both sides of the folded tab to create the hole. The edges of the band leaflets as well as the edges of the tab were carefully rounded using the scissors.

After finishing the enlarged prototype, smaller scaled prototypes were made following the same methods. The team, however, was unable to create smaller details of the design including the hole in the tab and the rounded edges using these methods.

Conclusions/action items: I will now add this to the final report and continue making edits as I see fit.

Matrix Band Evolution

MATTHEW FANG (mjfang@wisc.edu) - Sep 13, 2021, 8:45 PM CDT

Title: Matrix Band Evolution

Date: 9/13/2021

Content by: Matthew Fang

Present:

Goals: Determine how dental matrix bands have evolved over time in medical history

Content:

- Survey conducted from Egyptian dentists to determine the method they use for matrix surface banding.
    - Sectional prefered over circumferencial.
    - Most common technique is Torvm classic
        - Followed by torvm delta and torvm md
    - Improper wedges but proper tightness of proximal contacts
- "74% of the dentists preferred using the sectional matrix systems and 63% of the dentists considered the sectional matrix systems to be easily used and applied compared to the circumferential matrix systems "
- The sectional matrix systems are sensitive due to their rounded contours and thin thickness, which can cause a depression or bending in the matrix material during placement, rendering it unusable

Conclusions/action items:

Cite:

Shaalan O. O. (2020). Evaluation of Matrix Band Systems for Posterior Proximal Restorations among Egyptian Dentists: A Cross-Sectional Survey. *Acta stomatologica Croatica*, *54*(4), 392–400. https://doi.org/10.15644/asc54/4/6

Use for Matrix Band

MATTHEW FANG (mjfang@wisc.edu) - Sep 13, 2021, 9:17 PM CDT

Title: Use for Matrix Band

Date: 9/13/2021

Content by: Matthew Fang

Present:

Goals: Determine the specific use in technical terms for a matrix band

Content:

- Purpose is to restore contact areas within teeth
- Properties of a good matrix
  - Be rigid against the existing tooth structure
  - Establish proper anatomic contour
  - Restore correct proximal contact relation
  - Prevent gingival overhang
  - Be able to be easily removed
- Most normal matrix retainer (placers) have a head to guide the band, and then 2 knobs to lock diameter and slide the band out of the device
- Wedges help compress matrix bands to get a tighter seal on the teeth
  - Wedges are put in longitudinally instead of laterally.
- Bands should seal around a tooth such that
  - The occlusal portion of the band extends 1.5 – 2.0 mm above the marginal ridge of the adjacent tooth and the cavosurface margin (proper condensation)
  - The gingival portion of the band extends 0.5 mm below the gingival CSM

Conclusions/action items:

http://www.columbia.edu/itc/hs/dental/operative/matrixband.html

White Filling Material

MATTHEW FANG (mjfang@wisc.edu) - Sep 21, 2021, 9:48 PM CDT

Title: Dental Wedges

Date: 9/21/21

Content by: Matthew Fang

Present:

Goals: Determine what the purpose of a wedge is

Content:

- Mostly deal with overhanging filament in proximal area during procedures
- Can help angle the matrix band correctly
    - Wedges size ands shape can depend on getting this angle right]
    - Consider
        - Convergence angle
        - Mesiodistal width of base
        - Gingivo-occlusal height of transverse
        - Concavity of side walls
- Convergence angle is from horizontal plane to adjacent tooth
- Wedge height affects restored contact point

Conclusions/action items:

ELI, I., WEISS, E., KOZLOVSKY, A. and LEVI, N. (1991), Wedges in restorative dentistry: principles and applications. Journal of Oral Rehabilitation, 18: 257-264. https://doi.org/10.1111/j.1365-2842.1991.tb00055.x

Dead Soft Metal

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 3:59 PM CDT

Title: Dead Soft Material

Date: 9/22/2021

Content by:

Present:

Goals: Determine what a dead soft material is

Content:

- Soft and malleable
  - "Relaxed shape" at molecular metal
- Runs risk of not holding structure
- Often has less carbon than other metals

Conclusions/action items:

Bell, Eddie. “Understanding Metal Hardness.” *Rio Grande*, 29 Oct. 2020, www.riogrande.com/article?name=UnderstandingMetalHardness.

Molar Sizes

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 4:02 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Celebi, A. A., Lee, S. H., & Kau, C. H. (2017). Size discrepancies in molars and first key to optimal occlusion. *European journal of dentistry*, *11*(2), 250–252. https://doi.org/10.4103/ejd.ejd_339_16

- The maxillary measurements ranged from 3.6 to 6.9 mm with an average of 5.2 mm
    - The mandibular measurements ranged from 5.0 to 8.0 mm with an average of 6.5 mm
- On average, the mesiodistal length measured on maxillary first molars was about 80% of that of their mandibular counterparts.

Table 1:

Table 1: Distance of reference points (mm)

Measurements	*n*	Mean	SD	P
mbdbmax right (a)	78	5.12	0.68	0.004⋆
mboemand right (a1)	78	6.41	0.55	
mbdbmax left (b)	78	5.22	0.66	0.003⋆
mboemand left (b1)	78	6.52	0.54	
a/a1	78	80.3	10.7	0.93
b/b1	78	80.4	10.2	
⋆Statistically significant for *P*<0.05. SD: Standard deviation				

Conclusions/action items:

Global Implication

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 10:21 PM CDT

Title: Global Implication

Date: 10/15/21

Content by: Matthew Fang

Present:

Goals: Determine Global Implication of creating matrix band for interproximal cavities

Content:

- Generally, oral diseases and alterations are frequent and represent real oral health problems, affecting approximately 3.9 billion people around the world
    - Untreated dental caries in the permanent dentition affects 35% of people in all age groups worldwide. However, untreated dental caries in primary teeth affects 9% of the world's population.
- The main consequence of dental caries is tooth loss, which is also a prevalent oral condition.
    - Dental caries is a disease of the hard tissues of the tooth, and it is caused by an imbalance in the demineralization and remineralization processes on dental surfaces.
- Over the past decades, evidence has accumulated in several countries about the decrease in the prevalence and severity of this disease, and also an increasing number of caries-free individuals.

Conclusions/action items:

Lucas-Rincón, S. E., Robles-Bermeo, N. L., Lara-Carrillo, E., Scougall-Vilchis, R. J., Pontigo-Loyola, A. P., Rueda-Ibarra, V., Loyola-Rodríguez, J. P., Escoffié-Ramirez, M., & Medina-Solís, C. E. (2019). Interproximal caries and premature tooth loss in primary dentition as risk factors for loss of space in the posterior sector: A cross-sectional study. *Medicine*, *98*(11), e14875. https://doi.org/10.1097/MD.0000000000014875

Feeler Gauge Shim Stock Research

MATTHEW FANG (mjfang@wisc.edu) - Dec 15, 2021, 12:43 PM CST

Title: Feeler Gauge Research

Date: 11/15/21

Content by: Matthew Fang

Present:

Goals: Determine if we can use feeler gauges to create our model. I have experience using them and I feel like it might work

Content:

- Used for precise measurements that are on a very small scale
- Used in dental practice
  - Place the crown onto the prepared tooth.
  - Measure the gap by choosing the appropriate leave(s) of a feeler gauge. The proper number of leaves must pass the gap with the same amount of friction as dental floss passes through the contact point
  - The technician can restore the contact point(s) using the information provided.
- Typically half an inch wide
  - Will probably be too short for us to use if we want to pursue the folding method

Conclusions/action items:

Unusable I believe due to width issue

Morrow, R. M. (1986). *Dental Laboratory Procedures: Fixed Partial Dentures*. Mosby Elsevier Health Science.

Retainer Device #1

MATTHEW FANG (mjfang@wisc.edu) - Sep 13, 2021, 9:43 PM CDT

Title: Competing Design #1

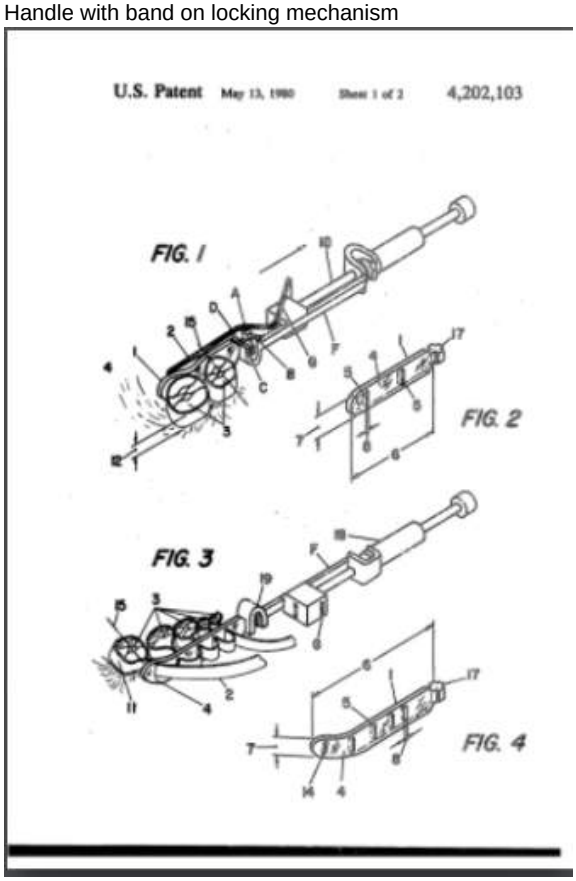
Date: 9/12/2021

Content by: Matthew Fang

Present:

Goals:

Content:

- Handle with band on locking mechanism


- The slot is the proper size to allow looping of the tooth

Conclusions/action items:

https://patents.google.com/patent/US4202103

Existing Model (for price)

MATTHEW FANG (mjfang@wisc.edu) - Sep 23, 2021, 4:48 PM CDT

Title: Existing Model (for price)

Date: 9/23/21

Content by: Matthew Fang

Present:

Goals: Determine the price of the average dental matrix band

Content:

- On average the matrix bands range from 50 cents to 1 dollar per unit.
- Often the devies are sterilized after use?
  - Might be only refering to the tofflemeir.
  - Supposed to be 1 time use according to client
- Only 7% change the band per new patient
  - 54% of dentists find it unnecessary to change the bands out
- Studies show that cleaning is unreliable/difficult to do correctly

Conclusions/action items:

Lowe, A., Burke, F., McHugh, S. *et al.* A survey of the use of matrix bands and their decontamination in general dental practice. *Br Dent J* **192,** 40–42 (2002). https://doi.org/10.1038/sj.bdj.4801286

Class of Medical Device

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 10:34 PM CDT

Title: Med Device Class

Date: Determine what the class of medical device our model will be

Content by: Matthew Fang

Present:

Goals:

Content:

https://www.accessdata.fda.gov/cdrh_docs/pdf9/K091533.pdf

- Device = Class 1
- Medical Specialty = Dental
- Needs to pass biocompatibility and shear force testing

Conclusions/action items:

Stainless Steel Outsourcing Research

MATTHEW FANG (mjfang@wisc.edu) - Dec 15, 2021, 12:57 PM CST

Title: Stainless Steel Research

Date: 11/22/21

Content by: Matthew Fang

Present:

Goals: Determine the typical tensile strength of a thin stainless steel band

Content:

- **3 types of bands**
  - 201
  - 304
  - 316
- American steel is generally higher grade?
- 201/304 are better at thinner lengths (.015"-.025")
  - 201/316 generally more suited for .03"+
- When looking for a vendor
  - Look for quick shipment
  - Location of vendor
  - Look for inventory to make sure they are credited and able to work quickly

Conclusions/action items:

https://www.isostainless.com/the-stainless-steel-banding-guide/

2 in 1 Loop design

Butterfly with U pinchers v1 CAD

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 8:54 PM CDT

Title: Butterfly with U pinchers v1

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 8:54 PM CDT

v1.pdf(3.4 MB) - download

Butterfly with U pinchers v2 CAD (for prelim pres)

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 9:00 PM CDT

Title: U Pinchers v2

Date:

Content by:

Present:

Goals:

Content:

Edit the preliminary design for the U pinchers design so we can show an updated model for the presentation.

