Approximating Surface Matrix Band for Dentist to Use for Patients

Team: Spencer Stowell (Leader), Leah Gause (Communicator), Liam Granlund (BPAG/BSAC), Melanie Sona (BWIG)

Abstract

Dental Cavities have been labeled as a silent “epidemic” as they are among the most prevalent and chronic diseases in children and adults in the US [1]. Approximately 175 million people receive at least one dental filling every year [2] and about 27% of adults (20 - 64 years of age) fail to receive any proper treatment for their tooth decay [3]. The implications of untreated decay could lead to severe pain, tooth abscess, or even tooth loss [4]. As dental fillings are the most commonly performed procedure to restore moderate cavities, it is critical that the procedure is optimized to save dentists and patients time and simultaneously preserve accuracy. Current matrix bands, such as the Sectional and Tofflemire bands, are effective in maintaining a tight and flossable tooth contact and providing a sturdy tooth contour, however, they fail to accommodate the concurrent restoration of two adjacent interproximal cavities. Our goal is to create a dual-matrix band system which can provide a sturdy contour for two adjacent teeth undergoing restoration and maintain a tight and flossable contact between them. Our solution will incorporate the general appearance and material basis of the Tofflemire matrix band; however, we will redesign it to accommodate two teeth at a time and account for proper contact between the teeth.

Problem Statement: Motivation & Background

- **Problem(s):**
  - Matrix bands are only capable of surrounding one tooth at a time
  - The thickness of two bands adjacent to one another exceeds the natural tooth contact gap
  - When restoring interproximal cavities, traditional matrix bands unnecessarily increase procedure time
- **Goal: Create a *dual* matrix band system which is ...**
  - Thin enough to fit in between the affected teeth and maintain the appropriate contact gap
  - Rigid enough to securely adapt to the shape of the tooth walls.
- **Background:**
  - A matrix is defined as a properly contoured piece of metal used to support and give form to the material used in restoration during its and hardening.[1]

Figure 1: Process of restoring a decayed tooth – function of matrix band depicted in images 3-5

Figure 2: Existing matrix bands which fail accommodate simultaneous interproximal restoration: Sectional matrix band (left) and Tofflemire band (right)

Design Criteria

	The Butterfly!🦋	(Doug) DoubleHug	The Potato Wedge🥔
Safety (30)	24 (4)	30 (5)	18 (3)
Effectiveness (20)	16 (4)	20 (5)	16 (4)
Cost (20)	16 (4)	20 (5)	12 (3)
Adjustability (15)	12 (4)	15 (5)	6 (2)
Patient Comfort (10)	8 (4)	6 (3)	10 (5)
Ergonomics (5)	5 (5)	4 (4)	5 (5)
Total	81	95	67

Manufacturing & Testing

Manufacturing:

1. Mechanical Requirements
- Must meet physical requirements laid out in our testing protocol.

2. Dimensional Requirements
- Thickness: 0015 to .002 in.
- Width: For testing consistency, 1.0 cm.

3. Materials
- Medical grade stainless steel, such as AISI Type 316L stainless steel

4. Methods
- First, reverse engineer the current retainer design in order to understand functionality
- Next, create new sketch which mirrors the retainer over it's long axis to allow for the actuation of two bands
- Finally, outsource the manufacturing process, as we do not possess the machining skills required to create something as detailed as this dental instrument.

Testing:

1. Functionality Testing
- **Premise:**
  - These tests will be used as an assessment to qualitatively determine the overall functionality, structural integrity, and ease of use of the “doublehug” matrix band.
- **Testing targets:**
  - Ease of bending the device
  - Ease of securing and removing the device between the teeth
  - Subjective structural integrity of the band
- **Method of Measurement :**
  - Questionnaire asking the client to assess the various physical characteristics on a scale of 1-5.

2. Mechanical Testing
- Goal: Check if cutting the thickness of the band in half is reasonable
- Model two designs in SolidWorks
  - Regular matrix band (control)
  - Band with half thickness in middle
- Controlled variables
  - 1.2 lbs. Of force (factor of safety: 2)
  - Sides fixed
  - Elastic support on side that is in contact with tooth

