BME Design-Fall 2021 - BENJAMIN SMITH
Complete Notebook

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OWEN KOLNIK

on

Dec 15, 2021 @02:41 PM CST

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Team contact Information

Tony Pribnow - Dec 14, 2021, 7:36 PM CST

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Project description

GIOVANNI MILITELLO - Dec 13, 2021, 2:45 AM CST

Course Number: BME 200/300 LAb 305

Project Name: VetMed: 3D Printed, Patient Specific Incline Plane For Management of Class 2 Malocclusion

Short Name: VetMed

Project description/problem statement:

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

About the client:

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

Client Meeting 09/14

LILY GALLAGHER - Dec 14, 2021, 2:53 PM CST

Title: First Client Meeting

Date: 09/14/21

Content by: All group members

Present: All group members

Goals: To meet Dr. Thatcher and understand the project goal

Content:

Vet School Graduate
Veterinary Dentist

- Past years group:
    - Proposed a new design and workflow for the correction of class II malocclusions
    - Graham implemented the new design, however it broke shortly after implementation
    - Workflow consisted of using Blender software to 3D design an incline plane using CT scans and 3D imaging

Background:

- Canine teeth are long, form a specific lock
    - IF teeth are too long, these teeth will hit tissue/pallet to damage and cause pain to the animal
- Tipping orthodontic work
    - Different than humans orthodontic work
    - Tipping is quick in dogs
        - Wants to utilize 3D printing

Problems

Prototype made…

- Broke after a few days
- Didn't fit dog super well
    - Painful
- Wants us to find holes in previous work and make i so that any veterinary dentist can look at a malocclusion and use software to create an incline plane to fix it
    - Take patient specific information, plug into data and get a solution
- CT Scan is very expensive

CT scan to find malocclusion, know where problems are in the animals mouth and the software to create a inclined plane

Need to do:

- Look for holes/improvements in past groups project
    - Take notes
    - Brainstorm ideas
- Background

        - Type II Malocclusions
        - Impact on dogs
        - Normal occlusion
        - Veterinary orthodontics
        - Current products to treat these malocclusions
        - Current treatment procedures
    - Materials
        - Materials stronger than LT Dental Resin

    - Software
        - Look for password/username for the software blendr from past groups project
        -

        - See if Graham can get it otherwise

Tony - send all the work from the previous group to Dr. Thatcher

Conclusions/action items:

Begin individual research

Client Meeting 09/27

GIOVANNI MILITELLO - Sep 27, 2021, 8:20 PM CDT

Title: Second Client Meeting

Date: 09/27/2021

Content by: All group members

Present: All group members

Goals: Ask questions about PDS and try to get software used previously.

Content:

- Updated Dr. Thatcher on what we have done so far
- Q n A

Questions and Answers:

Budget
- How much money can we spend
- Materials you've tried

Size
- Varied on size of dog

Performance
- How long will it need to be in the dog's mouth?
  - Tipping teeth does not take a lot of force
  - 4-6 weeks for tipping to fix the teeth
- Do you have any numerical statistics on how the device should perform (e.g. How much force does it need to be able to handle?)
  - Will let us how much force the design needs to not be able to break
  - Take into account specific dogs and what they do to not break their incline plane

Standards on veterinary orthodontics
- Safety/Ethics
  - No safety concerns
  - Little to no regulation

Design
- Did you like what the previous group came up with?
  - Take your own direction
  - Take DICOM file (CT data) plug CT scan into software to design incline plane right on the spot
- Are you looking for us to redesign the previous device or come up with a new one?
  - Stick with incline plane
  - Improve and modify on the previous design but wants a workflow for dentist to be able to print our design

Weight
- Are there any weight restrictions?
  - Give us extra prints to weigh
  - Differentiates between dogs
  - Not a big deal

Competitions
- Any competing products that you know of?
  - 3D print is the first way it has been done
  - Every other dentist makes incline plane
  - Removing teeth is not a good option
- Combining ideas

Get software
- Have you been able to get access to the software/ are we able to get access to software?

        - Has access to the software but needs to share it with us
    - How has the software been used?

Materials

- Materials you have used
    - Photopolymer (dental LT)
    - With incline plane, had holes in it and filled the holes with dental composite to have it stay in place
- Other materials that you have tried or can be used.
    - Don’t Need FDA approval for dogs
    - Can use any materials for the incline plane

Tilt

- Some literature says 60 degrees, but is very patient specific

Other

- How common is a class 2 malocclusion?
    - Some breeds just have it because of the trait is passed down
    - Treats 1 every two weeks but 1 every week more recently
    - Around 6 incline planes a year
    - Very common in Goldendoodles
    - Smaller market
- No big expectations
- What does Graham want?
    - Wants to be able to go from DICOM file (ct scan data), plug that into the software to design the incline plane, send it to a printer, and then print it
    - (uses 3matic) last years group worked with another software that allowed them to play around with the teeth
    - Currently, Graham comes up with concept and interacts with with software engineers multiple times before making the product
    - Would like it to be 3D printed
    - Ideally, would like to do it himself

- Graham to give us printed material from last group, to give data on forces in dogs mouth
- 3D printing can change angle of incline plane, also it’s cheaper and faster to 3D print the incline plane
- Video or description of how to make the inclined plane the standard way
- Password for software

Conclusions/action items:

Find dates to meet in person

Client Meeting 10/27

GIOVANNI MILITELLO - Oct 27, 2021, 7:22 PM CDT

Title: Second Client Meeting

Date: 10/27/2021

Content by: All group members

Present: All group members

Goals: Ask questions about PDS and try to get software used previously.

Content:

Updated Dr. Thatcher on our final design
- Only 3 variables to change in our design: Length of bar, Diameter of ring, Degree of incline
- Test with PMMA but look into Titanium
- Budget of $500: Must let Graham know the cost of our design

Conclusions/action items:

- Start making part in SolidWorks

Client Meeting 12/09/21

GIOVANNI MILITELLO - Dec 13, 2021, 1:34 AM CST

Title: Last Client meeting

Date: 12/09/21

Content by: Team

Present: Team

Goals: Present final work to client

Content:

- Gave our client a presentation of all the work conducted over the semester and showed him our poster.

- Our client mentioned that a 3 week timeline for printing is noit that bad as consultaiotion with a patient takes about 3 weeks

- Our client was really happy about our design and how easy each variable can be changed in solidworks to make it patient specific and appreciated the workflow document

- Asked us to continue the prject for next semester as he would like to try our produc on one of his patients

Conclusions/action items:

- Figure out if and how to be able to contiue this project with Dr. Puccinelli

Advisor Meeting 09/20

LILY GALLAGHER - Sep 20, 2021, 9:26 PM CDT

Title: First Advisor Meeting

Date: 09/20/21

Content by: All group members

Present: All group members

Goals: Meet our advisor and discuss expectations/ project plan

Content:

Introductions

- Everyone gave their introductions

What we went over with the client:

- Look at client notes
- Can continue with previous project
- But also look at your own pathway
- Different look at materials
-

Advisor Expectations:

- Pick up where they left off
- LABARCHIVES
    - Will comment on submissions

BME design room

- Lockbox with code ATP

Report help:
https://bmedesign.engr.wisc.edu/course/resources#reports

Conclusions/action items:

Continue research and begin PDS

Advisor Meeting 09/27

BENJAMIN SMITH - Sep 28, 2021, 12:46 AM CDT

Title: Advisor Meeting 2

Date: 09/27/2021

Content by: Team

Present: Team and Dr. Puccinelli

Goals: Talk about work conducted over the past week

Content:

We talked about work each of us conducted over the week. Mostly included more in depth research on material to use for the incline plane, other competing designs, and former papers written by our client explaining further in detail about his vision for the incline plane. We also talked about questions to bring up to our client for our client meeting.

To Do List:

- Ask our client about the software and how we can get our hands on it
- Have design criteria for our next advisor meeting (don't need the full design matrix)
- Start thinking about our presentation on Oct. 8th
    - Get statistics (quantitative)
    - Numerical specifications
    - Send slides by noon on Wed, Oct. 6th for review
    - Present live in the Design Lab
    - Should have a matrix included in this presentation
- Ask our client about standards

Conclusions/action items:

Start working on design matrix and figure out what exactly the client wants from us.

Advisor Meeting 10/04

GIOVANNI MILITELLO - Oct 04, 2021, 5:19 PM CDT

Title: Advisor Meeting 2

Date: 10/042021

Content by: Team

Present: Team and Dr. Puccinelli

Goals: Talk about work conducted over the past week

Content:

- Talked about the design matrix and went through each 3 different matrices and their criteria specifically
    - Start with design
    - Then with the design leads to what workflow/software we need to make the design
    - And once we know how to make the design with the specific workflow/software, then pick the material that works best
- Have markers on teeth to set scale for the incline plane to make it easier to adjust our design
- Workflow/Software matrix
    - Use a block diagram for each design
- Design matrix
    - Draw out or use CAD for each design
    - Use best last year design
    - Use one design with bridge
    - Use one design with impression to make full retainer
- Material matrix
    - Materials that can be 3D printed
    - Materials that can be used for molds as well

Conclusions/action items:

Finish design matrices and get software from Graham to play with.

Advisor Meeting 10/11

BENJAMIN SMITH - Oct 11, 2021, 4:17 PM CDT

Title: Advisor Meeting

Date: 10/11/21

Content by: Ben Smith

Present: Ben Smith, Daniel Konon, Owen Kolnik, Lily Gallagher, Tony Pribnow, Giovanni Militello, Dr. Puccinelli

Goals: Update Dr. P on our work

Content:

We updated Dr. P on our work on our design matrices as well as updates from our client Graham.

Conclusions/action items:

To Do:

- Get an estimate on how much it is to print titanium
- Find where we can print PMMA
- Research material properties of 3D printing materials at the Makerspace
- Get access to software from previous group

Advisor Meeting 10/25

GIOVANNI MILITELLO - Nov 07, 2021, 9:22 PM CST

Title: Advisor Meeting

Date: 10/25/21

Content by: Team

Present: Ben Smith, Daniel Konon, Owen Kolnik, Lily Gallagher, Tony Pribnow, Giovanni Militello, Dr. Puccinelli

Goals: Update Dr. P on our work

Content:

Talked about how presentations and preliminary reports went.

Conclusions/action items:

To Do:

- Start to work on design in Solidworks
- Look into makerspace for 3D printing

Advisor Meeting 11/01

GIOVANNI MILITELLO - Nov 07, 2021, 9:13 PM CST

Title: Advisor Meeting

Date: 11/01/21

Content by: Team

Present: Ben Smith, Daniel Konon, Owen Kolnik, Lily Gallagher, Tony Pribnow, Giovanni Militello, Dr. Puccinelli

Goals: Update Dr. P on our work

Content:

We updated Dr. P on our work on our design in Solidworks.

Conclusions/action items:

To Do:

- Print design for show and tell
- Finish design and perform simulation testing
- Research material properties of 3D printing materials at the Makerspace

Advisor Meeting 11/15

BENJAMIN SMITH - Nov 15, 2021, 4:06 PM CST

Title: Advisor Meeting

Date: 11/15/21

Content by: Team

Present: Group 5

Goals: Give weekly updates to our advisor.

Content:

Difficulties:

- Implementing incline plane while limiting variables

- Accurately measuring teeth to print a model that fits

Project suggestions:

- Make a free body diagram to help understand forces that will interact with design as well as show some mathematical analysis

- Use a finite element analysis on solidworks to help with above bullet

- Use makerspace staff to help with solidworks troubles

- Find more literature for standards and federal laws to implement into report

Conclusions/action items:

- Reach out to client to get more CT scans to measure tooth dimension variability

- Print out new model with first incline plane prototype

- Ask client how he determines angles for incline plane

Advisor Meeting 11/22

BENJAMIN SMITH - Nov 22, 2021, 3:55 PM CST

Title: Advisor Meeting

Date: 11/22/21

Content by: Ben Smith

Present: Group 5

Goals: Keep our advisor up to date with our progress

Content:

Things to get done:

- Meet with our client to update him on our design

- Consider stresses in normal titanium compared to 3D printed titanium material properties

- Can we try a 3D printed plastic version on an animal

- Start thinking about the poster session and final report (look at Dr. P's comments)

- 3 ft x 5 ft is pretty standard for a poster (Helen C. White or college library)

Advisor Meeting 12/06

GIOVANNI MILITELLO - Dec 13, 2021, 1:46 AM CST

Title: Advisor Meeting

Date: 12/06/21

Content by: Team

Present: Group 5

Goals: Keep our advisor up to date with our progress

Content:

- Went over the rough draft of our poster and see where improvements could be added to make the poster be more clear/understandable and visually better

- Requirements of the poster were also brought up during this meeting

- Showed Dr. Puccinelli our final design 3D printed in PLA and went over specifications for our design

PDS

GIOVANNI MILITELLO - Dec 13, 2021, 3:47 AM CST

Title: PDS

Date: 9/23/21

Content by: Team

Present: Team

Goals: Create a Preliminary Product Design Specification

Content:

Specifications given to us by Dr. Graham Thatcher:

Budget: $500 for printing cost

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

S. E. Kim, B. Arzi, T. C. Garcia, and F. J. M. Verstraete, “Bite Forces and Their Measurement in Dogs and Cats,” Front Vet Sci, vol. 5, p. 76, Apr. 2018, doi: 10.3389/fvets.2018.00076.

“ISO 13504:2012(en), Dentistry — General requirements for instruments and related accessories used in dental implant placement and treatment.” https://www.iso.org/obp/ui/#iso:std:iso:13504:ed-1:v1:en (accessed Sep. 24, 2021)

“AAHA-AVMA canine preventive healthcare guidelines,” American Veterinary Medical Association. https://www.avma.org/resources-tools/avma-policies/aaha-avma-canine-preventive-healthcare-guidelines (accessed Sep. 24, 2021).

Chakroun, F., Colombo, V., Lie Sam Foek, D., Gallo, L., Feilzer, A. and Özcan, M., 2021. Displacement of teeth without and with bonded fixed orthodontic retainers: 3D analysis using triangular target frames and optoelectronic motion tracking device. [Online] Available: https://pubmed.ncbi.nlm.nih.gov/30935614/

C. E. Harvey, “Shape and Size of Teeth of Dogs and Cats - Relevance to Studies of Plaque and Calculus Accumulation,”

“Dental lt clear resin 1 L,” *Formlabs*. [Online]. Available: https://formlabs.com/store/dental-lt-clear-resin/. [Accessed: 15-Oct-2021].

“CFR - code of federal Regulations Title 21,” *accessdata.fda.gov*. [Online]. Available: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=872.5410. [Accessed: 24-Sep-2021].

Orthodontic device for small animals, by Lloyd J. Mann. (1992, Sept. 29).*US5151027A.* Accessed on: Sept. 24, 2021. [Online]. Available: https://patents.google.com/patent/US5151027A/en?q=dog+orthodontics&oq=dog+orthodontics

Size

- Varied on size of dog
- Needs to be Patient specific

Performance

- Tipping teeth does not take a lot of force, max canine bite force of 1400 N
- 6-8 weeks for tipping to fix the teeth

Standards on veterinary orthodontics

- Safety/Ethics
    - No safety concerns
    - Little to no regulation
    - But use dental standard used in humans as dog owners want to have their pet treated as a human

Design

- Wants a quicker workflow to be able to produce himself
- Can decide to keep or eliminate the software portion
- Take design by our own direction as last years group was not as successful
- Incline plane usually 60 degrees but also patient specific
- Cost dependent on material but preferably less than current

Weight

- Weight will be dependent on the size which is patient specific

Competitions

- Any competing products that you know of?
    - 3D print is the first way it has been done
    - Other dentist makes their own version incline plane
    - Removing teeth or grinding teeth down are not a good option

Materials

- Materials to look at
    - Photopolymer (dental LT)
    - With incline plane, had holes in it and filled the holes with dental composite to have it stay in place
    - Can use any materials for the incline plane
    - Could potentially use metal as long as it is biocompatible

How common is the problem

- Some breeds just have it because of the trait is passed down
- Treats 1 every two weeks but 1 every week more recently
- Around 6 incline planes a year

- Very common in Goldendoodles
- Smaller market
- Only print out for the specific patient that Dr. Thatcher is treating at the moment

Conclusions/action items:

- Final PDS below

LILY GALLAGHER - Sep 24, 2021, 6:41 PM CDT

VetMed: 3D Printed, Patient Specific Incline Plane

Preliminary Product Design Specifications

BME 200/300

Team Members:

Benjamin Smith, *Team Leader*
Lily Gallagher, *BWIG*
Giovanni Militello, *BSAC*
Daniel Kotun, *BPAG*
Tony Pribanw, *Communicator*
Owen Kolnik, *Co-BWIG*

Client:
Dr. Graham Thatcher
Advisor:
Dr. John Puccinelli

September 22nd, 2021

24.pdf(199.2 KB) - download

Design Matrix

GIOVANNI MILITELLO - Dec 13, 2021, 3:56 AM CST

Title: Design matrix

Date: 10/09/21

Content by: Team

Present: Team

Goals: Create a Design Matrix

Content:

Material Matrix:

			
Criteria	Design 1 - Dental LT Resin (V2)	Design 2 - Polymethyl Methacrylate (PMMA)	Design 3 - 3D Printable Titanium
Durability (biofunction) (30)	4/5 (24)	5/5 (30)	5/5 (30)
Safety (biocompatibility) (25)	5/5 (25)	5/5 (25)	5/5 (25)
Cost (25)	3/5 (15)	4/5 (20)	1/5 (5)
Ease of Fabrication (availability) (10)	4/5 (8)	4/5 (8)	2/5 (4)
Weight (5)	4/5 (4)	4/5 (4)	2/5 (2)
Comfort (5)	5/5 (5)	5/5 (5)	3/5 (3)
Total Score (100)	80	92	69

Definitions:
Biofunction: Force able to withstand

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

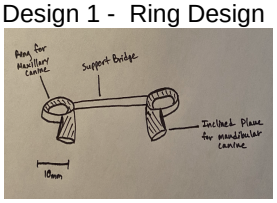
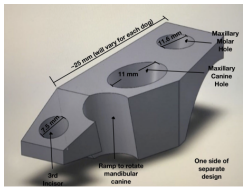
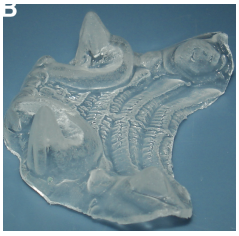
Biocompatibility: Ethically safe to be in a mouth.

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

Cost: Cost of fabrication/material
Ease of Fabrication: Time and accessibility
Weight: Weight of the material
Comfort: Malleability of material-- effect of teeth overtime

- Durability (biofunction) is the most important criterion, given a score of 30, as the material needs mechanical and physical properties that enable the implanted device to perform its function under the stresses imposed in the oral cavity. Designs 2 and 3 are ranked the highest in this criteria as both materials have mechanical and physical properties to withstand forces from a canine.
- Safety (biocompatibility) is the next biggest priority for the team, given a score of 25, as interactions between materials and the recipient tissues of the body are an important factor when selecting a material. Although there are no FDA safety regulations for canines, the team would like to take the same approach with canines as with humans. Given that all three materials are biocompatible with humans, the team ranked them all the same score as these materials are safe for human use.
- The cost of the material is equally important as the team would like to produce a product that is low cost so that the client can distribute and use the product in their treatment at a relatively low cost. Design 2 ranked the highest in this criteria as polymethyl methacrylate is lower cost compared to the other two materials looked at.
- Ease of fabrication in the next criteria, given a score of 10. This looks at the availability of the material for use during 3D printing. Both designs 1 and 2 are ranked the highest in this criteria as there are accessible 3D printers on campus that can print using dental LT resin V2 and PMMA.
- Weight and Comfort, both given a score of 5. The team wants a material that is light in weight so it would not cause damage to the canine's mouth and therefore not cause discomfort in the canine. Designs 1 and 2 ranked the highest in both criteria as dental LT resin V2 and PMMA are lighter compared to the 3D printable titanium, as titanium is metal, and therefore would be more comfortable in the patient's mouth.
- Design 2 (PMMA) ranked the highest compared to the other two materials with a score of 92/100 points.