Conclusions/action items:

MATTHEW FANG (mjfang@wisc.edu) - Oct 19, 2021, 8:55 PM CDT

v2.pdf(3.7 MB) - download

Folded Model

MATTHEW FANG (mjfang@wisc.edu) - Dec 15, 2021, 12:07 AM CST

Title: Folded Model CAD

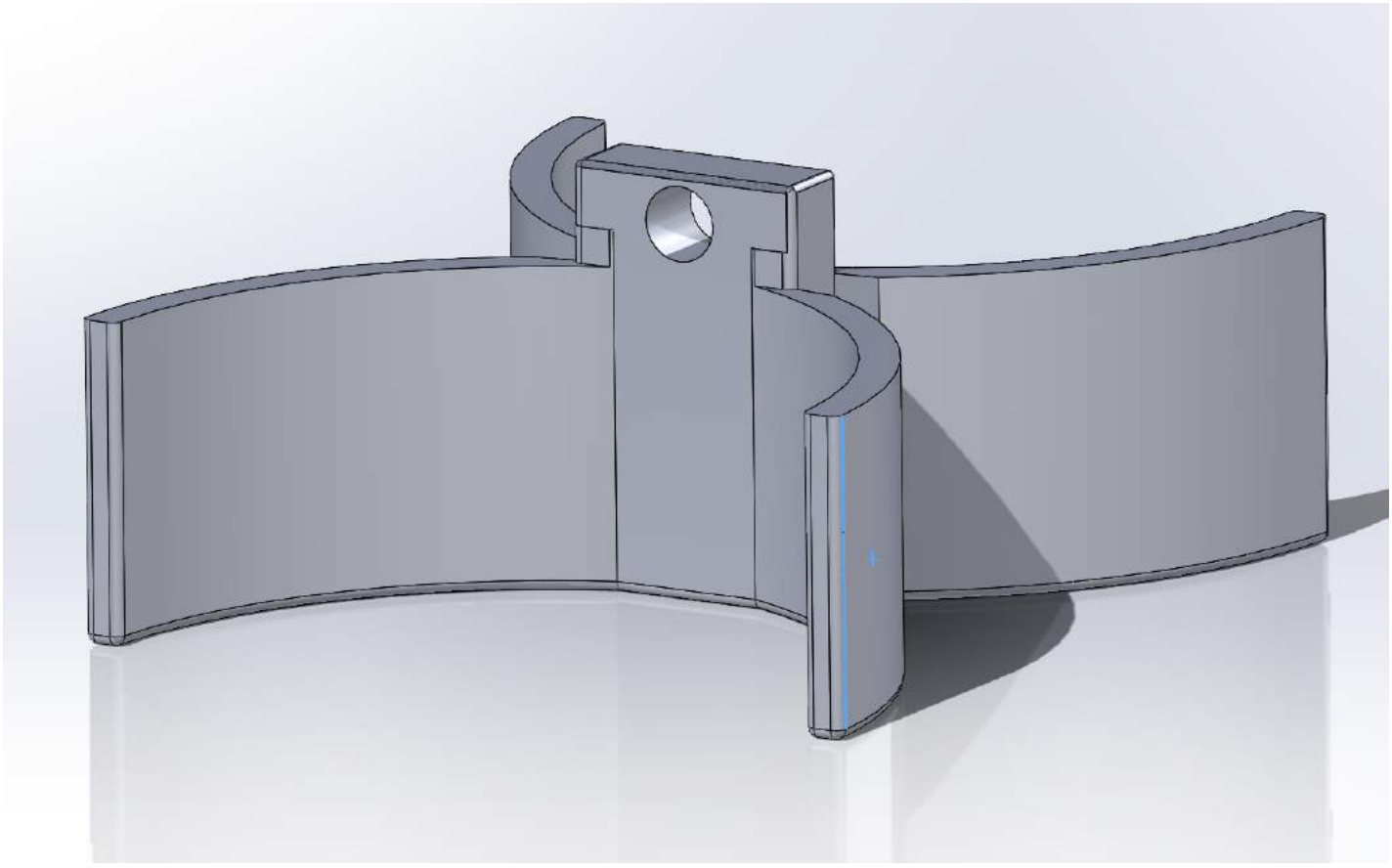
Date: 11/2/21

Content by: Matthew Fang

Present:

Goals: Create a CAD model to easy show to client and others how we plan to fabricate an easy version of the butterfly design

Content:



Conclusions/action items:

Folded Model 2.0

MATTHEW FANG (mjfang@wisc.edu) - Dec 15, 2021, 12:10 AM CST

Title: Revised Folded Model

Date: 12/7/21

Content by: Matthew Fang

Present:

Goals: Redesign the folded model to have proper dimensions and fit more tightly at the center of the "wings". Also add the dimensions so we can add it to the poster

Content:

Conclusions/action items:

2021/09/22 - Background Dental Info and Terminology

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 12:15 PM CST

Title: Dental Terminology and Basics

Date: September 22, 2021

Content by: Draeson Marcoux

Present:

Goals: To gain baseline knowledge necessary and relevant to dental cavity repair

Content:

1. "Do You Have A Cavity Between Your Teeth?" - https://www.healthline.com/health/cavity-between-teeth
    1. A cavity goes through the enamel and into the second layer called dentin
    2. Materials such as percelain, gold, silver, resin or amalgam are often used in restorations
    3. For deep cavities, more than halfway into the enamel, the area is often drilled out
    4. A root canal is a procedure done when the cavity is sever. To save the tooth the pulp is also removed, and the tooth is cleaned, disinfected, shaped and filled
    5. The bacteria *Streptococcus mutans* causes plaque to form which contains acids that demineralize the enamel, which is made primarily of calcium and phosphate, and creates small holes.

1. "Making Contact: A Method for Restoring Adjacent Posterior Direct Resin" - https://www.dentistrytoday.com/making-contact-a-method-for-restoring-adjacent-posterior-direct-resin/
    1. Proximal contact is important for supportive and protective reasons. Protects against plaque and supportive by force deflection to adjacent teeth.
    2. Tooth size, location, contours, adjacent tooth position, contact location and gingival location are all important factors that must be considered before a restoration procedure on the posterior teeth.
    3. Resin-based posterior restorations are placed twice as frequently as amalgam due to consistent concerns regarding mercury content
    4. Clinicians are still looking for a great technique for predictable and consistent placement of class II resin restorations, and even more daunting is doing multiple and adjacent fillings efficiently and successfully.
    5. Protocol for "placing multiple posterior resins in adjacent teeth, resulting in excellent marginal seal and ideal interproximal contacts"
        1. Characteristics of a "Correct" Contact
            1. Contact naturally occurs through tooth eruption and migration, making it a dynamic process that is dependent upon many genetic and environmental factors, meaning exact contacts vary from person to person.
            2. Figure 1 shows an analysis from a 1939 study by G. V. Black on posterior tooth contacts. It shows CP = contact point; IC = area cervically adjacent to the contact point; NSG = normal septal ginvgiva; ACJ = amello-cemental junction; RSG = receded septival gingiva; BGC = Buccal gingival crest; LGC = lingual gingival crest.
            3. Figure 2 shows the superior angle of a row of teeth. Naturally ocurring contacts can be seen clearly.

4. Figure 3 shows the SuperCurve Matrix by Triodent. It is a sectional matrix band that recreates the general contour of the tooth. It is also shaped and coated for easier placement and removal
5. Important characteristics of interproximal contacts include:
    1. Buccolingually centered below the marginal ridges
    2. Highly convex in middle and occlusal thirds
    3. Flat or concave (in the case of gingival recession) in the cervical third
6. Sectional matrices provide tighter contacts for posterior resin restorations (studies done)

2. "Planning for Placement of Multiple Adjacent Restorations
    1. Visual and Radiographic analysis to determine extent and location of caries (cavities)
    2. Assess adjacent teeth to ensure proper anatomy and shape
    3. Protect adjacent teeth
    4. Prepare teeth with caries
    5. Place matrix band (or other system) to ensure anatomic contours can be placed, packed and solidified
    6. Use the pre-etch technique to optimize the seal of the occlusal portion of the restoration
    7. Create an adhesive seal to the resin to the tooth
    8. Use glass ionomers in the proximal cervical area in high-risk or root caries
3. Case Report
    1. 57 year old male with adjacent class II resin restorations on the maxillary bicuspids. New caries within the restorations were found requiring replacement. Periodontal probing depth of 2mm and 1-2mm of gingival recession in the area. Tooth structure and occlusal scheme were sufficient for resin restoration. Distal occlusal (DO) restoration on the first bicuspid and mesial occlusal (MO) replacement on the second bicuspid.
    2. 37% phosphoric acid gel used on the occlusal enamel and adjacent fissures as part of pre-etching. A wedge guard was placed in the interproximal space to separate teeth and protect against preparation. Damaged tooth is removed. The dental matrices are placed and secured. "hot dog" resin placed against wall of dental matrix which creates a hole that can be filled in.
    3. Sectional matrices provide the fastest and most predictable resin placement.
    4. Pin-Tweezers (Triodent), a positive holding plier, two 4.5 mm V3 Tab Matrices (Triodent), a large (purple) Wave-Wedge (Triodent), and a narrow (yellow) V ring were used in the placement of the system. No need to burnish when using this technique, but necessary in many others for proper contact.
    5. Pre-etching of the peripheral enamel margins may be added to cleanse the area and provide better adhesion for the filling material
    6. A thin layer of heavily filled flowable resin is then placed in the proximal boxes and areas with sharp angles (from preparation). This layer is cured for about 30 seconds."Hot dog" forms of filling material are created and placed along the walls of the tooth and cavity to create a basin-like shape for the rest of the filling material.
    7. The tooth is then tinted white with a microbrush wetted with a tinting chemical. The filling material is also condensed and smoothed with a

resin-wetted microbrush and cured. The same technique is used on both teeth.

8. The tooth is finally polished with a carbide bur and shaped to ensure proper contour. A surface sealant is also placed and cured for 30 seconds.

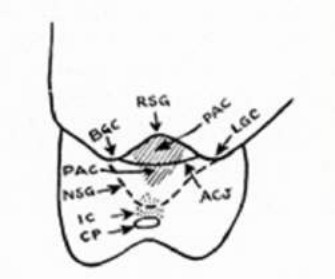


Figure 1: 1939 G. V. Black analysis of posterior contact

Figure 2: Naturally occurring tooth contacs

Figure 3: SuperCurve Matrix (Triodent)

Figure 4. Pretreatment adjacent failing Class II resin restorations.

Figure 5. Wedge (WedgeGuard [Triodent]) was inserted to facilitate tooth separation and rapid preparation.

Figure 6. Final adjacent preparations.

Figure 7. Placement of sealed adjacent matrices with Wave-Wedge (Triodent).

Figure 8. Simultaneous adhesive preparation of seated matrices.

Figure 9. IPC instrument with convenient “hot dog” form of resin for placement in proximal area.

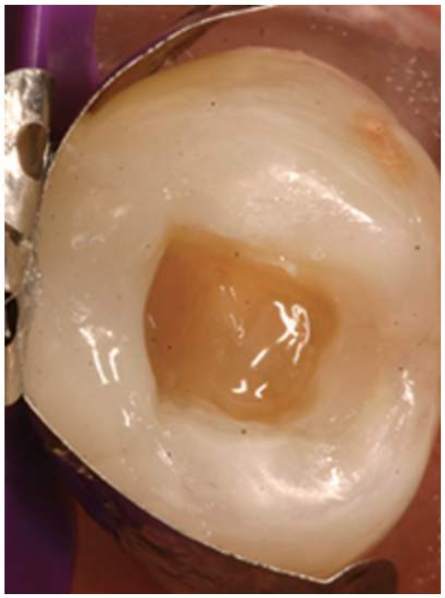


Figure 10. Placement of proximal wall with resin hot dog form.