Final Design

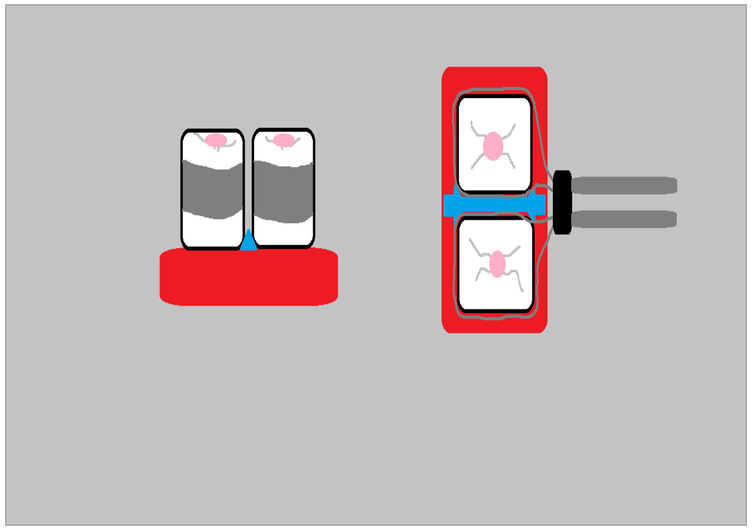


Figure 3: Our Final design, the Doug. Shows the front and top angle of the twin bands wrapping around the afflicted teeth.

Results

- **Yield Strength of AISI Type 316L stainless steel**
  - 170 MPa
- **Control**
  - Max stress: 90.46 MPa -> no tear
- **Proposed design**
  - Max stress: 249 MPa -> tear in middle

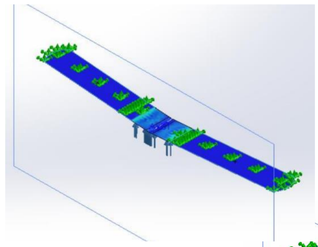
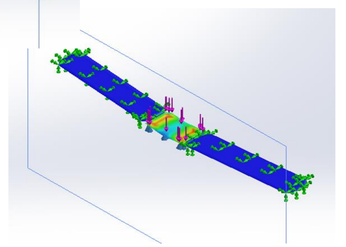


Figure 4 (left): The Proposed design's stress response. There is a small tear in the middle where the stress exceeded the yield stress.

Figure 5 (right): The control's stress response shows high stress on the sides, but no breakage.



Conclusion

Since the design failed during mechanical testing, some changes will need to be made. The thickness used in this experiment was the thinnest band a dentist uses, so next 0.002 in will be analyzed to see if a difference is seen. Hopefully, this will reduce the stress enough in the proposed design to avoid breakage. There were also other factors that might have been inaccurate in this experiment, including the factor of safety and force amount.

Future Work

- Redo mechanical testing with a full thickness of 0.002 in instead of 0.0015 in
- Try factor of safety of 1.5
- Ask Dr. Tipple for a more accurate force
- Start collecting materials for fabrication of prototype
- Once fabricated, conduct functionality tests
- Check in with client throughout

References

1.The art and science of operative dentistry.1995: Mosby-Year Book,Inc
2.Ryzvee, M., 2015. Matrix Bands. [online] Slideshare.net. Available at: <https://www.slideshare.net/masurizvi/matrix-bands> [Accessed 18 September 2020].
3.2009. Slicks Matrix Bands And Sectional Matrix Bands. [ebook] FDA. Available at: <https://www.accessdata.fda.gov/> [Accessed 18 September 2020].
4.re-invent Dental Products. 2020. Re-Invent Dental Products. [online] Available at: <https://re-inventdental.de/en/sterilization-guideline> [Accessed 18 September 2020].
5.Henry Schein, I., 2020. Tofflemire Matrix Band 1 Adult Universal 0.002 In 144/Pk - Henry Schein Dental. [online] Henryschein.com. Available at: <https://www.henryschein.com/us-en/dental/prestorative-cosmetic/matrix-materials/tofflemire-bands-1-002/9532378> [Accessed 18 September 2020].
6.Mitchell, J., 2020. How Long Does It Take To Fill A Cavity? | Colgate®. [online] Colgate.com. Available at: <https://www.colgate.com/en-us/oral-health/procedures/fillings/how-long-does-it-take-to-fill-a-cavity-> [Accessed 18 September 2020].
7.Net32.com. 2020. *Palodent Matrix System Refill - Standard Matrices 100/Bx. Contoured Sectional | Dental Supplies.* [online] Available at: <https://www.net32.com/ec/palodent-matrix-system-refill-standard-matrices-100-d-774277utm_source=google&utm_medium=cpc&adpos=&gclid=
8.Accessdata.fda.gov. 2020. *CFR - Code Of Federal Regulations Title 21.* [online] Available at: <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=872.4565>
9.U.S. Food and Drug Administration. 2020. *Overview Of Device Regulation.* [online] Available at: <https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/overview-device-regulation#dc>
Jeffrey M. Rosenberg, D., 2020. *Making Contact: A Method For Restoring Adjacent Posterior Direct Resin | Dentistry Today.* [online] Dentistrytoday.com. Available at: <https://www.dentistrytoday.com/restorative/8821-making-contact-a-method-for-re storing-adjacent-posterior-direct-resin>