Design Matrix (3 different inclined planes) :

Criteria	Design 1 - Ring Design 	Design 2 - Separate Incline 	Design 3 - Dental retainer 
Effectiveness / Durability (30)	4/5 (24)	3/5 (18)	4/5 (24)
Ease of Manufacturing (20)	5/5 (20)	4/5 (16)	3/5 (12)
Cost (20)	5/5 (20)	5/5 (20)	4/5 (16)
Safety (15)	5/5 (15)	5/5 (15)	5/5 (15)
Compatibility (10)	5/5 (10)	3/5 (6)	1/5 (2)
Treatment time (5)	4/5 (4)	3/5 (3)	1/5 (1)
Total (100)	93	78	70

Effectiveness: Does the design solve the problem
Ease of Manufacturing: How easy is it for the design to be 3D printed
Cost: How much does it cost to make the product
Compatibility: How compatible is the design with the workflow/software
Safety: How safe is the design to use in patients mouth and how safe is it to produce the design
Durability: How much force will the design be able to withstand
Treatment time: How much time will the design need to be used to treat the patient

- Effectiveness and durability are the ability of the design to correct Class 2 Malocclusions and the ability to withstand forces that are generated from a canine, such as biting forces, respectively. This is the reason why effectiveness and durability were ranked the highest, given a score of 30, as it is an important factor that the design completes its function and does not break during usage. Designs 1 and 3 received the highest score in this criteria, as both designs 1 and 3 are single pieces with multiple support points which allows for better durability which leads to better effectiveness. The reason design 2 did not receive a similar score to design 1 and 3 is that design 2 broke upon usage during one of the client's treatments of a patient.
- The ease of manufacturing is the next biggest priority with the team, given a score of 20. The ability to easily 3D print the design allows for the client to have the incline plane sooner and start his treatment process right away. Design 1 scored the highest in this criteria as this design is the simplest out of all three designs and would be able to be 3D printed the fastest. Additionally, design 1 would also be able to be modified for each specific patient as this is a request from the client.
- The costs of the design are equally important as the team would like to produce a product that is low cost so that the client can distribute and use the product in their treatment at a relatively low cost. Designs 1 and 2 ranked the highest in this criteria as both of these designs are small and would not cost as much to 3D print compared to design 3.
- Safety of the patient while using the incline plane for treatment is the next priority, with the given score of 15. All three designs do not concern the safety of the canine, all three designs received the same score.
- Compatibility is the ability of the design to work with the client's process to treat Class 2 Malocclusions, given a score of 10. Design 1 received the highest score in this criteria as it is the simplest design which allows for it to be easily modified for each patient and be 3D printed, which are specific requirements from the client.
- Treatment time is the amount of time it would take for each design to correct Class 2 Malocclusions. All three designs are incline planes, the treatment time is the same for all three, therefore the team ranked each design based on how much time it takes to create each design. Design 1 was ranked the highest in this criteria as it would be able to be 3D printed and modified the quickest for the client.
- Design 1 (Ring Design) ranked the highest compared to the other two designs with a score of 93/100 points.

Conclusions/action items:

- work on preliminary presentation

Initial Design

BENJAMIN SMITH - Dec 14, 2021, 11:18 PM CST

Title: Initial design

Date: 10/29/21

Content by: Team

Present: Team

Goals: Create an initial design for incline plane

Content:

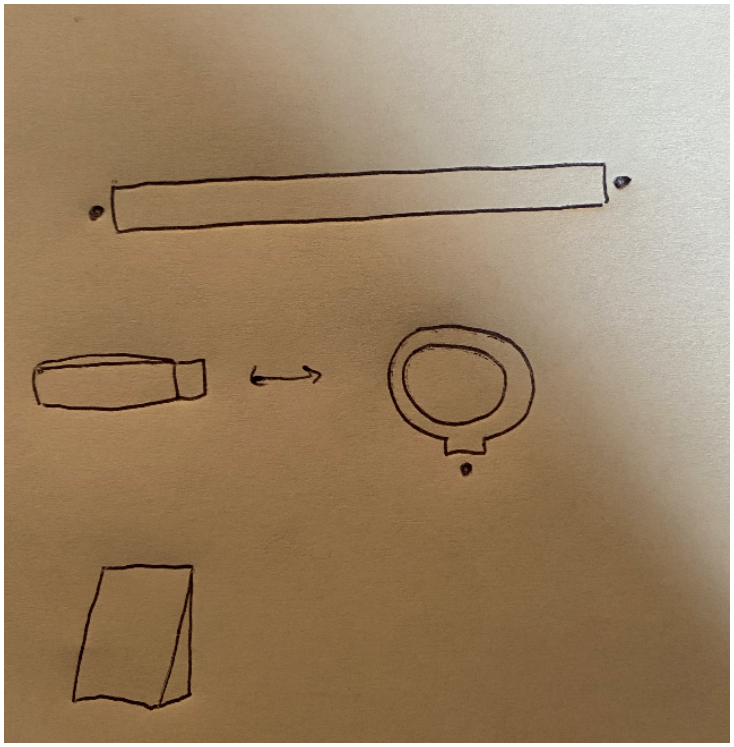


Figure 1: Initial drawing of design. The dots will be connection points.

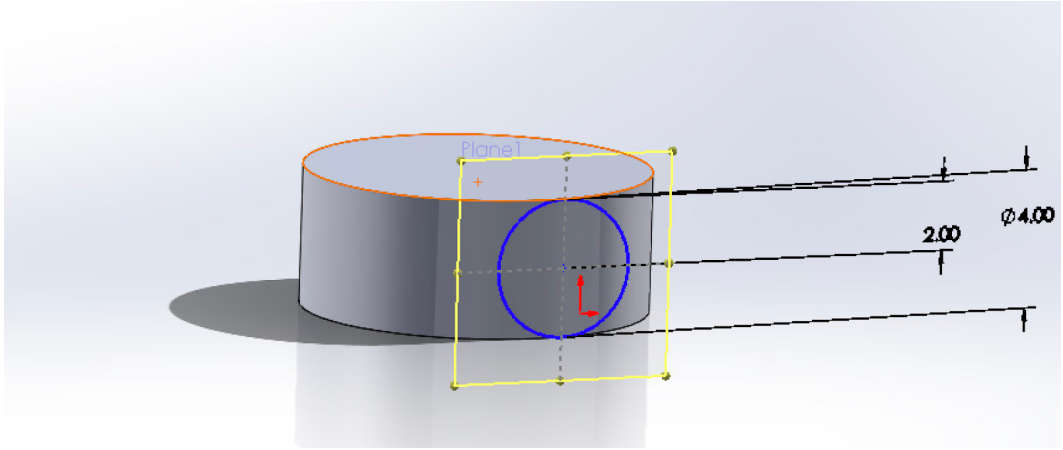


Figure 2: Ring design of incline plane

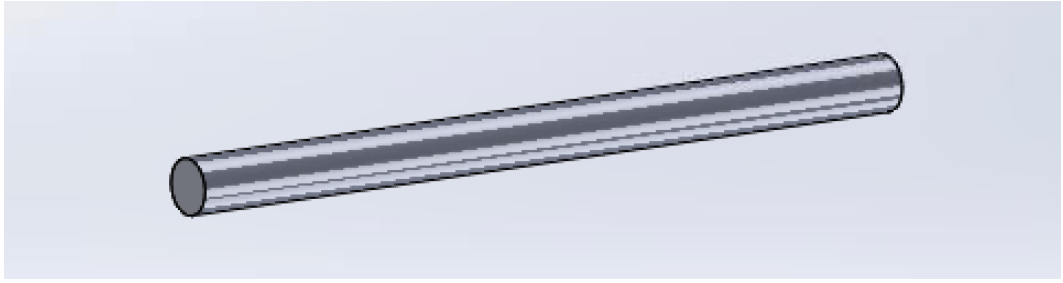


Figure 3: Bar design of incline plane

Conclusions/action items:

- Finish design

Solidworks first Model

GIOVANNI MILITELLO - Nov 12, 2021, 8:13 PM CST

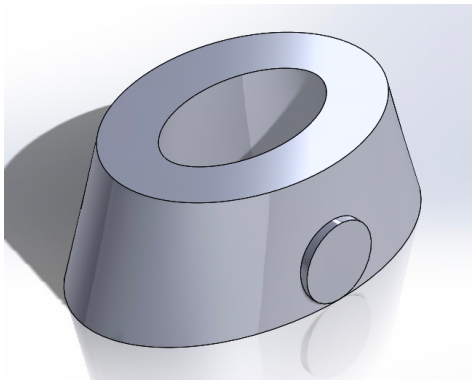
Title: Solidworks First Model

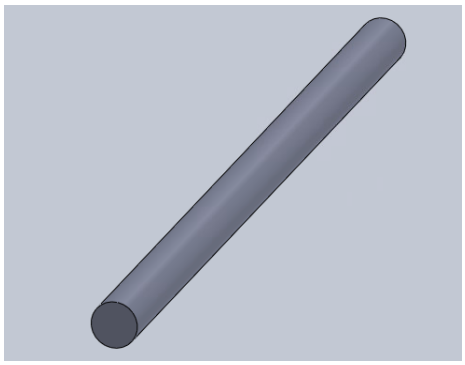
Date: 11/12/21

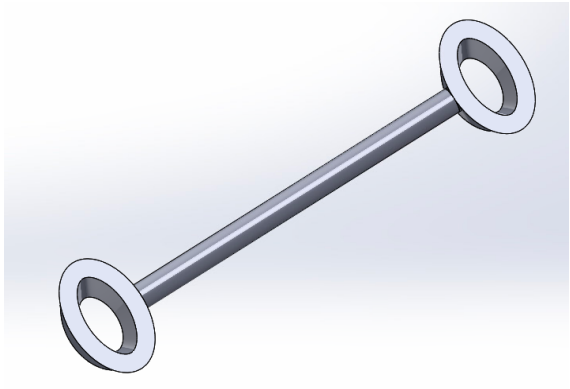
Content by: Ben Smith

Goals: Create an initial model of our design on Solidworks

Content:







Conclusions/action items:

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

Solidworks 2nd Model

BENJAMIN SMITH - Dec 13, 2021, 7:53 PM CST

Title: SolidWorks 2nd model

Date: 11/19/21

Content by: Team

Present: Team

Goals: Update design in solidworks

Content:

- Worked with Ben Hildebrandt to try and update and fix our design so that it would be easily adjusted by our client to specific patients.

- Worked on fixing the rings of our design so that when you increase the diameters, the whole design would increase instead of parts intruding into the part. Made the measurements reference off of the rings to complete this task.

- Worked on changing the support bridge to be curved to fit inside of the dogs mouth better and add more structural support. Made the measurements reference off of the rings to complete this task.

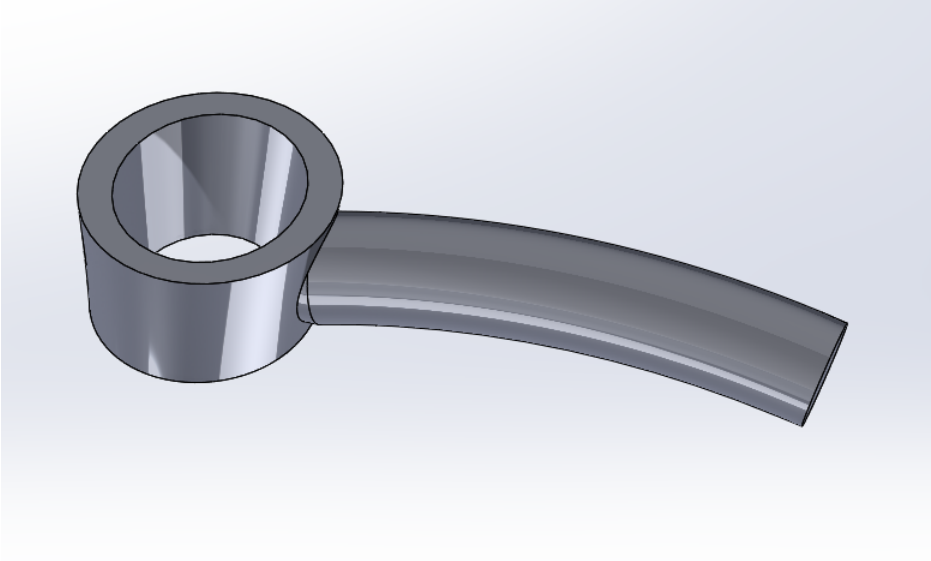


Figure 1: Updated solidworks model featuring a curve support bridge and elliptical rings.

Conclusions/action items:

- Look to add an incline plane to the device with Ben's help

Solidworks Final Model

BENJAMIN SMITH - Dec 13, 2021, 7:56 PM CST

Title: SolidWorks Final model

Date: 12/03/21

Content by: Team

Present: Team

Goals: Update design in solidworks

Content:

- Worked with Ben Hildebrandt to try and update and fix our design so that it would be easily adjusted by our client to specific patients.

- Worked on adding the incline plane to our device to finish the product. Had the incline plane reference off of the ring so that any changes to the diameter of the rings, changes to the length of the support bridge, or any changes to the angle of the incline plane would also change the whole design size and no portion of the design would interfere with other parts.

- The angle of the incline plane would be determined by the client based on how bad the Class 2 Malocclusion is in the patient.

- The angle is adjusted by changing the longer length of the incline plane to either increase or decrase the angle. Angle values are usually around 45-60 degrees to fix Class 2 Malocclusion.

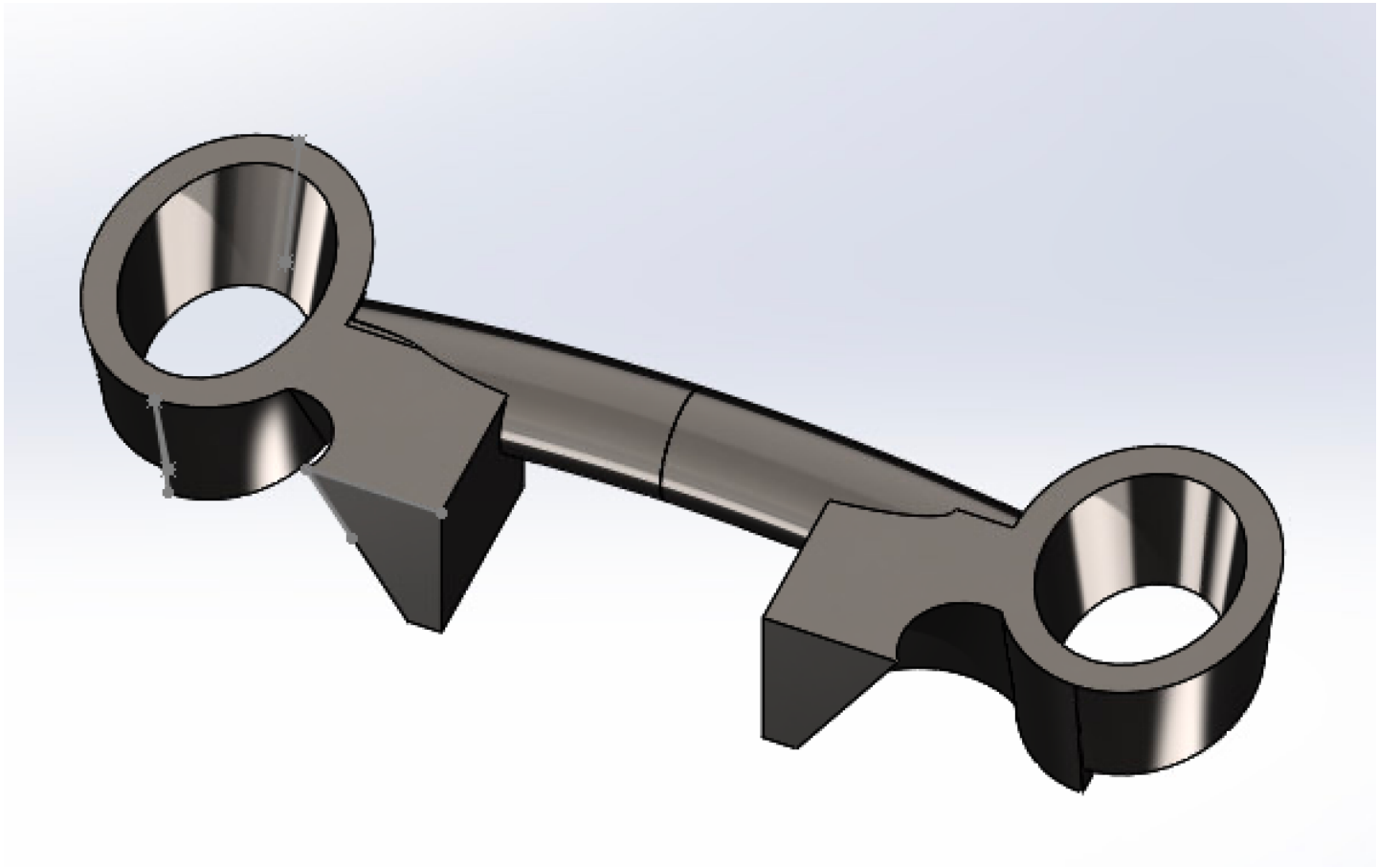


Figure 1: Final solidworks assembly for the final design

- Upper tooth diameter: 15.50 mm x 11.25 mm

- Lower tooth diameter: 13 mm x 8 mm

- Support bridge length: 38 mm

- Degree of incline plane: 60 degrees

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

Conclusions/action items:

- 3D print out final design for presentation

Team Meeting 9/24/21

BENJAMIN SMITH - Dec 14, 2021, 10:49 PM CST

Title: Team Meeting

Date: 9/24/21

Content by: Ben Smith

Present: Lily Gallagher, Ben Smith, Tony Pribnow, Daniel Konon, Owen Kolnik, Giovanni Militello

Goals: Create the first draft of our PDS

Content:

The team met up in person to set up the PDS. We started by listing the client specifications which were determined from our first meeting with Graham. These specifications are as follows:

- Incline plane device
- Device can be modified based on each specific patient based on their CT scan
- Device must be easy to create from CT scan using user-friendly software
- Device must be placed in the patient's mouth
- Simplified Software Workflow
- Withstand 6-8 weeks of use
- Reduce the 1-week fabrication timeline (using a software engineer)
- Eliminate the need to intubate in the case of the device breaking (cost $90 to $200)
- Reduce the need to take CT Scans ($100-$500) for each patient.

Then, we split up the Physical and Operational Characteristics portion and worked on sections individually. Once everyone was done with their section, we read over each others to make sure they were well written. The same procedure was taken for Production Characteristics.

After about 3 hours of work and proofreading, the PDS was written and ready to be reviewed with our client.

Conclusions/action items:

Our team finally met in person for the first time to complete the PDS and conduct other research. We are excited to keep working with each other.

Next steps: Meet with Dr. Thatcher in person to discuss the project and update the PDS with him, think about different materials to use, and

Team Meeting 10/1/21

GIOVANNI MILITELLO - Dec 14, 2021, 11:15 PM CST

Title: Team Meeting

Date: 10/1/21

Content by: Ben Smith

Present: Ben Smith, Tony Pribnow, Giovanni Militello, Lily Gallagher, Owen Kolnik, Daniel Konon

Goals: Get a good start on the preliminary presentation and define design criteria for our matrices

Content:

We have identified the matrices we want to complete for our project. These are a matrix for type of material, a matrix for the project work flow, and a matrix for the actual design of the inclined plane. After more research we will weight these criteria and fill out the matrices.

Material design matrix criteria:

Biofunction: Force able to withstand

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

Biocompatibility: Ethically safe to be in a mouth.