Figure 11. Completion of first restoration and proximal wall of adjacent tooth.

Conclusions/action items:

This background information on the physiology of a cavity must be considered as it will interact with our designed matrix band. Additionally, the chemicals and tools used throughout the procedure must be considered. Gaining insight into the procedural techniques will also help in designing a more functional, and easy to use matrix band.

2021/09/22 - History of Dental Matrices

DRAESON MARCOUX (dmarcoux@wisc.edu) - Oct 20, 2021, 3:04 PM CDT

Title: Historical Background on Dental Matrices

Date: Sept. 22, 2021

Content by: Draeson Marcoux

Present: N/A

Goals: To gather background information on the inception and evolution of dental matrices to this point.

Content:

"A Historical Review of Dental Matrices" - https://www.mda.org.my/mdj/archieve/2011-02/2011-Ahistorical.pdf

1. Matrix Bands
    1. Matrix - "a mould in which something is cast or shaped" (Clinically - "thin strip adapted around the tooth to supply missing walls and contours against which restorative materials may be placed and condensed").
    2. Proximoocclusal amalgam restoration is a common procedure where they are used and essential. For these procedures, the efficacy of the matrix band is imperative to the success of the restoration. Overhang can cause stress concentrations and failure of the filling.

1. Requirements of ideal matrix
    1. Amalgam is a strong material that is condensed firmly, therefore the matrix must have significant rigidity and integrity to prevent deformities.
    2. The surface of the band should be able to match even convex regions of the perimeter of the tooth but without damaging gingival tissue. This also helps eliminate the need for carving of the tooth.
    3. The use of dental wedges helps push the matrix band flush against the tooth, especially towards the root end, near where contact is made. This is important to prevent filling material from getting into the gingival tissue and overhang.
    4. Proper size selection for the dental wedge is important as wedges that are too large can cause displacement of the band and a wedge that is too small can allow slippage of the band and leakage of the filling.
    5. When the matrix band is removed from the interproximal space, it generates a contact void equal to the thickness of the band. Wedges are used to open and maintain this space when bands are being used with thinner bands requiring less wedging.
    6. Space (thickness) should be kept to a minimum without compromising the integrity of the band. Common thicknesses are about 0.015 - 0.02 inches.
    7. How smooth the finish of the matrix band is can effect things like the smoothness of the filling and consequently how plaque retentive it is. A smoother matrix band provide less plaque retention and creates a proper ridge.
    8. Should be sterilizable, compatible with restorative materials, and non-toxic.

1. Function

1. Provide walls for cavity preparation and serves as a mold for filling material and setting of the filling. The crown height of the band should match that of the tooth for a proper restorative crown to form.
2. The wedge and matrix band determine the separation of the contact area

1. Types of Matrices Available
    1. Custom-made
        1. A "Black's tie band" or Black's matrix band is a thin piece of metal, generally copper, glass, German silver, or stainless steel that is long enough to seal about half the tooth. A ligature is used to bind it to the tooth and the band is forced into the contours.
        2. (1937) "Compound and wedge-supported" matrix bands are a modified version of Black's bands which use a low fusing compound to bind the band to the tooth. This survived even high packing forces when amalgam was placed. Bands in 1940 were made from .002 inch untempered steel and triangular wedges made of wood were used for a tighter fit and widening the interproximal space. Extended 1mm above the crown and into the gingival tissue.
        3. (1955) Ingraham and Koser's 4 requirements for successful class II amalgam resoration: conformation to natural tooth contour, proper contact with adjacent tooth, correct marginal adaptation and proper filling density.
        4. (1970's) The T-band became commonly used for class II multi-surface amalgam restorations. Available in wide or narrow, curved or straight, and brass or stainless steel. In 1944 Bailes created a 1.5 inch long and 0.002 inch thick, that was processed by wrapping around the tooth using matrix-forming pliers, adding soldering material to the contours, then heated and cooled to bind them into shape.
        5. Tinner's Joint is used when a solder is not available. Excess band after wrapping the tooth is cut off slightly on one side and the longer side is wrapped around to secure the tooth and pliers are used to conform to the contours.
    2. Preformed
        1. Sectional matrix bands are used in conjunction with the Palodent brand matrix (or any other kind of current matrix ring). The sectional matrix band is placed, the matrix ring is spread with a rubber dam clamp holder, a warm modeling compound is placed on top of the ring and this complex is placed on the lingual and buccal sides of the tooth, on the ends of the sectional band. These are generally used for more minor restorations. 2 can be used in conjunction with 2 matrix rings. The band can then be burnished to improve contour and finish. Drawbacks to this system include time consumption, and obstruction.  **Figure 1**. Palodent matrix with sectional matrix bands shown.
        2. Circumferential matrix bands are generally used on more decayed and more complex procedures. The proper size is selected for the tooth, the band is annealed by heating

and quenching in water, the buccal side is scored to facilitate post-operative removal, and finally the band is placed and contoured with contouring pliers. Additional support/contouring is done with wedges and/or modeling compound.

3. (1977) Automatrix or retainerless matrix band by L.D. Chaulk Co. Milford Del operate as a pre-built band, wrapped into a circle with a coil of excess band and a pin mechanism. It comes with a tool that can be inserted into the coil and twisted to loosen or tight the band, and is available in 4 sizes. Dental wedges are often used to improve this contour and fit. This design is easy and quick to use for even complex, severe restorations.

Figure 2. Automatrix TM L.D. Caulk Co

3. Mechancial Retainers
    1. Ivory no 1 is a mechanical retainer often used in class I or unilateral restorations as it holds a band that provides structure for a single proximal surface. This is good for restorations where the interproximal space is very small or there is no adjacent tooth (circumferential band cannot be used) as the matrix band is secured to 2 projections on the adjustable retainer and wedges.
    2. Circumferential retainers hold, adjust and remove traditional circumferential matrix bands. These retainers include Ivory no 8, no 9, Siqveland, Wagner and Tofflemire.
        1. The Siqveland retainer, commonly used in the U.K., is self-adjusting and can be used on all teeth, utilizing a swivel lock. However, this is not the best for gingival ledges and overhangs. Wedging is also still recommended.

Figure 5. Siqveland Matrix Band

        2. The Tofflemire system uses both bands and retainers, where the bands can be placed in the two slits of the retainer forming a circular protrusion with the band that can be placed around the tooth. A screw can then be

tightened, moving the slide towards the head of the retainer and tightening the matrix band. This mechanism can be locked and released easily and quickly. The bands are made from stainless steel and available in 4 styles for both the 0.002 and 0.0015 inch thicknesses. Multiple other bands can also be used.

Figure 6. Tofflernire Matrix Retainer

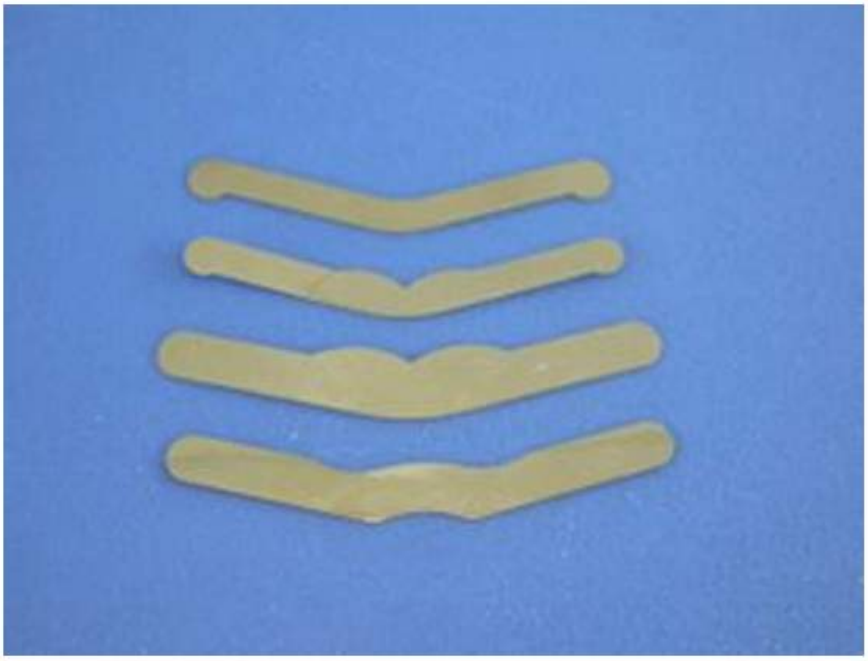


Figure 7. Tofflenire Matrix Band

3. The Omni-Matrix TM from Ultradent is a disposable matrix retainer with pre-loaded band. The product consists of a single-piece, plastic, lightweight retainer loaded with a 0.002" mylar bands or metal band. The metal bands are available in two thicknesses: 0.0015" and an "ultra-thin" 0.001." A 0.0015" pedo size metal band that is about 1-mm shorter than the other bands is also available preloaded in a separate retainer. The four retainers have color-coded knobs to make it easy for the users to know which retainer/band combination they are using.

Conclusions/action items:

The evolution of matrix bands has involved many different functions, some of which we may be able to incorporate into a novel design. Drawbacks such as time inefficiency due to modifications, and a narrow range of function due to tooth conformations should be avoided.

2021/09/14 - Existing Matrix Bands/Wedges and Procedural Techniques

DRAESON MARCOUX (dmarcoux@wisc.edu) - Oct 20, 2021, 3:00 PM CDT

Title: Existing Matrix Bands/Wedges and Procedural Techniques

Date: Sept. 14, 2021

Content by: Draeson Marcoux

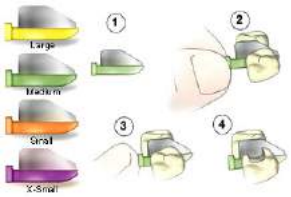
Present:

Goals: To gain some background information on the dental procedures that require matrix bands/wedges and how they are done to obtain a better understanding of the functional requirements of our device.

