



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

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Client:

Dr. Graham Thatcher

Advisor:

Dr. John Puccinelli



Problem Statement

Maximize function and improve workflow for the treatment of
Class II Malocclusion in Canines.

Presented By: Abbie



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Class II Malocclusion in Dogs

- Class II malocclusion is a common genetic skeletal deformity where the lower jaw is relatively shorter than the upper jaw.
 - Common among purebreds
 - A study of 139 purebreds, 14 of them had MAL2 (10%) [1]
 - Specific Teeth placement
- This condition leads to destruction of the palate and gum tissue of the upper jaw.
- This negatively affects the canine's quality of life by inhibiting necessary instincts



Figure [1]: Normal Occlusion [2]



Figure [2]: Class II Malocclusion [2]



Figure[3]: Puncture Wounds [2]

Presented By: Abbie



Current Treatment Options

- **Intrusive Orthodontics**
 - Extraction
 - Shortening
 - Inhibits functionability



Figure 4: Shortening of Teeth [3]

- **Tipping Orthodontics**
 - Crown extensions
 - Incline Plane and uncontrolled tipping



Figure 5: Crown Extension [3]



Figure 6: Incline Plane [3]

Presented By: Maddie



Uncontrolled Tipping Mechanics

- Gradually tips the tooth
- Root and crown move in opposite directions create moment force
- Rotates about the center of resistance
- Does not translate tooth

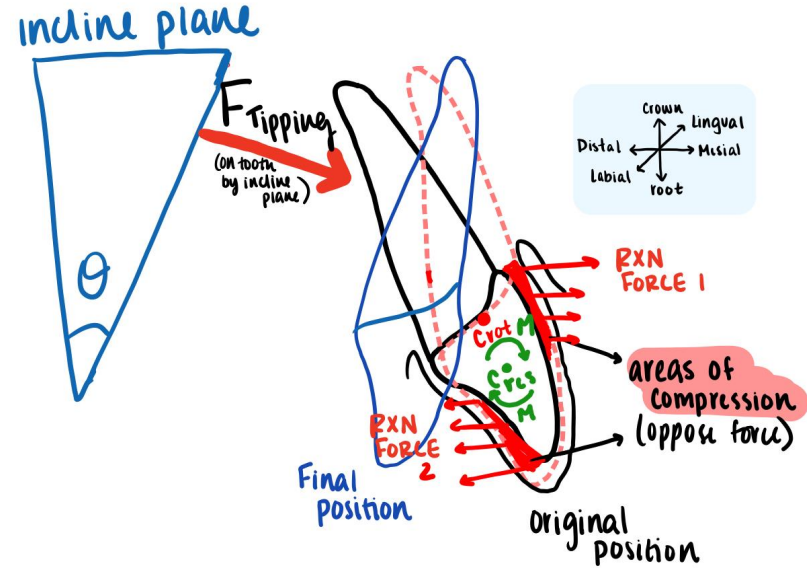


Figure 7 : Uncontrolled Tipping Free Body Diagram

Current Design and Gap

Carved Incline Plane

1. Take a CT scan of Canine's jaw
2. Generates a 3D printed mold of the jaw
3. Carves out incline plane on mold
4. Sends carving of the incline plane to an engineer to be designed and printed

Cost

- Cost of CT Scan and Anesthesia
- Outsource to engineer for design and 3D print incline plane

Workflow

- Tedious to carve out specific incline plane
- Wait on engineer to create the product

Material

- Fall 2020 VETMED created their final design from Dental LT resin - it broke within two weeks of use



Figure 8: Clients Carved Inclined Plane

Presented By: Lily



Design Specifications

3D Printable patient specific Incline Plane Device.

- Must fit average maxillary canine width of 11 mm [6].
- Dimensional errors must be under 300-500 micrometers.

Improve workflow and user friendliness.

- Reduce measurement and manipulation time to 1 hour.
- Final product be produced under 1 week.
- Produce device by orthodontist.

Performance

- Withstand 6-8 weeks of use.
- Material to withstand up to 1400 N of Bite Force [6].