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

Cost: Cost of fabrication/material

Ease of Fabrication: Time and accessibility

Weight: Weight of the material

Comfort: Malleability of material-- effect of teeth overtime

Design matrix criteria:

Effectiveness: Does the design solve the problem

Ease of Manufacturing: How easy is it for the design to be 3D printed

Cost: How much does it cost to make the product

Compatibility: How compatible is the design with the workflow/software

Safety: How safe is the design to use in patients mouth and how safe is it to produce the design

Durability: How much force will the design be able to withstand

Treatment time: How much time will the design need to be used to treat the patient

Conclusions/action items:

Questions for advisor:

How many different criteria do we need for each matrix?

Conduct more research on materials and different workflow options.

BENJAMIN SMITH - Oct 01, 2021, 1:25 PM CDT

Material Matrix:

	Pt 1	Pt 2	Pt 3
Criteria	Design 1 -	Design 2 -	Design 3 -
Safety			
Durability			
Cost			
Ease of Fabrication			
Comfort			
Weight			

Definitions:
Safety: Ethically safe to be in a mouth
Durability: Force able to withstand
Cost: Cost of fabrication/material
Ease of Fabrication: Time and accessibility
Comfort: Malleability
Weight:
Installation???

Workflow/Software Matrix:

	Pt 1	Pt 2	Pt 3
Criteria	Design 1 - Carving	Design 2 - CT Scans/Software	Design 3 - Mold impressions
Lead Time			
Cost			
Ease of process			
Labor			
Safety			
Compatibility			

Definitions:

Design_Matrix.pdf(27.2 KB) - download

Team Meeting 10/8/21

BENJAMIN SMITH - Dec 14, 2021, 11:15 PM CST

Title: Team Meeting

Date: 10/8/21

Content by: Ben Smith

Present: Ben Smith, Giovanni Militello, Lily Galagher, Owen Kolnik, Tony Pribnow

Goals: Continue work on design matrix and preliminary presentation

Content:

Accomplishments:

- We decided on designs and materials to put through the matrix
  - Designs
    - Ring Design
    - Separate Incline Plane (Previous Group's Design)
    - Dental Retainer
  - Materials
    - Dental LT Resin (Previous Group's material that broke under stress)
    - PMMA
    - 3D Printed Titanium (Ti64A14V)
- We observed the molds from our client and how they work
  - The mold attaches to the maxillary canines and other smaller surrounding teeth, and covers most of the roof of the mouth, being very obstructive
- We planned out our next meeting and next steps to work on
  - We need to evaluate the designs and materials in the design matrices

Conclusions/action items:

We made good progress and need to meet again to finish the design matrices

Team Meeting 10/14/21

BENJAMIN SMITH - Dec 14, 2021, 11:21 PM CST

Title: Team Meeting

Date: 10/14/21

Content by: Team

Present: Ben Smith, Giovanni Militello, Lily Galagher, Owen Kolnik, Tony Pribnow, Daniel Konon

Goals: Finish preliminary presentations

Content:

Accomplishments:

- Finished preliminary presentations
    - We assigned roles based on interest and knowledge levels from own research
    - We incorporated the necessary parts of the PDS into the presentation
    - We met for about 5 hours until the presentation was completed.
- Practiced presenting the preliminary presentation while making sure we were within the time limit.

Conclusions/action items:

We prepared for preliminary presentations on Oct. 15

Team Meeting 10/19/21

BENJAMIN SMITH - Dec 14, 2021, 11:32 PM CST

Title: Team Meeting

Date: 10/19/21

Content by: Team

Present: Ben Smith, Giovanni Militello, Lily Gallagher, Owen Kolnik, Tony Pribnow, Daniel Konon

Goals: Finish preliminary report

Content:

Accomplishments:

- Finished preliminary report
    - As was done with the PDS, we assigned sections individually and then proofread everyone's when they were done, all while following the preliminary report guidelines.
    - Sections like testing, fabrication, and results were left blank as we have no data to provide for these yet

Conclusions/action items:

Start to look toward creating our design in Solidworks.

Team Meeting 10/29/21

BENJAMIN SMITH - Dec 14, 2021, 11:34 PM CST

Title: Team Meeting

Date: 10/29/21

Content by: Team

Present: Ben Smith, Giovanni Militello, Lily Galagher, Owen Kolnik, Tony Pribnow, Daniel Konon

Goals: Start to make incline plane in Solidworks

Content:

Accomplishments:

- Initially created the incline plane design that can be seen in the initial design in the design process folder

- This design was created using two different solidworks files, one for the ring and one for the support bridge, that will be assembled in an assembly.

Conclusions/action items:

Look to add to initial design and print for show and tell.

Team Meeting 11/04/21

GIOVANNI MILITELLO - Nov 07, 2021, 9:59 PM CST

Title: Team Meeting

Date: 11/04/21

Content by: Team

Present: Ben Smith, Giovanni Militello, Lily Galagher, Owen Kolnik, Tony Pribnow, Daniel Konon

Goals: Print design for show and tell

Content:

Accomplishments:

- Printed our design of the incline plane in makerspace for show and tell. (Can be found on Solidworks design in design process folder)

Conclusions/action items:

Look to improve and finish design and perform tests on our design.

Team Meeting 12/13/21

GIOVANNI MILITELLO - Dec 13, 2021, 1:24 AM CST

Title: Presentation

Date: 12/13/21

Content by: Team

Present: Team

Goals: Meet with the team to work on the final report

Content:

- Met on the 13th to work on the final report

- Make adjustments to the comments made on the preliminary report

- Added to the fabrication and developmental process section of the report such as changing the material used to Ti64, incorperating our final design specifications into the final prototype section and describe our testing results

- Updated our disscusion and conclusion sections to incorperate details from the fabrication and developmental process section based on the work done over the past month and included new future work based on the progress we made and where we want to take this project going forward.

Conclusions/action items:

- Continue to edit report.

Expense Spreadsheet

DANIEL KONON - Dec 14, 2021, 2:47 PM CST

BPAG_Expense_Spreadsheet_-_Sheet1.pdf(30 KB) - download

Solidworks first Model

BENJAMIN SMITH - Dec 13, 2021, 8:32 PM CST

Title: Solidworks First Model

Date: 11/12/21

Content by: Team

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

Content:

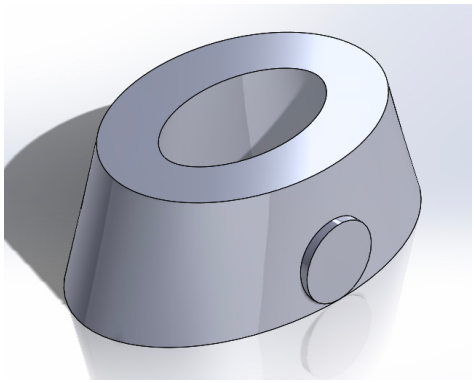


Figure 1: Ring component of the initial model

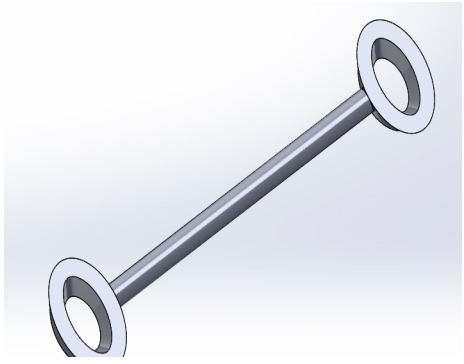


Figure 3: Assembly of the initial ring and support bridge

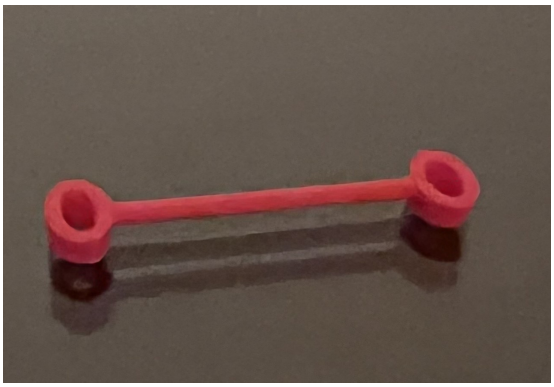


Figure 4: 3D printed PLA version of the initial design of the ring and support bridge.

Conclusions/action items:

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

Solidworks Final Model

BENJAMIN SMITH - Dec 14, 2021, 9:39 PM CST

Title: SolidWorks Final model

Date: 12/06/21

Content by: Team

Present: Team

Goals: 3D print design in makerspace

Content:

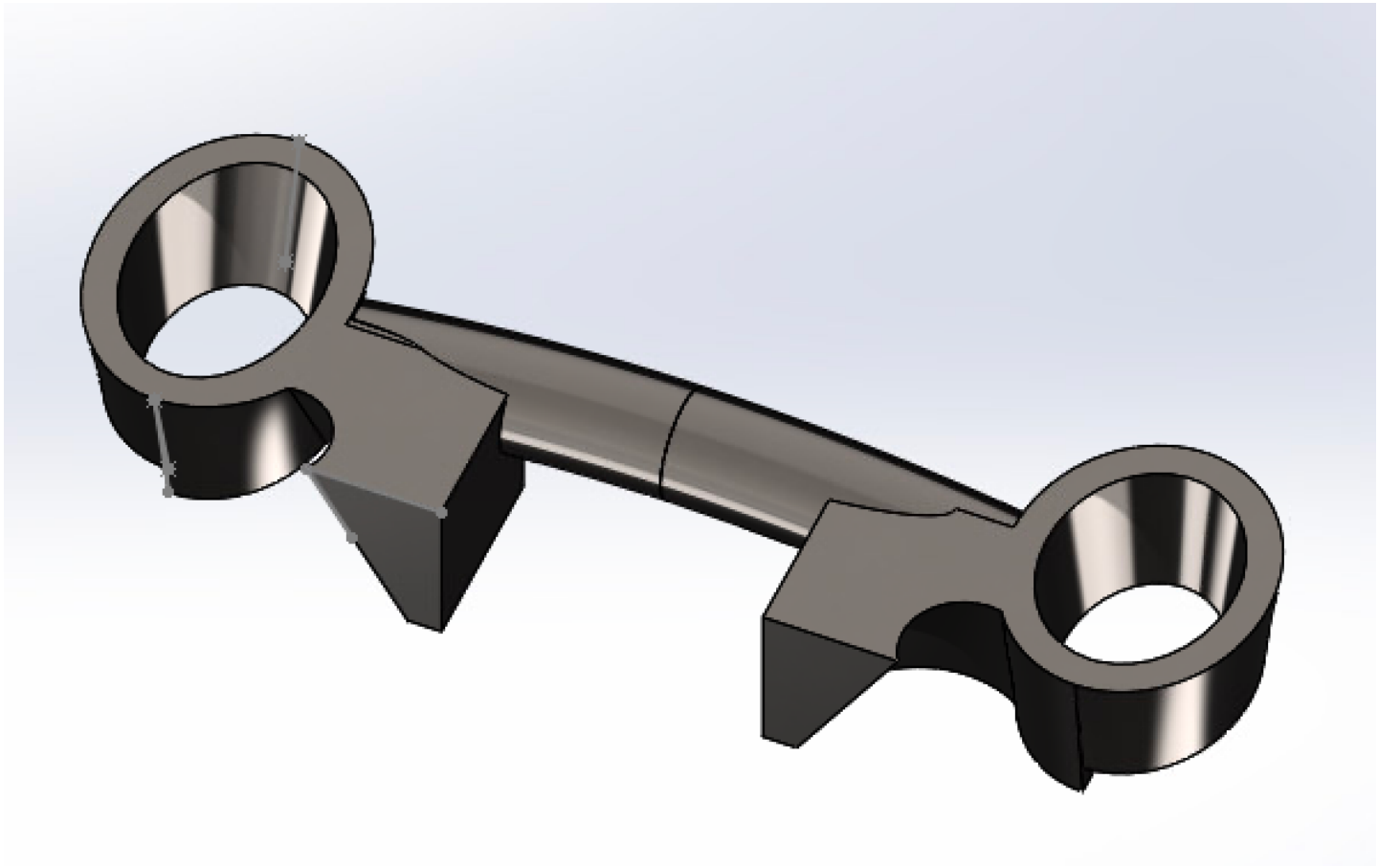


Figure 1: Assembly of our final design in solidworks

- Upper tooth diameter: 15.50 mm x 11.25 mm

- Lower tooth diameter: 13 mm x 8 mm

- Support bridge length: 38 mm

- Degree of incline plane: 60 degrees

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

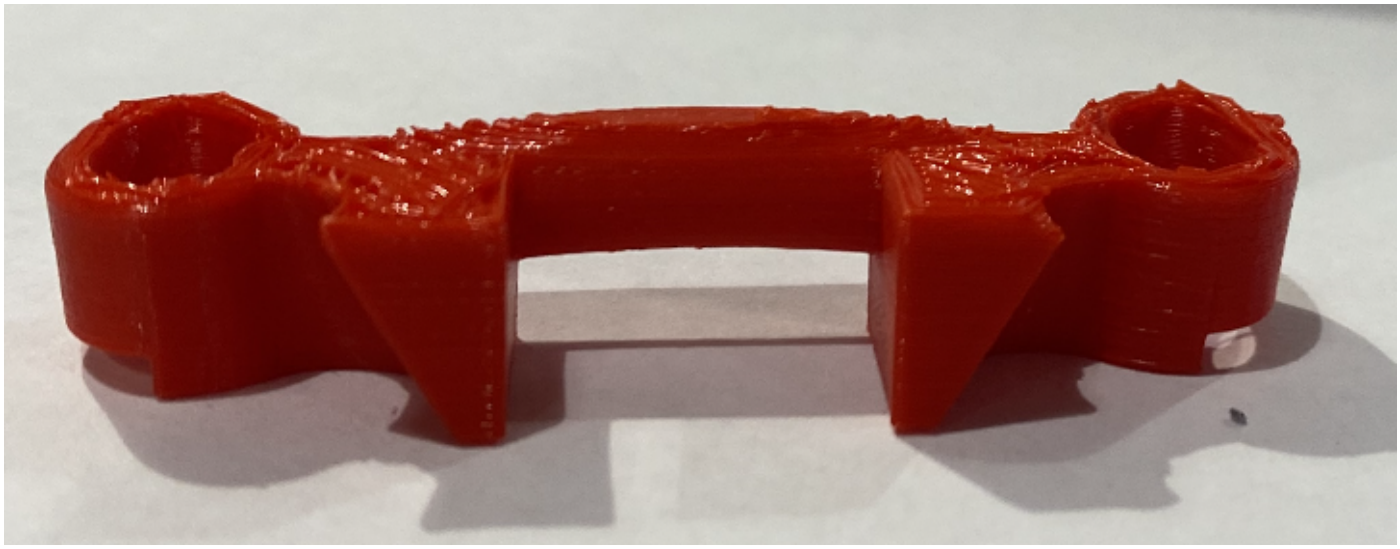


Figure 2: Final design printed in PLA from the makerspace .

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

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

Conclusions/action items:

- Use this model as a demonstration during the presentation.

BENJAMIN SMITH - Dec 14, 2021, 9:38 PM CST

Final_Design_45_degrees_.SLDPRT(321.6 KB) - download

Team Meeting 12/05/21-12/06/21

BENJAMIN SMITH - Dec 14, 2021, 11:47 PM CST

Title: Presentation

Date: 12/05/21-12/06/21

Content by: Team

Present: Team

Goals: Meet with the team to work on the final presentation

Content:

- Met on the 5th and 6th to go over what content should be included in the final poster.

- Shared our poster with Dr. Puccinelli to get feedback on it.

- Abstract: complete overview the work the team conducted over the semester.

- Background and Motivation: Research conducted on Class 2 Malocclusions and treatment options available and how to create a better solution to correct Class 2 Maloclussions.

- Design criteria: Specifications made by our client on what our final design wound need to accomplish.

- Final design: Description of our final design and how it meets the specific requirements made by our client.

- Stress testing: Solidworks testing on our design to see if it could withstand the conditions of a dogs bite.

- Workflow: Process in how our client would take our design and make specific changes to it for to be patient specific.

- Future plans: What other adjustments to our design/workflow we can do to make our product better and what future tests we would like to conduct with our product.

- We also fabricated the final design in the MakerSpace

Conclusions/action items:

- Present poster for final presentation.

Workflow Document for Client

BENJAMIN SMITH - Dec 13, 2021, 8:33 PM CST

Title: Workflow Document for Client

Date: 12/5/21

Content by: Team

Present: Team

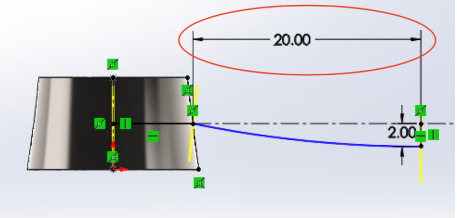
Goals: Create a document where the client will be able to read the directions and make adjustments, depending on his patients, to our final design.

Content:

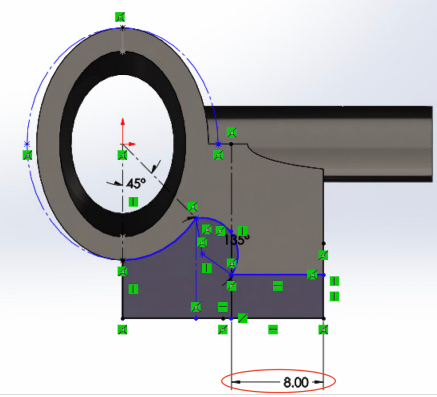
Creation of Patient Specific Part

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

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



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



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

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

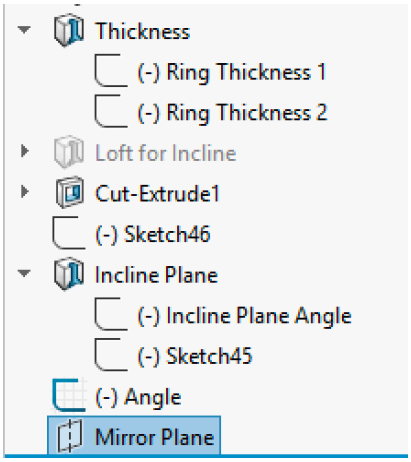
    For example, for a desired angle of 45 degrees, the equation is:

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

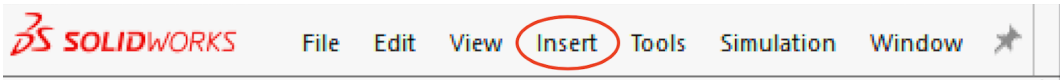
15. To verify the desired angle was obtained, exit this sketch, and click on the **Angle** tab in the design tree. In this sketch, the dimension shown is the angle of tilt for the incline plane.
16. At this point, the part should be fully dimensioned and patient specific. All that's left to do now is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

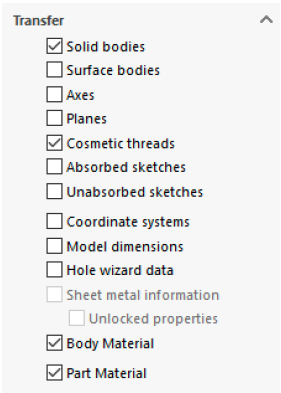
Creation of Mirrored Part

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

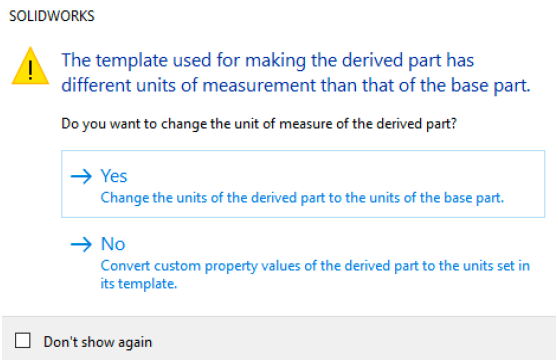


3. Next select **Insert** → **Mirror Part** found at the top of the screen, and make sure the boxes are checked as they are in the following picture