Content:

Garrison Dental Youtube Video - "Placing the Matrix Band": https://www.youtube.com/watch?v=5Tpj9xP2Zpc

1. Fender wedges can be used when there is still tooth contact to create a gap. They are placed with the plastic edge against the gum-line and the metal edge between the teeth. This allows for the tooth to be properly prepped as well. Regular wedges may also be used (they look like the plastic part of the fender wedge but with rubber-like looking flanges)



https://www.pearsondental.com/catalog/product.asp?majcatid=737&catid=6229&subcatid=19007&pid=48986

"Almost all matrix band manufacturers are using a dead-soft stainless steel at about 15/1000ths in thickness"

Tofflemire Matrix System Use - "Matrix Band Placement": http://www.columbia.edu/itc/hs/dental/operative/matrixband.html

1. Used in Class II restorations and functions by providing proximal contours and contact areas for the tooth and filling materials
2. Functions as follows: rigid against the existing tooth structure, proper anatomic contour, correct proximal contact relation, prevent gingival overhang, easily removed
3. Requires: Tofflemire matrix retainer, matrix band, dental wedges, cotton pliers, scissors and a knife

1. The wedge is placed to compress the band against the tooth creating better contour and tighter gingival seal 
2. The matrix band is then burnished - surface modification that creates contour shape to better fit in between the gum line and tooth

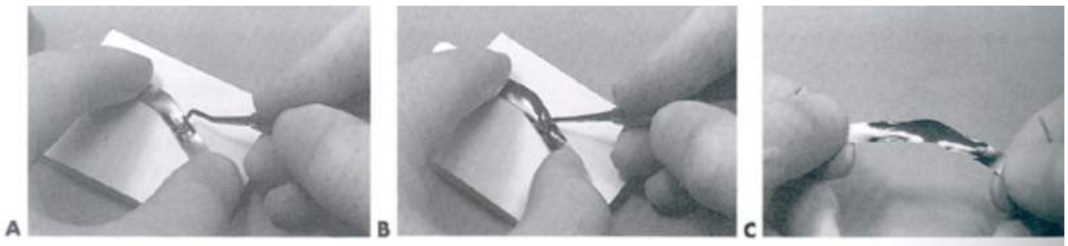
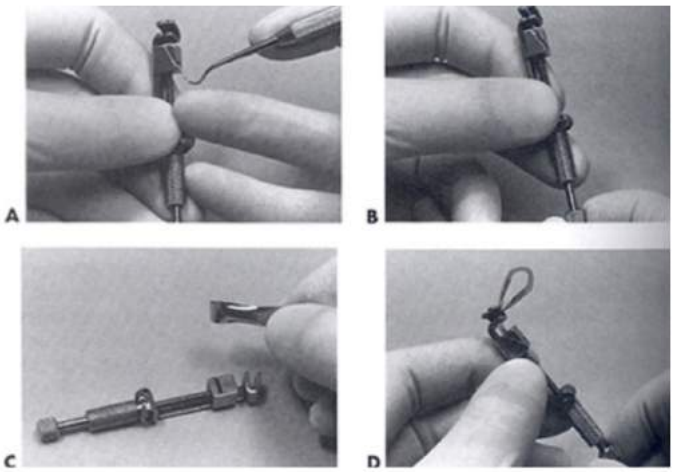


FIG. 17-78 Burnishing matrix band. **A,** With band on pad, use small burnisher to deform band. **B,** Use large burnisher to smooth band contour. **C,** Burnished matrix band for MOD tooth preparation.

3. The matrix band is then placed in the retainer after being folded into a teardrop shape and secured using a screw mechanism 

4. The retainer-band system is then fit over the tooth and tightened via a knob system

Conclusions/action items:

The procedures for using a matrix band should not be difficult or change too much from what already exists. This is to reduce the learning curve and allow for quick and easy implementation and shortened procedure time.

2021/10/5 - Review of Current Dental Matrix systems

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 12:25 PM CST

Title: Current Dental Matrix Band Information

Date: October 5, 2021

Content by: Draeson Marcoux

Present:

Goals: To identify the pros and cons of current matrix band systems, and thus what characteristics we may be able to keep in our design and what we need to improve on

Content:

1. "An evidence-based review of dental matrix systems" - https://www.agd.org/docs/default-source/self-instruction-(gendent)/gendent_so16_owens.pdf?sfvrsn=59907ab1_0
    1. Amalgam has faced scrutiny due to health and environmental effects as it can release mercury into the body.
2. "Thus usage of Matrix Band by Dental Students in Class II Restorations" - http://jamdsr.com/uploadfiles/18MatrixBandvol7issue7pp69-74.20190714014727.pdf
    1. The Tofflemire matrix band system is the preferred method, utilizing dental wedges and polish to supplement function.
    2. Most students took between 10-20 minutes to prepare the tooth for restoration
    3. Failure of the filling is relatively common with open margins being the greatest cause due to shrinkage

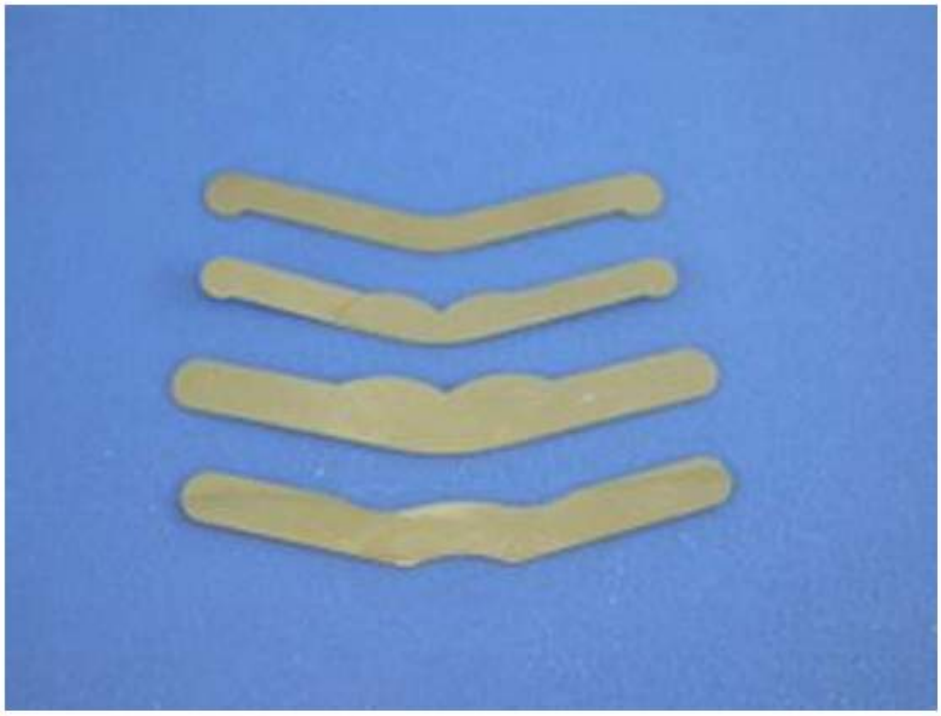


Figure 7. Tofflenire Matrix Band

Figure 6. Tofflernire Matrix Retainer

Conclusions/action items:

The Tofflemire system is the most widely used system for tooth restoration procedures and should be used as a baseline in the creation of our design. Our goal is to improve on the flexibility of use to interproximal restorations and time of use.

2021/10/31 - Denovo Preformed system

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 12:48 PM CST

Title: Denovo Dental Matrix Band System

Date: October 31, 2021

Content by: Draeson Marcoux

Present:

Goals: To analyze the characteristics of the Denovo Preformed Matrix Band system and its pros and cons.

Content:

- Denovo Preformed Matrix System - https://denovodental.com/wp-content/uploads/2015/11/IFU-MatrixBandInstructions-01-4.pdf
  - These matrix bands (figure 1) come in adult (6.4mm tall) and pediatric (4.8mm tall) variations, each with 15 discrete sizes
  - Woody wedges (figure 2) are also used with this design for proper tooth conformation
  - Matrix band sizes are chosen based on visual sizing and trial fitting
  - Once the matrix band size is chosen, the woody wedges are placed on either side for a tighter fit
  - Matrix bands are removed by being broken open along the tab with any dental tool already used in the procedure
  - Rough sizing can be seen in figure 3

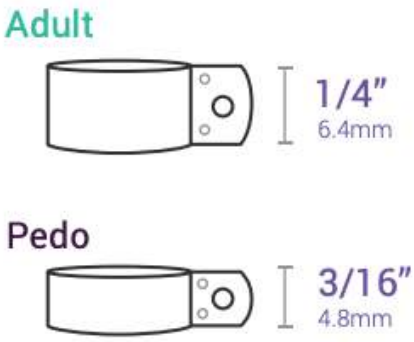


Figure 1: Denovo Preformed Matrix Bands

Figure 2: Woody Wedges in 4 discrete sizes

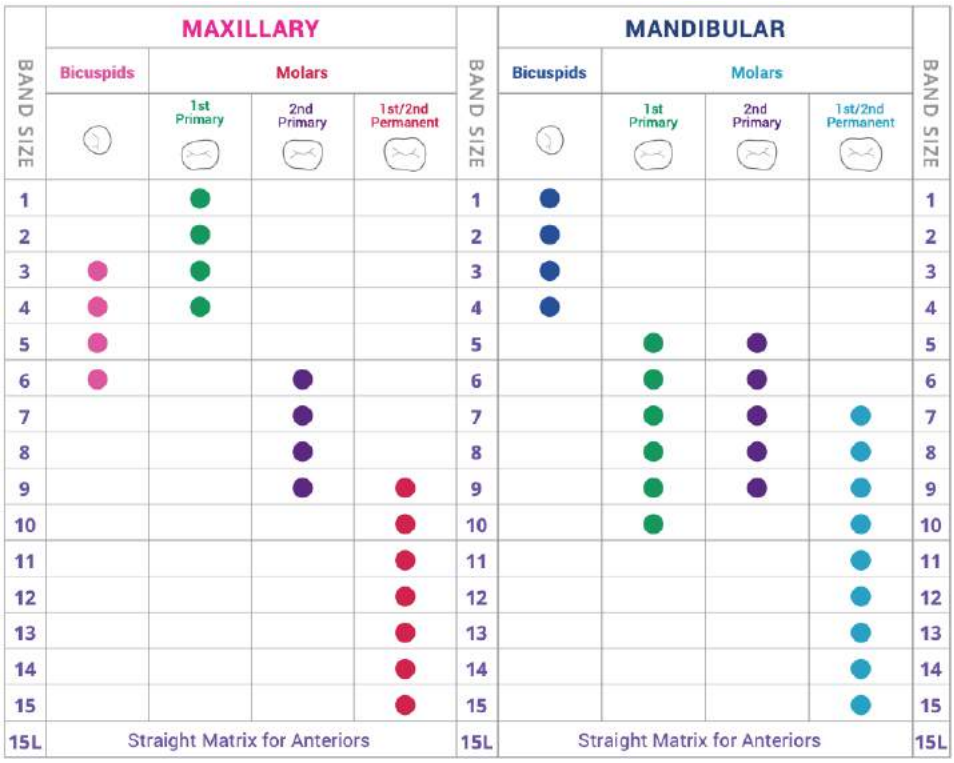


Figure 3: General sizing information for denovo matrix bands (sizes 1-15)

Conclusions/action items:

The Denovo Preformed Matrix Band system utilizes many discrete sizes and an already circumferential shape to reduce time spent on sizing and shaping. The tabs function to allow for easier placement and removal, however it must be broken making it a once use band. Single use bands are very common though.

2021/11/10 - Triodent V3 Ring Clamp, Wave-Wedge and SuperCurve Matrix

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 1:16 PM CST

Title: Triodent V3 Ring Clamp, Wave-Wedge and SuperCurve Sectional Matrix Band

Date: November 10, 2021

Content by: Draeson Marcoux

Present:

Goals: To analyze the characteristics of the Triodent Sectional Matrix Band, V3 Ring Clamp and Wave-Wedge system and its pros and cons

Content:

1. Triodent SuperCurve Sectional Matrix Band (Figure 1) - https://www.ultradent.com/products/categories/triodent/matrices/triodent-supercurve-matrix
    1. Matrices are color coded based on sizes
    2. Micro-thin, non-stick surface for easier placement and removal
    3. Rolled ridge on the occlusal margin
    4. Concave shape to better contour the tooth and fit better into the gingival margin

Figure 1: 4 sizes of the sectional SuperCurve matrix band

1. Triodent V3 Sectional Matrix Ring (Figure 2) - https://www.ultradent.com/products/categories/triodent/matrices/triodent-v3-ring
    1. Nickel-titanium composition for sufficient strength and elasticity to clamp matrix band and separate teeth
    2. V shape to prevent blocking or blockage of any wedges that may be used in conjunction with the ring
    3. Comes in 2 sizes for large and small teeth respectively
    4. Autoclavable for repeated use (Glass reinforced plastic)

Figure 2: Triodent V3 Sectional Matrix Ring for large (green) and small (yellow) teeth

1. Triodent Wave-Wedge (Figure 3) - https://triodent.com/product/wave-wedge/

1. Adaptive sealing from V shape and central concave shape (forming the "wave"). This also makes the wedge self guiding/locating and stackable

Figure 3: Triodent Wave-Wedge

Conclusions/action items:

This Triodent system has been mentioned in multiple articles as one of the better sectional matrix band systems. These tools use a variety of features that make placement more effective, efficient and easy to use which is why they are so popular. We should hope to create a system of equal or more convenience and efficacy.