Reduce current costs

- CT Scan ~\$100-500 [4].
- Anesthesia ~\$90-200 [5].

Presented By: Lily



Improved Design

- Three manipulatable variables:
 - Support bridge length, Ellipse dimensions, and Inclined plane angle.
- Reduced time
 - 1 hour.
- Ti64Al4V (Ti64) Material.
 - Elastic Modulus: 113.8 GPa [7]
 - Yield Strength: 880 MPa [7]
 - Cost: ~\$250 for Ti64 [8]
 - Time: < 1 hour to design, ~2-3 weeks to print in Ti64 [8]

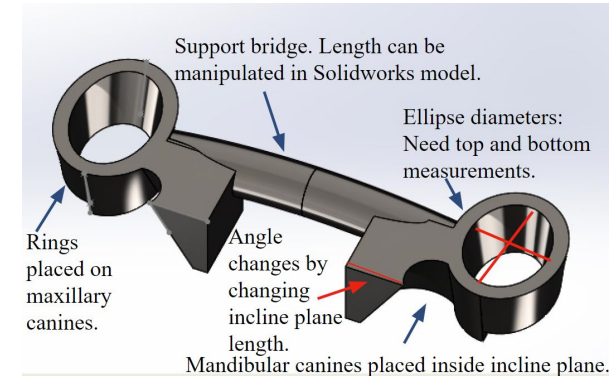


Figure 9: Final SolidWorks Design.



Figure 10: Final Design in PLA in 3D printed model canine.

Improved Workflow

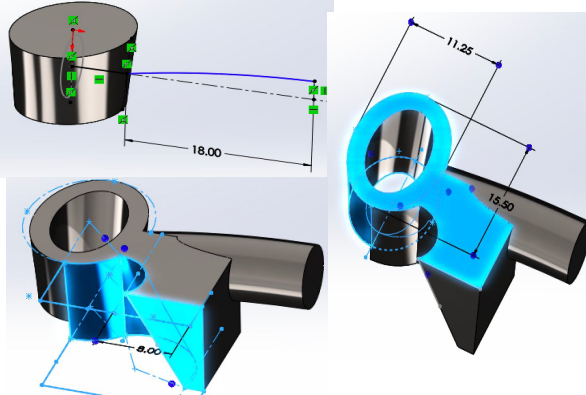
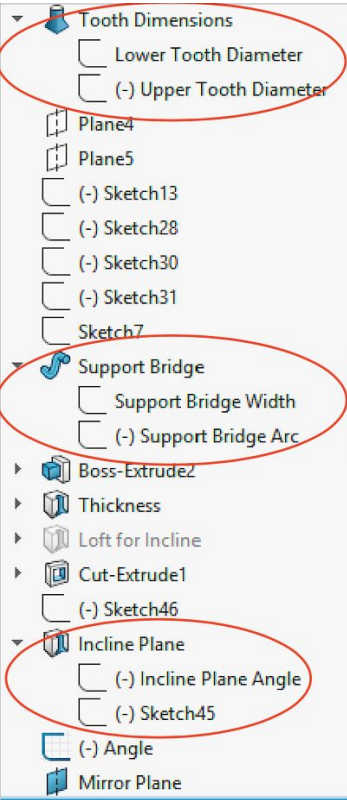


Figure 11: Patient Specific Variables
Take patient specific dimensions using dial calipers and input into the labeled sketches.

- 3D print the assembly in Ti64Al4V.
- Repeat process for the next patient.
- Cost: ~\$250 for Ti64 [8]
- Time: < 1 hour to design, ~2-3 weeks to print in Ti64 [8]

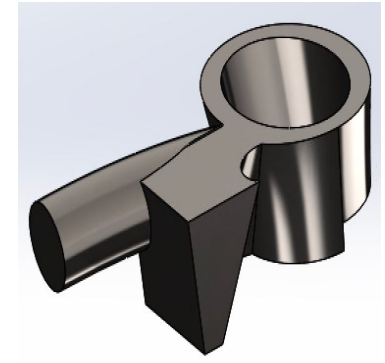


Figure 12: Mirrored Piece
Create a mirrored model of the design.

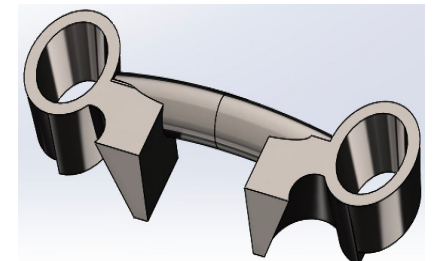


Figure 13: Assembly of parts
Assemble the two pieces together.



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1400 N Solidworks SimulationXpress Testing

Von Mises Stress From Direct Contact

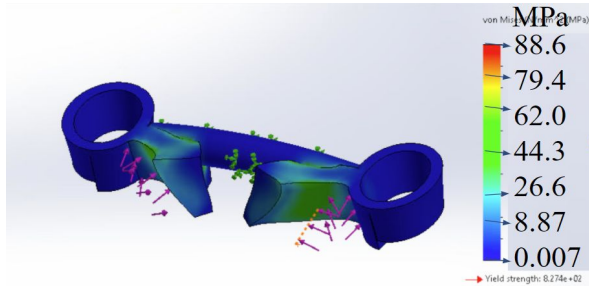


Figure 14: Von Mises stress throughout the final design.

- Stress values ranged from 0.007 MPa from blue regions to 44.3 MPa in green regions.
- Stress values highest at contact of incline plane and support bridge in red at 88.6 MPa
- Lowest FOS of 9.33.

Deformation of Final Design

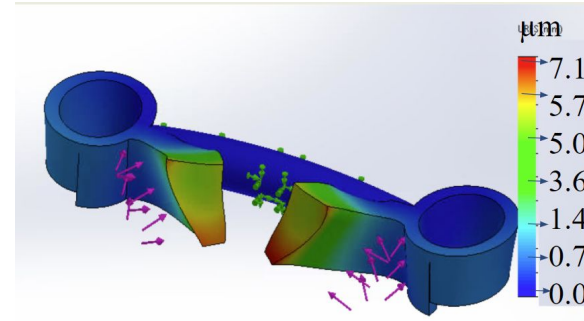


Figure 15: Deformation of device.

- Max deformation of 7.12 μm occurs at the 2 mm end of the incline plane in the red region.
- Closer to ring and support bridge deformation decreases.

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Mechanical Testing Plan

- Use an MTS machine for Compressive Testing
- Design a mold to hold incline plane in place
- Test for:
 - Elastic Modulus
 - Compressive Yield Strength
 - Deformation
- Goal: Verify the mechanical properties shown in SolidWorks to ensure the incline plane and Ti64 is suitable for use in patients

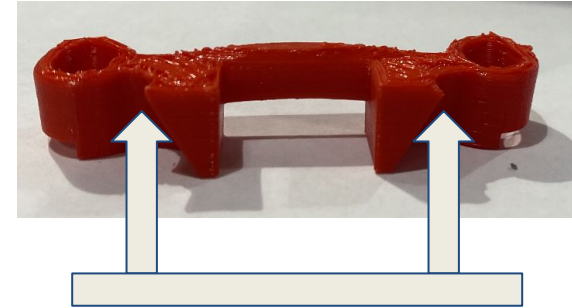


Figure 16: Demonstration of force applied to the incline plane via MTS compression testing

Patient Testing Plan

- Dr. Thatcher will collect measurements for a patient
- Team will make patient specific incline plane
- Apply incline plane to patient for 6-8 week treatment
- Track success of incline plane and amount of correction



Figure 17: Sad dog with Class II Malocclusion



Figure 18: Happy dog without Class II Malocclusion

Presented By: Gio



Future Work

- Fabricate our design in a finer resin material
- Fabricate our design in Titanium (Ti6Al4V)
 - 3D printing through Protolabs
 - CNC machining through Protolabs
- Design and Conduct Mechanical Testing Plan
 - Compressive testing
- Design and Conduct Patient Testing Plan



Acknowledgements

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Our advisor: Dr. Puccinelli

Presented By: Gio



References

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