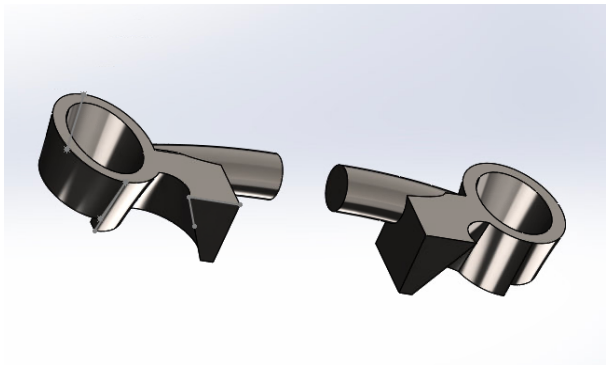
4. If the following message appears, click **yes**



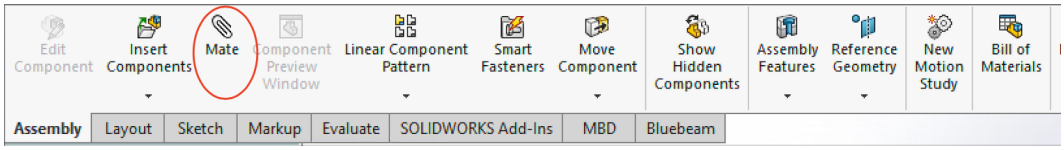
5. The mirrored part will appear, and you should now **Save As** a new part

Creation of Assembly

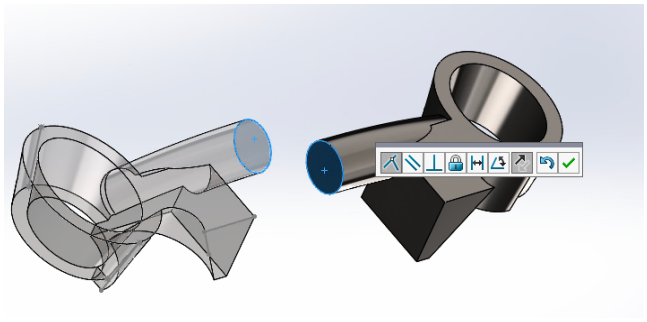
1. Open a new assembly in Solidworks
2. Insert both the initial part and the mirrored part in a similar configuration as shown below



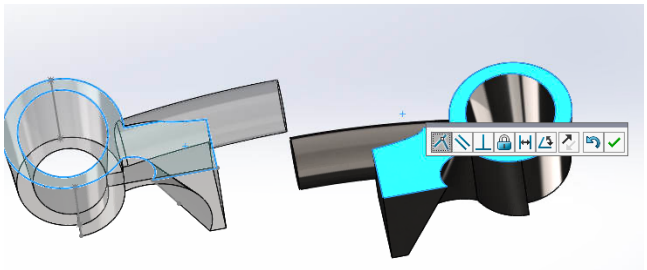
3. In the toolbar, select **Mate**



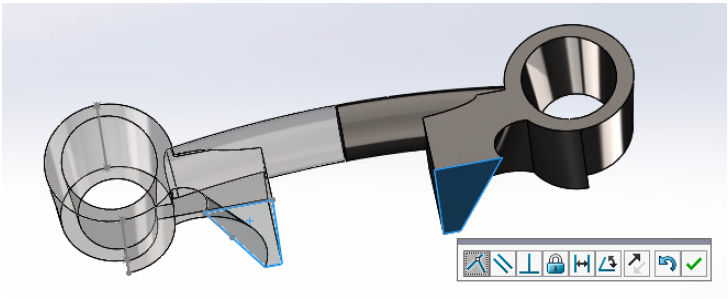
4. In the **Mate** tool, click on the two faces at the end of each support bar as shown below



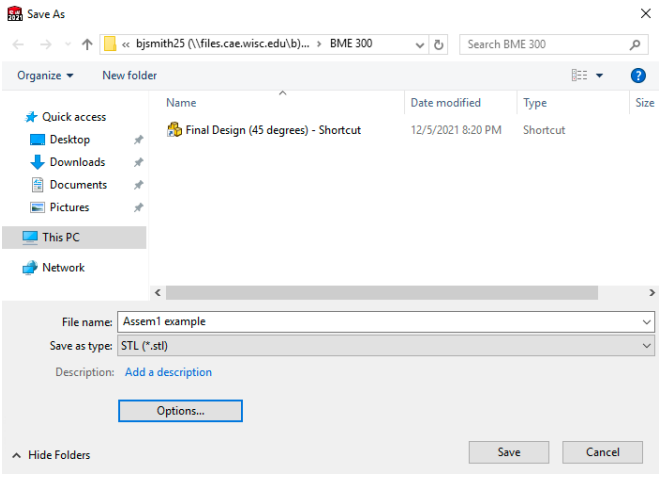
5. With these faces in the same place, click on **Mate** again, and this time click on the two faces in the image shown below.

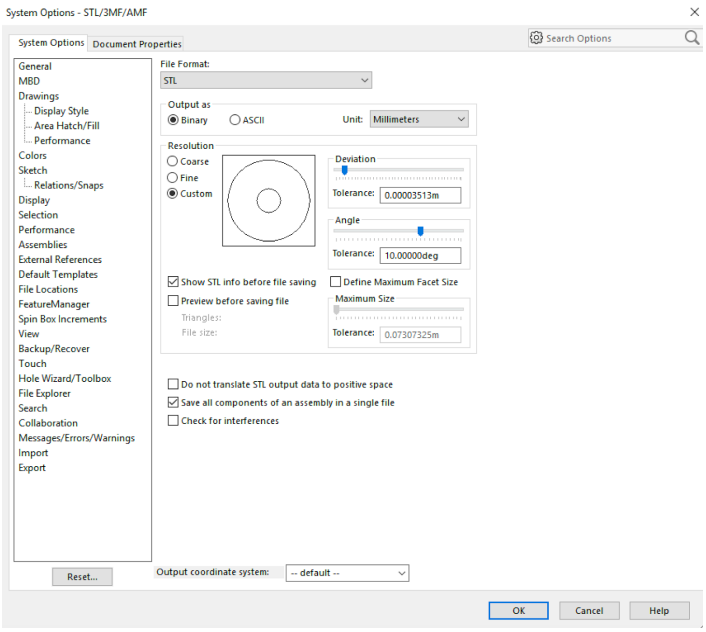


6. Click on **Mate** one more time, and this time, click on the two faces shown in the image below.



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





Conclusions/action items:

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

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

- Optimize wording and flow of the steps as needed

Solidworks SimulationXpress Analysis Wizard Test

BENJAMIN SMITH - Dec 13, 2021, 8:39 PM CST

Title: Solidworks SimulationXpress Analysis Wizard Test

Date: 12/5/21

Content: Team

Present: Team

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

Content:

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

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

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

Figure 1: Properties of Ti6Al4V (Ti64) from Solidworks

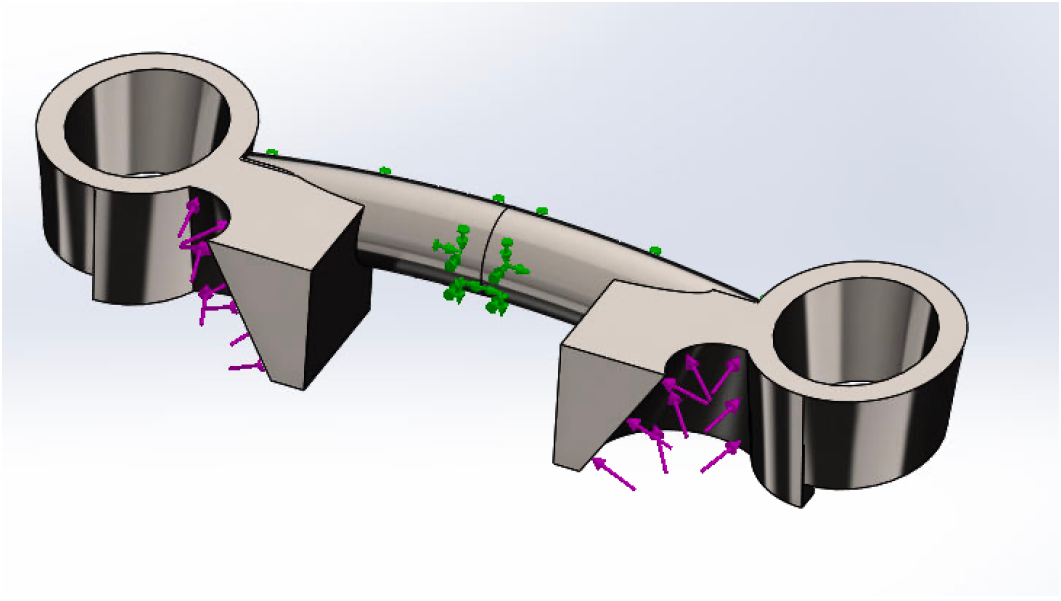


Figure 2: Demonstration of the forces on our device. The purple arrows show the applied force, and the green arrows show what is fixed.

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

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

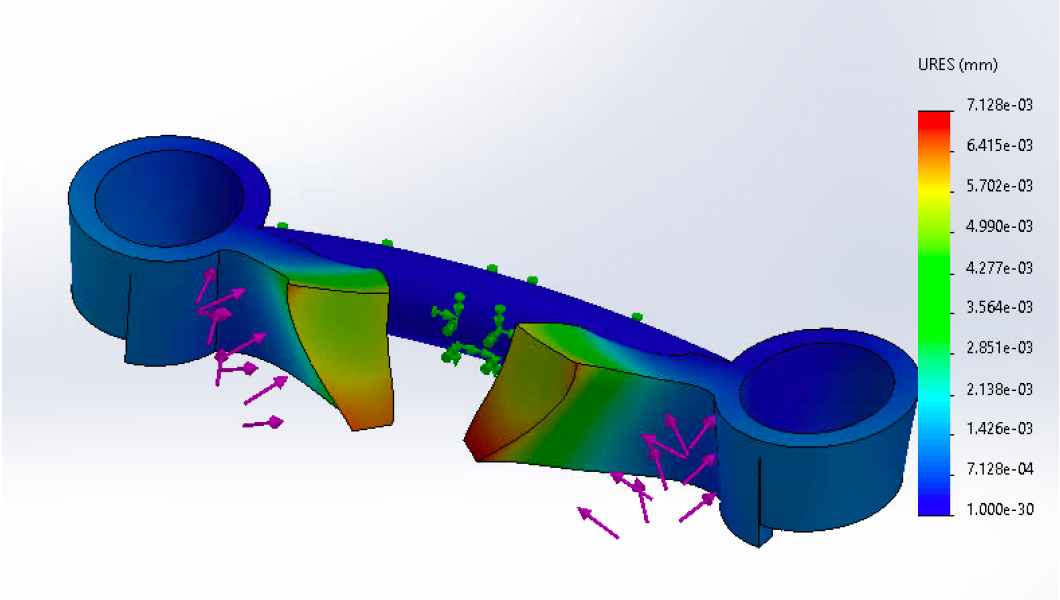


Figure 3: Demonstration of deformation from forces implied on the product during solidworks stress testing.

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

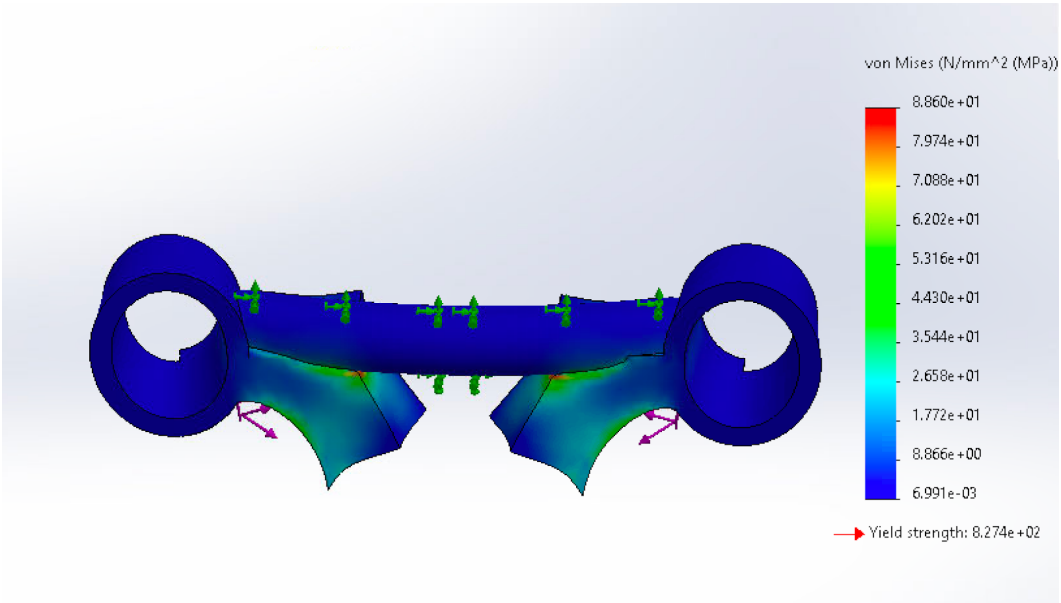


Figure 4: Demonstration of von Mises forces on our part after the force was implied.

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

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

Conclusions/action items:

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

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

Past work research 9/27/21

BENJAMIN SMITH - Dec 14, 2021, 11:55 PM CST

Title: Research on the work of the previous group

Date: 9/27/21

Content by: Ben Smith

Goals: Gain a base knowledge of the work that has already been completed for this project.

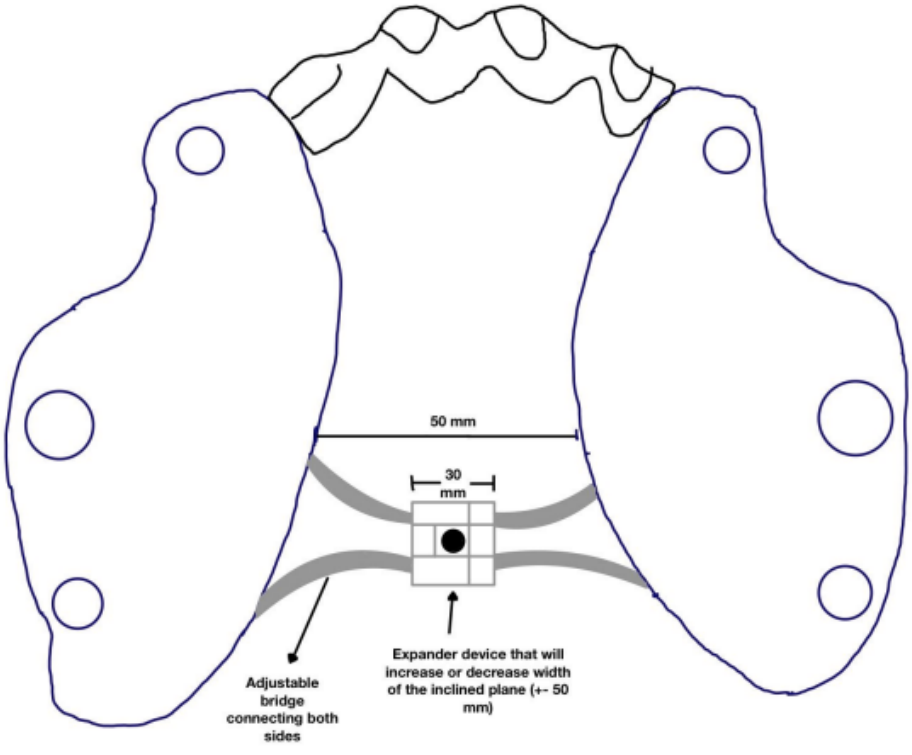
Content:

Reference:

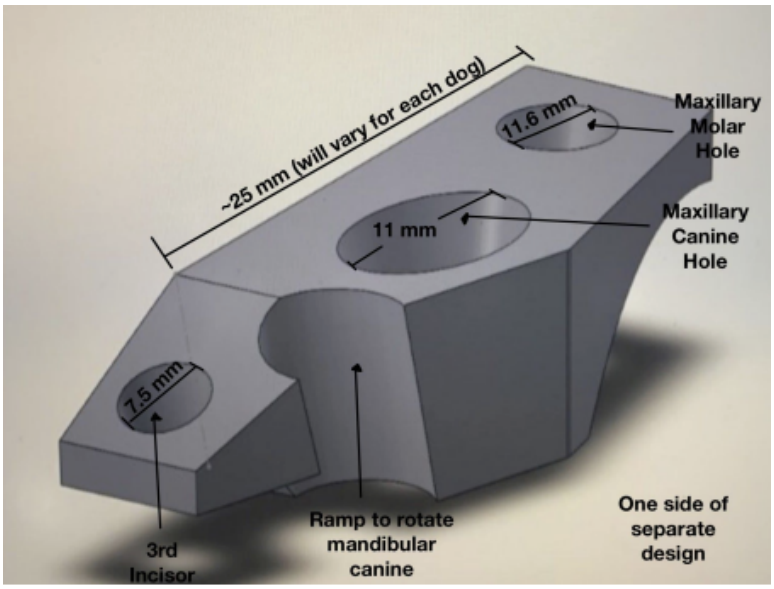
Parker Callender et. al, “VETMED: 3D Printed, Patient Specific Incline Plane for Management of Class 2 Malocclusion - Improvement in Design and Workflow Final Report,” unpublished.

Designs

- Adjustable Bridge
  - Replaces bridge in original team's design with an adjustable metal bridge that expands with the jaw



- Separate inclined planes
  - Aims to reduce the chances of a patient getting palantitis by separating the device into two separate pieces, one for each side of the mouth.



- Rubber Incline Plane
  - Similar device to Dr. Thatcher's original model, but made out of rubber rather than plastic

Software

- 3D Slicer
  - Software that allows you do process and view DICOM files from CT scans, but lacks the ability to easily manipulate cross-sections of images and is overall complicated
- Osiris X
  - Software that works with vectors and directions to help with thee production process and is useful in simply analyzing scans
- GeoMagic
  - Process large data sets including DICOM files and can be used to generate stl files for 3D printing
- Blender
  - 3D modeling and animation software that allows users to import and create models for design
- MeshMixer
  - used to manipulate the mesh in a new design and convert the mesh to a 3d solid that can be tested in solidworks

The group decided on using the separate inclined plane design as well as Blender and MeshMixer for software. They created the final design using a 3D printer with Dental LT as the material.

Conclusions/action items:

There is a lot of useful information on the work of the previous team and this will help us moving forward.

Class II Malocclusions

BENJAMIN SMITH - Dec 15, 2021, 12:00 AM CST

Title: Class II Malocclusion Research

Date: 9/27/21

Content by: Ben Smith

Goals: Learn more about Class II Malocclusions

Content:

Reference:

“Malocclusions and Orthodontic Treatment.” [Online]. Available: https://www.sacvds.com/forms/malocclusions-orthodontic-treatment.pdf. [Accessed: 27-Sep-2021].

What is a Malocclusion?

- An abnormal alignment of the teeth
- Can be harmless, or can be a problem when there is abnormal tooth-to-tooth or tooth-to-soft tissue contact
- Causes long-lasting side effects that have negative impact on pets
- Can involve one teeth or many teeth
- Causes: genetics, trauma, tumors, or infections that cause teeth to erupt abnormally

Class II Malocclusion (overbite)

- The lower jaw (mandible) is too short
- This can cause the mandibular canine teeth or incisors to traumatize the palate and gum tissue of thee maxilla (upper jaw), causing pain and damaging the teeth

Conclusions/action items:

The attached PDF provides a good start for knowledge on class II malocclusions.