2021/10/31 - Manufacturing Companies & Capabilities

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 1:18 PM CST

Title: Manufacturing Companies & Capabilities

Date: October 31, 2021

Content by: Draeson Marcoux

Present:

Goals: Gather information on potential materials and fabrication techniques for the current design iteration

Content:

- Precision Metal MFG - http://precisionmetalmfg.com/
  - Capabilities:
    - Laser Cutting - 60" x 120" table with 3937 in/min max process speed and 5550 in/min rapid travel speed
    - Punching - Accuracy of +- 0.002"
    - Forming - Many different machines with high capacity and bend
    - Deburring - Many different machines for large and fine deburring (2 in - 10 ft)
    - Machining - Many different machines including lathes, many different levels of tool capacity
    - Tube Bending
    - Welding - Many different machines for both Tig/Mig and spot welding
    - Painting - Large capacity with both powder coating and wet painting booths
    - Value-added Assembly - Produces wide range of assemblies from complex electro-mechanics to small sub-component assemblies in equipment
  - Acceptable File types:
    - Solidworks Files (*.sldprt, *.sldssm, *.slddrw)
    - Catia Graphics (*.cgr)
    - Pro E Part & Assembly (*.prt, *.xpr, *.asm, *.xas)
    - Inventor Part & Assembly (*.ipt, *.iam)
    - Solid Edge Part & Assembly (*.par, *.asm)
    - CADKEY (*.prt, *.ckd)
    - IGES (*.igs, *.iges)
    - Parasolid (*.x_t, *x_b, *.xmt_txt, *.xmt_bin)
    - STEP (*.step, *.stp) [2D or flat parts we ask for these file extensions]
    - DXF (*.dxf)
    - DWG (*.dwg)
  - Meets ISO 9001 and AS9100 requirements

Conclusions/action items:

After further discussion and advice from our advisor, the team will attempt to research and use campus resources before looking at 3rd party manufacturers.

2021/11/19 - Raw Materials and Vendors

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 2:15 PM CST

Title: Raw Materials and Vendors

Date: November 19, 2021

Content by: Draeson Marcoux

Present:

Goals: To find raw metal materials to use in the fabrication of an early design prototype

Content:

1. Dead-soft metal - The softest form of a metal based on how it was processed and a low carbon, or interstitial, content.
    1. Low carbon steel = dead-soft steel which is the current industry standards
2. Shim Stock - Thin precision stock material (often metal) generally used to measure and ensure clearance between machinery
    1. Shim stock was chosen as it was the only form of metal we could find thin enough for our applications. Grainger Industrial Supply had a variety of metals in shim stock that we could choose from. Without being able to see and feel the materials directly, I called and asked what material, ideally steel, would be best for our applications, meaning malleable for a metal but rigid enough to hold itself up and support a small amount of force without deforming. They recommended a 1008-1010, meaning 0.08-0.1% carbon. We chose the shim stock seen below, at a thickness of 0.001" (0.0254 mm) from this website: https://www.grainger.com/product/PRECISION-BRAND-Steel-Shim-Stock-Roll-5EY10?cpnuser=undefined&searchBar=true&searchQuery=5EY10&suggestConfigId=6

Roll over image to zoom.

PRECISION BRAND

Steel Shim Stock Roll, 1008-1010 Grade, 0.001 in Thickness, +/-0.0001 in Thickness Tolerance

Item # **5EY10** Mfr. Model # **16700**
UNSPSC # **31163301** Catalog Page # **2179**

Country of Origin **USA. Country of Origin is subject to change.**

Shim stock is easy to form and fabricate. Shim rolls can be cut, stamped, bored, milled, sheared, and drilled into almost any shape required to make custom shims.

☐ Compare this product

Conclusions/action items:

Use this material for early rough prototyping to quickly check the way material rigidity, durability and other material properties are viable for our matrix band. We could also perform mechanical testing and compare it to the matrix bands we already have to confirm this material is sufficient. If so, we can use this in the fabrication of better prototypes.

2021/11/22 - Team Lab Material Consultation

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 1:38 PM CST

Title: Team Lab Material Consultation

Date: November 22, 2021

Content by: Draeson Marcoux

Present:

Goals: To speak with the Team lab and ask for their opinion on materials and possible sources for that material based on our needs and applications for a dental matrix band.

Content:

1. Feeler gauges were initially discussed, but after limitations in available dimensions, namely the width, shim stock was recommended. Shim stock is generally a metal that is often used to ensure there is clearance between mechanical parts or machinery but it meets the thickness and material requirements for our purposes. The faculty member was able to show shim stocks in a few materials and thicknesses. Bronze was a more malleable material, more similar to aluminum foil while the steel was more rigid. They didn't have any as thin as we would like in steel but it seemed like the material properties were more suited for our applications.

Conclusions/action items:

The team ended up ordering a shim stock with 0.001" (0.0254 mm) thickness, which, folded in half, should provide a thickness within our range. There were some concerns about it being too malleable and forming wrinkles but after obtaining it, these concerns were mostly dispelled. Some preliminary testing on the mechanical properties were done but were not conclusive in confirming its viability. More testing and modeling will be done next semester.

2021/12/06 - MakerSpace WaterJet Consultation

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 1:57 PM CST

Title: MakerSpace Water Jet Consultation

Date: December 6, 2021

Content by: Draeson Marcoux

Present:

Goals: To ask the MakerSpace faculty about using the Water Jet to fabricate our final design or if there are other methods that may be more effective

Content:

1. After doing some preliminary research, I found that the Water jet was the only feasible machine that we could use with our material, or really an metal in general. From the meeting, I was told the Water jet could potentially carve out our design from the shim stock, but it would likely be low fidelity and could have rough edges from the water blasting. An alternative method would be to create a stencil in the laser cutter and use a sharp blade to cut it out. The most recommended method would be to use a laser cutter, but those available in the MakerSpace are not powerful enough to cut through our material. However, the faculty offered to connect us with the Electrical Engineering department that does have one available.
2. During our final poster presentation, a previous advisor for this project offered alternative advice, saying the water jet could be a good option for fabrication. Conversely, the laser cutter may melt the edges of the metal making them rough.

Conclusions/action items:

The team will continue seeking advice on the best method of fabrication, whether that be the laser cutter or water jet. It is possible that both will be tested next semester. If either of these options don't work, a 3rd party manufacturer will considered.

2021/11/30 - 2D Final Design

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 2:04 PM CST

Title: 2D Sketch of the Final Design

Date: November 30, 2021

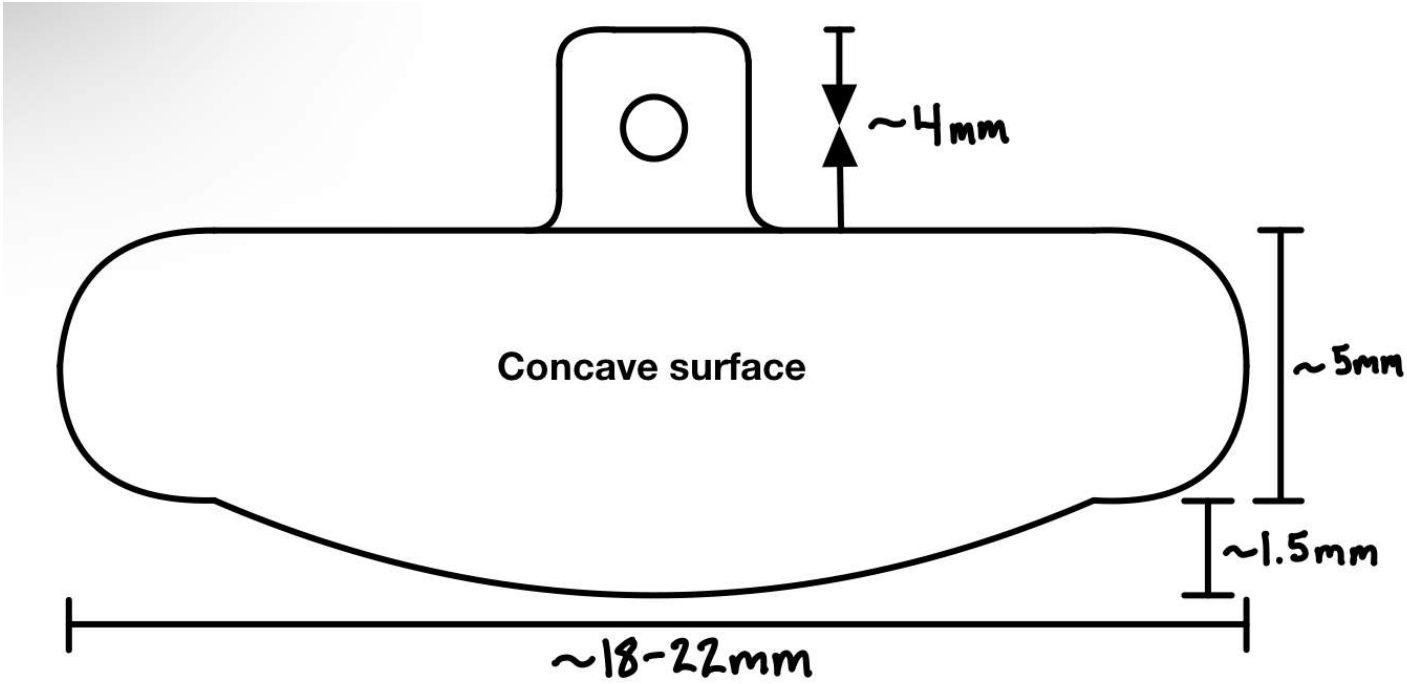
Content by: Draeson Marcoux

Present:

Goals: To lay out a 2D planar sketch of the design that might be able to be translated into a software model usable in the laser cutter or water jet.

Content:

1. This is a planar side view of the final butterfly design. The rough dimensions of each component are listed thought they may be changed for variable sized matrix bands. This image could be duplicated and flipped to create the foldable planar design.



Conclusions/action items:

Convert this design into a file compatible with our machining techniques.