BENJAMIN SMITH - Sep 27, 2021, 6:53 PM CDT

SacVDS SACRAMENTO DENTAL VETERINARY SERVICES

Malocclusions and Orthodontic Treatment

A malocclusion is an abnormal alignment of the teeth, also called a "abnormal bite. Malocclusions can be harmless, or they can be a problem for your pet when there is abnormal tooth-to-tooth or tooth-to-soft tissue contact. This tooth-tooth or tooth-soft tissue contact can cause pain and long-lasting side effects that have a negative impact on your pets health unless the malocclusion is addressed.

A malocclusion can involve one or many teeth, and can be due to genetic causes, trauma, tumors or infections that cause teeth to erupt abnormally, as well as baby teeth that fail to fall out. Breed differences in skull shape or changes in jaw length can lead to crowding and rotation of teeth that are common for a breed, but cause damage to the teeth and soft tissues. When malocclusions are caused by skeletal deformity and abnormal jaw length, this is considered genetic, and affected animals should not be bred.

This is a type II malocclusion in a dog- the lower jaw is shorter than the upper jaw by about 1 inch.

In order to correct an occlusion, multiple factors must be taken into account, including the type of malocclusion, whether it is genetic or acquired, and your pet's overall health status. Sometimes the bite can be returned to normal, but our main goal is always to have a pet with a comfortable and functional mouth, even if their bite is still slightly abnormal.

Treatment options vary for each type of malocclusion. Some of the various treatment options include extraction of the offending tooth or teeth, removing the crown of a tooth and performing

malocclusions-orthodontic-treatment.pdf(564.8 KB) - download

3D Printable Dental Materials 10/3/21

BENJAMIN SMITH - Dec 15, 2021, 12:01 AM CST

Title: 3D Printable Dental Materials

Date: 10/3/21

Content by: Ben Smith

Goals: Learn about materials used in human orthodontics

Content:

Reference:

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

Model Resin

- Prints removable dies with crisp margins and contacts within +-35 microns
- Uses: crown and bridge models, clear aligner models, orthodontic models, diagnostic models, and implant models 

Draft Resin

- fast printing material - can make a dental model in <20 minutes

- Uses: thermoforming models, orthodontic appliance models, diagnostic models, and crown and bridge models 

Surgical Guide Resin

- autoclavable, biocompatible resin used for 3D printing surgical guides for implant placement
- Uses: surgical guides, drilling templates, pilot drill guides, and device sizing templates

Dental LT Clear Resin

- highly durable and resistant to fracture, affordable, high quality

- Uses: splints, occlusal guards

Castable Wax Resin

- provides accurate, sealed margins and contains 20% wax for reliable casting with clean burnout, strong enough to handle with n.o post-cure required
- Uses; Casting copings and substructures, pressing and casting full contour crowns, casting removable partial denture frameworks

Custom Tray Resin

- fast printing, biocompatible, use 200 micron layer heights, reduce labor time and enable higher throughput
- Uses: custom impression trays

- 

Temporary CB Resin

- provides excellent marginal adaptation, strength, and aesthetics, may remain up to 12 months in the mouth, enables quick collaborative process between dentist, technician, and patient
- Uses: crowns, inlays, veneers, bridges, and onlays
- 

Conclusions/action items:

This is a good list of materials used in human orthodontics. Using this list, we can go further into research on all of them.

Clear Retainers

BENJAMIN SMITH - Dec 15, 2021, 12:04 AM CST

Title: Clear Retainers

Date: 10/3/21

Content by: Ben Smith

Goals: Learn how human clear retainer impressions are taken

Content:

References:

[1] “Clear retainer....how do we make it?? - youtube.” [Online]. Available: https://www.youtube.com/watch?v=3ShISrZP3M0. [Accessed: 04-Oct-2021].

[2] “Making orthodontic retainers - youtube.” [Online]. Available: https://www.youtube.com/watch?v=xbFzzhd5F-g. [Accessed: 04-Oct-2021].

[3] “Watch how we made a clear retainer!! - youtube.” [Online]. Available: https://www.youtube.com/watch?v=Pbf6KngfgAs. [Accessed: 04-Oct-2021].

Steps [2]:

1. Slowly add water in small increments to bowl of powder and mix
2. Put paste into a plastic tooth mold
3. Put mold in patients mouth
4. Now mix in water with another powder and mix
5. Put new paste into the mold of the teeth and fill all gaps with paste
6. Put hot plastic material over new mold of teeth and vacuum seal it
7. Cut out the clear retainer

**These steps are from reference [2], however references [1] and [2] are also supplemental to understanding how human retainers are made.

Conclusions/action items:

Having an idea of how human retainers are made will help brainstorm how we can replicate this process for use in canines.

Compression Testing for 3D Materials

BENJAMIN SMITH - Dec 15, 2021, 12:12 AM CST

Title: Compressive Properties for 3D Materials

Date: 10/8/21

Content by: Ben Smith

Goals: Identify 3D Printable Materials with the best compressive properties

Content:

Reference:

R. Lam, M. Orozco, E. Mendieta, B. Hunter, and J. Seiter, “ASEE peer - compressive mechanical properties of three ...,” *Compressive Mechanical Properties of Three-Dimensional (3D) Printed Thermoplastics*. [Online]. Available: https://peer.asee.org/compressive-mechanical-properties-of-three-dimensional-3d-printed-thermoplastics. [Accessed: 08-Oct-2021].

This information will be useful when we need to incorporate numbers in our report. It gives information on the mechanical properties of 3D printed thermoplastics.

Conclusions/action items:

More research to be done, but this data provides information/graphs

BENJAMIN SMITH - Dec 15, 2021, 12:12 AM CST

Compressive Mechanical Properties of Three-Dimensional (3D) Printed Thermoplastics

Raymond K.F. Lam, Michael Orozco, Erick Mendieta, Bernard Hunter, and Joseph Seiter

Queensborough Community College, The City University of New York, New York, U.S.A.

1. Introduction

Impact and adoption rate of 3-dimensional (3D) printing in manufacturing will increase dramatically over the next few years. The market for 3D printing technology itself is expected to grow to $5.2 billion by 2020 [1]. One example is General Electric (GE)'s decision to deploy 3D printers to manufacture nozzles for its LEAP engines. GE Aviation projects have printed more than 30,000 fuel nozzle tips in 2018 [2] and GE expects to print more than 100,000 additive parts by 2020 [3]. Engineering components printed by 3-dimensional printers are employed as mechanical structures in an assembly. In order for the printed components to be useful for engineering applications, mechanical properties of printed parts must be known for structural design. The properties provide answers to the strength of the material, the types of stresses a component can endure before failure, and the size of a component based on the loads it experiences. 3D printed materials have recently been studied for their mechanical properties [4, 5, 6]. This study was undertaken to further understand the compressive mechanical properties of thermoplastic materials printed by 3D printers and provide the fundamental mechanical compression data of thermoplastic for structural design by students. This project also provided training in mechanical engineering research to two students in addition to their regular coursework in Mechanical Engineering Technology.

2. Experiment

Acrylonitrile butadiene styrene (ABS), a common type of thermoplastic material for three-dimensional (3D) printing, was the material used in the construction of the specimens for compression testing. The material was printed by three 3D printers including Stratasys Fortus 450mc Printer (Figure 1), Stratasys Mojo Printer (Figure 2), and Stratasys uPrint SE Plus Printer (Figure 3). The printers employed the 3D deposition technology of fused deposition modeling (FDM) process. Fused deposition modeling process extrudes molten thermoplastic material through a nozzle, deposits the molten material as a cylindrical layer on a planar substrate initially or on a previously deposited thermoplastic layer at subsequent depositions, and solidified in situ. The process repeated itself until a three-dimensional structure was formed. The manufacturing process is known as 3D printing or additive manufacturing.

Specimens of cylindrical shape were printed at nominal dimensions of 13 mm in diameter and 20 mm in height. They were printed at a combination of raster angles of 0 degree, 45 degrees, and 90 degrees, and orientations of flat and upright. Figure 4 shows the print orientations of each set of specimens printed by a printer. Two specimens were each printed at

compressive-mechanical-properties-of-three-dimensional-3d-printed-thermoplastics_1_.pdf(1022.6 KB) - download

Research Study Notes

BENJAMIN SMITH - Dec 15, 2021, 12:14 AM CST

Title: Research Study

Date: 10/10/21

Content by: Ben Smith

Goals: Learn some statistics from a study on dogs with malocclusions

Content:

Reference:

[1] S. H. Storli, R. A. Menzies, and A. M. Reiter, “Assessment of temporary crown extensions to correct linguoverted mandibular canine teeth in 72 client-owned dogs (2012-2016),” *Journal of Veterinary Dentistry*, vol. 35, no. 2, pp. 103–113, 2018.

Title of Article: Assessment of Temporary Crown Extensions to Correct Linguoverted Mandibular Canine Teeth in 72 Client-Owned Dogs (2012-2016)

- Most commonly found in dolichocephalic breeds
- Result of maloclussions:
  - soft tissue trauma
  - oronasal fistula formation
  - periodontal disease
  - dental attrition
  - displacement of opposing teeth
  - tooth fracture
  - endodontic disease
  - disturbance of orofacial development
  - pain
- 3 ways to correct maloclussions:
  - preventive
  - interceptive
  - corrective
    - defined as correction of the maloclussion without loss of the maloccluding tooth or part of its crown, by means of tooth movement
      - Can use inclined planes or ball therapy
- This study is on 72 dogs that received temporary crown extensions (TCE)
  - 14 with a class II malocclusion

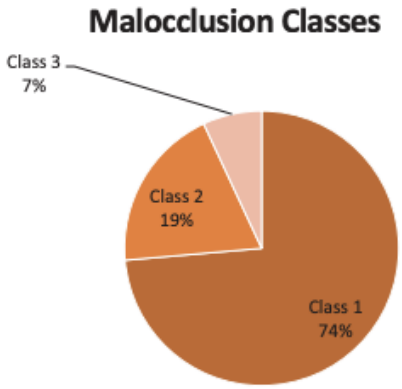


Figure 1: Distribution of malocclusion classes in72 dogs [1]

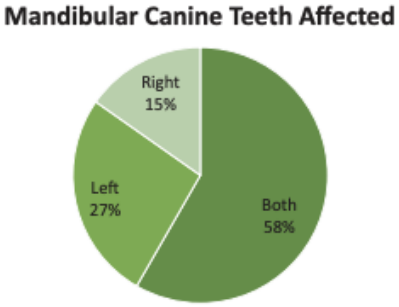


Figure 2: Distribution of mandibular canine teeth affected by malocclusion in 72 dogs [1]

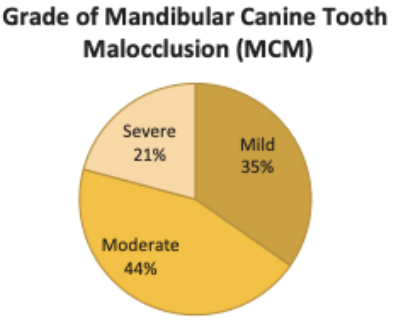


Figure 3: The proportion of different severities of mandibular canine malocclusion in 72 dogs [1]

TCE

- It is possible to widen the diastema between the maxillary third incisor and canine teeth with TCE in young dogs (typically between 5 and 7 months of age) [1]
- The teeth move into desired position within 2-6 weeks
- TCEs are easy to install and cost-effective
- They are applied while the patient is under general anesthesia
- TCEs allow continued growth of upper jaw whereas an inclined plane typically does not

Conclusions/action items:

There is some interesting information in this article about another treatment for class II malocclusions, as well as some helpful statistics on the study that can be used to make claims on the frequency of class II malocclusions.

PMMA vs. Dental LT Resin V2

BENJAMIN SMITH - Oct 11, 2021, 3:32 PM CDT

Title: PMMA vs. Dental LT Resin V2

Date: 10/11/2021

Content by: Ben Smith

Goals: Get data sheets comparing two possible materials to use with our design

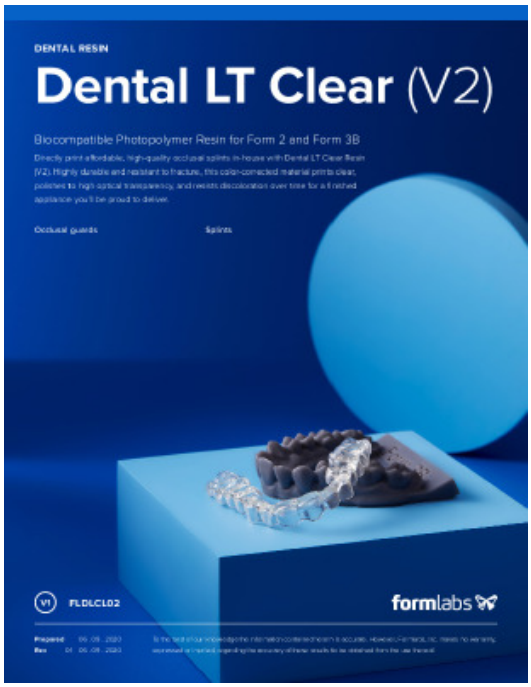
Content:

Attached below are the data sheets for both Dental LT Resin V2 and PMMA, two materials we are looking into using for our design. Upon reviewing the data sheets, we found PMMA to have stronger mechanical properties than Dental LT Resin V2 and thus we will use that in out design.

Conclusions/action items:

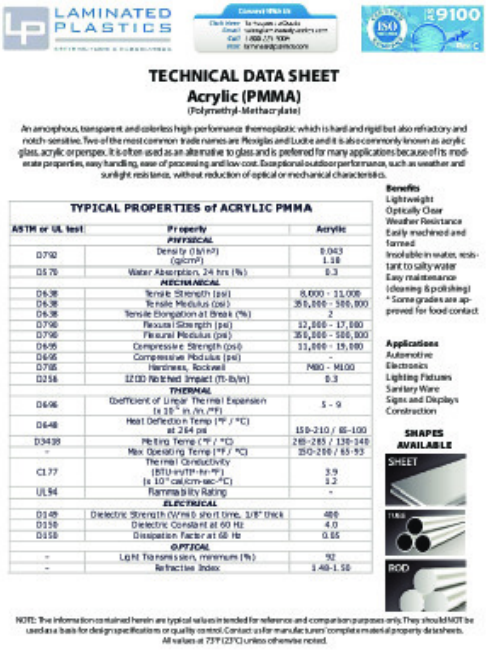
These are helpful to provide numerical data in our reports.

BENJAMIN SMITH - Oct 11, 2021, 3:32 PM CDT



Dental_LT_Resin_V2_Data_Sheet.pdf(459.1 KB) - download

BENJAMIN SMITH - Oct 11, 2021, 3:32 PM CDT



LAMINATED PLASTICS

AS9100

TECHNICAL DATA SHEET

Acrylic (PMMA)

(Polymethyl-Methacrylate)

An amorphous, transparent and colorless high-performance thermoplastic which is hard and rigid but also refractory and notch-sensitive. Two of the most common trade names are Plexiglas and Lucite and it is also commonly known as acrylic glass, acrylic or perspex. It is often used as an alternative to glass and is preferred for many applications because of its moderate properties, easy handling, ease of processing and low cost. Exceptional outdoor performance, such as weather and sunlight resistance, without reduction of optical or mechanical characteristics.

TYPICAL PROPERTIES of ACRYLIC PMMA

ASTM or UL test	Property	Acrylic
	PHYSICAL	
D792	Density (lb/in³) (gr/cm³)	0.043 1.18
D570	Water Absorption, 24 hrs (%)	0.3
	MECHANICAL	
D638	Tensile Strength (psi)	8,000 - 11,000
D638	Tensile Modulus (psi)	350,000 - 500,000
D638	Tensile Elongation at Break (%)	2
D790	Flexural Strength (psi)	12,000 - 17,000
D790	Flexural Modulus (psi)	350,000 - 500,000
D695	Compressive Strength (psi)	11,000 - 15,000
D695	Compressive Modulus (psi)	-
D785	Hardness, Rockwell	M80 - M100
D256	1200 Notched Impact (ft-lb/in)	0.3
	THERMAL	
D696	Coefficient of Linear Thermal Expansion (x 10⁻⁵ in./in./°F)	5 - 9
D648	Heat Deflection Temp (°F / °C) at 264 psi	150-210 / 65-100
D3418	Melting Temp (°F / °C)	248-285 / 120-140
-	Max Operating Temp (°F / °C)	150-200 / 65-93
C177	Thermal Conductivity (BTU-in/ft²-hr-°F) (x 10⁻⁴ cal/cm-sec-°C)	3.9 3.2
UL94	Flammability Rating	-
	ELECTRICAL	
D149	Dielectric Strength (V/mil) short time, 1/8" thick	480
D150	Dielectric Constant at 60 Hz	4.0
D150	Dissipation Factor at 60 Hz	0.05
	OPTICAL	
-	Light Transmission, minimum (%)	92
-	Refractive Index	1.48-1.50

Benefits
Lightweight
Optically Clear
Weather Resistance
Easily machined and formed
Insoluble in water, resistant to salty water
Easy maintenance (cleaning & polishing)
* Some grades are approved for food contact

Applications
Automotive
Electronics
Lighting Fixtures
Sanitary Ware
Signs and Displays
Construction

SHAPES AVAILABLE

SHEET

TUBE

ROD

NOTE: The information contained herein are typical values intended for reference and comparison purposes only. They should NOT be used as a basis for design specifications or quality control. Contact us for manufacturers' complete material property datasheets. All values at 73°F (23°C) unless otherwise noted.

PMMA_Data_Sheet.pdf(610.2 KB) - download

Measurements of Dog's teeth

BENJAMIN SMITH - Dec 15, 2021, 12:24 AM CST

Title: Measurements of Dog's Teeth

Date: 10/19/21

Content by: Ben Smith

Goals: Find information of the size of dog's teeth

Content:

Reference:

Harvey, C., 2021. *Shape and Size of Teeth of Dogs and Cats-Relevance to Studies of Plaque and Calculus Accumulation - Colin E. Harvey, 2002*. [online] SAGE Journals. Available at: <https://journals.sagepub.com/doi/10.1177/089875640201900401> [Accessed 15 December 2021].

Table 1

Width (mm) of crowns of teeth in dogs, cats, and humans.

	Maxillary					Mandibular			
	I2/3	C	P3/1	P4/2	M1	C	P3/1	P4/2	M1
Dog[a]	7.5	11.0	11.6	19.4	12.7	10.6	11.0	12.7	23.4
%[d]	*32*	*47*	*50*	*83*	*54*	*45*	*47*	*54*	*100*
Cat[a]	-	5.0	6.2	11.2	-	4.8	5.7	7.1	7.7
%[d]	-	*45*	*55*	*100*	-	*43*	*51*	*63*	*69*
Human[b]	5.3	7.6	7.5	7.1	10.6	6.7	7.2	7.3	11.5
%[d]	*46*	*66*	*65*	*62*	*92*	*58*	*63*	*63*	*100*
Human[c]	6.6	7.6	7.1	6.8	10.5	6.9	7.0	7.1	11.2
%[d]	*59*	*68*	*63*	*61*	*94*	*62*	*63*	*63*	*100*

Figure 1: This is a table that shows width dimensions of the maxillary and mandibular teeth in dogs. This will be helpful to reference for the size we need the rings in our model to be.

Table 2

Height (mm) of crowns of teeth in dogs, cats, and humans.

	Maxillary					Mandibular			
	I2/3	C	P3/1	P4/2	M1	C	P3/1	P4/2	M1
Dog[a]	10.8	20.8	7.6	11.7	5.9	19.6	9.2	9.1	14.1
%[d]	*52*	*100*	*37*	*56*	*28*	*94*	*44*	*43*	*68*
Cat[a]	-	11.0	4.6	4.6	-	9.1	4.3	5.2	5.2
%[d]	-	*100*	*42*	*42*	-	*83*	*39*	*47*	*47*
Human[b]	8.7	10.0	8.3	7.9	6.9	9.9	8.2	7.0	6.7
%[d]	*87*	*100*	*83*	*79*	*69*	*99*	*82*	*70*	*67*
Human[c]	9.4	10.3	8.6	8.1	7.5	11.0	8.7	8.1	7.6
%[d]	*85*	*94*	*78*	*74*	*68*	*100*	*79*	*74*	*69*

I = Incisor (2nd in humans, 3rd in canine), C = Canine, P = Premolar (1st and 2nd in human, 3rd and 4th in canine and feline), M = Molar.