2021/12/03 - Revised Handcuff Design Sketch

DRAESON MARCOUX (dmarcoux@wisc.edu) - Dec 15, 2021, 2:07 PM CST

Title: Revised Handcuff Design Sketch

Date: December 3, 2021

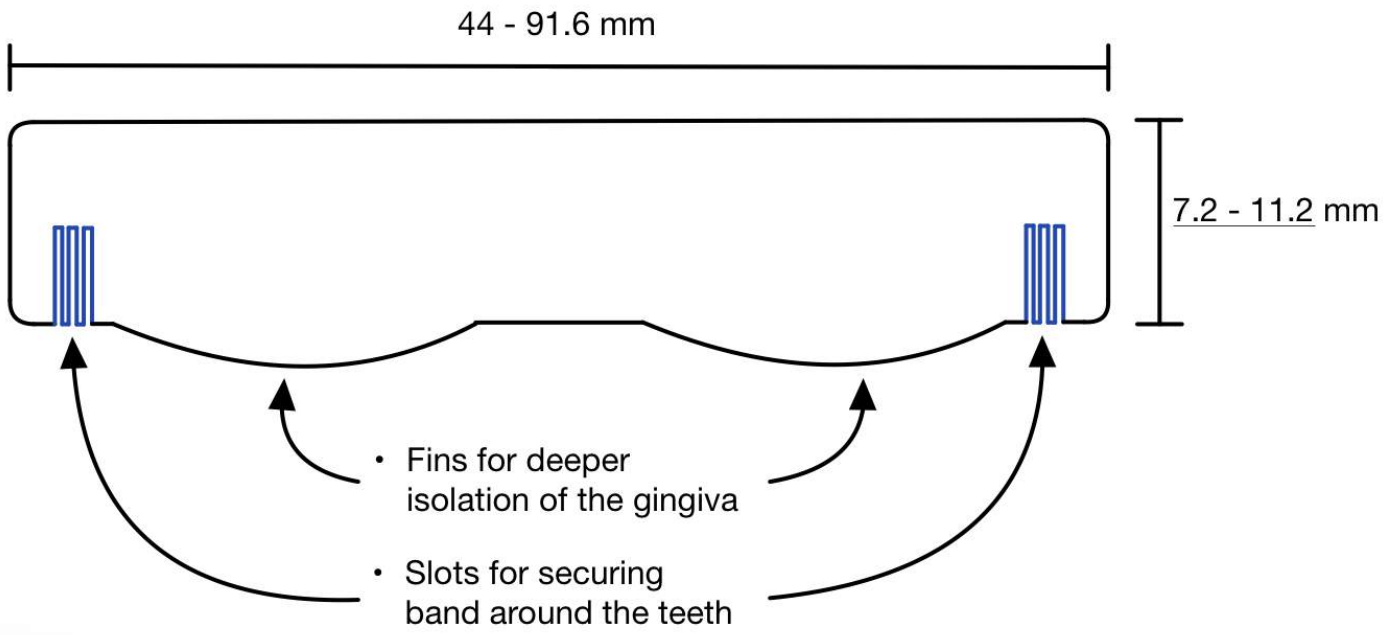
Content by: Draeson Marcoux

Present:

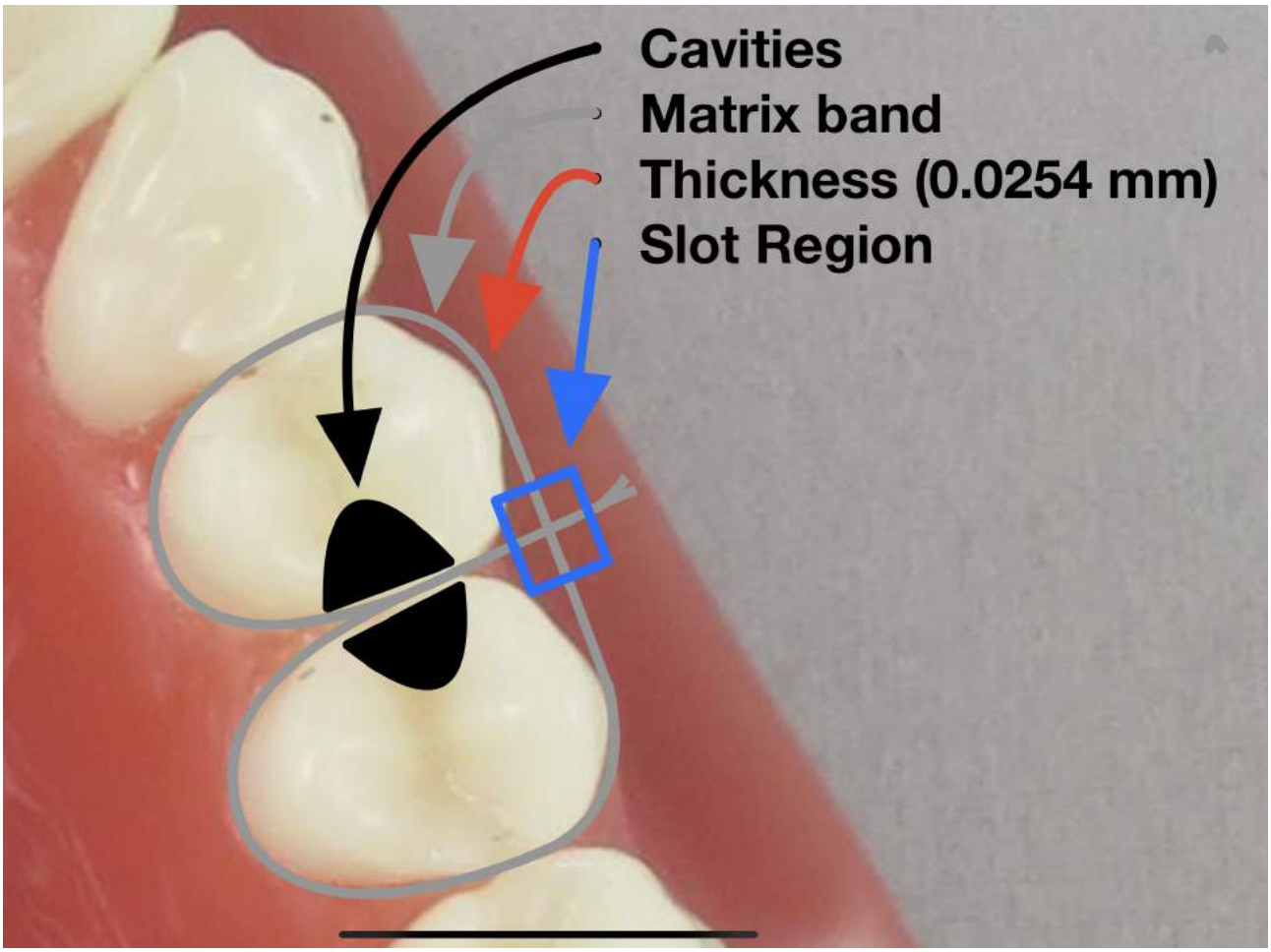
Goals: To create cleaner images for the preliminary handcuff design.

Content:

1. A cleaner drawing of the handcuff design can be seen in the figure below. The dimensions are variable depending on the size of the matrix band. Multiple sizes could be fabricated for better performance with different cavity locations, teeth type and size, patients, etc.



1. A top view of the placement of this design was also revised and can be seen below.



Conclusions/action items:

Incorporate these images into the final report for better documentation and description of the design process.

2021/09/24 - BME Outreach Seminar

DRAESON MARCOUX (dmarcoux@wisc.edu) - Sep 24, 2021, 12:56 PM CDT

Title: BME Outreach Seminar

Date: Sept. 24, 2021

Content by: Draeson Marcoux

Present: BMEs

Goals: Explain what the BME Outreach program is and what experiences previous students have had

Content:

1. Going into a K-12 school and teaching the students about a Biomedical engineering topic. An interactive activity is used to engage students and explain mechanisms behind topic (as much as you can).
2. Advice: Go in with an open mind and prepare as much as you can as early as possible. If you have a positive attitude the children are very receptive. Also does not need to be overly technical, focus on the main points.
3. BME Outreach program is run by Dr. Tracy Puccinelli (big part of post-doc work).
    1. Why do we do BME Outreach?
        1. Build awareness about the BME program and try to build it. Get kids more interested in education.
        2. Give back to the community through volunteer teaching.
        3. Practice public speaking and educating an audience without technical background knowledge.
        4. Can speak to high school students and explain what they might be able to expect
        5. Potential voting/donation influence
        6. Ensure diversity and equal opportunity which is important when considering design specifications for well functioning devices
    2. Do at least one practice run to ensure the activity is fully planned and prepped (maybe use a roommate as a test subject).
    3. Can recieve funding is proposal is accepted and underrepresented students constitute 30%+ of class
    4. Madison/Milwaukee area school districts, boys and girls club, Madison Children's museum, etc.
    5. Follow BME deliverables and requirements!!
        1. Presentation w personal story (intro), define BME and activity explanation
        2. ~30 min, fun, hands-on activity that follows learning objectives
        3. Report and Teacher Eval
    6. Meet with Dr. Puccinelli once we've chosen a topic
    7. Don't reinvent the wheel with the activity

Conclusions/action items:

Take a look at the potential outreach locations and activities. Begin to formulate a plan and contact Dr. Puccinelli once we've selected a topic.

Tooth Size

TREVOR SILBER - Dec 14, 2021, 10:14 PM CST

Title: Woelfel's Dental Anatomy, 9th edition

Date: 9/22/21

Content by: Trevor Silber

Present: N/A

Goals: Learn the sizes of teeth to specify the size of our device in the PDS

Content:

R. I. C. K. N. E. C. SCHEID and G. A. B. R. I. E. L. A. WEISS, *Woelfel's dental anatomy*. BURLINGTON, MA: JONES & BARTLETT LEARNING, 2020.

Conclusions/action items:

Using these parameters, an average tooth size can be estimated from the crown width MD and crown width FL. Crown width MD measure the tooth size in the medial (towards your two front teeth) to distal (towards your wisdom teeth) directions. Crown width FL measure the tooth sizes in the facial (towards your cheek) to the lingual (towards your tongue). These measurements can be thought of a lengths of a rectangle to estimate tooth size as I was not able to find any sources that measure average tooth circumference.

Pro-Matrix Device

TREVOR SILBER - Dec 14, 2021, 11:41 PM CST

Title: Pro-Matrix Disposable Matrix System

Date: 9/15/21

Content by: Trevor Silber

Present: N/A

Goals: Learn how other market devices work

Content: https://www.astekinnovations.co.uk/promatrix.php

These matrix band devices allow for a much faster time to apply matrix bands than the convention method of using a tofflemire. The bottom dial allows for fast tightening and the button up top allows for a tighter fit.

Conclusions/action items: This device brings a much more modern feel to cavity filling. While this device can speed up the process, it doesn't fix the clients issue. Down the road we may be able to use this device as inspiration in our design process.

A key take away from this diagram and product is that we may be over estimating how large a matrix band needs to be. It was estimated that average crown height is 10 mm, yet the largest band they have available is 6 mm is height. It may be valuable to start considering looking at bands smaller than 6.25 mm (current size of prototype) instead of creating a band that is larger.

How do Matrix Bands work

TREVOR SILBER - Dec 14, 2021, 10:26 PM CST

Title: How to Assemble/Place Matrix Bands

Date: 9/15/21

Content by: Trevor Silber

Present: N/A

Goals: Learn how Matrix Bands are put in place

Content: https://youtu.be/-E2QvRnBxuY

Steps to install a circumferential matrix band

1. If working on a patient, be sure to wear gloves, jacket, mask, and goggles

2. Prep tooth for cavity filling

3. Gather tofflemire, matrix band, wedges and pliers

4. Take the matrix band with pointed side down

5. Fold matrix band in half and place into tofflemire with the pointed edge in contact with tofflemire

6. Tighten band in place with bottom knob

7. Use second knob to adjust size of band to fit around different tooth size if necessary

8. Place matrix band between teeth with the pointed side opposite of the gums

9. Fill cavity

Conclusions/action items: After watching the video I have a much better understanding of how matrix bands work and why our client wants us to solve this problem. The existing process is very time consuming and can be greatly improved with the help of some engineers.

Update: After getting my hands on the tofflemire provided by Dr. Tipple, I can confirm that the tofflemire seems to be over engineered for its purpose. There are plenty of moving parts and the tofflemire can be very easily loosened, causing the matrix band to fall out. Also, the tofflemire appeared to plastically deform all of the matrix bands, meaning if they were originally made too small, they were in an incorrect shape when made larger to fit around larger teeth.

Matrix Band Sizes

TREVOR SILBER - Dec 14, 2021, 10:29 PM CST

Title: Matrix Band Sizes

Date: 9/22/21

Content by: Trevor Silber

Present: N/A

Goals: Learn about the different thicknesses of matrix bands

Content:

“JR Rand Tofflemire,” Net32. [Online]. Available: https://www.net32.com/search?q=JR%2BRand%2BTofflemire%2Btype. [Accessed: 22-Sep-2021].