[a] Mean of measurements from images of four specimens.

[b] Mean of measurements from two human dentition models.

[c] Mean of measurements from references 9 and 10.

[d] Height of crown as percentage compared with highest crown, rounded to nearest whole number.

Figure 2: This is a table that shows height dimensions of the maxillary and mandibular teeth in dogs. This will be helpful to reference for the size we need the rings in our model to be.

Conclusions/action items:

The paper has great information to quantify specifications in our report.

BENJAMIN SMITH - Oct 19, 2021, 10:55 PM CDT

Shape and Size of Teeth of Dogs and Cats-Relevance to Studies of Plaque and Calculus Accumulation

Colin E. Harvey, BVSc, FRCVS*

Summary:

Introduction

Materials and Methods

Figure 1

,

27120d3d0cd8699794717a385372ada4.pdf(8.6 MB) - download

Patent Research 9/24/21

BENJAMIN SMITH - Dec 15, 2021, 12:25 AM CST

Title: Patent Research

Date: 9/24/2021

Content by: Ben Smith

Goals: Find patents for competitive products.

Content:

References:

[1] Orthodontic device for small animals, by Lloyd J. Mann. (1992, Sept. 29).*US5151027A.* Accessed on: Sept. 24, 2021. [Online]. Available: https://patents.google.com/patent/US5151027A/en?q=dog+orthodontics&oq=dog+orthodontics

US Patent #: US5151027A

Title: Orthodontic device for small animals

Description:

A veterinary orthodontic fixture useful in correcting lingual displacement of the mandibular canine teeth of an animal [1]. This device utilizes inclined planes attached to the maxillary canine to tilt the mandibular canines into a normal position where they will not interfere with the gingival tissue of the maxilla.This device does not inhibit normal growth of the patient's jaw.

- I like the simplicity of this design as there is not much material needed and it does not interfere much with the patient

- Metal is hard to work with and very expensive

- Would like to know if we can use the simplicity of this design and combine it with a 3D printable resin in which we can make a similar, non-obstructive device that is easier to manufacture and patient specific

Conclusions/action items:

I identified a patent for a product that solves the issue at hand. It will be useful to reference this patent when we start coming up with a design of our own.

BENJAMIN SMITH - Sep 27, 2021, 9:45 AM CDT

United States Patent [19]
Mann

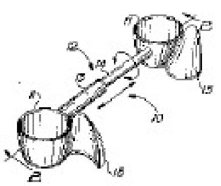
[11] Patent Number: 5,151,027
[45] Date of Patent: Sep. 29, 1992

[54] ORTHODONTIC DEVICE FOR SMALL ANIMALS

[56] References Cited
U.S. PATENT DOCUMENTS

FOREIGN PATENT DOCUMENTS

[57] ABSTRACT



US5151027.pdf(731.1 KB) - download

Ring Design

BENJAMIN SMITH - Oct 19, 2021, 11:02 PM CDT

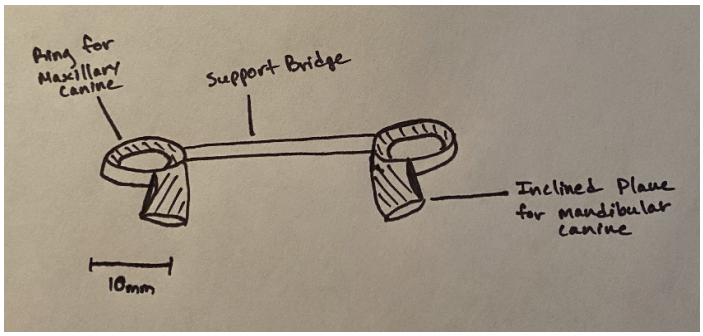
Title: Ring Design

Date: 10/19/21

Content by: Ben Smith

Goals: Present a new design idea

Content:



This design is similar to the expired patent researched on 9/24/21. It features two rings to be mounted onto the upper maxillary canines, two inclined planes on each ring, and a support bridge. This design minimized variables and ultimately the need for software as our client can simply take measurements of the inside of the patient's mouth and alter the dimensions in solidworks.

Conclusions/action items:

We have a hopeful new design idea.

Class 2 Malocclusion Research

DANIEL KONON - Dec 14, 2021, 3:05 PM CST

Title: Class 2 Malocclusion

Date: 9/23/2021

Present and content by: Daniel Konon

Goals: Understand more about Class 2 malocclusions by doing my own research.

Content:

Adult dogs have 42 permanent teeth and when they are puppies they normally have 24 deciduous teeth, which are like primary or baby teeth, which appear during the first 6 months of life. Dogs have four types of teeth: [1]

Incisors: are the teeth located between the canines on the upper and lower jaws. They are used for grasping food and they, along with the lower canines, help keep the tongue within the mouth.

Canine: teeth are located on the sides of the incisors and are used to grasp food and other objects. The lower canines help retain the tongue within the mouth.

Premolars: are located behind the canines in both the upper and lower jaws and work together to shear or cut food.

Molars: are behind the premolars and are the teeth found at the back of the mouth. They are used for grinding food to prepare it for swallowing.

What is Malocclusion?

Malocclusion refers to abnormal tooth alignment. There are two types of malocclusion: skeletal and dental. A skeletal malocclusion results when an abnormal jaw length creates a malalignment of the teeth. A dental malocclusion, or malposition, occurs when the upper and lower jaw lengths are considered normal but there may be one or more teeth that are out of normal alignment (malpositioned tooth/teeth). [1]

When a dental or skeletal malocclusion causes trauma to other teeth or to the oral soft tissues, the condition is termed non-functional or traumatic and treatment is needed. Therapy options include: [1]

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

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

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

Conclusions:

They are many different malocclusions that can happen in dogs, which can be dental and skeletal. I learned more about the Class 2 Malocclusion and now I understand how it happens.

Bis Acryl

DANIEL KONON - Dec 14, 2021, 3:09 PM CST

Title: Bis Acryl

Date: 10/19/2021

Content by: Daniel Konon

Goals: Understand the material that our client uses now

Content:

See paper below

Conclusions/action items:

Has great information about current material that the client uses in his incline plane design.

DANIEL KONON - Oct 19, 2021, 9:43 PM CDT

Comparative Evaluation of Flexural Strength of Provisional Crown and Bridge Materials-An Invitro Study

ABSTRACT

INTRODUCTION

Bis_Arcyl.pdf(529.8 KB) - download

von Mises Stress

DANIEL KONON - Dec 14, 2021, 3:04 PM CST

Title: von Mises Stress

Date: 12/5/21

Content by: Daniel Konon

Goals: Understand von Mises stress for analyses of stress testing in Solidworks

Content:

What is von Mises Stress?

Von Mises stress is a value used to determine if a given material will yield or fracture. It is mostly used for ductile materials, such as metals. The von Mises yield criterion states that if the von Mises stress of a material under load is equal or greater than the yield limit of the same material under simple tension then the material will yield. [1]

Elastic Limit: The elastic limit defines the region where energy is not lost during the process of stressing and straining. That is, the processes that do not exceed the elastic limit are reversible. This limit is also called yield stress. Above that limit, the deformations stop being elastic and start being plastic, and the deformation includes an irreversible part. The stress value of the elastic limit is used here as Sy. [1]

Upper yield and lower yield: When mild steel is in the plastic range and reaches a critical point called the upper yield limit, it will drop quickly to the lower yield limit, from which deformation happens at constant stress, until it starts resisting deformation again. [1]

Rupture stress: Rupture, or fracture, is the separation of an object caused by stress. Therefore, at this point, the fracture of the body is expected. Materials such as mild steel which have the property of fracturing only after large plastic deformations are called ductile. The fracture illustrated here is called a ductile fracture. You can recognize a ductile fracture when the diagram has a curve like the one shown below. This means that as the material gets thinner more pressure is applied until it suddenly breaks at the rupture stress point. [1]

Conclusions/action items:

This helps understand what the von Mises stress numbers on Solidworks means on our model.

References:

[1] "What is Von Mises Stress in FEA?" Simscale. https://www.simscale.com/docs/simwiki/fea-finite-element-analysis/what-is-von-mises-stress/ (accessed Dec. 5, 2021)

Retainers

DANIEL KONON - Oct 19, 2021, 11:02 PM CDT

Title: Retainer

Date: 10/4/2021

Present and content by: Daniel Konon

Goals: Understand how retainers are made and what they are made of

Content:

Retainers are dental devices that are used to help keep teeth in place after orthodontic treatment, especially after braces.

Retainers are made by taking impressions of the teeth in their current positions, then a plaster replica or mold is created to mimic the exact shape and alignment of your teeth.

Clear Retainers- They are made from a plastic material that is vacuum formed to the plaster mold taken of your teeth. They are not that noticeable. Uses flexible polypropylene to form it.

Figure [1] - Clear Retainer[1]

Hawley Retainers- The plaster mold taken of your teeth is sent to a laboratory. At the lab, they make a retainer from an acrylic material for the palate (or roof) of your mouth and a wire on the front of your teeth. More noticeable than a clear retainer. Uses acrylic and wire to form it.

Figure [2] - Hawley Retainer[1]

Fixed or Bonded Retainers- Fixed or bonded retainers are created by bonding a thin wire to the back of your anterior (front) teeth. They are called a fixed retainer because they can not be removed by the patient. Only a dental professional can remove a fixed retainer. A bonded retainer only retains, or holds, the front four or six teeth, so any

width created during orthodontic treatment can be lost to relapse. Great care and responsibility is also needed to keep bonded retainers clean.

Figure [3] - Wire Bonder Retainer[2]

[1] AO Smiles. "Retainer Options Following Orthodontic Treatment." Advanced Orthodontics. https://aosmiles.com/retainer-options-following-ortho-treatment/#:~:text=How%20are%20Retainers%20Made%3F,and%20alignment%20of%20your%20teeth [accessed Oct 4, 2021].

[2] Dr. T. McCarthy. "WHAT ARE TEETH RETAINERS MADE FROM?" Sporting Smiles. https://www.sportingsmiles.com/blog/what-are-dental-retainers-made-from/ [accessed Oct 4, 2021].

Conclusion:

Retainers are useful for helping keep the teeth in place after treatment is done on the teeth in Orthodontics.

Invisalign

DANIEL KONON - Oct 04, 2021, 2:02 PM CDT

Title: Invisalign

Date: 10/4/2021

Present: Daniel Konon

Goals: Understand how Invisalign treatment works and what materials are used to form it

Content:

What is Invisalign?

- Invisalign clear aligners is an innovative teeth-straightening technique. Metal braces are cosmetically undesirable, and take a lot of maintenance. These clear aligners overcome these snags: clear removable trays help straighten teeth without obvious metal brackets with sharp edges in your mouth.

Invisalign treatment process

1. Your Initial Appointment

2. Molding Process

- Digital scan, photographs, and x-rays create an accurate model of your mouth and teeth. These are sent to the Invisalign laboratory for your custom aligner trays to be created.

3. Fitting the First Tray

- When your Invisalign trays are ready, it's time to return for your pick-up. Your dentist may fit small attachments on your teeth to help the trays stay in place. These buttons are clear, almost invisible, painless to install, and temporary. After, Your dentist will check if your aligners fit, and With your trays fitted, and your aftercare program clearly explained.

4. Your Follow-Up Appointments

- A few weeks after your first tray is fitted, it's time to return to the dentist. Your dentist will check your tooth movements, and tray fit.

- A series of Invisalign trays make up the entire process. Unlike metal braces, you won't need to return for regular appointments with Invisalign. Instead, you can return periodically to check your progress. You won't need to see the dentist each time you change to a new aligner. If your treatment is not progressing as planned, you may need a new digital scan to order a additional set of aligners.

5. Straighter Teeth!

Other:

- Need to wear it at all times except when eating and brushing teeth

- Treatment time depends on the severity of the crooked teeth

Material:

Invisalign aligners are customized trays that are made out of plastic, or something called “polyurethane resins.” To get really technical, these resins are actually a blend of methylene diphenyl diisocyanate and 1.6-hexanediol. They are also medical grade with a high molecular weight.

This biocompatible material is strong enough to gradually shift the teeth through focused pressure, but also comfortable enough that you can wear them without any issue.

SoHo Dental. "From Start to Finish: What to Expect From the Invisalign Process." SoHo Dental Group. https://www.sohodentalgroup.com/invisalign-process [accessed Oct 4, 2021].

"What Are Invisalign Trays Made of?" Schumacher Dental. https://www.schumacherdental.com/blog/invisalign-wakefield-2/ [accessed Oct 4, 2021].

Conclusions:

This process may be helpful to determine a way to use software to sculp the incline plane around the teeth of the patient(dog).

Class 2 Malocclusion

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

Title: Class 2 Malocclusions

Date: 9/23/21

Content by: Giovanni Militello

Present:

Goals: Learn about Class 2 Malocclusions

Content:

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

Class 2 Malocclusions:

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

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

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

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

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

Conclusions/action items:

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

Last Year Report

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

Title: Last Year's Report

Date: 9/14/21

Content by: Giovanni Militello

Present:

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

Content:

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

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

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

Conclusions/action items:

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

Workflow/Software design

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

Title: Software/Workflow

Date: 10-03-21

Content by: Giovanni Militello

Present: Giovanni

Goals: Research software and workflow designs

Content:

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

Workflow for material Dental LT Resin (V2) from Formlab

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

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

Essentials

Needed From the Dentist

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

Required Hardware and Materials

Made by Formlabs:

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

Made by Third Parties:

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

Required Software

Made by Formlabs:

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

Made by Third Parties:

- Dental design software or outsourcing to a dental design provider

1. Scan

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

2. Design

2.1 Design the Appliance

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

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

2.2 Export the STL File

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

3. Print

3.1 Import the File(s)

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

3.2 Material Selection

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

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

3.3 Orientation

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

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

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

3.4 Generate Supports

3.4.1 Automatic Support Generation

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

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

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

3.4.2 Manual Support Editing

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

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

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

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

3.5 Printing Layout

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

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

3.6 Transferring Job to the Printer

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

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

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

3.7 Set up the Printer

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

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

4. Post Processing

Always use gloves when handling uncured resin and parts.

4.1 Part Removal

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

4.2 Washing

Precautions

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

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

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

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

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

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

4.3 Drying

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

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

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

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

4.4 Post Curing

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

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

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

4.5 Support Removal

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

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

Removing supports should leave a small positive feature.

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

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

4.6 Finishing and Polishing

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

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

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

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

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

5. Cleaning and Disinfecting

5.1 Cleaning the Parts

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

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

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

5.2 Disinfection

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

Conclusions/action items:

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

Materials design

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

Title: List of Materials

Date: 10-03-2021

Content by: Giovanni Militello

Present: Giovanni

Goals: Gather types of materials to use for our project

Content:

From Stratasys.com

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

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

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

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

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

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

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

From Formlabs

Model Resin

An accurate material for dental modelmaking and clear aligner production

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

Draft Resin

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

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

Surgical Guide Resin

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

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

Dental LT Clear Resin (V2)

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

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

Castable Wax Resin

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

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

Digital Dentures

Truly accessible direct printed dental prosthetics

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

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

Custom Tray Resin

A fast-printing biocompatible material for custom impression trays

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

Temporary CB Resin

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

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

Permanent Crown Resin

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

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

IBT Resin

A flexible biocompatible material for efficient, accurate dental bracket placement

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

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

Soft Tissue Starter Pack

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

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

Conclusions/action items:

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

Incline plane design

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

Title: Incline plane design

Date: 10/07/21

Content by: Giovanni Militello

Present: Giovanni

Goals: Come up with design of incline plane

Content:

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

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

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

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

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

Design 1:

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

- Similar to the patten that Ben Smith found

Design 2:

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

Design 3:

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

Conclusions/action items:

Talk with team and pick a design to go with.

Past Project Research

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

Title: Past Project Research

Date: 09/17/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To gain and understanding of the past groups work

Content:

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

Past Project Summary

Problem Statement:

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

Current Methods & Devices:

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

Motivation

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

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

Physiology and Biology

- Normal Occlusion in a Canine
- Class II Malocclusion

Existing Treatment/Device

Extraction:

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

Shortening:

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

Incline plane:

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

Existing Development Process of the Incline Plane

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

Client Information

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

Design Specifications

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

Preliminary Designs

Incline Plane:

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

Software:

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

Conclusion:

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

Class II Malocclusions

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

Title: Past Project Research

Date: 09/17/21

Content by: Lily Gallagher

Present: Lily Gallagher

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

Content:

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

Project:

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

Class 2 Malocclusion:

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

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

Title: Class II Maloclussion in Canines

Date: 09/22/21

Content by: Lily Gallagher

Present: Lily Gallagher

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

Content:

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

Displaced Mandibular Canines & Hard Palate Trauma

Identifying...

Class II malocclusion

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

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

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

- Lower canines occlude into the soft tissue of the roof

-causing discomfort and inflammation

Causes...

Inherited Condition (autosomal recessive mutation)

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

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

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

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

Preventing...

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

- no test to identify this gene

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

Removal

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

why?

1. Sharp teeth, cannot close mouth without pain

2. negatively affect the growth on the mandible

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

3. affect ligands in the mouth

- crown extensions

ADLUT DOGS

- Ball therapy

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

- size and type of ball is critical

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

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

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

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

SURGICAL OPTIONS

- CROWN AMPUTATION partial coronal pulpectomy

- reduces height of the lower canines

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

- SURGICAL EXTRACTION

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

- not an easy extraction

-CROWN EXTENSION

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

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

- remain in place for 2 months

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

ORTHODONTIC TIPPING

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

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

4-8 weeks

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

Conclusion:

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

Material Research

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

Title: Orthodontic Material Research

Date: 09/28/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: to brainstorm materials

Content:

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

BPA FREE

polyurethane resins

Man made Polymeric materials

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

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

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

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

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

Titanium- metallic implants are sterile and strong

Conclusions/action items:

pick materials for design matrix

Title: Orthodontic Material used as attachments for orthodontics

Date: 09/28/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: to brainstorm materials

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

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

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

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

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

Low degree of hardness, good elasticity, high resilience

Most important aspects: comfort and aesthetics

Thickness: .5mm to 1.5mm

Thicker deliver higher forces than thin

Difficult to correct tooth torque and rotation with aligners

- need attachments

Process:

Conclusion:

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

A high modulus material may be suitable for clinical applications.

Conclusion:

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

Ethics/Standards

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

Title: Orthodontic Implants Insertion

Date: 10/04/21

Content by: Lily Gallagher

Present: Lily Gallagher

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

Content:

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

Material

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

Surface roughness:

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

Clinical Procedure:

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

Dimensions

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

Hygiene control

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

Conclusions/action items:

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

Title: Veterinary orthodontics

Date: 10/20/21

Content by: Lily Gallagher

Present: Lily Gallagher

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

Content:

Ethical Standard of Orthodontics

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

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

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

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

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

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

WHEN GENETICS ARE INVOLVED... [2]

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

- LACK of information to distinguish hereditary and systemic

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

- Orthodontics are never provided for sole cosmetic purposes.

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

Normal occlusion take in an account of..

Head dimension or shape

- mesaticephalic (medium length)

- brachiocephalic (short, wide head)

- dolichocephalic (long narrow)

and symmetry

conclusion:

take these points into account when diagnosing treatment plans

Teeth angles and forces

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

Title: Teeth angles and forces

Date: 10/17/2021

Content by: Lily Gallagher

Present: Lily Gallagher

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

Content:

- External forces are managed by by the practitioner

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

-avoids discomfort and complications

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

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

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

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

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

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

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

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

Conclusions/action items:

Continue research

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

Title: Teeth angles and forces

Date: 10/17/2021

Content by: Lily Gallagher

Present: Lily Gallagher

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

Content:

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

60 subjects were categorized into 4 groups

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

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

in this study...

class ii malocclusion is defined as

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

Conclusion:

Does not show useful data

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

Title: Teeth angles and forces to move teeth

Date: 10/17/2021

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: Provide data on the forces needed to move teeth

Content:

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

- causing pain

insufficient forces will have no effect

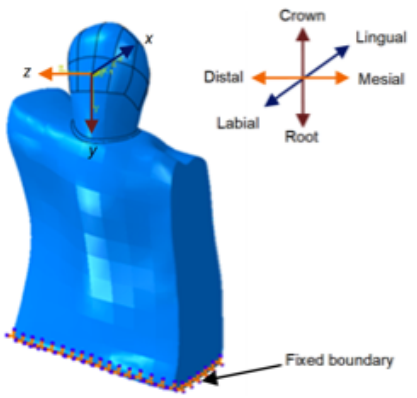
Study was to investigate the optimal orthodontic forces on a maxillary canine

- using hydrostatic stress and logarithmic strain

Types of forces:

Distal translation/tipping forces

labial translation/tipping forces



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

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

Table[1] Optimal Force/moment on a canine

Results:

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

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

Conclusion:

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

Thermoplastic Incline plane for Cats

LILY GALLAGHER - Dec 15, 2021, 2:26 PM CST

Thermoplastic Inclined Plane Aligner for Correction of Bilateral Mandibular Canine Tooth Distoclusion in a Cat

Stanley W. Blazejewski III, VMD

Summary:

Mandibular brachygnathia was the etiology for moderate mandibular distoclusion and bilateral palatal canine cusp penetrations in a feline. The course of treatment included deciduous canine tooth exodontia, tooth extensions, and ultimately aligners that incorporated inclined planes fabricated from a thermoplastic sheet that was "hollowed" to vacuum thermoformed over a dental model. Thirteen flexible aligners fit over the rostral maxillary teeth and palate, and were attached to a single flat on the right, divergent mandibular canine tooth. Advantages over "directly" applied composite inclined planes include: serial gradations of angulations for more gradual tooth movement, elimination of dental trauma from composite adhesion and removal, owner-removable and cleanable appliances, and a single anesthetic event required for distal impressions. Five progressively angled aligners were used sequentially over a 3-month period to achieve edgewise "cuspid" reocclusion of the rostral dentition. J Vet Dent 30:4: 236-247, 2013

Introduction

Malocclusions can be traumatic to soft and osseous oral tissues, affect mastication and TMJ function, disturb enamel or even development of erupting teeth, foster periodontal disease and caries, and affect craniofacial growth and development.[1] Animals with malocclusion (Class 1 malocclusion) have most teeth in normal occlusion, with one to several teeth malpositioned.[2] One common example of Class 1 malocclusion is hyperversion of the mandibular permanent canine teeth (304 and 404) where one or both are in the correct position, but inclined in a lingual direction.[3]

Mandibular distoclusion (Class 2 malocclusion, also termed retrusive mandible) is an abnormal rostrocaudal relationship of the dental arches created by either mandibular brachygnathia (short mandibular dental arch), or maxillary prognathism (long maxillary dental arch). The mandibular teeth are, to various degrees, positioned in a more caudal relationship (distoclusion) to the maxillary teeth.[4] When sufficient distoclusion is coupled with the normal mesiognathia (mesial key dental arch of dogs and cats to date than the mandibular), the 304 and 404 tall cusps lingual to (or inside of) the maxillary canine teeth (104 and 204). In this position, they will be traumatic to the maxillary gingiva, canine teeth, and/or palate.

Treatment options for traumatically occluding mandibular canine teeth include orthodontics, interceptive coronal reduction with vital pulp therapy, surgical translations, or extractions.[5–11] These procedures have the goal of restoring a comfortable occlusion and oral health. Contrain is not the primary goal.[1] Each procedure has advantages and disadvantages that include a prerequisite dentistry skill level, appliance and procedure costs, morbidity and mortality risks to teeth and soft tissues, the number of anesthetic events, the number of patient visits, and compromises in dental function.

Orthodontic movements require healthy teeth, a destination space, and a clear path.[1] Orthodontics is usually reserved for crowded or ectopic teeth, of which canine teeth are both. Active orthodontic expansion devices apply continuously distributing or constant force, with springs, or screws.[1,2,6] Active orthodontics can be complicated or simple, but they typically require adjustments due to force degradation. They must be appropriate for the situation.[1,2,6]

Intermittent force techniques are self-regulated by mouth closure, such as chewing a properly sized ball, temporary tooth extractions, or maxillary inclined planes (IPs), all acting to deflect canine teeth into an atraumatic (such labial) position.[1,2,6] IPs are typically sculpted out of composite that is "directly" applied to the maxillary teeth during anesthesia, or fabricated "indirectly" of metal from the patient's dental models, and then cemented to the maxillary canines at a second procedure.[1,2,6] An additional anesthetic event is usually required for removals.

Cats allow for fewer orthodontic treatment options than do dogs, for reasons of oral space, dentition morphology, and temperaments. For example, recurrence cannot be tolerated in cases on rubber ball, so ball therapy is usually not an option. The tight material (shearing) bite affords little space between opposing arcades for appliance attachment. Feline incisors are too small to secure attachment or anchoring points.

Though advantages of orthodontic correction versus tooth loss in humans are obvious, orthodontics for pets is more debatable. Edentulous (non-articulated) dogs and cats still play with toys and may even consume hard food preferentially to soft. On the other hand, extractions can have undesirable consequences. Without 104 and 404, the tongue may slide out of the mouth and distocclude, albeit unlikely in cats. Without 304 and 404, nasal loss by trauma or entrapment may ensue, often with cutaneous excoriations and dermatitis.

It is the author's opinion that rather than deny orthodontic corrections to pets, patients should be selected carefully, and owners educated. The search is ongoing for efficient, safe, and compassionate techniques, and those capable of greater orthodontic challenges. The efforts on behalf of this patient exemplify that philosophy. Thermoplastic aligners have been described previously for use in dogs[6], but not in cats. After a brief treatment effort with tooth extensions, these aligners were employed for the correction of moderate bilateral mandibular canine tooth distoclusion in a cat.

Case Report

A 15-week-old, 1.6 kg, male Domestic Shorthair was presented with mandibular deciduous (primary) canine teeth (704, 804) penetrating the rostrum just lingual to the mandibular

Thermoplastic_Incline_plane.pdf(11.2 MB) - download S. W. Blazejewski, "Thermoplastic Inclined Plane Aligner for Correction of Bilateral Mandibular Canine Tooth Distoclusion in a Cat," J Vet Dent, vol. 30, no. 4, pp. 236–247, Dec. 2013, doi: 10.1177/089875641303000405.

LILY GALLAGHER - Oct 20, 2021, 12:50 PM CDT

Title: Thermoplastic Incline plane for cats

Date: 09/20/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To research competing designs

Content:

Thermoplastic Incline plane (see PDF)

- to create mold is similar to how an orthodontist makes a retainer mold

- Incline planes built into mold

-Aligner fits all teeth

Conclusions/action items:

Add an idea like this into our matrix

S. W. Blazejewski, "Thermoplastic Inclined Plane Aligner for Correction of Bilateral Mandibular Canine Tooth Distoclusion in a Cat," J Vet Dent, vol. 30, no. 4, pp. 236–247, Dec. 2013, doi: 10.1177/089875641303000405.

Cast metal Incline Plane

LILY GALLAGHER - Oct 04, 2021, 1:52 PM CDT

VETERINARY DENTIST AT WORK

Cast Metal Bilateral Telescoping Inclined Plane for Malocclusion in a Dog

Figure 1

Cast_metal_Incline_plane.pdf(2.1 MB) - download [1]K. Bannon and L. Baker, "Cast Metal Bilateral Telescoping Inclined Plane for Malocclusion in a Dog," J Ve Dent, vol. 25, no. 4, pp. 250–258, Dec. 2008, doi: 10.1177/089875640802500406.

LILY GALLAGHER - Oct 20, 2021, 12:54 PM CDT

Title: Cast metal Incline plane

Date: 09/20/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To research competing designs

Content:

See attached PDF

Cast metal incline plane fits around the canines and it attached by a bar

it has an incline plane built into the attachment and uses the same tipping orthodontics

Conclusion:

Add design idea into design matrix

Adjustable Bar (+ Ring Design)

LILY GALLAGHER - Dec 15, 2021, 2:20 PM CST

Title: Expander mechanic with the ring design

Date: 12/01/2021

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To integrate a different bridge approach with the ring design (possibly for the future?)

Content:

"Palatal Expanders." http://www.orthodontic-associates.com/treatment/palatal-expanders

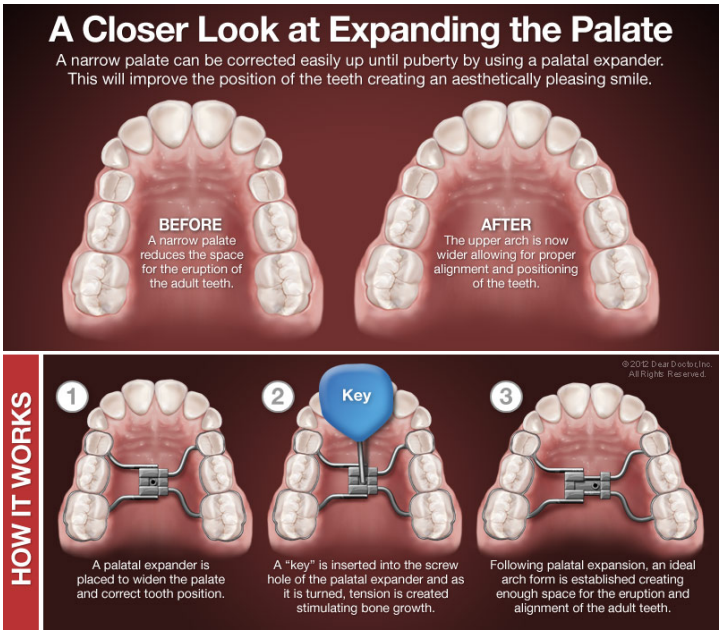


Figure [1]: An explanation and visual on how palate expanders work

Overall, an expander works to widen the distance between the teeth.
The most useful aspect of an expander is that it can be adjusted, this could remove a variable that Dr. Graham would

have to change on the current solid works design.

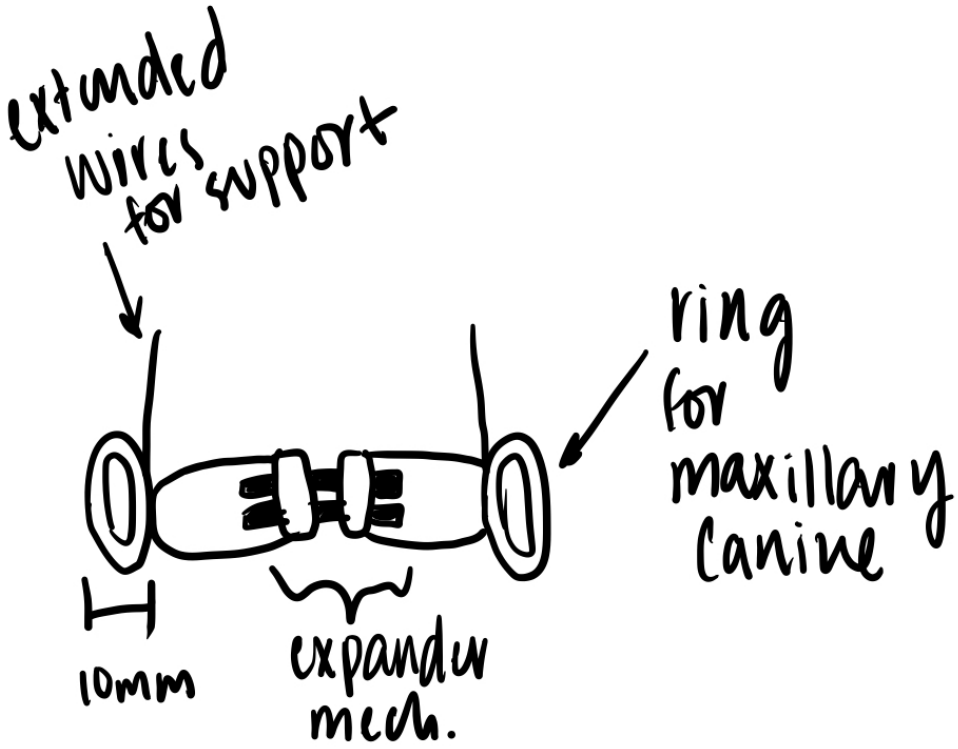


Figure [2]: The ring design integrated with a palate expander

In this drawing, there are extended wires for support, this is because the expander will only be attached to the ring that is on one canine. This expander is bigger and might make it difficult to fit an incline plane into the design.

Conclusions:

This design could be tested in the future as a improved ring design.

Maybe this will be future work, it does not make sense to use this design now, the bridge arch was not a main concern.

Title: Trans Palatal Arch Appliance with the ring design

Date: 12/01/2021

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: To integrate a different bridge approach with the ring design (possibly for the future?)

Content:

"Trans Palatal Arch TPA Appliance TPA Braces," *Ivanov Orthodontic Experts*. https://ivanovortho.com/trans-palatal-arch-tpa-appliance/

Transpalatal arch represents an orthodontic tool.

on the upper jaw and acts as a palatal expander of the roof of the mouth.

The TPA Arch is used to hold upper molars in place, stabilizing the position of these teeth during or after the movement of other teeth.

Can also beused to rotate molars into ideal positions to improve the bite.

Figure [1]: The TPA attachment in the human mouth

Benefits:

- Expansion and rotation of the top molars.
- Filling in the omega loop in the palate.
- Very compatible with gums and mouth tissue, does not cause irritation.
- Expansion of the upper arch, thus making space for the teeth.
- Managing upper molars irregularities/issues.
- Treating unilateral crossbite, especially in patients with buccal root torque of top molars.
- Fixing mesiodistal irregularities.
- Controlling the vertical placement of the permanent molars.

- Preventing forward tipping of upper molars and space loss.
- Is comfortable to wear and does not cause speech issues.

Length of wear:

As short as 3 months, or as long as 36 months

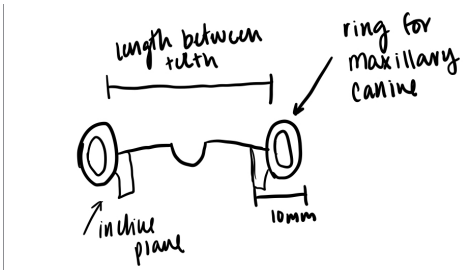


Figure [2]: Our ring design with the TPA arch connection the two rings

Conclusions/action items:

This design could be tested in the future as a improved ring design.

Maybe this will be future work, it does not make sense to use this design now, the bridge arch was not a main concern.

Dental Retainer

LILY GALLAGHER - Dec 15, 2021, 2:40 PM CST

Title: Thermoplastic Incline plane for dogs

Date: 10/01/21

Content by: Lily Gallagher

Present: Lily Gallagher

Goals: Design an incline plane device

Content:

S. W. Blazejewski, “Thermoplastic Inclined Plane Aligner for Correction of Bilateral Mandibular Canine Tooth Distoclusion in a Cat,” J Vet Dent, vol. 30, no. 4, pp. 236–247, Dec. 2013, doi: 10.1177/089875641303000405.

Workflow

create mold is similar to how an orthodontist makes a retainer mold

- an impression is taken of the dogs bite

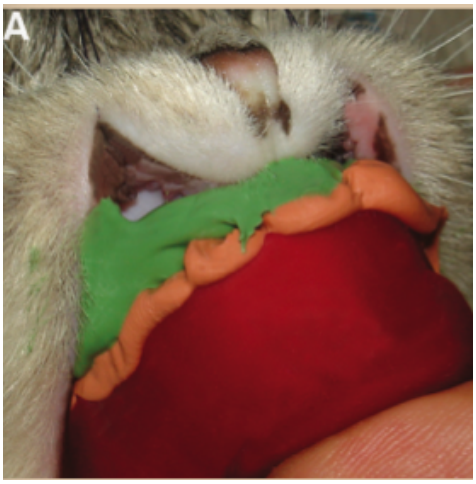


Figure 1: An impression being taken of a cats mouth- the putty is VPS

- Use a 2 part vinyl polysiloxane putty

- need anesthetics

add incline plane device to mold

once the mold is created, a thermoplastic sheet is vacuumed onto of the mold

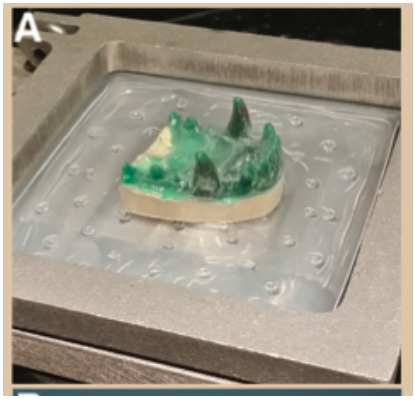


Figure 2: The mold being vacuum sealed

a thin retainer aligner is created

this will fit the dogs mouth perfectly

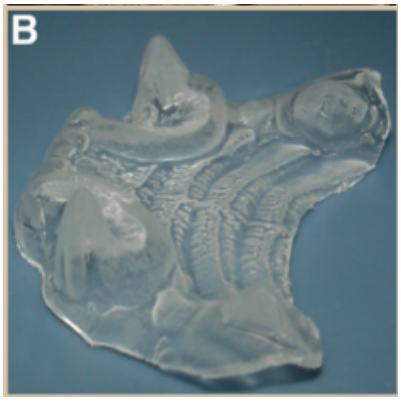


Figure 3: The final product

The important difference of this process is there is no 3D printing or scanning so that saves the veterinarian a lot of time.

Anesthetics are still required to get the mold

Having a full retainer on an animal might be hard to keep on, maybe you would need to use resin to attach it so it lasts longer.

Not be able to take it out- will the dog be uncomfortable?

will it be able to withstand a bite force?

doesn't allow room for growth

Would have to update as teeth shift?

Conclusions/action items:

Add this design workflow/ device into the design matrix

Previous Class 2 Malocclusion research

OWEN KOLNIK - Oct 20, 2021, 12:36 PM CDT

Title: Fall 2020 research

Date: 9/21/2021

Content by: Fall 2020 VetMed Group

Present: Owen

Goals: To understand how the previous groups research will be applicable to our future designs and research.

Content:

R. Furman and B. Niemiec, “Variation in acrylic inclined plane application,” *Journal of Veterinary Dentistry*, vol. 30, no. 3, pp. 161–166, 2013.

- Inclined Planes move teeth in a passive manner, using consistent tension
- A class 2 malocclusion is classified as a misalignment of the mandibular and the maxillary jaw
- In this type of malocclusion the mandibular jaw is shorter in length that the maxillary jaw
- Hence the mandibular canine is translated inward potentially causing intraoral palatal trauma
- This palatal trauma can often decrease the quality of life for the patient as the can pierce themselves while closing their mandibular jaw
- Current treatments involve shortening teeth, removing the teeth, crown extensions, and incline planes
- This groups inclined plane was 3D printed using computer software
- The inclined plane was made of Dental RT resin
- Their final prototype had slots for the upper maxillary, upper canine ,and upper incisor

Design criteria:

- Inclined plane must be able to withstand 400 lbs of force
- In addition, the inclined plane must last longer than 6-8 weeks
- The design software must have a user friendly interface

Conclusions/action items:

This can be used as a reference for future research and designs.