After checking across multiple websites, the only dimension of matrix bands I was able to find was the thickness. On this site, they sell matrix bands of thickness 0.001 gauge, 0.0015 gauge, and 0.002 gauge.

Conclusions/action items: Based on these thicknesses, we will model our design on the smallest thickness to make sure it fits in between the majority of individuals teeth. If a different thickness is chosen than those listed above, the strength of the material will need to be tested as decreasing thickness by a half could cause the strength of the material to decrease by a factor of 8. A proper balance of thickness and strength will need to be determined to find a proper band for our prototype.

Steel Density

TREVOR SILBER - Dec 14, 2021, 10:35 PM CST

Title: Steel Density

Date: 9/22/21

Content by: Trevor Silber

Present: N/A

Goals: Learn the density of steel to compute the mass of a matrix band

Content:

Using the average tooth size and common thickness of matrix bands, a theoretical volume can be calculated and then a theoretical mass can be calculated once the density of steel is known. We will be using a dead soft metal, so stainless steel was chosen as it is a dead soft metal.

Thickness = 0.0381 mm, average height = 8.695 mm, average tooth perimeter = 33.83 mm, density of stainless steel = 7.99 g/cm^3.

Theoretical mass = 0.0895 grams

Conclusions/action items:

Weight of our design needed to be specified in the PDS. Here a theoretical mass of 0.0895 grams was calculated. However, this number will vary by a lot as the final design may be half as thick as current matrix bands. Also, the height of each band will be anywhere from 6 to 11 mm, this could cause the expected mass to double. Final measurement should be a range from 0.01119 g (if all dimensions were cut in half to account for the smallest teeth with small gaps between them) to 0.716 grams a (if all dimensions were double to account for the largest teeth with large gaps between them).

SAE/AISI Carbon Steel Naming Conventions

TREVOR SILBER - Dec 14, 2021, 11:03 PM CST

Title: SAE/AISI Carbon Steel Naming Conventions

Date: 12/8/21

Content by: Trevor Silber

Present: N/A

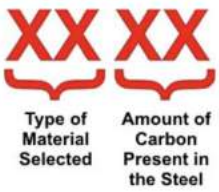
Goals: Learn the naming convention of carbon steel to ensure a dead soft metal was purchased

Content:

F. T. C. Ltd, “SAE/Aisi Carbon Steel Naming Conventions,” *AZoM.com*, 08-Aug-2014. [Online]. Available: https://www.azom.com/article.aspx?ArticleID=6151. [Accessed: 08-Dec-2021].

“Cold rolled 1008/1010 Steel Physical & Chemical properties,” *Mead Metals, Inc.* [Online]. Available: https://www.meadmetals.com/metal-products/cold-rolled-1008-1010-steel/physical-chemical-properties. [Accessed: 08-Dec-2021].

Material purchased: 1008 - 1010 grade stainless steel, temper: full hard



Stainless steels are also included in the AISI steel specifications range. The stainless steels are provided with three digit numbers starting with 2, 3, 4, or 5. The 300 series austenitic stainless grades and the 400 series martensitic grades are the popular stainless steel specifications.

Given below is a table of AISI material grades explaining the steel type indicated by each four digit number along with its specifications.

Table 1. AISI Material Grades

AISI Steel	Specifications
Carbon Steel	10XX Plain carbon steel , Mn 1.00% max
	11XX Resulfurized free cutting
	12XX Resulfurized - Rephosphorized free cutting
	15XX Plain carbon steel, Mn 1.00-1.65%

This material is a plain carbon steel with a maximum Manganese content of 1% by weight. The last two digits of our material specify that the material contains anywhere from 0.08 to 0.1% weight by carbon.

Cold Rolled 1008/1010 Steel Physical Properties		
ASTM A1008/1010		
Temper	Designation	Alloy
Dead Soft	DS Type - B	1008
Commercial Quality	CS Type - B	1008/1010
1/4 Hard		1008/1010
1/2 Hard		1008/1010
Full Hard		1008/1010

Cold Rolled 1008/1010 Chemical Composition															
ASTM A1008/1010															
Designation	C	Mn	P	S	Al	Si	Cu	Ni	Cr	Mo	V	Cb	Ti	N	B
CS Type A	0.10	0.60	0.030	0.035	-	-	0.20	0.20	0.15	0.06	0.008	0.008	0.025	-	-
CS Type B	0.02-0.015	0.60	0.030	0.035	-	-	0.20	0.20	0.15	0.06	0.008	0.008	0.025	-	-
CS Type C	0.08	0.60	0.10	0.035	-	-	0.20	0.20	0.15	0.06	0.008	0.008	0.025	-	-
DS Type A	0.08	0.50	0.020	0.030	0.01 min	-	0.20	0.20	0.15	0.06	0.008	0.008	0.025	-	-
DS Type B	0.02-0.08	0.50	0.020	0.030	0.02 min	-	0.20	0.20	0.15	0.06	0.008	0.008	0.025	-	-
DDS	0.06	0.50	0.020	0.025	0.01 min	-	0.20	0.20	0.15	0.06	0.008	0.008	0.025	-	-
EDDS	0.02	0.40	0.020	0.020	0.01 min	-	0.10	0.10	0.15	0.03	0.10	0.10	0.15	-	-
Note: All values referenced are max unless otherwise specified															

Unfortunately, we do not know the exact designation of the type of stainless steel as it wasn't listed on the Grianger website. However, we can observe that the maximum range of Manganese content will be somewhere between 0.4 and 0.6.

Conclusions/action items:

This material meets the carbon standards to be a dead soft metal, however it may not meet the Manganese requirements. For a material to be dead soft it must have less than 0.1% weigh of Carbon and less than 0.2 to 0.5% weight of Manganese. The material would need to be tested figured out the exact Manganese content before it can truly be considered a dead soft metal. However, since the maximum Manganese content is no larger than 0.6, it is safe to assume that the material purchase is or is very close to being a true dead soft material.

Laser Cutting or Water Jet

TREVOR SILBER - Dec 14, 2021, 11:34 PM CST

Title: Laser Cutting or Water Jet Cutting: Which is Best for Your Application?

Date: 12/14/21

Content by: Trevor Silber

Present: N/A

Goals: Learn if laser cutting or water jet cutting will work better for our prototype

Content:

Sculpteo, “Laser Cutter vs Waterjet Cutting: 5 points to set them apart,” *Laser Cutting or Water Jet Cutting: Which is Best for Your Application?* [Online]. Available: https://www.sculpteo.com/en/3d-learning-hub/laser-cutting/laser-cutting-vs-water-jet-cutting/. [Accessed: 15-Dec-2021].

Lasers -

Cut: plastic, glass, wood and non-highly reflective metals.

Optimal thickness: 3 to 10 mm

Minimum size of cut: 0.15 mm

Processing tolerance: 0.05 mm

Damage material: burn marks, visibly darkened cuts, may create thermal stress cracking

Safety: Glasses and proper ventilation

Clean up: Vacuum up dust

Water jet -

Cut: all materials with its 60,000 psi ejecting from the nozzle.

Optimal thickness: 10 to 50 mm

Minimum size of cut: 0.5 mm

Processing tolerance: 0.2 mm

Damage material: high forces may deform small parts

Safety: Glasses, ear protection, cover around machine to prevent getting hit by water

Clean up: Very messy and abrasive/water mixture can be hard and dangerous to clean

Conclusions/action items:

Laser cutting would more than likely lead to more accurate prototypes due to the smaller minimum size of cut and processing tolerance. However, some real issues may arise when considering the reflectiveness of the material. The laser cutter may not physically be able to cut through the metal. Also, with how thin the material is it may be more susceptible to thermal stress cracking. If this is the case, a proper cooling method may help to eliminate this problem.

Water jet cutting would lead to less accurate prototypes due to its larger minimum size of cut and processing tolerance, however I believe that we might still be able to work with these values. The stream may end up damaging the material, which would be something to watch out when conducting water jetting.

I think the best idea would be to try and fabricate the prototype on both a laser cutter and water cutter and choose whichever prototype comes out best. If neither work we may have to work with a prototyping company or develop some sort of handmade punch press to punch out the matrix bands from the shim stock ourselves.

Y Band Design

TREVOR SILBER - Oct 19, 2021, 11:04 PM CDT

Title: Y Band

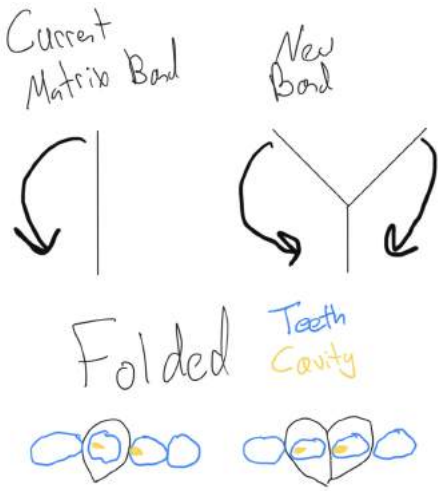
Date: 9/5/21

Content by: Trevor Silber

Present: N/A

Goals: Come up with design for proposal

Content:



Conclusions/action items: This design was going to be submitted with the original proposal for the project but an image could not be attached to the design website. This design was based solely of the problem statement listed on the design page website. This design would have required the group to create a new tofflemire and when I originally expressed this idea to the client he thought that we should take the design in a different direction.

Spiked X Design

TREVOR SILBER - Sep 22, 2021, 11:55 PM CDT

Title: Spiked X Design

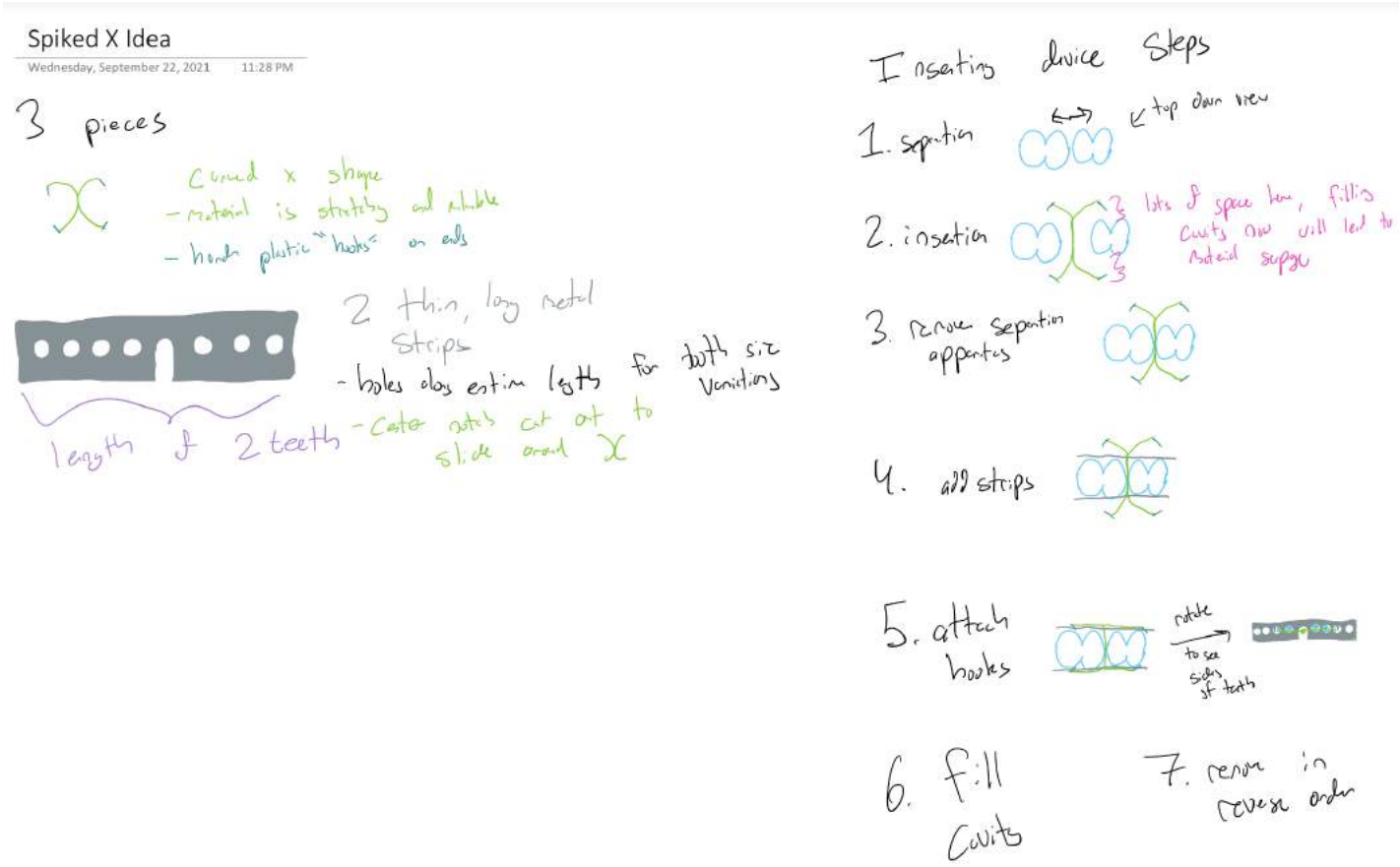
Date: 9/22/21

Content by: Trevor

Present: N/A

Goals: Create a new design idea roughy based on sectional matrix bands

Content:



Conclusions/action items:

I think this idea has some potential but there are some design flaws. The tightening to the teeth may be very helpful for securing cavity filling material and lead to less of a clean up after the fact. I'm not sure if there is a material that can be stretchy enough that doesn't react with cavity filling material that could be used. I also believe that the process could be time consuming. I would like to revisit this design idea where the entire device is one piece and can be easily tightened and loosened to the teeth by pulling on something.

Butterfly + U Pinchers

TREVOR SILBER - Sep 27, 2021, 8:24 PM CDT

Title: Butterfly + U Pinchers

Date: 9/27/21

Content by: Trevor Silber

Present: All of Team via Zoom

Goals: Created a Butterfly design mixed with Grace's U Competing Designs

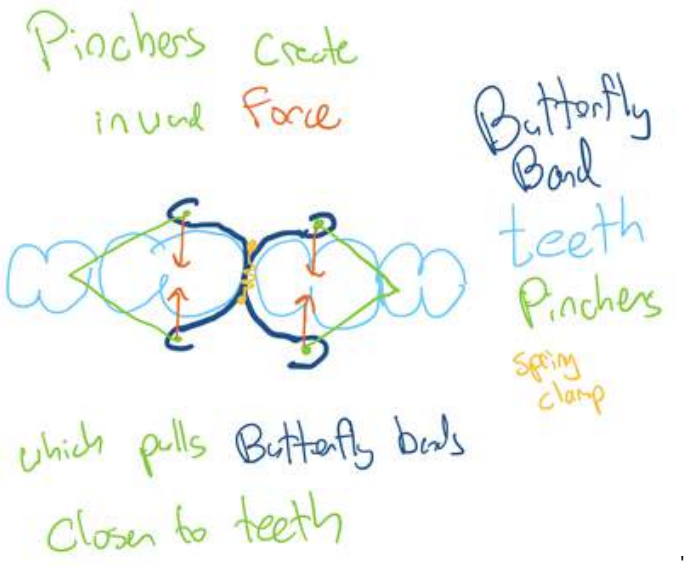
Content:

Please see attached image below

Conclusions/action items:

This design is the combination of the previous teams butterfly design with a competing design we found, the U design. Issues with the butterfly of not being able to secure to the teeth are solved with the pinchers from the U design. This design would work by essentially combining two sectional matrix bands of half the normal thickness into a "butterfly" shape. At the end of each of the butterfly wings there would be tiny loops. These loops would have pinchers the ends of pinchers put into them. These pinchers would create a force, that would push the end of the wings into the teeth. There would also be an additional spring clamp or wedge in place to insure the butterfly band does not move.

TREVOR SILBER - Sep 27, 2021, 8:16 PM CDT



F6982281-1D41-4DD5-A6FB-C5249F2C3033.jpeg(561.9 KB) - download

Dimensioning Devices for Presentation

TREVOR SILBER - Oct 19, 2021, 10:55 PM CDT

Title: Dimensioning Devices for Presentation

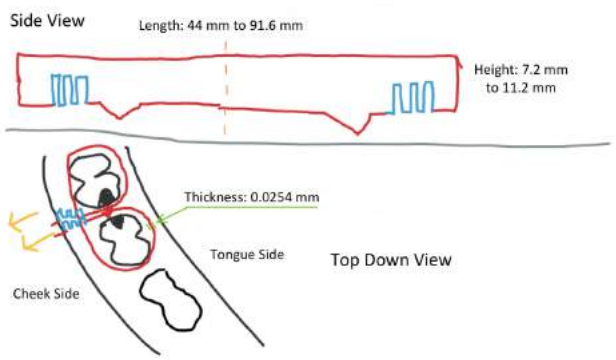
Date: 10/13/21

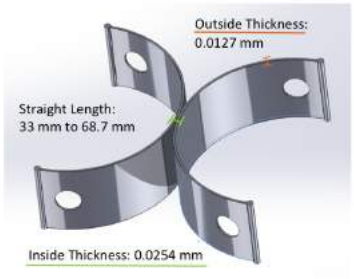
Content by: Trevor Silber

Present: N/A

Goals: Create dimensioned graphics for preliminary presentation and preliminary report

Content:





Conclusions/action items:

Dimensions were added to graphics from Matt to help create a better understanding of scale of the devices. These measurements were chosen based on the range of values calculated for average tooth size. Any values within or close to this range may be chosen to create the desired product. These images will be used on the preliminary presentation and preliminary report.

Fabrication Idea for Butterfly Design

TREVOR SILBER - Dec 14, 2021, 11:45 PM CST

Title: Fabrication Idea for Butterfly Design

Date: 10/27/2021

Content by: Trevor Silber

Present: In call with rest of team

Goals: Create a fabrication plan for the butterfly design that does not involve welding

Content:

Conclusions/action items: This fabrication plan is a way to get around having to weld two extremely thin pieces of metal together. The bands would be connected together at one end of the band. If this connection is placed at the top, it would also allow for easy wedge access along the bottom of the band. This method may alter the strength of the band and there may be a stress concentration at the top of the band. A strength test should be conducted to show any weak points in the band. If a larger separation is wanted between the two bands, say to add a tab for easy removal, then the total width (top to bottom of page) of the band can be increase as well as the width of the cut placed into the band. The wings may need to be held in place for a while to help ensure that the matrix band stays curved and can easily fit around teeth.

Aluminum Foil as a Prototype

TREVOR SILBER - Nov 18, 2021, 1:36 PM CST

Title: Aluminum Foil as a Prototype

Date: 11/12/21

Content by: Trevor Silber

Present: Team

Goals: Learn how well of a material aluminum foil will be as a prototype

Content:

“Aluminum foil,” *How Products Are Made*. [Online]. Available: http://www.madehow.com/Volume-1/Aluminum-Foil.html. [Accessed: 18-Nov-2021].

Aluminum foil is typically between 0.00017 - 0.0059 in thick, which is on the same scale of how thick our design should be 0.001 - 0.002 in.

Aluminum is made of 92-99 percent aluminum. The rest comes from a mixture of water, silica, iron oxide, and titania.

Aluminum foil is non-toxic, resists chemical reactions, and is impermeable to water and gases.

Conclusions/action items:

Aluminum foil could be a great material to use for our prototype due to its extreme thinness and being a non-toxic metal. It is also easy to shape and easy to cut. However, the material isn’t very strong to shear force and may be easily ripped apart when being removed from the thin gap from between teeth. It also undergoes plastic deformation very easily and once a crease is made in the metal, it is hard to undo that crease. I believe it would make a good prototype but should not be used as a final product or be tested on a human subject.

Dental Implant Teeth Model Study Teach Standard Model with Removable Teeth

TREVOR SILBER - Oct 20, 2021, 1:55 PM CDT

Title: Dental Implant Teeth Model Study Teach Standard Model with Removable Teeth

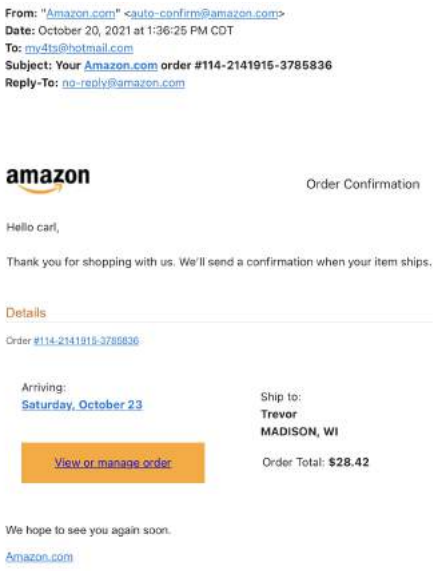
Date: 10/20/21

Content by: Trevor Silber

Present: N/A

Goals: Place receipt in notebook for proof of purchase

Content:



From: "Amazon.com" <auto-confirm@amazon.com>
Date: October 20, 2021 at 1:36:25 PM CDT
To: my4ts@hotmail.com
Subject: Your Amazon.com order #114-2141915-3785836
Reply-To: no-reply@amazon.com

amazon

Order Confirmation

Hello carl,

Thank you for shopping with us. We'll send a confirmation when your item ships.

Details

Order #114-2141915-3785836

Arriving:
Saturday, October 23

Ship to:
Trevor
MADISON, WI

View or manage order

Order Total: $28.42

We hope to see you again soon.

Amazon.com

note, this was purchased off of my parents Amazon Prime account which is why it is addressed to their email and to Carl instead of Trevor

Conclusions/action items: This receipt will be given to our client at the end of the semester for reimbursement.

Steel Shim Stock Roll

TREVOR SILBER - Dec 02, 2021, 2:40 PM CST

Title: Steel. Shim Stock Roll

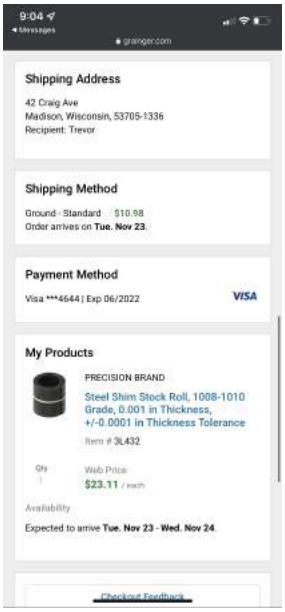
Date: 11/21/21

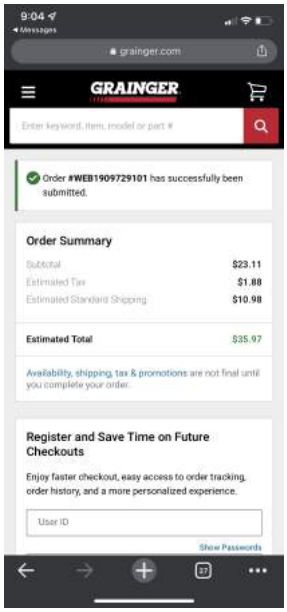
Content by: Trevor Silber

Present: N/A

Goals: Place receipt in notebook for proof of purchase

Content:





Conclusions/action items: This receipt will be given to our client at the end of the semester for reimbursement.

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

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

2014/11/03-Template

TREVOR SILBER - Sep 15, 2021, 2:22 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

New Page