Prevalence of Class two malocclusions

OWEN KOLNIK - Oct 20, 2021, 12:42 PM CDT

Title: Prevalence of Malocclusion of Deciduous Dentition in Dogs: An Evaluation of 297 Puppies

Date: 9/27/2021

Content by: Naomi K Hoyer , Jennifer E Rawlinson

Present: Owen

Goals: To understand the prevalence of Class 2 malocclusions to better understand our potential patients

Content:

> N. K. Hoyer and J. E. Rawlinson, “Prevalence of malocclusion of deciduous dentition in dogs: An evaluation of 297 puppies,” *Journal of Veterinary Dentistry*, vol. 36, no. 4, pp. 251–256, 2019.

- Research was conducted on 297 8-12 week puppies to determine prevalence of varying classes of Malocclusions
- Roughly 25% of puppies had some degree of a Malocclusion
- Of the 297 roughly 5% of puppies had Class 2 Malocclusions
- The vast majority of this data was independent of breed of dog
- This being said, specific litters of dogs of certain breeds often all had many individual puppies with malocclusion
- This implies that the cause may be genetic in nature, or at least genetics acts as a major factor predisposing Class II malocclusions.

Conclusions/action items:

This information could be useful in determining the severity of the problem and our potential patient pool size.

Bite Force of Dogs

OWEN KOLNIK - Oct 19, 2021, 11:09 PM CDT

Title: Cranial dimensions and forces of biting in the domestic dog

Date: 10/17

Content by: Jennifer Lynn Ellis, Jeffrey Thomason, Ermias Kebreab, Kasim Zubair, and James France1

Present: Owen

Goals: To understand the individual force from the mandibular canine force.

Content:

Ellis, J., Thomason, J., Kebreab, E., Zubair, K. and France, J., 2021. *Cranial dimensions and forces of biting in the domestic dog*.

- This describes the individual force produced by the canine from the bite
- The study used 3 different skull skeletal structures and compared the bite force of each tooth for each skull type
- Found that the maximum bite force recorded in the study was less than 1400N
- Therefore our inclined plane should be able to withstand this force
- The study then concluded that the maximum average force for all the skull structures was 380N
- However, there are instances of greater force being applied
- To be safe we should use 1400N as a benchmark for strength for our design

Conclusions/action items:

Share in Preliminary report.

New Page

3D printer filament research

OWEN KOLNIK - Oct 20, 2021, 12:59 PM CDT

Title: Evaluation of fit for 3D-printed retainers compared with thermoform retainers

Date: 10/3

Content by: David Cole, Sompop Bencharit,, Caroline K. Carrico, Andrew Arias, and Eser Tufekc € ¸

Present: Owen

Goals: To identify potential 3D printer filaments that are capable of

Content:

Chakroun, F., Colombo, V., Lie Sam Foek, D., Gallo, L., Feilzer, A. and Özcan, M., 2021. *Displacement of teeth without and with bonded fixed orthodontic retainers: 3D analysis using triangular target frames and optoelectronic motion tracking device*.

In, summary this study 3D printed dental retainers and tested the discrepancy between software CAD models vs. the printed device. This study focus on the printer material as the variable that affects the accuracy of the 3D printed product. PMMA was one of the materials that may pertain to our project and the study states that the products had a discrepancy of 127 micrometers at the maximum point of difference (300-500 micrometers or less is accepted in orthodontic). Similarly, Dental LT had a discrepancy of roughly 400 micrometers at the maximum point of difference.

- PMMA has a average discrepancy of 127 micrometers at point of max variance
- Dental LT has roughly 400 micrometers of average discrepancy at the point of max variance
- Both are compatible with Form 3B printers from Formlabs
- In human orthodontics 300-500 micrometers of variance are accepted.

Conclusions/action items:

For our research either material should be sufficient.

Light hardened Acrylic

OWEN KOLNIK - Sep 20, 2021, 4:32 PM CDT

Title: *Variation in Acrylic Inclined Plane Application*

Date: 9/17/2021

Content by: Owen

Present: Me

Goals: To understand the material benefits of using light hardened acrylic as a treatment for Class 2 malocclusions in dogs.

Content:

Furman R, Niemiec B. Variation in acrylic inclined plane application. J Vet Dent. 2013 Fall;30(3):161-6. doi: 10.1177/089875641303000305. PMID: 24371924.

Notes:

- *Very similar to the kind of treatment we are interested in designing*
- *The material of the inclined plane was hardened acrylic paired with Scotchbond, 3M ESPE Dental Products*
- *The acrylic was fitted and hardened by dentistry equipment will the acrylic was removed*
- *Then the bonding agent (ScotchBond Universal) was added followed by the acrylic which was then light cured*
-

Conclusions/action items:

This treatment could be used as a reference for the possible applications of acrylic as an inclined plane for the treatment of class 2 malocclusions.

Incline plane design

OWEN KOLNIK - Dec 15, 2021, 12:32 PM CST

Title: Tipping orthodontics

Date: 12-15-2021

Content by: Dr. Graham Thatcher

Present: Owen

Goals: To summarize tipping orthodontics for our final report

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

- Tipping orthodontics involve the use of a device situated intraorally to provide an angled counter force
- For class II malocclusions the device in situated on the upper jaw (maxillary canines)
- The device is often composed bisacryl composite, however this isn't an option as a 3D printer fillament
- The device acts of a 6-8 week periord to gradually force the malocclusion outside of the mouth, and away from any gum and palatal tissue
- The device is situated in the patients mouth over the maxillary canine, and secure by dental cement (used to form a lasting bond)
- The device must withstand forces synonymous with the max bite force of the mandibular canine to perform properly
- Current methods for constructing these devices is teadous and costly

Conclusions/action items:

Use this information to describe our project in the Abstract of our final report.

Past Project Research

Tony Pribnow - Oct 18, 2021, 4:11 PM CDT

Title: Past Project Research

Date: 9/24/21

Content by: Tony Pribnow

Present: self

Goals: Read through and understand the past year's final report. Takes notes focusing on the background section to understand past research.

Content:

- The goal is to create 3d printed inclined plane that can fit multiple different varieties of dogs
- The material used is important because it can cause damage to the dog's mouth if the wrong one is used
- Many different methods are currently in place
- 3d printing does not cause damage to the dog's mouth and is also much cheaper and more adjustable than other options like metal
- The main issue with 3d printing is that the models break easily in the middle of attempting to fix the teeth
- Attempting to streamline the process of how malocclusions are fixed
- Canines also have issues with their teeth that affect their daily lives especially eating
- Class II malocclusions affect the maxillary canine, the maxillary 3rd incisor, and the mandibular canine which is the 2 upper and 1 lower canine
- Normally, the bottom canine fits within the upper canines on the outside of the upper gums
- In class II malocclusion the lower canine is distorted to point more towards the middle of the mouth and this hits the upper gums and canines
- It is essentially an overbite in dogs canines
- It can cause dental attrition, periodontal diseases, and oronasal fistula
- Dogs frequently use their canines, so it's essential that they are correctly positioned
- One current treatment is to just remove it altogether, but this brings up many more lifestyle issues
- Another treatment is to shorten it but this doesn’t keep its full function
- A third treatment is what we are attempting to refine- the 3d printed incline plane which acts as an upper retainer for the dog with inclined planes pressing against the bottom two canines to direct them into the correct position
- This is happening when the dogs close their mouths
- Over time it will shift the teeth into the correct position
- Once done a retainer is no longer needed
- Process Dr. Thatcher currently using is too slow and inefficient
- Software is needed to create models and molds of the teeth to allow for lots of adjustabilities

Conclusions/action items:

The issue of malocclusions is that the lower canine is positioned in a way that it stabs the upper gums and causes extreme pain. The main goal of this year's project is to improve the workflow and make this an actual method of fixing malocclusions. Another goal is to make it a more durable 3d printable material. Some action items are to work with the software and meet with out client more.

Material Research

Tony Pribnow - Oct 18, 2021,

Title: Material Research

Date: 10/4/21

Content by: Tony Pribnow

Present: self

Goals: Research dental 3d printing and determine if there are better, more structurally sound options out there.

Content:

- 3d printing is very important to dentistry now
- The industry has lots of new information and products coming in fast and with many claims
- Maybe moving too quickly
- What's the difference between a regular printer and a dental one?
    - Dental printers need speed and accuracy
    - More importantly, dental printers need good resin
        - This is where the issue lies in our project
- Dentists have a unique set of rules for their manufacturing systems
- Dental 3D material is a resin designed for the production of dental appliances
- Not all resins are suitable for basic models
- Resin is the future of dentistry, needs to be further developed
- Two categories of dental resin
- This material needs to be much more specific and easy to use than basic 3d printing materials
- In humans the look is important, however, that is not nearly as important for our project
- The most important part is the accuracy
- Desktop DLP printers can make entire layers of aligners with a single flash of a UV
- Many new breakthroughs in FDA approved resins specifically for dental applications
- Hard, clear plastic mouth guards and night guards can now be printed on some printers
- Dentures can now be printed with PMMA micro filled hybrid material
- Still hard to do so because the software must be able to work with the new resins
- Most resins are made by 3rd party suppliers and most software won't accept this
- Resins are improving fast

“Dental 3D printing materials guide,” *SprintRay Inc.*, 05-Nov-2019. [Online]. Available: https://sprintray.com/dental-3d-printing-materials-guide/. [Accessed: 18-Oct-2

Conclusions/action items:

Dental 3d printing is changing and developing very fast to become better, faster, and stronger. Resin is a good material and will be the future, but it needs to developed much more first. Having accuracy in dentistry is extremely important. One main action item is to continue to research PMMA, as it seems like a g option.

PMMA Research

Tony Pribnow - Dec 15, 2021

Title: PMMA Research

Date: 10/6/21

Content by: Tony Pribnow

Present: self

Goals: Continue to research PMMA and determine if it is a viable replacement for dental resin.

Content:

source 1:
PMMA

- Various applications in prosthodontics
- Commonly used for fabrication of artificial teeth, denture bases, dentures, obturators, retainers, crowns, repair, splints, casts, etc
- Has great properties:
  - Low density
  - Aesthetics
  - Cost-effective
  - Easily manipulated
  - Tailorable
- Currently modifying it to give it more important properties like impact and flex strength
- source 2:
- properties:

Property	Value
Density (g/cm3)	1.18
Surface Hardness	RM92
Tensile Strength (MPa)	70
Flexural Modulus (GPa)	2.9
Notched Izod (kJ/m)	0.02
Linear expansion (/°C x 10-5)	7
Elongation at Break (%)	2.5
Strain at Yield (%)	N/A
Max. Operating Temp. (°C)	50
Water Absorption (%)	0.3

Oxygen Index (%)	19
Flammability UL94	HB
Volume Resistivity (log ohm.cm)	15
Dielectric Strength (MV/m)	25
Dissipation Factor 1kHz	0.03
Dielectric const. 1kHz	3.3
HDT @ 0.45 MPa (°C)	103
HDT @ 1.80 MPa (°C)	95
Material. Drying hrs @ (°C)	2 @ 75
Melting Temp. Range (°C)	220 - 240
Mould Shrinkage (%)	0.6
Mould Temp. Range (°C)	60 - 80

1. M. Zafar, “Prosthodontic applications of polymethyl methacrylate (PMMA): An Update,” *Polymers*. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/33049984/#:~:text=Polymethyl%20methacrylate%20(PMMA)%20is%20commonly,the%20repair%20of%20dental%20 [Accessed: 18-Oct-2021].

2. F. H. International, F. I. O. N. I. C. O. N. Analytik, F. T. A. Instruments, F. M. M. E. FZC, F. L. E. C. O. Corporation, F. R. V. Systems, and F. Carver, “Polymethylmethacrylate - acrylic - PMMA general purpose,” *AZoM.com*, 28-May-2019. [Online]. Available: https://www.azom.com/article.aspx?Article [Accessed: 18-Oct-2021].

Conclusions/action items:

PMMA is definitely a viable material option. It is much stronger than dental resin and has been used in multiple dental circumstances. Finally, PMMA is also 3D print. We need to determine where we can print PMMA on campus and how easy it is.

Ethics Research

Tony Pribnow - Dec 15, 2021, 1:32 PM CST

Title: Ethics Research

Date: 10/20/21

Content by: self

Present: self

Goals: research the FDA ethics in veterinarians

Content:

- Fda sends out warning letters if any violations are made
- Fda fines any criminal actions
- Federal Food, Drug, and Cosmetic Act makes sure that drugs, devices, and food is safe for pets
- The Animal Medicinal Drug Use Clarification Act of 1994 was added to allow the use of human drugs in pets in special cases
- Animal Drug Availability Act of 1996 was enacted to help streamline the drug approval process
- Animal drugs have to be safe and and effective when in use
- A drug is considered unsafe unless it is tested and is approved for use in animals
- FDA regulations are in Title 21 of the CODE OF FEDERAL REGULATIONS

Medicine, Center for Veterinary. “Laws FDA Enforces.” *U.S. Food and Drug Administration*, FDA, https://www.fda.gov/animal-veterinary/resources-you/laws-fda-enforces.

Conclusions/action items:

There are a variety of FDA rules and acts that must be followed in order for medicine and products to pass.

Class 2 Malocclusion Research

Tony Pribnow - Dec 15, 2021, 1:48 PM CST

Title: Class 2 Malocclusion Research

Date: 10/25/21

Content by: self

Present: self

Goals: Further research class 2 malocclusions in digs

Content:

- Incisors- teeth between canines on both jaws
- Canines are on the sides of the incisors and used for food
- Occlusion describes how teeth line up
- Normal occlusions occur when the upper and lower incisors overlap
- lower canines are located at an equal distance between the upper third incisors and the upper canine teeth and when the premolar crown tips of the lower jaw point between the spaces of the upper jaw teeth.
- Malocclusion is a misalignment of the teeth
- The current methods of fixing the malocclusion extraction, moving, or surgically creating space

Conclusions/action items:

Class 2 malocclusions occur when there is a misalignment of the canines and there are a variety of fixing methods

Dog Braces

Tony Pribnow - Dec 15, 2021, 2:17 PM CST

Title: Dog Retainer

Date: 10/28/21

Content by: self

Present: self

Goals: Research alternate methods to fix malocclusions

Content:

- Retainers and braces have been used since the 80s to fix dangerous issues in dogs mouths
- Many tools can be taken from human orthodontics w a different goal
- Difficult task to apply braces to a dog
- Braces can help w everything from crowded teeth to cancer
- Malocclusions can also be fixed by them
- Only used to fix problems not for aesthetic reasons
- Diagnosis must occur when young and easy to move teeth
- Can also extract or file down teeth but this leads to more issues
- To apply braces dog must undergo multiple rounds of anesthesia and then x rays and cleanings, all very expensive
- Relatively quick process once in
- Between $1500 and $4000 – very expensive

Editorial, PetMD. “Dog Braces: Everything You Need to Know.” *PetMD*, PetMD, 14 Apr. 2017, https://www.petmd.com/dog/care/dog-braces-everything-you-need-know.

Conclusions/action items:

Dog braces a not a viable option as they are very expensive and require a lot of extra steps to make an effective final product.

Incline Plane

Tony Pribnow - Dec 15, 2021, 2:33 PM CST

Title: Incline Plane

Date: 12/01/21

Content by: self

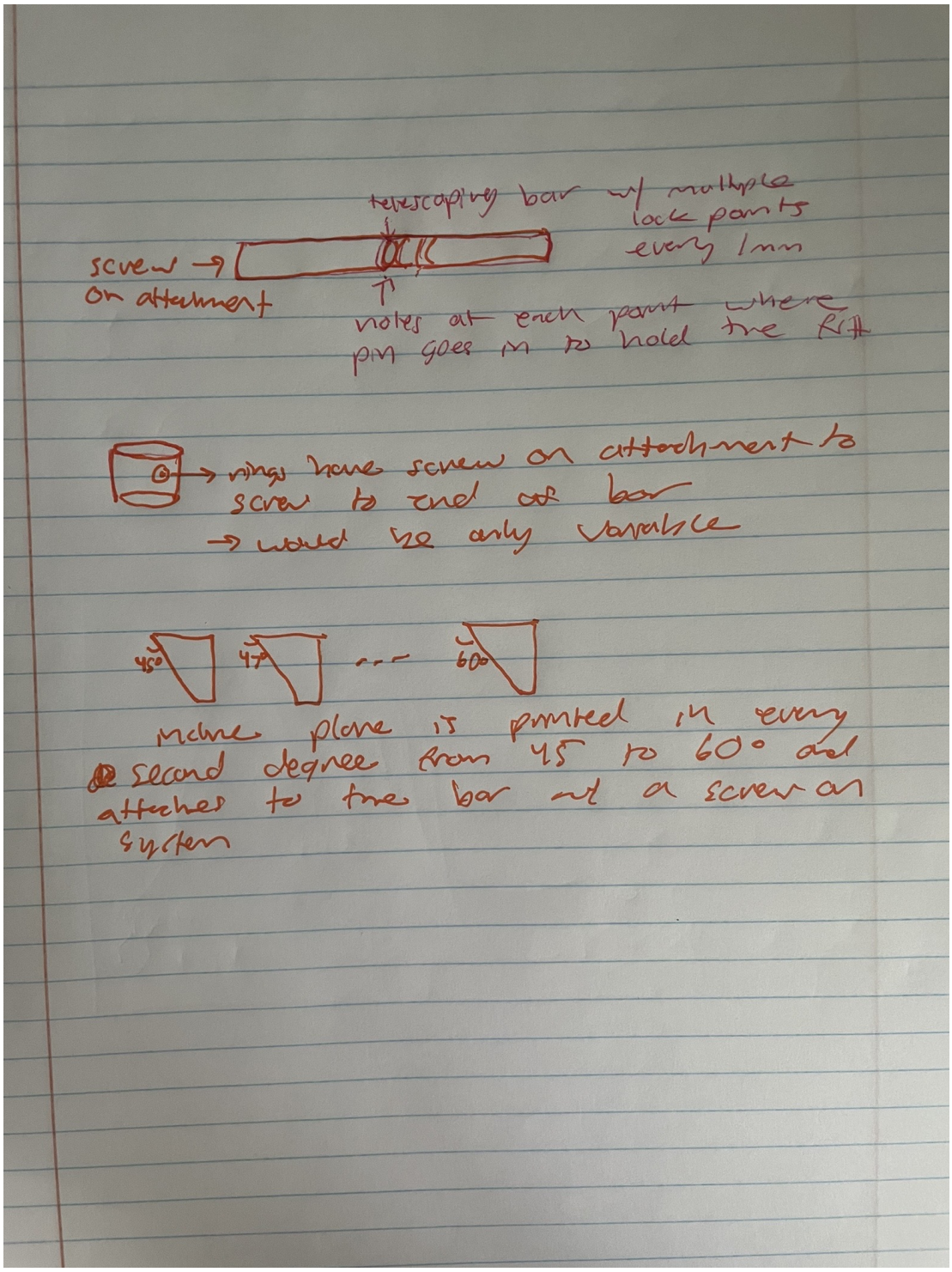
Present: self

Goals: Create an incline plane design used to treat class 2 malocclusions in dogs

Content:

- Product should last 6-8 weeks
- Product should be made of a strong 3d printable material- Ti64- to ensure durability throughout the process
- Product should be reduced in size as it is made of a strong material so the size can be limited
- The manipulatable variables should be reduced as much as possible to ensure a simple workflow that the client can easily work through
- If possible, should be reduced to 3 variables - maxillary canine circumference, distance between maxillary canines, and degree of tilt of the incline plane
- Could further reduce these variables by having a telescoping bar - would require more solidworks work and testing the durability
- Could further reduce variables by having each of the pieces screw together
- Variable can be reduced down to simply the size of the maxillary canine

- See design



Conclusions/action items:

The number of manipulatable variables can be significantly reduced with more time in solidworks. Can simplify the design down to one variable in the end, making the workflow very simplistic.

2014/11/03-Entry guidelines

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

Use this as a guide for every entry

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

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

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

Date: 9/5/2016

Content by: The one person who wrote the content

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

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

Content:

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

Conclusions/action items:

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

2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: