BME Design-Fall 2020 - PARKER CALLENDER
Complete Notebook

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Team contact Information

AMY CAO - Sep 30, 2020, 1:34 PM CDT

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
		Advisor			
		Client			
		Leader			
		Communicator			
Frohna	Ethan	BSAC	ejfrohna@wisc.edu	414-731-7776	
		BWIG			
Cao	Amy	BPAG	ahcao@wisc.edu	262-888-7755	

Project description

ETHAN FROHNA - Oct 07, 2020, 11:37 AM CDT

Course Number: BME 300/200

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

Short Name: VETMED - Improvement in Workflow of Canine Tooth Adjustment

Project description/problem statement:

We will be working to improve both the software and physical device for the correction of class II malocclusions in dogs. This will include improving the work flow so that the veterinary orthodontist is able to adjust the teeth without having to use a software engineer. This will also include making a device that can be implanted in the dog's mouth in order for the teeth to be corrected.

About the client:

Dr. Thatcher works at the UW Veterinary School and specializes in orthodontic treatment for canines and other pets.

9/11 Client Intro Meeting

SANAM JHAVERI - Sep 16, 2020, 6:45 PM CDT

Title: Client Intro Meeting

Date: 9/11

Content by: Sanam

Present: Sanam, Sammi, Parker, Ethan, Justin, Amy

Goals: To gain insight into the project by talking with our client, Dr. Graham Thatcher

Content:

Dr. Thatcher

→ said other client contact has more info on software

→ most common malocclusion is when the teeth are framed straight up instead of buccal

→ the teeth will penetrate into the palette and just it will be uncomfortable

→ Options are 3-fold

1. Extraction (take those teeth away) -- not ideal
    1. Tongue will fall out though
    2. Canine teeth for eating will be gone
2. Shorten teeth
    1. Treat inside the tooth (root canal)
3. Orthodontics
    1. Tip teeth into the normal position

→ He wrote a general paper on treatments and he can send it to us

Incline Plane

→ attaches to maxillary

→ temporary crown material

→ will force tooth to the outside of the mouth over time

→ Two weeks to Two months timeline

→ Canine teeth will sit in diastema if corrected

→ Natural placement acts as retainer

→ Doesn’t take a lot of force to move canine teeth but is just a long process

→ One anesthesia treatment to put on and another to remove and clean

→ 3-Matic and Material software (Materialize Suite)

→ Uses dental material printer (Form 3B)

Biocompatible material

→ Used dental composite

GOALS:

→ wants to create software package with CT scan (DICON file)

→ upload scan and manipulate in 3D easily and fluidly

→ wants to make it adjustable

3-Shape (3-Space?)

→ dentist software for creating bite guards

→ inter-oral scanner

Step-By-Step

1. CT scan (anesthetized)
2. Create full mouth model (physical)
3. Build with impression material
4. Jason Bledorne imports DICOM into Materialize Mimics
5. Opens in 3-Matic and creates physical model
6. Looks at it together and adjusts
7. Prints

Conclusions/action items:

Conclusion --> We learned more about what the project entailed and what Graham's goals are for us.

Action --> Debrief with Professor Block to discuss the direction for the semester.

9/11 Questions for Client

SANAM JHAVERI - Sep 16, 2020, 6:47 PM CDT

Title: Questions for Client

Date: 9/11

Content by: All

Present: All

Goals: Develop any questions we have for our client before our meeting with him.

Content:

How do you want this device to be made?

Do you want the device to accommodate for Class II malocclusions only or for all types of malocclusion?

What kinds of materials would you recommend we use?

Do you have any initial designs that you would like us to follow through with?

Would you like for us to specifically use the Materialize Software?

Will we be doing this for one dog or for multiple veterinary patients?

Have there been previous failed design attempts for this problem?

Will the device be permanent (implant) or temporary (like braces)?

Will the device differ based on the skull type?

Overview:

Teeth shifting upwards to be straight/perpendicular to the pallet of the mouth. Dogs have a learned behavior to avoid the vet touching their mouth, so they

- “Salvage procedure”: extracting the teeth completely; tongue falls, no “killing,” put abnormal stress on the lower jaw and causes TMJ
- Shorten procedure: shortening teeth which is difficult because have to treat the inside of the tooth
- Preferred to do (by dentist): orthodontic procedure to move the teeth and tilt them out

Tipping/Tilting:

Tipping a tooth 30 degrees is very different than shifting teeth and making room for other teeth

Both procedures are done with putting the dog to sleep

Ask about “materialize sweet”

Same thing that is adjustable or a workflow (dicom) that allows any person (not software background) to be able to make an stl file

Currently has to have a software engineering that edits code and has to build 3+ prototypes before knowing which one will work

Too many steps-How can we make the process easier for the client?

Things to do:

Freeshape or 3-shape? Dental scan that prints particular to one’s perfect teeth

Look at intraoral scanners

Research Form 3B - dental 3d printer

Ask Block about makerspace

Should we adjust or make a workflow

Ask about “materialize sweet”

Reports:

What is your task

What have you done

Where are you stuck

Conclusions/action items:

Conclusion --> We have a clear set of questions for Dr. Thatcher

Action --> Have the meeting with Dr. Thatcher

9/18 Client Meeting - Getting a Better Understanding

AMY CAO - Sep 18, 2020, 12:35 PM CDT

Title:

Date: 9/18/2020

Content by:

Present: All

Goals:

Content:

Device broke due to the thin material between the canines (very tight fit)

Took 3 weeks for teeth to shift

No need for retainer - natural interlock

- For young dogs it may be too short for full interlock and retention

Root of dogs teeth is longer than the crown - easy to rotate and tilt but not to translate

Device was in contact with the palate - palatitis

- Add in soft tissue in the .stl

Material: Dental LT - has FDA approval

Formlabs has webinars

Used dental steel to reinforce and dental resin is poured over the tooth

Used dental composite in holes on the side to keep it on the tooth

Conclusions/action items:

10/19 Client Meeting

AMY CAO - Oct 19, 2020, 1:52 PM CDT

Title: 10/19 Meeting With Dr. Thatcher

Date: 10/19/2020

Content by: Amy Cao

Present: Everyone, Dr. Graham Thatcher

Goals: Clarify mechanical aspects of the design, ask for input on designs

Content:

- Separate design
    - Not enough surface area for bonding to the enamel? - Testing
        - Previous design used the holes in the side to attach to the incisor
        - Could possibly use the glue on the tooth
        - Don’t know how well the glue will attach to the 3D printed material
- Space between the teeth
    - Anatomic variation between dogs
    - (Not possible to eliminate all variation/standardize, focus on workflow which will solve these issues)
- What adjustments are needed
    - Sometimes angle of the ramp needs to be adjusted
    - Lower third incisors hit the incline plane and prevent mouth from fully closing
        - Inclined plane was built pretty bulky
- How angle is determined
    - Drawing a line from point of canine to the diastema, line defines the ramp
    - Will be patient specific and need to be defined in the software
- Dogs and cats don’t chew (teeth used to kill and cut but no mastication)
- Clients come for weekly checkups
    - Photographs taken of teeth to check for proper adjustment
    - Visually evaluate for issues
- 0.1 millimeters removed around the inside of the device (where inclined plane meets teeth) for easier fitting
    - Hole on side for attachment was not calculated - trial and error
- CT Scan used because it can be converted to an .stl file
    - Would prefer to use 3D printing
    - 3D printing common in human dentistry but not veterinarians (as of yet)

Conclusions/action items:

Fill Advisor Wally Block in on meeting happenings and new information

10/23 Client Meeting- Mechanics of Device

SANAM JHAVERI - Dec 08, 2020, 1:56 PM CST

Title: Client Meeting- Mechanics of Device

Date: 10/23/2020

Content by: All

Present: All

Goals: Propose two piece design and get feedback about it.

Content:

Meeting with Dr. Thatcher- Mechanics

1. Share possible designs
    1. Get feedback

    Separate → enough surface area to stay

    → possible to fill holes on side with glue to stick

    → testing: glue bondage to the device

2. 2. Design matrix?
3. Questions
    1. Main issue with the device is the varying bridge sizes?
        1. Are there varied distances between the teeth the device will attach to?
    2. Adjustable bridge design
        1. Will a metal material be safe in a dog's mouth?
        2. What is the range of palate sizes that the device must be able to accommodate?
        3. What adjustable mechanisms do you recommend?
    3. 2 piece design
        1. Will 2 pieces cause a greater choking risk?
        2. Will this be easier for dogs to remove?
            1. Surface area could be an issue
    4. Rubber design
        1. Will rubber material cause irritation to the dog?
        2. Will rubber potential alter the orientation of the teeth of which the device is fitted on to?
        3. Will rubber be strong enough to push lower canines into place?
    5. Angle of inclined plane
        1. How is the correct angle determined?
        2. What is considered a successful alignment
            1. When the teeth have been adjusted to their correct
        3. When do you know the device is wrong?

1. Weekly Evaluation

4. How is it determined the device is wrong?

6. What variables are of concern with the inclined plane itself?
    1. What are you looking for that makes you say “this will work”?
7. What adjustments are needed throughout the process of treatment?
    1. Typically with the angle of the ramp
    2. With 1st trial, had to remove some material where incisors were hitting the device
    3. Bulkiness of material
8. Specifics of process
9. Feedback on designs (taking out specific variables)

Ethan’s Notes

Simplify WorkFlow for the Brace

The distance that was specified by Thatcher?

Distance from the starting point to the teeth they are supposed to sit next too. Find two points and find the angle between the two to find the slope of the incline place

Weekly evaluation of the teeth is performed and design is changed between weeks

Present: All, Dr. Graham Thatcher

Date: 10/19/2020

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        - Previous design used the holes in the side to attach to the incisor
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- Visually evaluate for issues
- 0.1 millimeters removed around the inside of the device (where inclined plane meets teeth) for easier fitting
  - Hole on side for attachment was not calculated - trial and error
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  - Would prefer to use 3D printing
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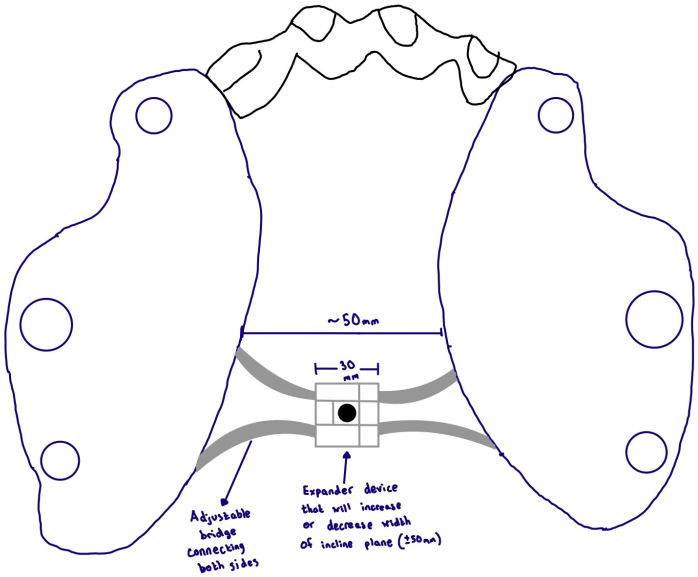
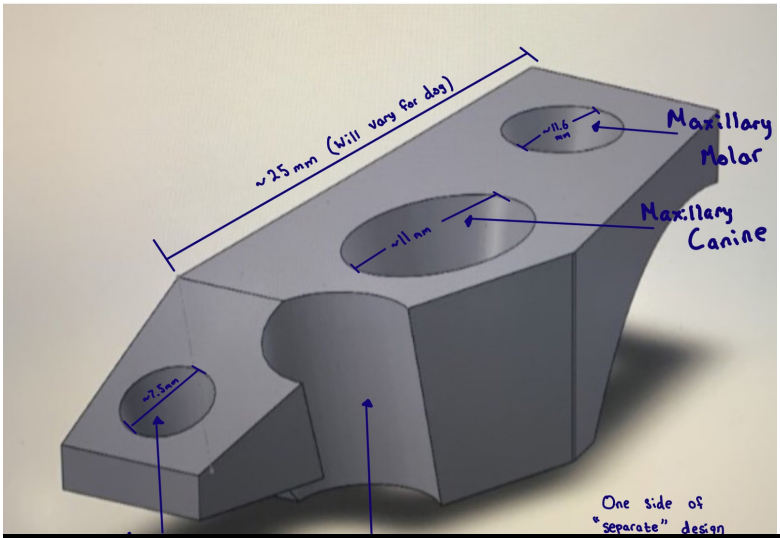
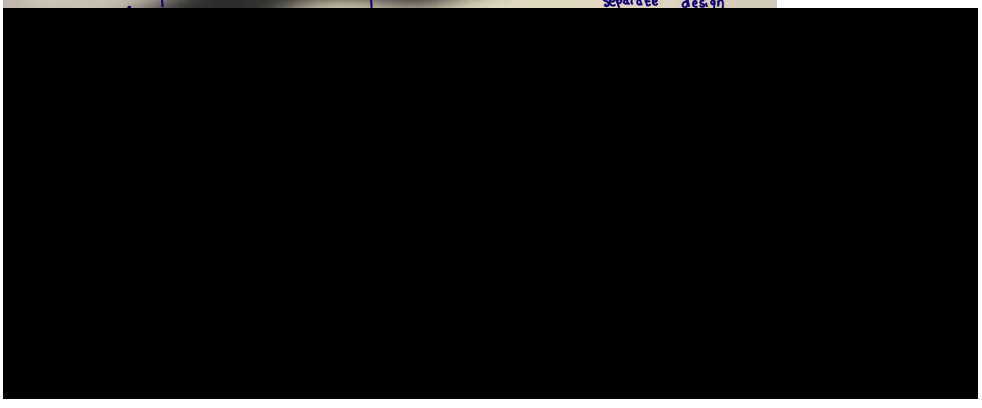
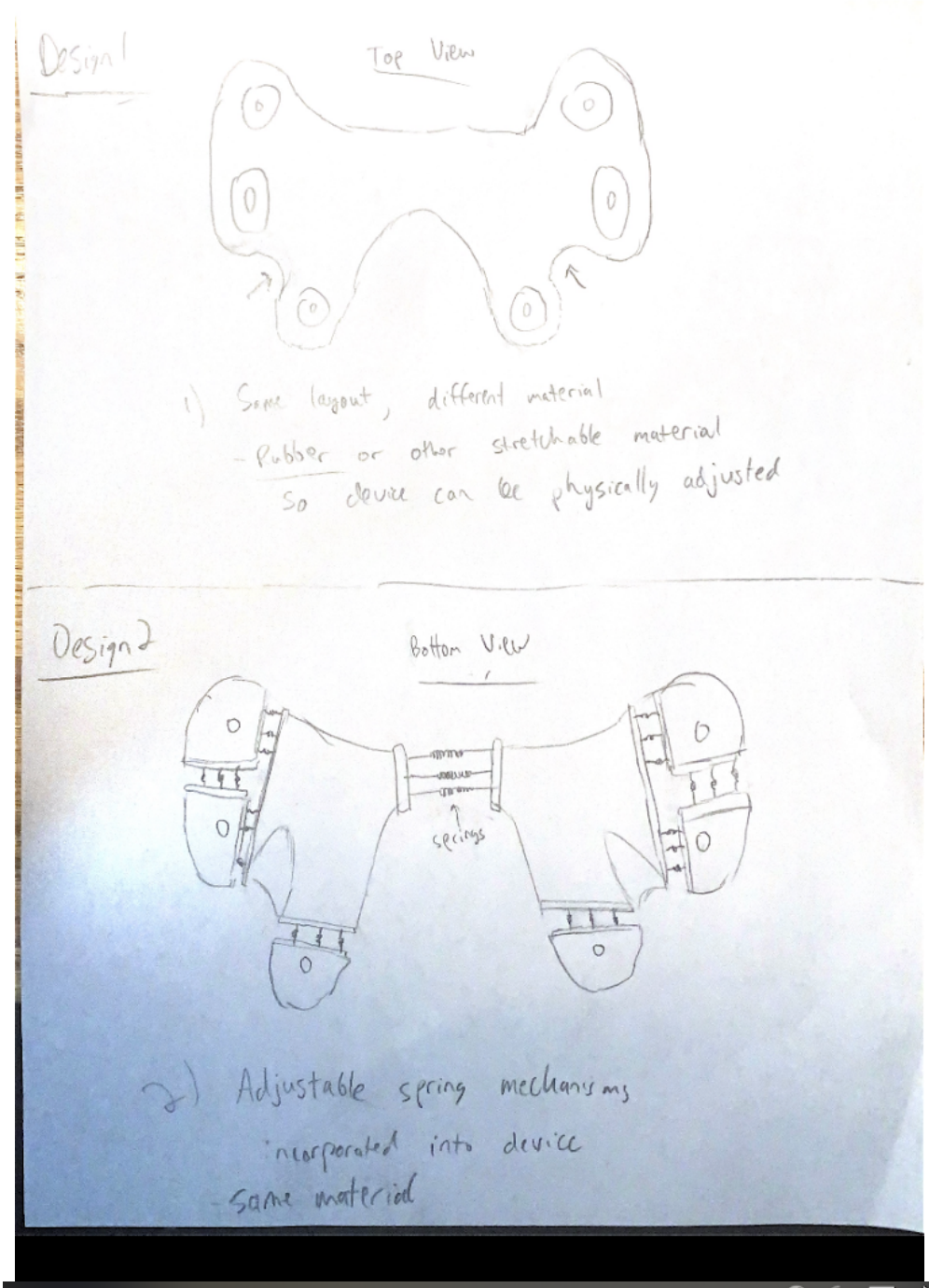
Future Model

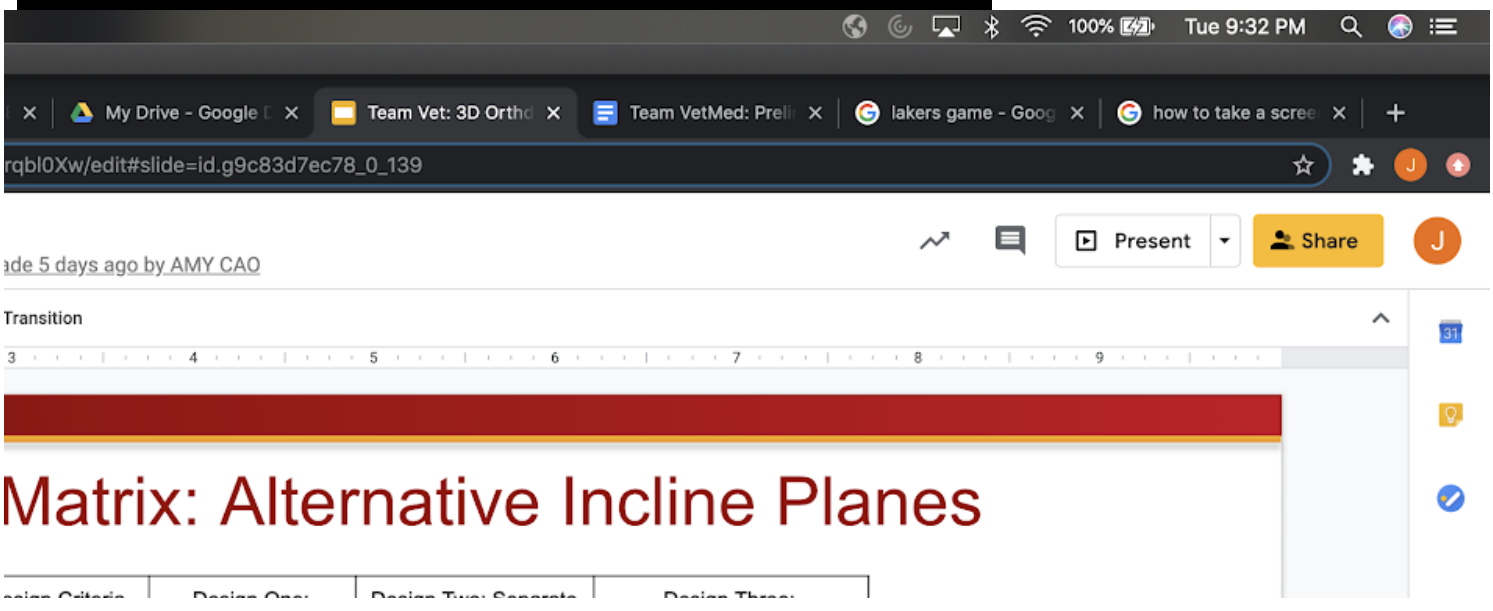
-CT scan to 3D print








Design 1
Top View
1) Same layout, different material
- Rubber or other stretchable material
So device can be physically adjusted
Design 2
Bottom View
springs
2) Adjustable spring mechanisms
incorporated into device
- Same material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Transition
Matrix: Alternative Incline Planes

esign Criteria	Design One: Adjustable Bridge 	Design Two: Separate 	Design Three: Rubber Inclined Plane 
ffectiveness 0)	25	20	25
daptability (20)	15	20	15
ase of anufacturing 5)	5	15	10
urability (15)	10	15	5
afety (10)	5	5	10
ost (10)	10	10	10
otal(100)	70	85	75

Conclusions/action items:

Client likes two-piece design. Next steps are to work with Blender and another software to edit the .stl file

9/18 Advisor Meeting- Workflow Discussion

ETHAN FROHNA - Sep 21, 2020, 1:44 PM CDT

Title: 9/18 Advisor Meeting

Date: 9/18

Content by: Ethan Frohna

Present: Team Vet Members

Goals: To understand the next steps in of the design process and get new information and opinions about where the Team is at with the project

Content:

- Use more appropriate engineering terms when filling out the PDS
- Concrete phrasing and terminology
- Is the movement of the teeth translational? Is it rotational?
- How many degrees of translational are there?
- Keep researching software and begin work on design for design matrices

Conclusions/action items:

While we have had a good start on seeing what types of software can be implemented into the workflow, there still needs a lot of work to be done regarding the design of the orthodontic device. Design Matrices will need to be made and research needs to be completed so Team Vet can make the best designs possible for the preliminary presentations.

10/9 Advisor Meeting

PARKER CALLENDER - Oct 09, 2020, 2:02 PM CDT

Title: 10/9 Advisor Meeting

Date: 10/9/2020

Content by: Amy Cao

Present: Amy Cao, Wally Block, Justin Grudem, Parker Callender, Sammie Gilarde, Sanam Jhaveri

Goals:

Content:

- How tooth is moved in jaw was not as clear in presentation
- Possible subprojects
    - Making inverse model of the jaw for the device
    - Defining incisors using thresholds and making stl of the jaw

- This week work on trying to separate the teams in order to figure out what each team will try to accomplish in this semester
- making alternative brace
- making an inverse model of the jaw
- how are we going to present this idea of where the current enviers are and where they are going to be; steps of that: where the current angle is, what the angle will be.
- changing to define the change of the angle: modify the center line of the tooth to see the translate - showing lines that are changing angles and displaying those angle changes
- we need to define what the software is allowing to change for the client - what specific variables

Conclusions/action items:

- Think about semi-autonomous projects to separate the team into

10/16

PARKER CALLENDER - Oct 16, 2020, 1:48 PM CDT

Title: Advisor Meeting

Date: 10/16

Content by: Parker Callender

Present:

Goals: The goal is to be able to hold the contents of our meeting.

Content:

We need to start defining the specific variables that are being tested with the client:

Specifically, we need to define the variables that he checks when he decides whether the piece is acceptable or not for the procedure moving forward.

- Is it the incline planes?
- Is it fit?
- Is it the holes?

Conclusions/action items:

The conclusion is that we need to define these variables and the next week will be to determine the gap of the understanding.

10/23 Advisor Meeting

AMY CAO - Oct 23, 2020, 2:03 PM CDT

Title: 10/23 Advisor Meeting

Date: 10/23/2020

Content by: Amy

Present: All, Dr. Wally Block

Goals: Update Dr. Block and rest of team on activities

Content:

Software team update

- Blender for Dental is an add-on to Blender, able to animate tooth movement (~$80)
- Waiting on a quote from Geomagic

Mechanical team

- Use the models we have from Thatcher for testing
- Make prototype and fit to model

How to test the new design in comparison to the old one?

May need a real dog to test with (for future work)

Conclusions/action items:

Mechanical team meeting soon

10/30 Advisor Meeting

PARKER CALLENDER - Oct 30, 2020, 2:08 PM CDT

Title: 10/30 Advisor Meeting

Date: 10/30/2020

Content by: Parker

Present: All, Dr. Wally Block

Goals: Update Dr. Block and the rest of the team on activities

Content:

- change the pitch to be shorter and better for communicating exactly what we are doing
- the client isn't that important in the pitch
- team working to edit stl
- blender: using to animate orientation of teeth for show and tell

future goals for mechanical design (200s)

- mechanical testing to **quantify** the brace
- looking into filling more holes for glue

Conclusions/action items:

Finish working on show and tell and continue with inner team activities

11/20 Advisor Meeting

AMY CAO - Dec 08, 2020, 9:56 PM CST

Title: 11/20 Meeting

Date: 11/20/2020

Content by: Amy

Present: All, Dr. Wally Block

Goals: Discuss presentation and project progress

Content:

- Part has been split in two and cleaned up in Meshmixer
- Will print out the part before Thanksgiving break
- 300s are still working with Blender - trying to sculpt away at the piece
    - Scaling the piece in Blender distorts it
    - Trying to set dimensions for the piece
- Presentation
    - Use animation in presentation
    - Learn to explain the software in engineering terms
- What we have accomplished
    - Removing variables (no connecting bridge)
    - Trying to manipulate pre-existing piece
    - Unsure if we are able to create piece for a different jaw

Conclusions/action items:

Start making the poster + presentation

9/27 Design Matrices for Plane and Software

SANAM JHAVERI - Oct 07, 2020, 11:18 AM CDT

Title: Design Matrices for Plane and Software

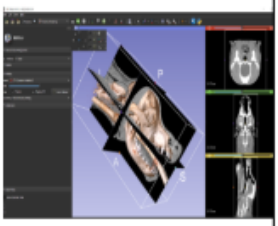
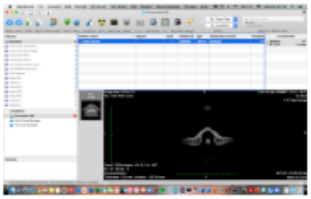
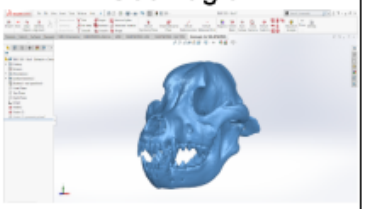
Date: 9/27/2020

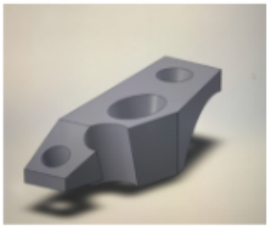
Content by: All

Present: All

Goals: Create comparisons for our preliminary designs and grade each of them on our needs.

Content:

Design Criteria	Design One: 3D Slicer 	Design Two: Osirix 	Design Three: Geomagic 
Effectiveness (30)	15	20	25
Adaptability (20)	0	10	18
Ease of Use (15)	15	10	10
Cost (10)	0	0	5
Total(75)	30	40	58

Design Criteria	Design One: Adjustable Bridge 	Design Two: Separate 	Design Three: Rubber Inclined Plane
Effectiveness (30)	25	20	25
Adaptability (20)	15	20	15
Ease of Manufacturing (15)	5	15	10
Durability (15)	10	15	5
Safety (10)	5	5	10
Cost (10)	10	10	10
Total(100)	70	85	75

Conclusions/action items:

We have created two design matrices and have drawn conclusions on the best design from both. Time to start fabrication

9/17 Product Design Specification

SANAM JHAVERI - Oct 07, 2020, 11:20 AM CDT

Title: Product Design Specification

Date: 9/17

Content by: All

Present: All

Goals: Create a detailed report on what our designs should entail.

Content:

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

Product Design Specifications

Team:

Ethan Frohna - BSAC

Parker Callender - Team Leader

Sanam Jhaveri - Communicator

Amy Cao - Co-BPAG

Sammie Gilarde - Co-BPAG

Justin Grudem - BWIG

Date: 9/17/20

Function:

Veterinary canine patients often experience Class II Malocclusions; A movement of the upper jaw that causes the bottom canine teeth to puncture and injure the roof of the mouth. The goal of this project is develop a smooth workflow through software that will assist with the creation of a lower jaw device to move the lower canines into a suitable position within the lower jaw. Specifically, the team wants to utilize the software program Osirix to be able to view the DICOM file in 3D, section off pieces of the file/image, and alter the pieces in order to effectively streamline the process for the orthodontist.

Client requirements (itemize what you have learned from the client about his / her needs):

- Workflow must be simplified using software
- CT Scan must be configured into an stl file
- Device outcome should fit CT Scan
- Device needs to be moldable to other canine jaws based on CT Scan
- Device must be 3D printed
- Device must be held within canine jaw for 6-8 weeks

- Device must move canines lateral to upper jaw

Design requirements: This device description should be followed by a list of all relevant constraints, with the following list serving as a guideline. (Note: include only those relevant to your project):

1. Physical and Operational Characteristics

a. Performance requirements: The performance demanded or likely to be demanded should be fully

defined. Examples of items to be considered include: how often the device will be used; likely loading

patterns; etc.

The mechanical aspect of the device will be placed on the maxillary palate of a dog with Class II Malocclusion with a goal to, over-time, guide the mandibular canines into their correct positions within the diastema of the 3rd maxillary incisor and maxillary canine.

1. The device will be designed to fit the canine's mouth through editing the DICOM file/stl file using 3D imaging and reduring tools (Geomagic)
2. The mechanical piece will be used for 3-8 weeks on a 24/7 basis as it is secured to the canine's palate with 'dental glue'

b. Safety: Understand any safety aspects, safety standards, and legislation covering the product

type. This includes the need for labeling, safety warnings, etc. Consider various safety aspects relating

to mechanical, chemical, electrical, thermal, etc.

Material used should be nontoxic to dogs. The piece should effectively lock onto upper canine teeth in order to create the right forces to wing/push misaligned teeth outward. It should not move teeth that are in proper positions, or apply too much force to the moving teeth. The device should not break in the dog's mouth or cause breakage of the teeth.

c. Accuracy and Reliability: Establish limits for precision (repeatability) and accuracy (how close to the

"true" value) and the range over which this is true of the device.

The device will need to be an exact fit for the patient's mouth. This will require a CT scan to get an accurate image of the jaw structure. In addition, the software will need to be able to create a model of the device that will fit perfectly around the patient's teeth. Specifically, the range over the true values are approximately 1cm, rather than a smaller value because the main goal is to correctly align teeth and not interrupt breath flow through the roof of the mouth tissue. In other words, the accuracy of dimensions pertaining to the exact DICOM file is less important than having the correct fit. As of now, the system is trial and error and the team hopes to limit the steps of trial and error through precision more than accuracy.

d. Life in Service: Establish service requirements, including how short, how long, and against what

criteria? (i.e. hours, days of operation, distance traveled, no.of revolutions, no. of cycles, etc.)

The device will be attached to the patient's mouth for up to several weeks. The interval of weeks depends on the following:

1. As long as the treatment needs; this is a new procedure, meaning trial and error

2. The age of the dog
3. How far the maloccluded teeth need to be moved outward (typically this value is ~30˚ but can be more or less pertaining to the patient

e. Shelf Life: Establish environmental conditions while in storage, shelf-life of components such as

batteries, etc.

The device will need to last at least 6-8 weeks while attached to the patient's mouth, but once removed the device will not need to be used again and will be discarded to ensure sanitation.

f. Operating Environment: Establish the conditions that the device could be exposed to during operation

(or at any other time, such as storage or idle time), including temperature range, pressure range,

humidity, shock loading, dirt or dust, corrosion from fluids, noise levels, insects, vibration, persons who

will use or handle, any unforeseen hazards, etc.

Mechanical piece places to correct misalignment in teeth:

The device will be attached to the patient's (dog) mouth 24 hours a day- 7 days a week so its operating environment involves the conditions of a normal day-to-day environment. The device should be able to withstand temperatures ranging from -20°F to 120°F to account for any extreme conditions the patient may experience. The average force of a bite from a dog is approximately 320 pounds so the device should be able to withstand forces ranging up to 400 pounds without fracturing, loosening from mouth, or cracking. The device should also not interfere with food consumption nor should it be affected by it. Food should easily pass by the device and not stick nor peel the device's material.

Interface used for streamlining software engineering:

The software should be able to be utilized by a veterinary orthodontist. The interface should be compatible for most computers and easy to follow. The software should include 3D imaging of the DICOM file to give access to all images as well as the ability to convert to an stl file. Once the image is converted into an stl file, the user (without software engineering prior knowledge) should be able to section off desired piece of image and alter to the users discretion, knowing that these edits will be visible on the mechanical piece once printed.

g. Ergonomics: Establish restrictions on the interaction of the product with man (animal), including

heights, reach, forces, acceptable operation torques, etc..

The ramping grooves (used for correcting the canines alignment during continuous bitting) of the device should be applied to the maxillary teeth. The device will come into contact with the mandibular canines when the mouth closes and apply passive force to direct the teeth away from the palate. The device should avoid contact with the mucosa. The slope of the incline plane will be 45-60 degrees.

h. Size: Establish restrictions on the size of the product, including maximum size, portability, space

available, access for maintenance, etc.

The size of the product will be dependent on each patient and their mouth size and unique Class II Malocclusion. Maintenance could be a factor depending on the integrity of the incline place. Removal of the incline plane may need to take place but cannot be out for more than 72 hours to avoid any reversal of tooth movement.

i. Weight: Establish restrictions on maximum, minimum, and/or optimum weight; weight is important when it comes to handling the product by the user, by the distributor, handling on the shop floor, during installation, etc.

The device should weigh no more than a few ounces to ensure it sits correctly in the mouth and does not become misaligned due to weight adjusting the fit over time.

j. Materials: Establish restrictions if certain materials should be used and if certain materials should NOT be used (for example ferrous materials in MRI machines).

The device will be planted in a canine's mouth so the material used should not be toxic to the animal. The material also should erode or deteriorate over time due to water and food being passed by it.

k. Aesthetics, Appearance, and Finish: Color, shape, form, texture of finish should be specified where possible (get opinions from as many sources as possible).

Aesthetics will not be considered, but the incline plane of the device should be smooth enough to not apply excessive friction to the tooth. Rough edges should be taken away in imaging to ensure that the 3D piece is high quality and fits/operates correctly.

2. Production Characteristics

a. Quantity: number of units needed

Production will be on a customer-need basis. One device per patient with condition.

b. Target Product Cost: manufacturing costs; costs as compared to existing or like products

Currently the client has offered the team to use their 3D printer that prints with a specific material used for safety during orthodontic procedures. Therefore the team has not made purchases on materials. However, the team expects to use most of its budget towards software development tools, such as advanced Geomagic.

3. Miscellaneous

a. Standards and Specifications: international and /or national standards, etc. (e.g., Is FDA approval required?)

An orthodontic brace that has the ability to reposition teeth is known as a Class I device, meaning it has low to moderate risk of injury.

b. Customer: specific information on customer likes, dislikes, preferences, and prejudices should be

understood and written down.

The client wants the software interface to be able to create a mechanical tool that works for any canine with these Class II malocclusions. The team should be using software to adjust a specific model of the ramping grooves to fit any sized lower jaw.

c. Patient-related concerns: If appropriate, consider issues which may be specific to patients or research subjects, such as: Will the device need to be sterilized between uses?; Is there any storage of patient data which must be safeguarded for confidentiality?

A new device will be created for each dog through a software developed by the team so sterilization will not be necessary. The patient (owner of the dog) should be given a rundown of what the device is and how it operates before being inserted into the mouth of the dog.

d. Competition: Are there similar items which exist

There exists a metal incline plane called a Mann incline plane.1,5. However, this method/device is very costly to the patient and intra treatment adjustments cannot be made to the device. In other words, there are seemingly no competitors in this exact field, as it is a new procedure that the team gets the chance to help streamline.

Conclusions/action items:

We have created a solid first take of our PDS and will continue to update it as we build our design.

9/16 Photos of Dr. Thatcher's Prototypes

SANAM JHAVERI - Oct 07, 2020, 11:25 AM CDT

Title: Photos of Dr. Thatcher's Prototypes

Date: 9/16

Content by: Parker

Present: Parker, Ethan, Sanam

Goals: To take Dr. Thatchere's prototypes and learn from them to see what we can do better for him.

Content:

Conclusions/action items:

We attained the prototypes and identified key aspects of them. We will now utilize them to help build our designs.

11/1 - Using the Blender for Dental Software to edit the brace design

ETHAN FROHNA - Nov 01, 2020, 2:12 PM CST

Title: Using the Blender for Dental Software to Edit the Brace Design

Date: 11/1

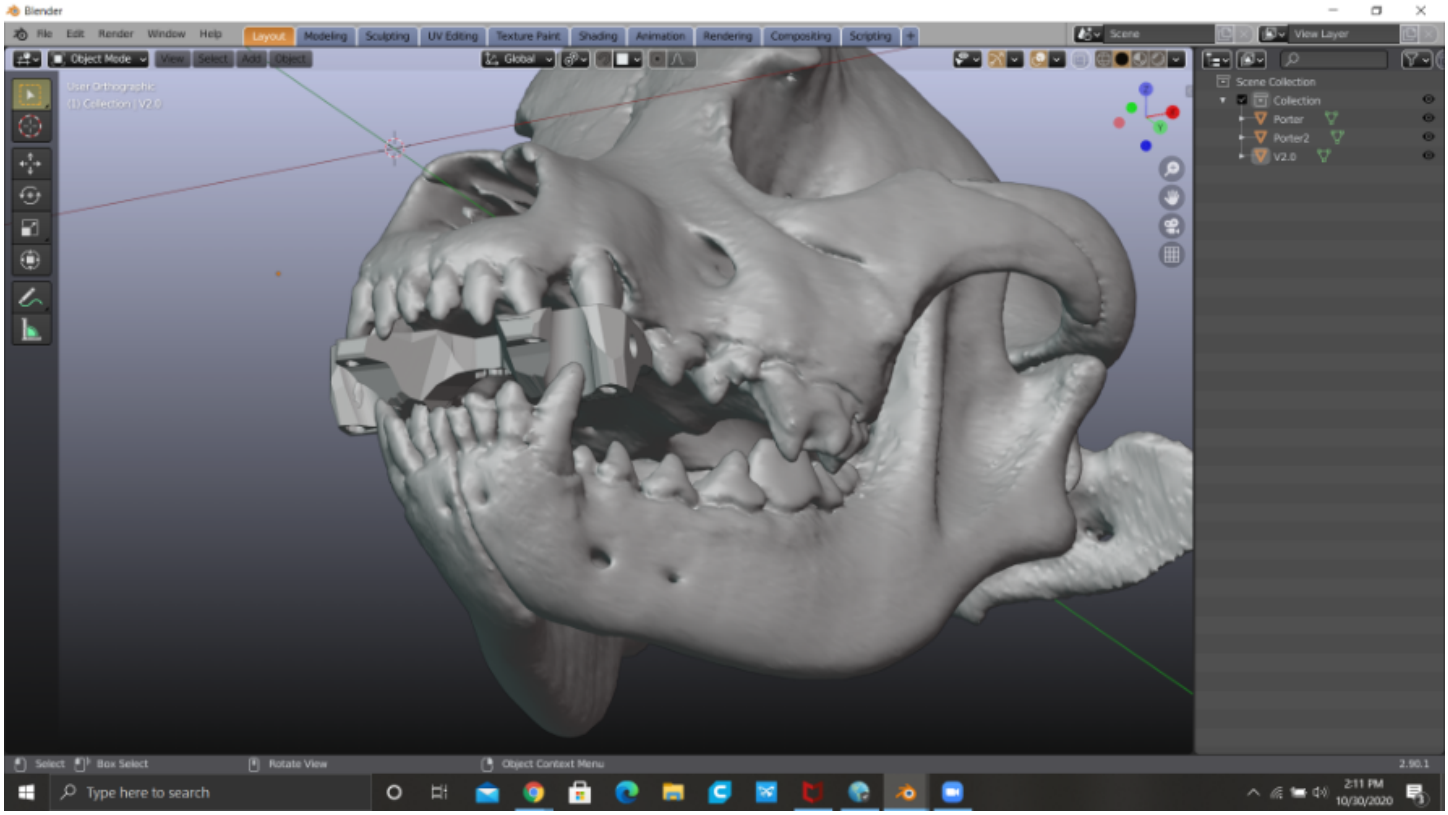
Content by: Ethan Frohna

Present: N/A

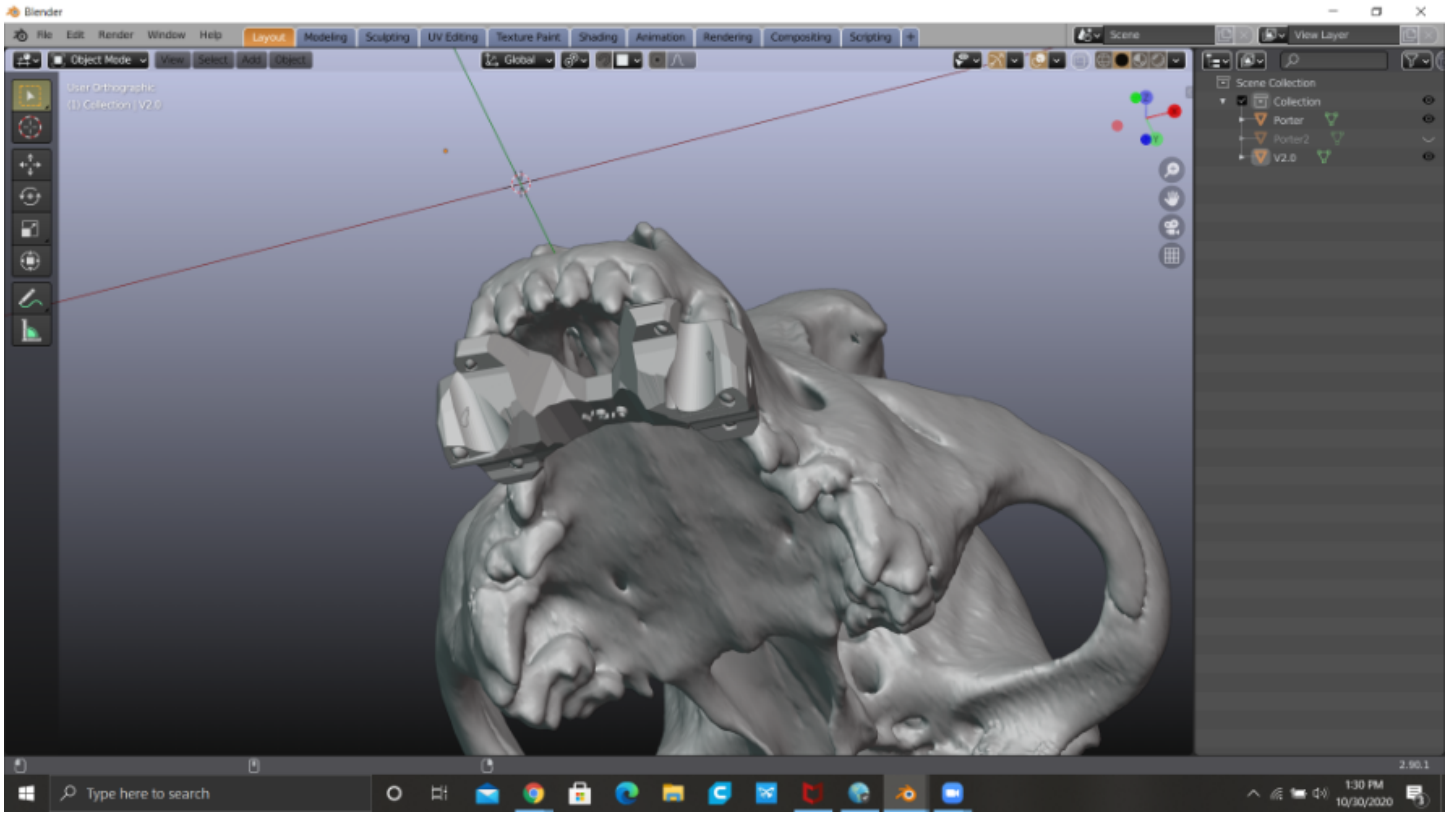
Goals: To use the Blender for Dental Software to edit the brace design and animate teeth movement caused by the device.

Content:

Below is the user interface for the Blender software. The stl files of the upper jaw, lower jaw, and orthodontic device have been loaded into how the piece fits into the scan of the upper jaw. On the right-hand side is the collection toolbar, which can be used to hide the individual scans and enables the user to work on the scan they want to work on.



In this screenshot, the lower jaw has been hidden to show how the device fits onto the upper canines. The incline plains are clearly visible on each side which pushes the lower teeth into the correct occlusion position. A new piece is currently being developed by the 200's of Team Vetmed that will not have a bridge but instead be two separate pieces. This solves the problem of upper tissue damage that Dr. Thatcher has experienced with some of his patients.



Attached to this page is a small video clip of the lower canine tooth animation that was made possible through Blender. The animation shows a non-normal occlusion of the lower teeth that causes the upper mouth tissue to become damaged. The movement shows how the incline plane should move the teeth over the course of the device application. The teeth start at a near-vertical position and slowly move to an inclination of 30 degrees, around the correct position that the lower canines need to be in.

The blender software has many editing tools that will allow Team Vetmed to scale the design to whatever size is needed. More research on Blender must be done to see if the device can actually be edited within the blender software, but it does look like the device can be scaled in any axis, which will allow Dr. thatcher to fit the device to any size jaw he needs depending on the patient.

Conclusions/action items:

ETHAN FROHNA - Nov 01, 2020, 1:55 PM CST

Blender__C__Users_ethan_Downloads_BME_300_Files_FirstModel-teethmovement.blend_2020-11-01_13-51-22.mp4(55.5 MB) - download

11/12 Two-Piece Design Cut

SANAM JHAVERI - Dec 08, 2020, 2:26 PM CST

Title: Two-Piece Design Cut

Date: 11/12

Content by: Sanam, Justin, Amy, Sammie

Present:

Goals: Make the cut of the original inclined plane to create the two-piece design.

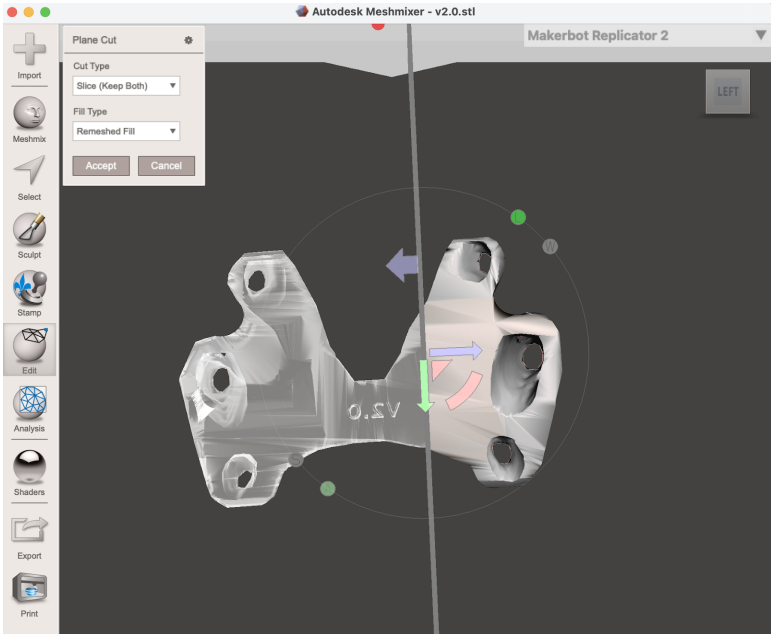
Content:

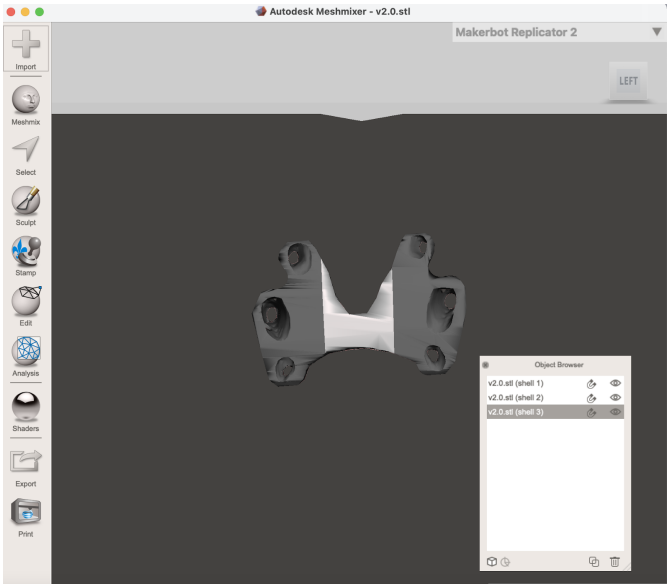
Process:

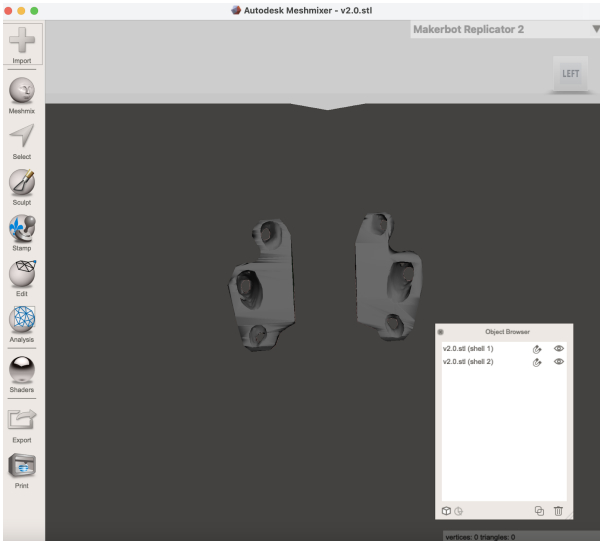
1) Make two Plane Cuts

2) Separate shells by removing the middle bridge piece

3) Test for weak points in SolidWorks







Conclusions/action items:

Cut was made and .stl file now contains two pieces. Send to Ethan and Parker.

Materials and Expenses

SANAM JHAVERI - Dec 08, 2020, 2:25 PM CST

Title: Ethan Frohna

Date: 12/6/20

Content by: Ethan Frohna

Present: N/A

Goals: To track the expenses it took to fabricate and design the project

Content:

See attachment

Conclusions/action items:

Keeping track of expenses over any engineering project is essential. It gives the engineers a budget to work with so they decide what the most cost-effective parts to use are and the most efficient fabrication methods that will not go over their designated budget.

SANAM JHAVERI - Dec 08, 2020, 2:25 PM CST

BPAG_Expense_Spreadsheet_-_Sheet1.pdf(31.7 KB) - download

3D Print of Piece

JUSTIN GRUDEM - Dec 08, 2020, 9:59 PM CST

Title: 3D Print of Piece

Date: 12/7

Content by: Justin Grudem

Present: N/A

Goals: To explain the process of 3D printing the incline plane device

Content: The stl file that the team received from our client was edited and cut appropriately in the program MeshMixer. From here, the stl file was uploaded into the slicing software Cura, where the device was rotated into correct printing orientation. Cura also enabled us to make proper support pieces in order to successfully print the device. The support pieces were set to minimum thickness and automatically generated within the software to create a flat base, of which the device could rest on when being printed. The stl file with the support pieces was uploaded to a flash drive and transferred to the 3D printer, which was a Creality Ender 3 Pro V2. The device and various support pieces were then able to print, lasting approximately an hour. The first printed device was printed with standard 1.75 mm PLA filament (polylactic acid), simply because that was the only material available at the time. However, we received another printed prototype from our client, which was printed on the correct material, being Dental LT Resin. Although the first printed piece was not an acceptable material to use within a dog's mouth, it still provided an accurate representation of how the device looks and functions.

Conclusions/action items:

The team was able to successfully 3D print the inclined plane, as well as learn more about the 3D printing and various other softwares associated with the process.

Geomagic Software Protocol

ETHAN FROHNA - Oct 07, 2020, 11:47 AM CDT

Title: Geomagic Software Protocol

Date: 10/7/20

Content by: Ethan Frohna

Present: N/A

Goals: To have a protocol set up so the Team knows how to accomplish the task of editing the design.

Content:

1. Open Geomagic for Solidworks
2. Load in DICOM file in the Solidworks interface
3. Remesh structure to 15 mm for accurate dimensions
4. Use window feature to window out upper jaw
5. Load in stl file of brace design
6. Using assembly, mate the brace to the upper canines
7. Make any design adjustments necessary for fit
8. Using the simulation feature on Solidworks, change the material to match dental LT resin
9. Perform mechanical testing on brace
10. Change any aspects of design based on fit and testing

Conclusions/action items:

Now that the Team has a general protocol for Geomagic Software, it should be a much simpler process to edit and configure the design so it fits to a specific DICOM file.

Mechanical Force Testing

ETHAN FROHNA - Nov 25, 2020, 12:42 PM CST

Title: Mechanical Force Testing for Orthodontic Brace

Date: 11/25/20

Content by: Ethan Frohna

Present: N/A

Goals: To find out how much force the orthodontic brace can take and where its weak spots are.

Content:

In order to use Solidworks testing for the stl file, the polygon number of the file had to be reduced by 95%. The number of selected fixtures on the top face of the brace is 66, only including fixtures that are parallel to the horizontal axis of the piece. The material of the piece was custom Dental LT Resin created based on yield strength and compressive force values given by the manufacture of the resin, Formlabs. The resin has a 50 MPa yield strength which is very impressive considering the material is 3D printed.

https://dental-media.formlabs.com/datasheets/Dental_LT_Clear_Technical.pdf

Above is the link to the Formlabs Dental LT Resin data sheet.

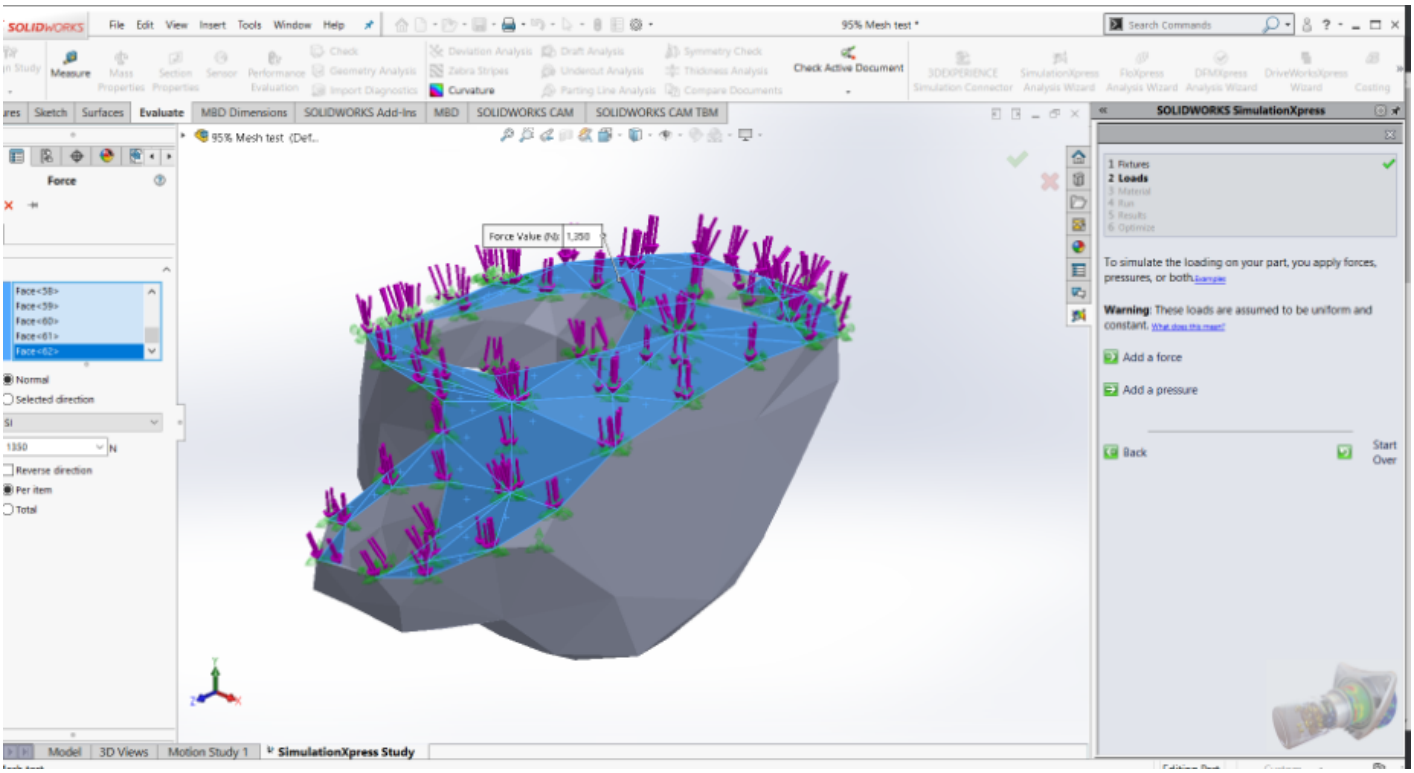


Figure 1: Selected Fixtures for the top face of the piece

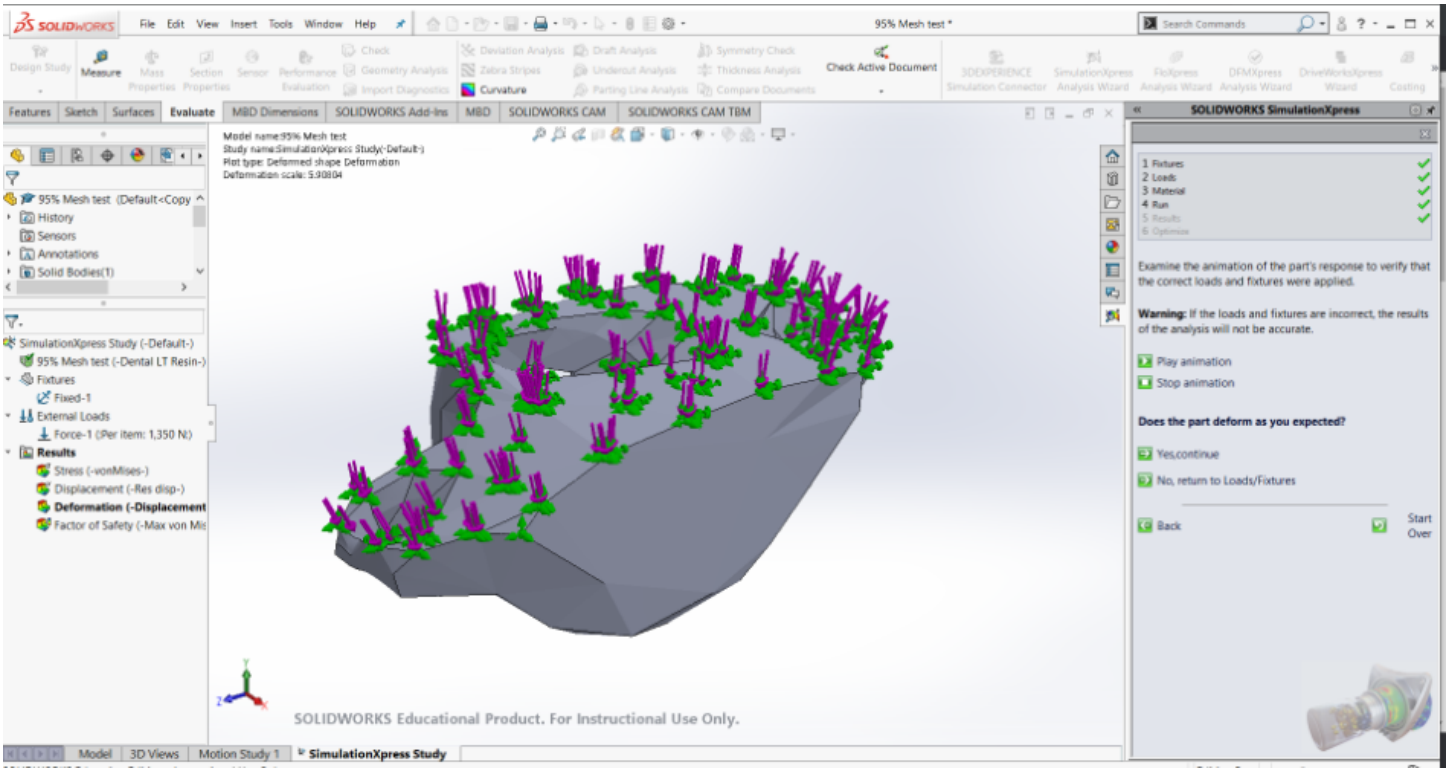


Figure 2: Applied forces on top side of the brace. Each purple arrow shows the applied force at the vertice of a polygon. The value of the applied force is 1350N, as the max average bite force of a rottweiler approximately 300 pounds, which is equal to 1350 N.

Figure 3:

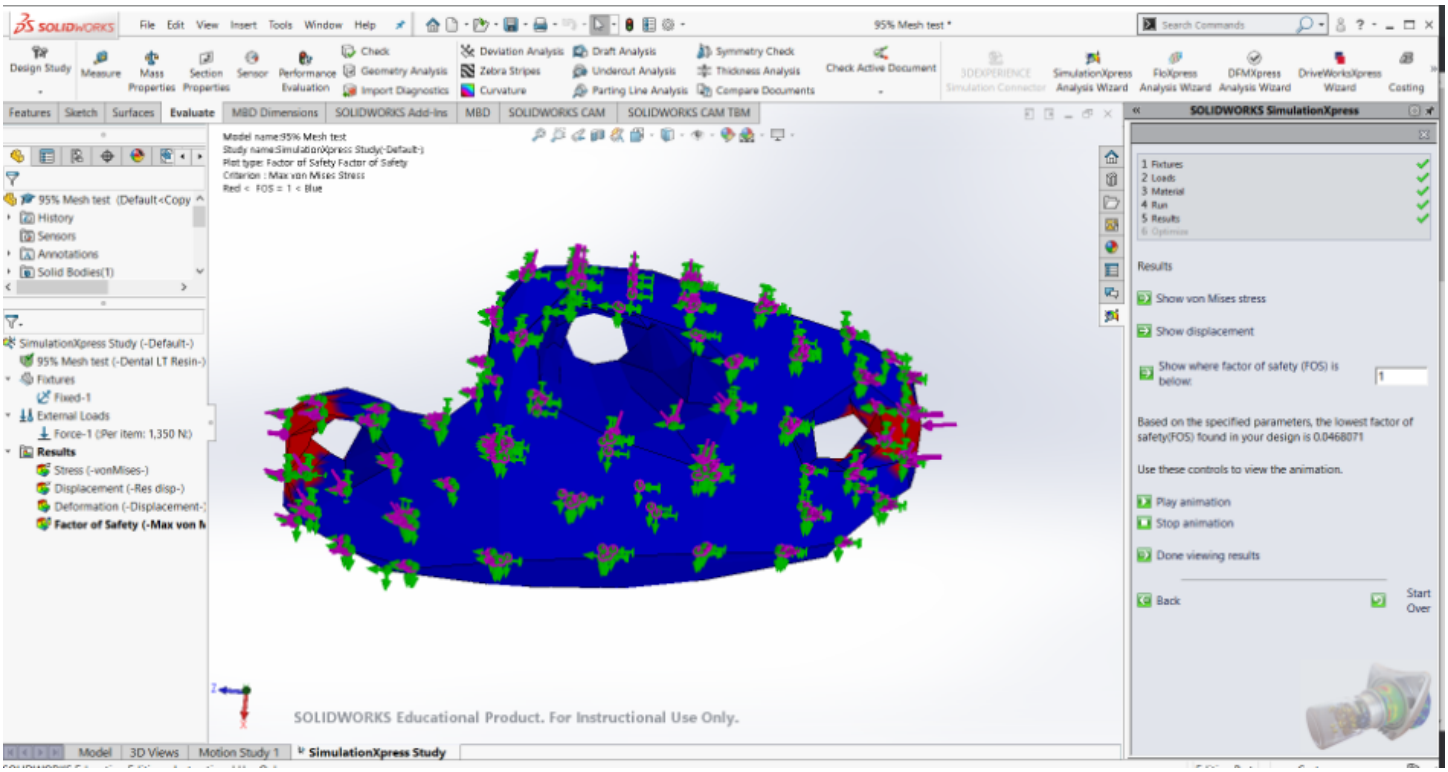


Figure 3: The blue highlighted portions of the model are areas where there is little to no deformation or strain. The red shows areas of high vulnerability and where strain has occurred.

https://www.rottweilerlife.com/what-is-the-strength-of-the-rottweiler-bite-force/

Conclusions/action items:

As expected, the device showed strain and deformation near the edge of the tooth anchors using the maximum bite force of a Rotweiller. This force will rarely be achieved by the animal during use, as the brace showed very minimal deformation even at this force. If given more time, the VetMed team could find a way to

strengthen the edges of the brace so there i little cause for worry about device breaking under pressure.

ETHAN FROHNA - Nov 25, 2020, 12:42 PM CST

Simulation of 95% Mesh test

Date: Wednesday, November 25, 2020
Designer: Team VetMed
Study name: SimulationXpress Study
Analysis type: Static

Table of Contents

Description
Assumptions
Model Information
Material Properties
Loads and Fixtures
Mesh information
Study Results
Conclusion

Description

This report details the deformation and force loadings for the VetMed orthodontic brace based on the average bite force for a Rottweiler.

SOLIDWORKS Analyzed with SOLIDWORKS Simulation Simulation of 95% Mesh test 1

95_Mesh_test-SimulationXpress_Study-1.docx(2.2 MB) - download

10/1 Preliminary Presentation

SANAM JHAVERI - Dec 08, 2020, 2:22 PM CST

Title: Preliminary Presentation

Date: 10/1

Content by: All

Present: All

Goals: Create an initial presentation with proposed designs

Content:

https://docs.google.com/presentation/d/16VUb0KseeGXS-4KEAkHvKHJWsQZFHQqbqEuXrqbl0Xw/edit#slide=id.p

Conclusions/action items:

Present presentation and continue working on designs.

10/2 Preliminary PowerPoint Presentation

ETHAN FROHNA - Oct 04, 2020, 2:53 PM CDT

Team_Vet__3D_Orthdontic_Device_Autosaved_.pptx(87.4 MB) - download

10/2 Q&A from Presentation

SANAM JHAVERI - Oct 07, 2020, 11:13 AM CDT

Title: Q&A from Presentation

Date: 10/2

Content by: Everyone

Present: Everyone

Goals: Answer the questions directly and keep a note of them for future reference

Content:

Questions	Answers
What were the ratings for safety based off of and why were they so low on the priority list for the design matrix? Does it refer to the chance of mechanical failure for a separable design which could result in choking on a plastic piece?	Dr. Thatcher explained that choking is not a big concern for the safety of these incline planes due to the ease for canines to swallow and process small items. Yes, while we want to avoid the material from breaking and the dogs eating it, it is not a huge concern in terms of the safety of the dog.
What aspect of the separate pieces design allows you to eliminate the bridge? What is the bridge's normal function?	The bridge was just part of Dr. Thatcher's original prototype. There was no specific purpose for it. It actually had a negative consequence causing palatitis in the canine so our separate design attempts to eliminate that.
What material would the "separate" design be of? What would the cost be for each dog?	Our design will be made out of dental resin material that is readily available and inexpensive.
Is there a high chance of the pieces falling out of the dogs mouth? Or are all of the pieces fitted enough that it isn't something to worry about	The pieces are fitted well enough that they should not fall out. Just like human orthodontal equipment, a similar type of dental glue for canines is used to ensure the product does not fall out.

Conclusions/action items:

We had minimal questions and answered them all well. Looking forward to moving along with project design and fabrication.

10/5 Preliminary Report

SANAM JHAVERI - Dec 08

Title: Preliminary Report

Date: 10/5

Content by: All

Present: All

Goals: Create the team's first report to highlight sustained progress since August.

Content:

Department of Biomedical Engineering
UNIVERSITY OF WISCONSIN-MADISON

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

BME 200/300

10/7/20

Client: Dr. Graham Thatcher

Advisor: Dr. Walter Block

Team Members:

Parker Callender - Team Leader

Ethan Frohna - BSAC

Sanam Jhaveri - Communicator

Amy Cao - BPAG

Sammie Gilarde - BPAG

Justin Grudem - BWIG

Abstract

Class II malocclusions in dogs are often treated with orthodontic brace devices, called incline planes. incline planes move teeth through passive force using a slope, and can be created thro different methods. A common way of producing incline planes is to directly apply composite resin to the dog's maxillae and drill the slope into the material. Another design is made of cas telescoping bridge to allow for growth of the patient's jaw. The method that the client, Dr. Graham Thatcher, used is a 3D printable incline plane that is constructed using scans of the patie exist with the current design and workflow of the 3D printed incline plane. The process requires many prototypes and the help of a software engineer to produce a device that will be used client has also requested a more adjustable, flexible design that can fit patients of different sizes and allow for growth over time. To improve the design of the incline plane, the team devis alternative designs and evaluated them. The chosen design consists of two 3D printed pieces on each side of the mouth, allowing for growth of the maxillae, and decreasing risk of palatiti piece. The team also evaluated different softwares that can be used to produce the 3D printable model of the incline plane. The Geomagic program was chosen for its compatibility with S ability to manipulate the model and convert different file types.

Table of Contents

1.

Introduction

Problem Statement

In order 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 patients. The curre creating a 3D printed incline plane starts with taking a CT scan of the patient's jaw. The data from the DICOM file is then used to produce the printable incline plane with the aid of a softv prototype incline plane would be placed and tested on a model of the patient's jaw then adjusted for the next prototype with the software engineer's help. This process is time-consuming a addition, the design of the current 3D printed incline plane does not allow for flexibility between different patients, being designed for the individual dog only.

Dr Graham Thatcher has asked the team to design a software workflow that will save time and eliminate complications in the current workflow, as well as improve on the current design s more adjustable and versatile for a wider range of patients.

Current Methods & Devices

Several other methods for creating incline planes exist. One method is to apply self-curing bis acryl composite material directly to the teeth in the dog's mouth, then shaped with filing t hole by which the tooth will be guided by [4]. This method may lead to some complications; if the material is applied and contacts the mucosa, inflammation can occur [12]. If the orthodc not handled properly, the material used for the incline plane can generate too much heat and burn the dog's mouth [13].

Another design is the Mann incline plane, which is a fixed incline plane made of cast metal [10]. The Mann design is telescoping so that the size of the incline plane changes with growt maxillae. Another advantage to cast metal incline planes is that they contact only with hard tissue, thus avoiding inflammation of soft tissue [11]. However, construction of this kind of inc models of the patient's teeth to be made. This increases costs and complicates the process. Due to the metal material, it is not easy to make adjustments as well. The fixed metal device is d from the mouth.

Yet another method involves the use of telescoping metal rods combined with composite resin [14]. This device is built intraorally during one anesthesia procedure. The design allows f maxillae due to the telescoping aspect, but can also result in gingivitis and other complications associated with direct composite resin incline planes.

Motivation

Malocclusions are heritable traits that can cause issues for dogs and cats if not treated. The treatment process for malocclusions with incline planes involves visits for adjustments in add and removing the orthodontic treatment device, and these procedures require anesthesia. The creation process of the 3D printed incline planes is also inefficient. Treatment using inclined p many possible complications, as adjustments may be needed throughout the process, and gingivitis is a very common side effect to treatment. This project's goals are to not only improve t patients but streamline the process for veterinarians and veterinary orthodontists alike.

2. ## Background

1. **Physiology and Biology**

Class II Malocclusion

Just like humans, many canines have orthodontic problems that affect their ability to live and especially eat. Types of these orthodontic problems range similarly to those of humans. Th orthodontic issue called Class II Malocclusion that is directly specific to the misalignment of three teeth within a canine's mouth. These three teeth involve the maxillary canine, the maxil the mandibular canine. In normal occlusion of the upper and lower jaws, the mandibular (lower) canine sits within a diastema between the upper canine and the upper third incisor, as shov However, in Class II Malocclusion, the occlusion of the dog's jaws is distorted with an emphasis on the location of the lower canine. As shown in *Figure 2*, the lower canine will sit more d (towards the middle of the mouth) rather than the normal position up against the diastema [1].

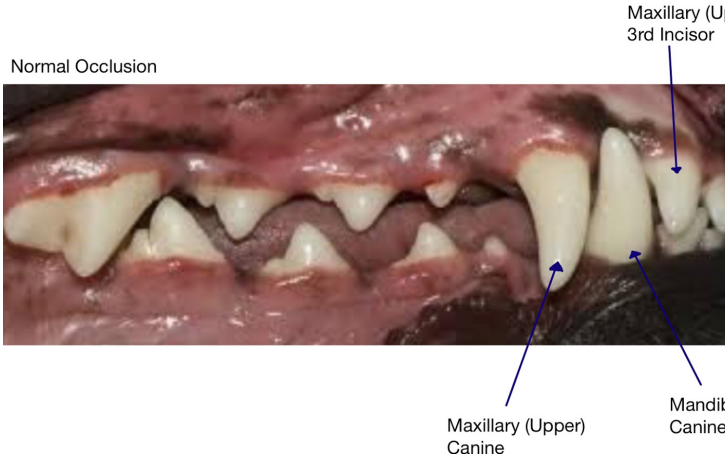


Figure 1: Normal Occlusion in a Canine. This figure shows a side view of a canine mouth with normal occlusion between the maxillary and mandibular jaws. The mandibular canine sits (gap) between the maxillary canine and maxillary third incisor.

Class II Malocclusion is generally defined as "mandibular distoclusion" which is commonly referred to as an overbite [1]. The lower jaw sits entirely too far distal in the mouth causing th canines to not sit correctly in relation to the upper teeth. The reason this type of alignment is problematic for canines is due to the damage it can cause. A misaligned canine can cause irrita surrounding tissue and teeth. In addition, the misalignment can cause conditions such as dental attrition, periodontal diseases, and oronasal fistula [4]. As well, dogs use their canines to bo and hold items so they are a crucial part of their lives and daily tasks [2]. Thus, there is a high importance to ensuring they are in the correct position and alignment.

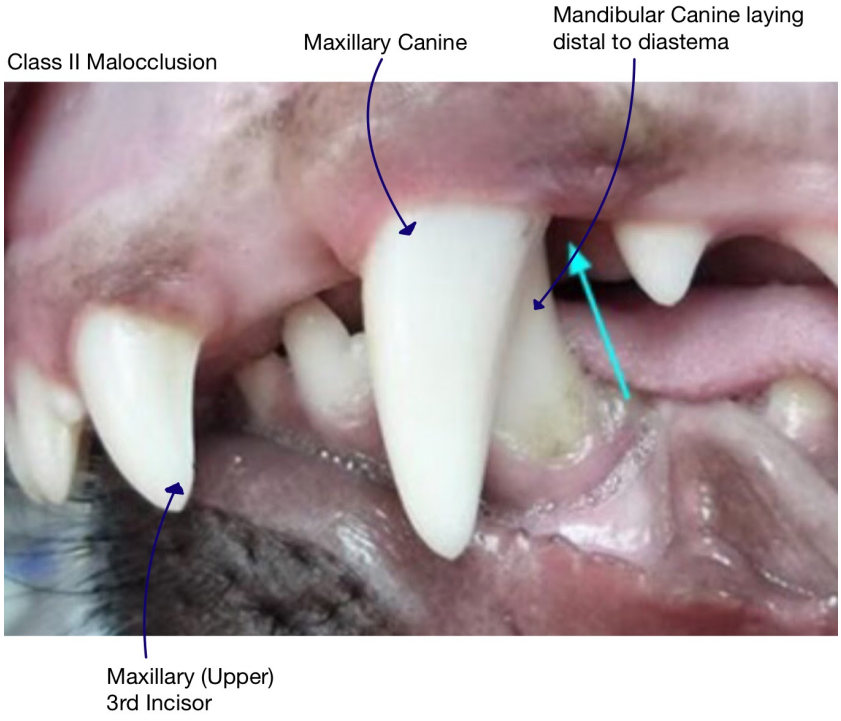


Figure 2: Class II Malocclusion. This figure shows a side view of a canine mouth with class II malocclusion. The mandibular canine sits distal to its normal position within the diastema.

2. **Existing Treatments/Device**

Extraction:

One treatment type is to simply remove the misaligned canine. This may get rid of the misalignment, but, removing the teeth will bring up more lifestyle problems for the dog. This is due need their canines to eat food and hold things in their mouth. Thus, this is not a preferred method.

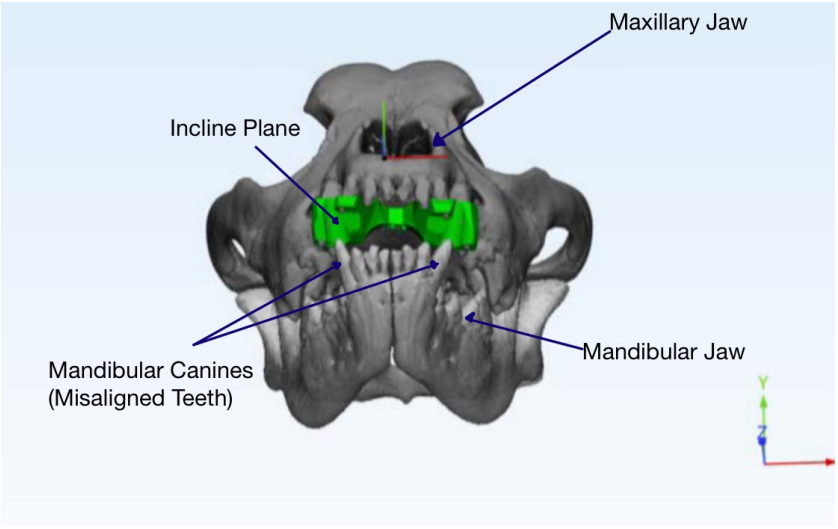
Shortening

Another treatment type is to shorten the tooth so the canine does not cause irritation to the palette. While this will cause some temporary relief, again, the canine is distorted and not being normally for the dog.

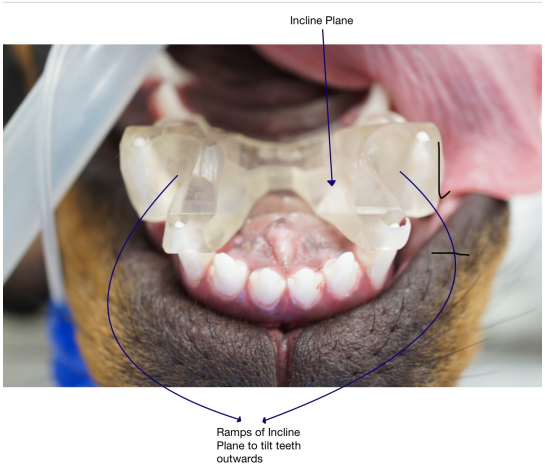
Incline Plane

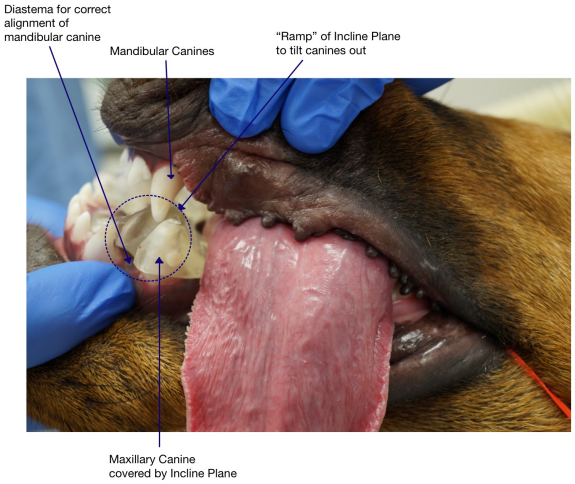
The last type of treatment was designed by client Dr. Graham Thatcher and involves dental orthodistry treatment for the dog. The incline plane is a 3D printed device made of FDA approv The device acts as a retainer for the dog and is attached to the mandibular jaw through hole attachments. As shown in Figure 3, the incline plane attaches to the mandibular jaw through ho on the mandibular canines and molars.

Figure 3 Incline Plane in stl file. This figure shows a CT scan of the dog's skull with the green portion indicating the incline plane device used to tilt the mandibular canines out.



The plane is essentially a combination of two ramps that are aligned to direct the mandibular canines into the correct position. Canine teeth, in dogs, are easily tilted without the need of m use of the ramps within the inclined plane work effectively. As shown in Figures 4 and 5, the inclined plane is designed so that the mandibular canines, when the dog closes their mouth, ti the correct position in the diastema.





Figures 4 (Top) and 5 (Bottom) Client 1. These figures show the incline plane attached to Dr. Thatcher's first client and how the ramps work to push the teeth outward.

Over time, the incline plane will shift the permanent position of the mandibular canines so they are set into their correct alignment. In addition, the placement of the canine in it's correct p permanent retainer for the dog due to it resting along the diastema along the gumline so no further treatment is necessary. Although the incline plane designed by Dr. Thatcher was success client, it poses many inefficiencies that are associated with negative consequences of the plane as well as the development of the plane itself.

3. Existing Development Process of Incline Plane.

While Dr. Thatcher has succeeded in creating an incline plane, his process for doing so is very inefficient and complicated. His process involves first taking a CT scan of a dog's mouth. H skull of the mouth and uses a dental material to arbitrarily mold a potential design for the plane onto the skull model. Once he is satisfied with the design, he sends the CT scan (DICOM f to a software engineer who takes all the information and builds an stl file of the incline plane in an engineering software. Dr. Thatcher and the engineer then work back and forth to perfect adjustments, printing prototype designs, and trials. Ultimately, this process isn't efficient nor timely. Resultantly, the second half of the team's project involves the development of an inter program that expedites and simplifies the process of designing the incline plane.

4. 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. He is responsible for the dentoalveolar and orofacial diseases and trauma as well as is an educator to current veterinary students [5]. Dr. Thatcher is currently working on this project and has solicited this team's h better his current designs.

5. Design Specifications

Incline Plane:

The new incline plane has several specifications that must be met to satisfy both Dr. Thatcher's requests as well as improve the product in general. Firstly, the product must be able to w 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 by about 30 degrees of tilt. This angle will vary by each dog's unique anatomy.

Software/Interface:

When designing the software program, many specifications must be considered when choosing the right pathway. For one, the process must be simple enough where a veterinary orthod utilize the software without the help from a software engineer. The software must also be compatible with common computers found in veterinary hospitals and offices. Lastly, the main sp the software must be able to manipulate multiple cross sections of a DICOM file so the veterinary orthodontist can move the mandibular canines to the right position within the program.

Preliminary Designs

1. Incline Plane:

Design 1: Adjustable Bridge

The team's first design consists of manipulating the portion of the original prototype that connects the ramps on the incline plane of both sides of the mouth. In the original prototype, this of the same dental material as the ramps and created one continuous device. That continuity resulted in palatitis in the dog's mouth due to the dental material causing irritation. It also resu adaptability and adjustability for the incline plane to be used for other dogs and for intra-treatment changes. In this design, the team seeks to solve both these solutions by replacing the bri adjustable bridge. They took inspiration from a human orthodontic expander [6]. The metal bridge would consist of a centric mechanical element that can be used to adjust the width of the as an expander is adjusted to widen, and to thus widen the maxillary jaw, the same would apply here but with a purpose to help the incline plane be adaptable to other dogs. The rest of the similar to that of the original prototype with the ramps serving the same function and being made of the same material.

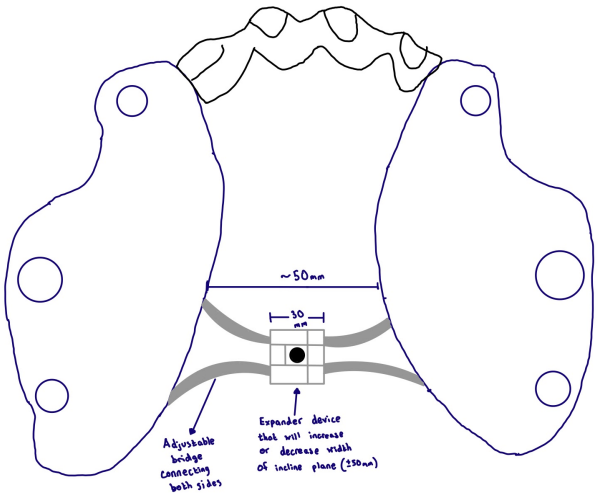


Figure 6 Adjustable Bridge. As seen in the figure above, the design consists of an expander device that can shorten or lengthen the width of the entire incline plane. This helps increase ac adjustability.

Design 2: Separate

The second design also is aimed to address the issue of palatitis and adaptability by separating the incline plane into two pieces. This eliminates the bridge component which eliminates the irritation on the palette due to a lack of any material being in contact with the top of the mouth. The separate design consists of two pieces for the correction of each mandibular canine ind design aims to separate the malocclusion of each canine into its own unique situation to create a specially designed ramp for each canine on both sides of the mouth. The diameters of the r the mandibular teeth are shown in *Figure 7*. Again, while separate, the ramps will be of the same dental material and have the same task to tilt the lower canines outwards.

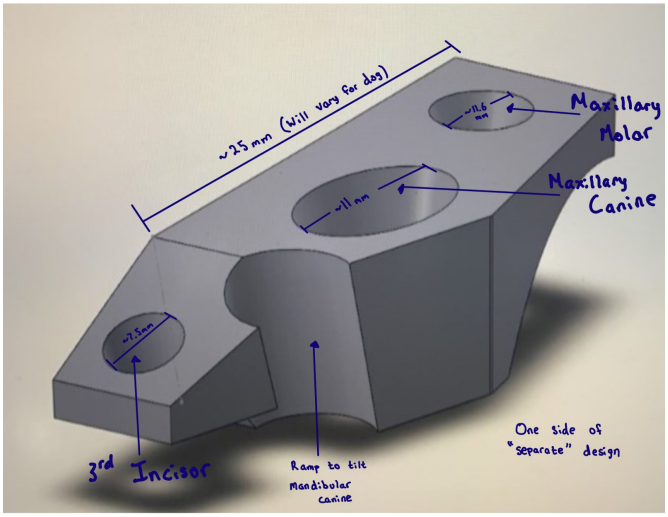


Figure 7 Separate Design. Here shows one side of the separate design. The holes are the locations for the respective maxillary teeth and each of their approximate diameters are shown. T normal to tilt the mandibular canines outwards.

Design 3: Rubber incline Plane

The third and final incline plane design is a model that is very similar in size and shape to Dr. Thatcher's incline plane, but instead of being made of plastic, it will be made of a rubber r material will allow the device to be stretched and manipulated to various different orientations, which in turn will be able to fit a variety of dog mouths'. The main goal of this design is to adaptability of the device, and overall decluster the current process of generating and creating the incline plane. This design will also provide the dog with a more comfortable fit due to th material.

2. Software

Design 1: 3D Slicer

The first design interface to help with the process of designing the incline plane is the program called 3D slicer. This program has functions that work best with processing and viewing CT Scans. It is based on the purpose to easily view medical images and be able to draw conclusions and conduct research from those images. It allows the user to isolate different levels of scan and to also see individual frames of it as seen in *Figure 8*. However, it lacks the feasibility and ease of manipulating cross-sections of images and overall is a very complicated softwa

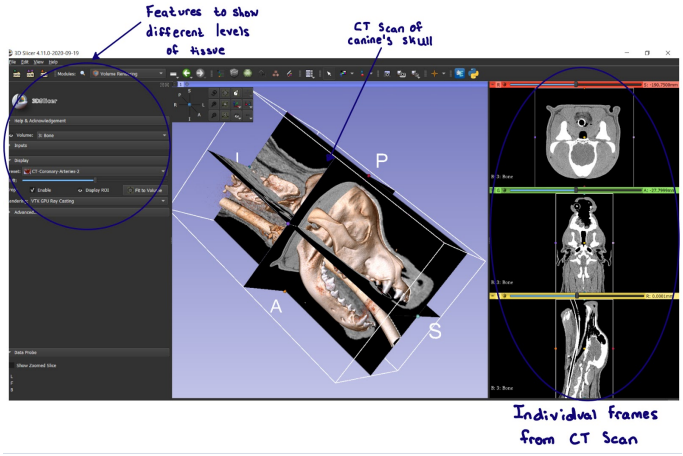


Figure 9 3D Slicer: The 3D Slicer interface shows it's ability to better view CT scans and to see cross-sections of tissue levels.

Design 2: Osiris X

Osiris X was the next software the team sought to utilize to help with the production process. This is a very mathematical based software that works with vectors and directions. It is hel manipulating cross sections and is specific to being able to view DICOM files well. The software was designed for medical imaging so it is very useful in simply analyzing scans.

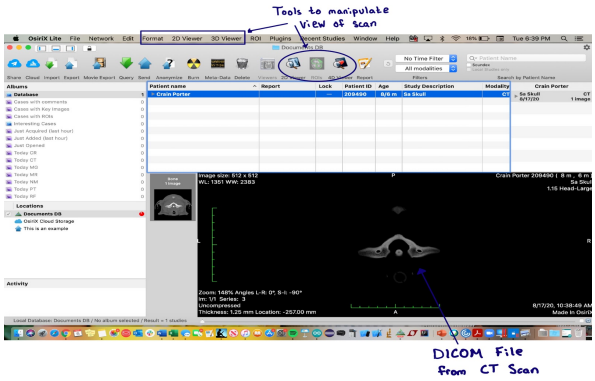


Figure 10 OsirisX. There are many tools within this program to better view and understand the CT scan

Design 3: GeoMagic

Lastly, GeoMagic is a software that works within SolidWorks which is a CAD software used by engineers to create 3D products. GeoMagic is able to process large data sets including D can be used to generate stl files for 3D printing as well. Due to this program being embedded into CAD software, the feasibility of use is greatly simplified and allows for matriculate adju

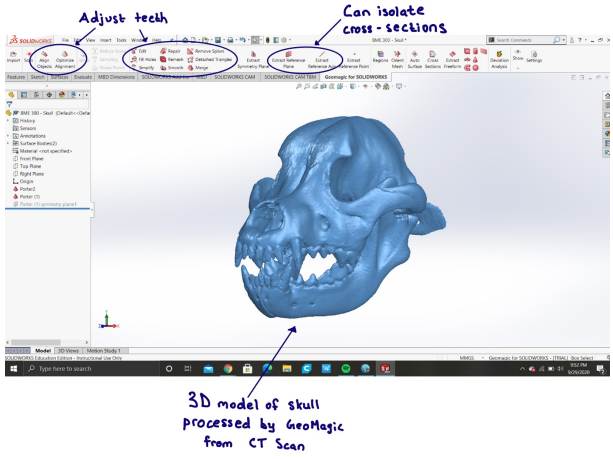


Figure 11 GeoMagic within SolidWorks. This interface demonstrates an ability for the program to manipulate teeth, process CT scans, and create additional devices and parts wit

Protocol for Geomagic software- Repeated in Appendix A

Below is the list of processes that will be used to design and edit the stl files:

1. Open Geomagic for Solidworks
2. Load in DICOM file in the Solidworks interface

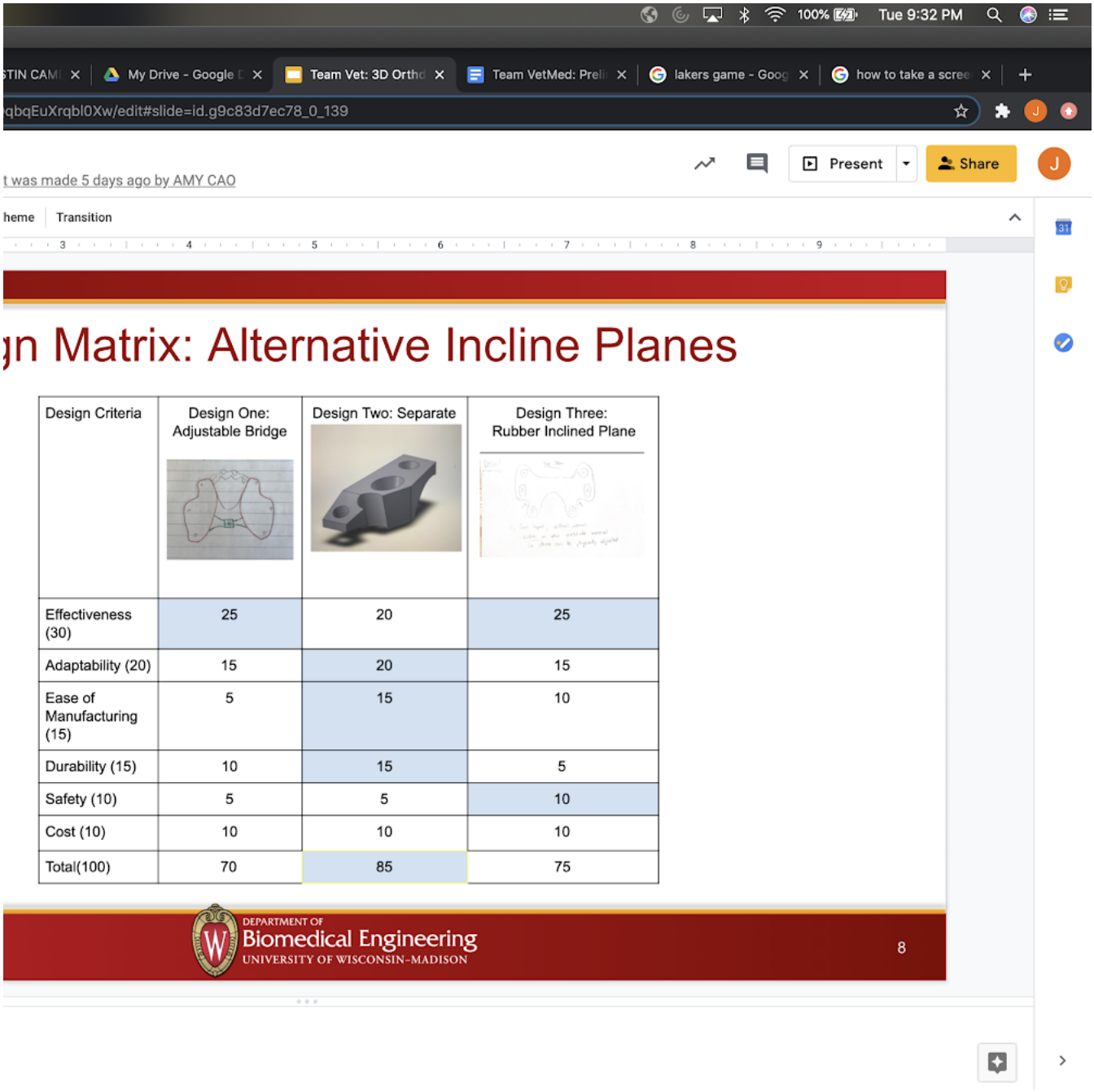


Figure 12 incline Plane Design Matrix.

As far as choosing the criteria went, the team chose what were believed to be the 6 most important aspects that applied to all 3 incline plane designs. The team ranked these criteria l
importance to this specific project, assigning each of the 3 designs with a score based on how accurately they represent each criteria. Effectiveness was defined as how well the desi
and was ranked the highest, at 30. This is because effectiveness is the main priority of the project; if the device doesn't execute its job properly, it is a failed project. Designs 1 and 3
highest score in this criteria, just because they are both single-piece devices that model Dr. Thatcher's successful incline plane, meaning that the worry of how a dog will react to mu
its mouth is nonexistent. After effectiveness is adaptability, which the team defined to be how easily the device can be adjusted to different dogs. The team ranked this aspect at 20,
adaptability was one of the main reasons this project was assigned, and the goal is to improve the overall process of creating the incline plane for different dogs. They then gave des
highest score in this category because it eliminates the problem of differing sizes of the dog's palate. Next is ease of manufacturing, which the team ranked at 15 and defined as how
to create each of the designs. This criteria is ranked where it is because not only will ease of manufacturing make the overall process much more efficient, but it will also allow veter
produce and print these designs without the help of an engineer. The team ranked design 2 the highest in this criteria because Dr. Thatcher has already proven that printing the inclin

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Editing

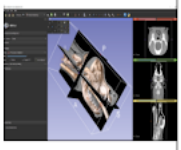
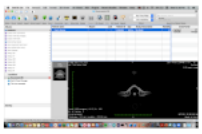
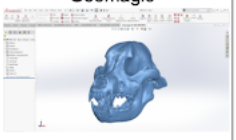
Design Criteria	Design One: 3D Slicer	Design Two: Osirix	Design Three: Geomagic
			
Effectiveness (30)	15	20	25
Adaptability (20)	0	10	18
Ease of Use (15)	15	10	10
Cost (10)	0	0	5
Total(75)	30	40	58

Figure 13 Software Design Matrix.

The Team chose the criteria for the software design matrix in a similar fashion to the incline plane design matrix, choosing what the team thought were the most important aspects o programs. However, the team excluded ease of manufacturing from this design matrix because the 3 software programs that the team chose do not require any manufacturing in tern the program. The team also did not include safety, because this does not apply to online softwares. Effectiveness was once again ranked highest at 30, for the same reason as above; ineffective is considered a failure. However, with the software in mind, the team defined effectiveness as how efficiently the software functions. Design 3, Geomagic, received the h this category because after playing around in the software, the team determined that Geomagic was able to process a CT scan and convert it into an stl file, of which can be manipul SolidWorks. The next criteria is adaptability which the team ranked at 15, and defined as how well each of the software programs can convert between different types of files. This received the ranking that it did because being able to convert various types of files into an stl file is crucial in this project, because it removes the step of having to send the CT scan engineer. Once again, Geomagic received the highest score in this criteria because it is the most versatile software. The third criteria, ease of use, was defined as how user-friendly t Ease of use is an important criteria, especially in software programs, simply because the more easily the software is used, the more likely that the user will be able to generate what looking for. Design 1, Slicer, received the highest score in this criteria because it allows the user to view CT scans in a variety of ways, giving them different viewpoints and overall understanding of the scan. The final criteria is cost, and Geomagic received the highest score in this aspect simply because it is a free program to use. With this being said, the team the proposed final software design to be Geomagic, due to the fact that it is most representative of what the team is trying to accomplish with this project and received the highest sc design matrix, being a 58 out of 75.

Fabrication/Development Process

Materials

Once an stl file of the final design has been created, the team may use the 3D printers located in the UW Veterinary School to print off the desired pieces. The braces should stay uniform material properties to limit the amount of variables that different materials will give the team. Dental LT was used as the material in Dr. Thatcher's initial brace design. It is a clear resin us FormLabs 3D printers for biocompatible dental splints and guards. It is also FDA approved and is known to be resistant to the mechanical and chemical stresses that occur within the mou and canines. Nylon and polycarbonate are also ideal candidates for the brace material as each has an extremely high abrasion and temperature resistance; Perfect for long term orthodontic

Methods

As of the submission of this report, a final fabrication method has not been deduced. The COVID-19 Pandemic has impeded on many facilities that are used by engineering students to wo however, Team VetMed hopes to use some of the 3D printing facilities that are available through the client Dr. Thatcher. Moving forward, the team needs to become familiar with the softv Solidworks as it will be imperative to the mating and creation of the first brace prototype. Using this software, the team will create a design that can be easily mated to the CT file of the up design changes can/will be made so the design fits to the upper canines. The team then hopes to learn how to use a 3D printer so the first prototype can be made and tested. See Appendix pictures.

Final Prototype

Team VetMed is currently working on refining the design for the final prototype. The final design will incorporate two separate brace pieces that are similar to Dr. Thatcher's original desig bridge connecting the two to each other. For pictures of this design, see the preliminary design section. In addition, the final software will be based in GeoMagic in SolidWorks. Creating a process to design an inclined plane with this software will be the main focus of this project.

Testing

No testing has yet to be done upon the submission of this report. However, mechanical testing will be done through SolidWorks on the design. By giving the design similar properties to th material, the team can gather mechanical data that would rather be acquired in a lab setting.

Results

Since there has been no testing at this point, there are no results to discuss. However the team plans to take the results of the mechanical testing done in SolidWorks and determine how is in tilting the mandibular teeth. The team will be able to adjust the device if necessary based on the outcome of this testing.

Discussion

The device will need to be effective in turning the patient's teeth in order to fix a class II malocclusion. However the team will also need to consider other factors when determining the device. This includes the comfort of the patient while wearing the device. In order to make an ethical design the team must ensure the safety and comfort of the dog as well.

Conclusion

The team's client is Dr. Graham Thatcher, an orthodontist that specializes in veterinary services at UW-Madison Hospital. The client's goal is to streamline the workflow of repairing malo mouth, specifically distal misalignment of the mandibular (lower) with the maxillary (upper) jaw. There is currently no other process on the market that does this work in a streamlined ma the primary goal of the team's project. The team will need to work in parallel with the software system, Geomagic, and the mechanical system, the implant, to allow the orthodontist to be adjustments to the implant (specific to the dog) on his own without the use of a software engineer.

The design that the team is currently developing is using Geomagic to splice specific pieces of the mouth, particularly the teeth in question. Once the team has effectively found a way to c alter the dimensions, or angle of the tooth, the orthodontist will be able to effectively test the mechanical implant against the stl file of the mouth. This process will minimize steps of proto veterinary orthodontist will be able to make adjustments before printing, instead of having to make adjustments after each print of the implant. As expected, the team also has the goal of n gaps" in the dimensions to ensure that the implant fits correctly in the mouth and still allows room for breathing and/or air flow.

In the upcoming weeks, the team plans on learning more about the use of Geomagic in order to make these altercations of specific implants of a specific stl file, pertaining to the patient. A team plans on printing these pieces to see where the software process runs into issues (i.e. does not allow space for enough airflow, does not fit around the teeth effectively, does not stay p not uphold mechanical loading necessary to not break etc.). Potential issues that may arise stem from the inability to work with a direct patient at the beginning; in other words, most of the done on a model, not a real dog. Additionally, issues may arise from the difficulty of use of Geomagic (i.e. trying to alter dimensions and splice desired anatomy).

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Appendices

Appendix [A] - Protocol for Geomagic software

Below is the list of processes that will be used to design and edit the stl files:

1. Open Geomagic for Solidworks
2. Load in DICOM file in the Solidworks interface
3. Remesh structure to 15 mm for accurate dimensions
4. Use window feature to window out upper jaw
5. Load in stl file of brace design
6. Using assembly, mate the brace to the upper canines
7. Make any design adjustments necessary for fit
8. Using the simulation feature on Solidworks, change the material to match dental LT resin
9. Perform mechanical testing on brace
10. Change any aspects of design based on fit and testing

Appendix [B] - Product Design Specifications

Edited: 10/05/20

Function:

Veterinary canine patients often experience Class II Malocclusions; A movement of the upper jaw that causes the bottom canine teeth to puncture and injure the roof of the mouth. The is develop a smooth workflow through software that will assist with the creation of a lower jaw device to move the lower canines into a suitable position within the lower jaw. Specificall to utilize the software program Osirix to be able to view the DICOM file in 3D, section off pieces of the file/image, and alter the pieces in order to effectively streamline the process for th

Client requirements (itemize what you have learned from the client about his / her needs):

- Workflow must be simplified using software
- CT Scan must be configured into an stl file
- Device outcome should fit CT Scan

- Device needs to be moldable to other canine jaws based on CT Scan
- Device must be 3D printed
- Device must be held within canine jaw for 6-8 weeks
- Device must move canines lateral to upper jaw

Design requirements: This device description should be followed by a list of all relevant constraints, with the following list serving as a guideline. (Note: include only those relevant to yo

1. Physical and Operational Characteristics

a. Performance requirements: The performance demanded or likely to be demanded should be fully

defined. Examples of items to be considered include: how often the device will be used; likely loading

patterns; etc.

The mechanical aspect of the device will be placed on the maxillary palate of a dog with Class II Malocclusion with a goal to, over-time, guide the mandibular canines into their co within the diastema of the 3rd maxillary incisor and maxillary canine.

1. The device will be designed to fit the canine's mouth through editing the DICOM file/stl file using 3D imaging and reduring tools (Geomagic)
2. The mechanical piece will be used for 3-8 weeks on a 24/7 basis as it is secured to the canine's palate with 'dental glue'

b. Safety: Understand any safety aspects, safety standards, and legislation covering the product

type. This includes the need for labeling, safety warnings, etc. Consider various safety aspects relating

to mechanical, chemical, electrical, thermal, etc.

Material used should be nontoxic to dogs. The piece should effectively lock onto upper canine teeth in order to create the right forces to wing/push misaligned teeth outward. It s teeth that are in proper positions, or apply too much force to the moving teeth. The device should not break in the dog's mouth or cause breakage of the teeth.

c. Accuracy and Reliability: Establish limits for precision (repeatability) and accuracy (how close to the

"true" value) and the range over which this is true of the device.

The device will need to be an exact fit for the patient's mouth. This will require a CT scan to get an accurate image of the jaw structure. In addition, the software will need to be ab model of the device that will fit perfectly around the patient's teeth. Specifically, the range over the true values are approximately 1cm, rather than a smaller value because the ma correctly align teeth and not interrupt breath flow through the roof of the mouth tissue. In other words, the accuracy of dimensions pertaining to the exact DICOM file is less impo the correct fit. As of now, the system is trial and error and the team hopes to limit the steps of trial and error through precision more than accuracy.

d. Life in Service: Establish service requirements, including how short, how long, and against what

criteria? (i.e. hours, days of operation, distance traveled, no.of revolutions, no. of cycles, etc.)

The device will be attached to the patient's mouth for up to several weeks. The interval of weeks depends on the following:

1. As long as the treatment needs; this is a new procedure, meaning trial and error
2. The age of the dog
3. How far the maloccluded teeth need to be moved outward (typically this value is ~30˚ but can be more or less pertaining to the patient

e. Shelf Life: Establish environmental conditions while in storage, shelf-life of components such as

batteries, etc.

The device will need to last at least 6-8 weeks while attached to the patient's mouth, but once removed the device will not need to be used again and will be discarded to ensure s

f. Operating Environment: Establish the conditions that the device could be exposed to during operation

(or at any other time, such as storage or idle time), including temperature range, pressure range,

humidity, shock loading, dirt or dust, corrosion from fluids, noise levels, insects, vibration, persons who

will use or handle, any unforeseen hazards, etc.

Mechanical piece places to correct misalignment in teeth:

The device will be attached to the patient's (dog) mouth 24 hours a day- 7 days a week so its operating environment involves the conditions of a normal day-to-day environment. T be able to withstand temperatures ranging from -20°F to 120°F to account for any extreme conditions the patient may experience. The average force of a bite from a dog is approx pounds so the device should be able to withstand forces ranging up to 400 pounds without fracturing, loosening from mouth, or cracking. The device should also not interfere wi consumption nor should it be affected by it. Food should easily pass by the device and not stick nor peel the device's material.

Interface used for streamlining software engineering:

The software should be able to be utilized by a veterinary orthodontist. The interface should be compatible for most computers and easy to follow. The software should include 3l DICOM file to give access to all images as well as the ability to convert to an stl file. Once the image is converted into an stl file, the user (without software engineering prior know able to section off desired piece of image and alter to the users discretion, knowing that these edits will be visible on the mechanical piece once printed.

g. Ergonomics: Establish restrictions on the interaction of the product with man (animal), including

heights, reach, forces, acceptable operation torques, etc..

The ramping grooves (used for correcting the canines alignment during continuous bitting) of the device should be applied to the maxillary teeth. The device will come into conta mandibular canines when the mouth closes and apply passive force to direct the teeth away from the palate. The device should avoid contact with the mucosa. The slope of the ir 45-60 degrees.

A torque needs to be applied from the brace to create an axial moment. This type of shear moment causes a sagittal rotation of the tooth that leads to a normal occlusion. [15]

h. Size: Establish restrictions on the size of the product, including maximum size, portability, space

available, access for maintenance, etc.

The size of the product will be dependent on each patient and their mouth size and unique Class II Malocclusion. Maintenance could be a factor depending on the integrity of the Removal of the incline plane may need to take place but cannot be out for more than 72 hours to avoid any reversal of tooth movement.

i. Weight: Establish restrictions on maximum, minimum, and/or optimum weight; weight is important

when it comes to handling the product by the user, by the distributor, handling on the shop floor, during

installation, etc.

The device should weigh no more than a few ounces to ensure it sits correctly in the mouth and does not become misaligned due to weight adjusting the fit over time.

j. Materials: Establish restrictions if certain materials should be used and if certain materials should NOT

be used (for example ferrous materials in MRI machines).

The device will be planted in a canine's mouth so the material used should not be toxic to the animal. The material also should erode or deteriorate over time due to water and foo it.

k. Aesthetics, Appearance, and Finish: Color, shape, form, texture of finish should be specified where

possible (get opinions from as many sources as possible).

Aesthetics will not be considered, but the incline plane of the device should be smooth enough to not apply excessive friction to the tooth. Rough edges should be taken away in that the 3D piece is high quality and fits/operates correctly.

2. Production Characteristics

a. Quantity: number of units needed

Production will be on a customer-need basis. One device per patient with condition.

b. Target Product Cost: manufacturing costs; costs as compared to existing or like products

Currently the client has offered the team to use their 3D printer that prints with a specific material used for safety during orthodontic procedures. Therefore the team has not mad materials. However, the team expects to use most of its budget towards software development tools, such as advanced Geomagic.

3. Miscellaneous

a. Standards and Specifications: international and /or national standards, etc. (e.g., Is FDA approval

required?)

An orthodontic brace that has the ability to reposition teeth is known as a Class I device, meaning it has low to moderate risk of injury.

b. Customer: specific information on customer likes, dislikes, preferences, and prejudices should be

understood and written down.

The client wants the software interface to be able to create a mechanical tool that works for any canine with these Class II malocclusions. The team should be using software to a model of the ramping grooves to fit any sized lower jaw.

c. Patient-related concerns: If appropriate, consider issues which may be specific to patients or research

subjects, such as: Will the device need to be sterilized between uses?; Is there any storage of patient

data which must be safeguarded for confidentiality?

A new device will be created for each dog through a software developed by the team so sterilization will not be necessary. The patient (owner of the dog) should be given a rundo device is and how it operates before being inserted into the mouth of the dog.

d. Competition: Are there similar items which exist

There exists a metal incline plane called a Mann incline plane.1,5. However, this method/device is very costly to the patient and intra treatment adjustments cannot be made to the words, there are seemingly no competitors in this exact field, as it is a new procedure that the team gets the chance to help streamline.

Table of Expenditures and Budgeting:

Material Name	Part Numbers	Place Purchased	Cost	Quantity	Budget Left
					500

Conclusions/action items:

Present preliminary presentation and continue working on final designs.

12/2 Final Poster Presentation

SANAM JHAVERI - Dec 08, 2020, 2:18 PM CST

Title: Final Poster Presentation

Date: 12/2/2020

Content by: All

Present: All

Goals: Create Final Poster and presentation for Friday's deliveries

Content:

https://docs.google.com/presentation/d/1lvEwEBzge9bQj1whyRmQzfo86RlC4ythPTn7q8cyohU/edit

Conclusions/action items:

Poster is ready. Need to record presentation.

SANAM JHAVERI - Dec 08, 2020, 2:23 PM CST

Final_Poster-VetMed.pdf(8.9 MB) - download

12/5 Final Report

ETHAN FROHNA - Dec 08, 2020, 9:39 PM CST

Title: Final Report

Date: 12/5

Content by: All

Present: All

Goals: Create our final report that highlights everything the team has accomplished this semester.

Content:

https://docs.google.com/document/d/17HamFQ6h1EizFtQaeIaE7JgG2rwsWFeobS0gkQMKzCM/edit?usp=sharing

Conclusions/action items:

The Final Report lists all of the designs, protocols, and research that went into this project. It allows someone who is not familiar with the project to get a lot of good and meaningful information without having to see the actual design process themselves. Especially with COVID-19 restrictions, these reports are extremely useful for others to see what has been completed with a project over the course of a semester.

9/10 Progress Report 1

SANAM JHAVERI - Sep 16, 2020, 6:51 PM CDT

Title: Progress Report 1

Date: 9/10

Content by: Ethan

Present: All

Goals: Create our first report of the progress we have made that will be sent to Professor Block and Dr. Thatcher

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 9/10/20

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

We will all meet with Dr. Thatcher on Friday (9/11/20) to have our first client meeting. This meeting will give us introductory information and help us figure out what kind of device we are going to make and what it will help do in regards to malocclusions in dogs. We have all met as a group and have started researching what a malocclusion is and how it affects different animals, including humans and dogs. After Friday, the group should have a good understanding of how to solve this problem based on information given to us by Dr. Block and Dr. Thatcher.

Summary of Weekly Team Member Design Accomplishments

- **Team**: No work on the design has been completed yet, but research on how malocclusions affect dogs has started and will be developed over the course of the week.

- **Ethan** - Set up a Zoom meeting and worked with Parker on establishing guidelines and answering questions for the BME 200's of the group.

- **Parker** - Set up a Zoom meeting and worked with Ethan on establishing guidelines and answering questions for the BME 200's of the group. I also researched project further in order to better formulare questions for client and formulate team understanding.

- **Amy** - Research on class II malocclusions.

- **Justin**- Researched about the project, created a team photo collage and uploaded it to website, updated team information on the website
- **Sanam** - Set up a Zoom meeting with our client for Friday (9/11/2020) @ 12:00 pm. Meeting is to discuss the project and semester goals. I also researched the project and educated myself on project-specific terminology.
- **Sammie** - Began research on the topic and made interview questions that will help us in our first client meeting

Weekly/Ongoing Difficulties

Learning how to navigate this project without meeting face to face has been a real challenge so far. Everyone has different schedules with online learning so it makes meeting and discussing the project with each other more difficult. Hopefully, we can establish a set meeting schedule that works for everyone in the group and figure out a way to work more efficiently in this virtual setting.

Upcoming Team and Individual Goals

- **Team**: To begin research on malocclusions in dogs and how they are treated
- **Ethan** - Attend the first BSAC meeting as well as researching the physiology behind malocclusions.
- **Parker** - Establish and develop methods on how we can meet as a virtual team more efficiently
- **Amy** - Create some questions for the client, and research current malocclusion treatment methods.
- **Justin**- Keep website up to date with progress reports and other documents, create a list of questions for the client
- **Sanam**- Create questions for the client and send the first progress report to the client. Keep researching project background.
- **Sammie** - To research how malocclusions are treated in veterinary patients so the group can start thinking about solutions and designs.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	20%	
Product Design Specifications	9/18	All		
Design Matrix and Design Ideas	9/25	All		

Preliminary Presentations	10/2	All
Preliminary Deliverables	10/7	All
Show and Tell	10/30	All
Poster Presentations	12/4	All
Final Deliverables	12/9	All

Expenses

N/A

Item	**Description**	**Manufacturer**	Part Number	Date	QTY	Cost	Total	Link

Conclusions/action items:

Conclusion --> We have made progress in researching our project

Action --> Continue to speak with our advisor and client

9/17 Progress Report 2

SANAM JHAVERI - Sep 24, 2020, 4:03 PM CDT

Title: Progress Report 2

Date: 9/17

Content by: Ethan Frohna

Present: All

Goals: Create our second report of the progress we have made that will be sent to Professor Block and Dr. Thatcher

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 9/17/20

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

Since meeting with Dr. Thatcher, we have begun researching different software programs that will be able to help us with the DICOM and stl files. Parker has been working diligently on using the OsirisX software on her Macbook to change DICOM files into stl files, which we hope to use to some capacity in the future. Tomorrow's meeting should help the team clearly understand the objectives of this project moving forward now that everyone has done thorough research of the problem at hand.

Summary of Weekly Team Member Design Accomplishments

- **Team**: No work on the design has been completed yet, but research on how malocclusions affect dogs has started and will be developed over the course of the week.

- **Ethan** - Described the function and basic criteria for the project in the PDS. Continued research on Malocclusions and basic physiological data

- **Parker** - Did research on procedure. Heavily focused on working with DICOM files to create stl files with OsiriX.

- **Amy** - Researched methods involved in making incline planes, worked on Product Design Specification.

- **Justin**- Continued research on malocclusions and helped team with the product design specifications

- **Sanam** - Meeting with Dr. Thatcher answered many of my questions. I filled out/answered multiple parts within the Product Design Specification. I also researched current methods used by human orthopedic surgeons and dentists for analyzing teeth/mouth scans.

- **Sammie** - Worked on Product Design Specification, and continued researching malocclusions and the current treatments available.

Weekly/Ongoing Difficulties

It has been difficult to figure out exactly what we are going to do to assist with the workflow of creating the device. Unfortunately, it seems that the team has very limited knowledge of software and coding, which is going to make this part of the project fairly difficult. It has also been an issue to fill out the PDS considering that much of the first part of this project is software related. Options regarding the creation of an adjustable incline plane are being discussed amongst the team members, which is something that will be discussed with the client and advisor.

Upcoming Team and Individual Goals

- **Team**: To look into different softwares and how they can help the Team create inclined planes that can fit a certain scan of a veterinary patient
- **Ethan** - Look up and research software that will enable us to maximize efficiency and workflow
- **Parker** - Establish and develop methods to better edit DICOM files into stl files.
- **Amy** - Become acquainted with some softwares, look at different materials currently used for incline planes.
- **Justin**- Keep adding team documents to the website, research software programs that could potentially be used for the project
- **Sanam**- Continue doing research on software used by current dentists to create 3D models of the mouth/teeth.
- **Sammie** - Continue to research how malocclusions are treated in veterinary patients, research more about current software being used and how it can be improved.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20

Design Matrix and Design Ideas	9/25	All
Preliminary Presentations	10/2	All
Preliminary Deliverables	10/7	All
Show and Tell	10/30	All
Poster Presentations	12/4	All
Final Deliverables	12/9	All

Expenses

N/A

Item	**Description**	**Manufacturer**	Part Number	Date	QTY	Cost	Total	Link

Conclusions/action items:

9/24 Progress Report 3

ETHAN FROHNA - Oct 04, 2020, 3:20 PM CDT

Title: Progress Report 3

Date: 9/24/20

Content by: Ethan Frohna

Present: All

Goals: To keep track of the Teams process throughout week 3 of the semester

Content:

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

This week, Ethan got the chance to meet with Dr. Thatcher to discuss the previous design iterations he has tried in the past for the orthodontic device. The Team took these design iterations and came up with new, preliminary designs to make the device easier to produce and use.

Summary of Weekly Team Member Design Accomplishments

- **Team**: Work on the design matrix has started, as well as research on how DICOM/stl files can be utilized to easily model a canine's mouth

- **Ethan** - Met with Dr. Thatcher in person and was able to acquire past iterations of the orthodontic device. Worked on initial designs for an improved version of the device on paper and Solidworks.

- **Parker** - Did research on procedure. Heavily focused on working with DICOM files to create stl files with OsiriX and Geomagic. Met with the team to look at the pieces given to us by the client. Drafted design matrix.

- **Amy** - Worked on sketches of the design, worked on the design matrix with the team.

- **Justin**- Drew rough sketches of possible improved designs, worked on design matrix with team

- **Sanam** - Took a look at Dr. Thatcher's physical prototypes that he was able to give our group. Talked with the team to discuss designs for the design matrix. Also worked on drawing a few of those designs.

- **Sammie** - Began working on possible designs and design matrix.

Weekly/Ongoing Difficulties

It has been difficult to figure out exactly what we are going to do to assist with the workflow of creating the device. Unfortunately, it seems that the team has very limited knowledge of software and coding, which is going to make this part of the project fairly difficult. It has also been an issue to fill out the PDS considering that much of the first part of this project is software related. Options regarding the creation of an adjustable incline plane are being discussed amongst the team members, which is something that will be discussed with the client and advisor.

Upcoming Team and Individual Goals

- **Team**: To look into different softwares and how they can help the Team create inclined planes that can fit a certain scan of a veterinary patient
- **Ethan** - Start work on the presentation for next Friday and finish up any design ideas that I might have
- **Parker** - Seeing the difference between Osirix and Geomagic. Set plan for material development
- **Amy** - Brainstorm other possible designs and ideas, continue working with software.
- **Justin**- Stay up to date with the website, brainstorm other possible designs
- **Sanam**- Help create the preliminary presentation for next week and continue working on designs.
- **Sammie** - Continue working on designs and work on preliminary design presentation

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20
Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All		
Preliminary Deliverables	10/7	All		
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	Descrip	Manufa	Part	Date	QTY	Cost	Total	Link

tion	**cturer**	Number

10/1 Progress Report 4

ETHAN FROHNA - Oct 04, 2020, 3:20 PM CDT

Title: Progress Report 4

Date: 10/1/20

Content by: Ethan Frohna

Present: All

Goals: To prepare for the preliminary presentation by finishing the powerpoint and recording the presentation

Content:

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

This week, the team worked on preparation for the preliminary presentations on October 1st. All research on software programs and design iterations were completed to be ready for presenting,

Summary of Weekly Team Member Design Accomplishments

- **Team**: Work on the design matrix has started, as well as research on how DICOM/stl files can be utilized to easily model a canine's mouth

- **Ethan** - Downloaded Geomagic for Solidworks and worked on altering the first CT scan

- **Parker** - Focused on the presentation for group as well as working with Ethan on Geomagic.

- **Amy** - Preparation for the preliminary oral presentation, recording presentation with the rest of the team.

- **Justin**- Helped team prepare and record presentation, updated website

- **Sanam** - Worked on preliminary presentation and summarizing all our information to present on Friday. Recorded presentation as well.

- **Sammie** - Worked on preparing for presentation and recording presentation with team.

Weekly/Ongoing Difficulties

It has been difficult to figure out exactly what we are going to do to assist with the workflow of creating the device. Unfortunately, it seems that the team has very limited knowledge of software and coding, which is going to make this part of the project fairly

difficult. It has also been an issue to fill out the PDS considering that much of the first part of this project is software related. Options regarding the creation of an adjustable incline plane are being discussed amongst the team members, which is something that will be discussed with the client and advisor.

Upcoming Team and Individual Goals

- **Team**: To look into different softwares and how they can help the Team create inclined planes that can fit a certain scan of a veterinary patient
- **Ethan** - Start learning Geomagic for Solidworks and integrate stl files into the CT scan on Solidworks.
- **Parker** - Seeing how we can put the design and software together. Isolating desired areas of mouth on Geomagic.
- **Amy** - Working on the preliminary report.
- **Justin**- Stay up to date with the website
- **Sanam**- Start working on what can go into our software and physical design.
- **Sammie** - Start working with designs, continue research on device.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20
Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All		
Preliminary Deliverables	10/7	All		
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	Description	Manufacturer	Part Number	Date	QTY	Cost	Total	Link

10/7 Progress Report 5

SANAM JHAVERI - Dec 08, 2020, 2:00 PM CST

Title: Progress Report 4

Date: 10/7/20

Content by: Ethan Frohna

Present: All

Goals: To present preliminary presentation and then start working on final designs

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 10/07/2020

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

This week, the Preliminary Report was written.

Summary of Weekly Team Member Design Accomplishments

- **Team**: Major work on the preliminary report was done this week. Also organizing LabArchives and filling out peer evaluations. Final design decisions have also been set in motion.

- **Ethan** - Worked on the Fabrication and Development part of the progress report

- **Parker** - Focused on the preliminary report with the team. Dividing up goals and trying to make goals concise for the team.

- **Amy** - Worked on the preliminary report and peer and self evaluations.

- **Justin**- Completed peer evaluations and helped team complete the first draft of our preliminary report, uploaded weekly documents to the website

- **Sanam** - Completed background and a part of preliminary designs portion for preliminary report. Also uploaded documents and files to LabArchives.

- **Sammie** - Completed results and discussion on preliminary report. Completed peer evaluations and LabArchives work.

Weekly/Ongoing Difficulties

It has been difficult to figure out exactly what we are going to do to assist with the workflow of creating the device. Unfortunately, it seems that the team has very limited knowledge of software and coding, which is going to make this part of the project fairly difficult. It has also been an issue to fill out the PDS considering that much of the first part of this project is software related. Options regarding the creation of an adjustable incline plane are being discussed amongst the team members, which is something that will be discussed with the client and advisor.

Upcoming Team and Individual Goals

- **Team**: Decide on the final design for the incline plane and the software- most likely GeoMagic. Start a fabrication plan.
- **Ethan** - Use Geomagic to mate two different pieces together and see how the original design can be edited
- **Parker** - Seeing how we can put the design and software together. Isolating desired areas of mouth and editing angles/dimensions on Geomagic.
- **Amy** - Make decisions with the team on final designs, start fabrication plan for the design, including material costs.
- **Justin**- Continue to update the website
- **Sanam**- Work with the team to come up with final design and then start our fabrication process. Email report, LabArchives, and progress report to Block and Thatcher.
- **Sammie** - Begin deciding on final design and continue planning for fabrication.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20
Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All	100%	10/02/20

Preliminary Deliverables	10/7	All	100%	10/07/20	
Show and Tell	10/30	All			
Poster Presentations	12/4	All			
Final Deliverables	12/9	All			

Expenses

N/A

Item	**Description**	**Manufacturer**	Part Number	Date	QTY	Cost	Total	Link

10/15 Progress Report 6

SANAM JHAVERI - Dec 08, 2020, 2:02 PM CST

Title: Progress Report 4

Date: 10/15/20

Content by: Ethan Frohna

Present: All

Goals: Divide up group into Mechanics team and Software team to get each side of project rolling.

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 10/15/2020

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

Parker and Ethan have been able to divide the 200s into a separate team so they could divide up work and goals amongst themselves. They are specifically working on the hardware portion of this project while Parker and Ethan work together on software development and manipulating DICOM files for design use.

Summary of Weekly Team Member Design Accomplishments

- **Team**: Divided into teams to take on different aspects of the design project

- **Ethan** - Worked on obtaining the full software for Geomagic for Solidworks and used the software to fit an stl around the jaw model

- **Parker** - Worked on obtaining the full software for Geomagic for Solidworks and used the software to fit an stl around the jaw model with Ethan. Divided team up for tasks.

- **Amy** - Started work on goals for the divided team. Looking into methods of visualizing the function of the device -- animation with SolidWorks.

- **Justin**- Collaborated with inclined plane team and came up with mechanical talking points for meeting with Graham.

- **Sanam** - Started working on goals for us 200s in terms of the inclined plane design. Organized a meeting with Graham on Monday.

- **Sammie** - Began working with other 200s on the mechanical design and discussed next steps for the physical device.

Weekly/Ongoing Difficulties

This week we have been able to divide teams but it is difficult to see what physical progress has been achieved over a zoom call. Our Geomagic for Solidworks free trial has also expired, so obtaining and purchasing the new license might take longer than expected.

Upcoming Team and Individual Goals

- **Team**: Decide on the final design for the incline plane and the software- most likely GeoMagic. Start a fabrication plan.

- **Ethan** - Acquire or have Thatcher obtain the Geomagic for Solidworks License.

- **Parker** - Seeing how we can put the design and software together. Isolating desired areas of mouth and editing angles/dimensions on Geomagic.

- **Amy** - Come up with questions for meeting with Dr. Thatcher on Monday, work on subgroup goals.
- **Justin**- Continue to update the website, gather more information about inclined plane from Graham
- **Sanam**- Have meeting with Graham on Monday to discuss designs of inclined plane. Get feedback and start semester plan from there on.
- **Sammie** - Meet with Dr. Thatcher and continue working on mechanical elements of the device.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20

Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All	100%	10/02/20
Preliminary Deliverables	10/7	All	100%	10/07/20
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	**Description**	**Manufacturer**	Part Number	Date	QTY	Cost	Total	Link

Conclusion:

Teams are made. Mechanics team to meet with Graham. Software team to work on getting licenses.

10/22 Progress Report 7

SANAM JHAVERI - Dec 08, 2020, 2:05 PM CST

Title: Progress Report 4

Date: 10/22/20

Content by: Ethan Frohna

Present: All

Goals: Expand on initial designs and learn more about necessary tools/softwares to achieve final design.

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 10/22/2020

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

Parker and Ethan have been able to divide the 200s into a separate team so they could divide up work and goals amongst themselves. They are specifically working on the hardware portion of this project while Parker and Ethan work together on software development and manipulating DICOM files for design use. The 200 members of the group are working diligently to expand on the initial designs. Meeting with Thatcher to clear things up has been extremely helpful and will allow us to plan ahead over the next few weeks

Summary of Weekly Team Member Design Accomplishments

- **Team**: Team met with Dr. Thatcher to answer crucial questions and get feedback on mechanical design.

- **Ethan** - Played around with Blender Software to see what sort of tasks the software can perform

- **Parker** - Working to obtain full rights to geomagic.

- **Amy** - Attended meeting with client, clarified many questions useful for improving the mechanical design. Played with Solidworks animation.

- **Justin**- Talked with Dr. Thatcher to gather more information on the specifications of the inclined plane, cleared misunderstandings about inclined plane

- **Sanam** - Met with Dr. Thatcher and team on Monday and got confirmation that the separate mechanical design may work the best. Also got many questions answered about what variables to focus on.

- **Sammie** - Attended meeting with Dr. Thatcher to discuss designs and clarify questions the team had.

Weekly/Ongoing Difficulties

Geomagic for Solidworks has been unattainable for the team at the moment as we are awaiting to hear back from a representative about pricing. In the meantime, we will begin to explore other softwares in case Geomagic for Solidworks is unattainable.

Upcoming Team and Individual Goals

- **Team**: Decide on the final design for the incline plane and the software- most likely GeoMagic. Start a fabrication plan.

- **Ethan** - Acquire or have Thatcher obtain the Geomagic for Solidworks License. There is a blender add-on where one can animate teeth movement, but needs to be purchased. We will work with Thatcher to see what is the best option to purchase.

- **Parker** - Isolating desired areas of mouth and editing angles/dimensions on Geomagic.

- **Amy** - Decide next steps with the mechanical team.
- **Justin**- Continue to update the website, continue researching incline plane specifications
- **Sanam**- Convey all information from Dr. Thatcher to Dr. Block at Friday meeting. Meet with the rest of the team to decide next steps.
- **Sammie** - Meet with Dr. Block and discuss meeting with Dr. Thatcher. Begin working on next steps for design with team.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20

Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All	100%	10/02/20
Preliminary Deliverables	10/7	All	100%	10/07/20
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	**Description**	**Manufacturer**	Part Number	Date	QTY	Cost	Total	Link

Conclusion:

Met with Dr. Thatcher to discuss two-piece design. Each team is starting their own fabrication

10/29 Progress Report 8

SANAM JHAVERI - Dec 08, 2020, 2:07 PM CST

Title: Progress Report 4

Date: 10/29/20

Content by: Ethan Frohna

Present: All

Goals: Create show-and-tell post and work with Blender to create tooth animation.

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 10/29/2020

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

Parker and Ethan have finally obtained Dental for Blender, a Blender software add-on that will allow us to edit the teeth model and possibly introduce and build a new model based on the DICOM scan of the dog head. Justin, Sanam, Amy, and Sammie have been working with Solidworks to edit the design of Dr. Thatcher's initial prototype. The Team is working on a Show and Tell Graphic so the team can receive feedback on their current design process.

Summary of Weekly Team Member Design Accomplishments

- **Team**: Team met with Dr. Thatcher to answer crucial questions and get feedback on mechanical design.

- **Ethan** - Obtained Blender for Dental from Dr. Thatcher, a Blender Add-on that can be used to edit stl meshes and animate certain aspects of of a model

- **Parker** - Working with the 200s on their stl file and working with Ethan.

- **Amy** - Working with SolidWorks to make an assembly of the inclined plane and jaw, working on manipulating the design.

- **Justin**- Worked on altering the stl file of the device in soldiworks

- **Sanam** - Imported the inclined plane and jaw model stl files into SolidWorks. Working on manipulating the version 2.0 incline plane design to fit our design of a separate piece.

- **Sammie** - Attended meeting with Dr. Thatcher to discuss designs and clarify questions the team had.

Weekly/Ongoing Difficulties

Geomagic for Solidworks has been unattainable for the team at the moment as we are awaiting to hear back from a representative about pricing. In the meantime, we will begin to explore other softwares in case Geomagic for Solidworks is unattainable.

Upcoming Team and Individual Goals

- **Team**: Decide on the final design for the incline plane and the software- most likely GeoMagic. Start a fabrication plan.

- **Ethan** - Work with Dental for Blender and finish watching the tutorial videos so we can edit the DICOM scan of the teeth and show how the teeth are supposed to move once integrated with the orthodontic device.

- **Parker** - Isolating desired areas of mouth and editing angles/dimensions on Blender.

- **Amy** - Create graphic for call to action post, work on post.

- **Justin**- Continue to update the website, continue researching incline plane specifications

- **Sanam**- Finish up show-and-tell post and continue working on creating the separate plane design from the 2.0 version model that Dr. Thatcher has made.

- **Sammie** - Meet with Dr. Block and discuss meeting with Dr. Thatcher. Begin working on next steps for design with team.

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20

Product Design Specifications First Draft	9/18	All	100%	9/18/20
Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All	100%	10/02/20
Preliminary Deliverables	10/7	All	100%	10/07/20
Obtain Dental for Blender	10/28			
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	**Description**	**Manufacturer**	Part Number	Date	QTY	Cost	Total	Link

Conclusion:

Finally obtained license to Blender.

11/05 Progress Report 9

SANAM JHAVERI - Dec 08, 2020, 2:09 PM CST

Title: Progress Report 4

Date: 11/05/20

Content by: Ethan Frohna

Present: All

Goals: Find a way to edit the stl file and create two piece design

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 10/22/2020

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

Parker and Ethan have met with Dr. Thatcher to discuss different parts of the Blender software and how they can be used to alter the sizing of the device. The 200's are working on editing the stl of the initial design so the bridge can be deleted and more edits can be made to the device.

Summary of Weekly Team Member Design Accomplishments

- **Team**: Team met with Dr. Thatcher to answer crucial questions and get feedback on mechanical design.

- **Ethan** - Used Blender to work on scaling and editing the size of the design. Also met with Dr. Thatcher to see what we could work on and what concerns he had.

- **Parker** -Research: scaling abilities in blender, dimension change abilities in blender, mesh mixer (new software).
- **Amy** - Working with SolidWorks to manipulate the device design.
- **Justin**- Helped team create show and tell post, also commented on one other group's post, continued editing in solidworks
- **Sanam** - Continuing to find a way to alter the original stl file into two pieces.
- **Sammie** - Worked with other 200's to continue altering stl file.

Weekly/Ongoing Difficulties

Parker and I met with Dr. Thatcher to discuss the method of using Blender to scale the design to fit a patient's jaw. He did have some concerns due to the variability of anatomy between different patients. This might have to force us to look at a simpler method or a way of using blender to perfectly match the design to whatever scan of the jaw that Dr. Thatcher has acquired.

Upcoming Team and Individual Goals

- **Team**: Decide on the final design for the incline plane and the software- most likely GeoMagic. Start a fabrication plan.
- **Ethan** - Use Blender for dental to edit the design made by the 200's
- **Parker** - Working with Ethan to make edits and hopefully sculpt current model to fit specific dogs.
- **Amy** - Continue work on the design, learn Solidworks stress testing
- **Justin**- Continue to update the website, continue solidworks editing
- **Sanam**- Continue working on creating the separate plane design from the 2.0 version model that Dr. Thatcher has made.
- **Sammie** - Continue manipulating stl file to reflect 2 piece design idea

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20

Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All	100%	10/02/20
Preliminary Deliverables	10/7	All	100%	10/07/20
Obtain Dental for Blender	10/28			
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	Description	Manufacturer	Part Number	Date	QTY	Cost	Total	Link
Blender for Dental	**An module add-on to the free Blender software**	**Blender for dental international**	**1**	**10/27/20**	**1**	**$79.00**	**$79.00**	**https://www.blenderfordental.com/**

Conclusion:

Use advice from show and tell to edit .stl file in MeshMixer

11/12 Progress Report 10

SANAM JHAVERI - Dec 08, 2020, 2:10 PM CST

Title: Progress Report 4

Date: 11/12/20

Content by: Ethan Frohna

Present: All

Goals: Combine 200s' work and 300s' work in Blender

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 11/12/2020

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

Parker and Ethan have met with Dr. Thatcher to discuss different parts of the Blender software and how they can be used to alter the sizing of the device. The 200's are working on editing the stl of the initial design so the bridge can be deleted and more edits can be made to the device.

Small Update- The 200 team was able to work on the device model and split up the design using MeshMixer, a 3D editing software.

Summary of Weekly Team Member Design Accomplishments

- **Team**: Team met with Dr. Thatcher to answer crucial questions and get feedback on mechanical design.

- **Ethan** - In the process of working with the 200's design stl on Blender and seeing what sort of scaling can be done on the software.

- **Parker** -Research: scaling abilities in blender, dimension change abilities in blender, mesh mixer (new software).

- **Amy** - Working in Meshmixer to manipulate design, importing into SolidWorks.

- **Justin**- Worked in meshmixer and was able to remove a chunk from the middle of the inclined plane

- **Sanam** - Downloaded Meshmixer. The 200s and I were able to make the necessary cuts to remove the middle bridge of the inclined plane.

- **Sammie** - Installed MeshMixer and cut the original design into 2 pieces.

Weekly/Ongoing Difficulties

Parker and I met with Dr. Thatcher to discuss the method of using Blender to scale the design to fit a patient's jaw. He did have some concerns due to the variability of anatomy between different patients. This might have to force us to look at a simpler method or a way of using blender to perfectly match the design to whatever scan of the jaw that Dr. Thatcher has acquired. The team hopes to print off the new design on a 3D printer within the next few weeks.

Upcoming Team and Individual Goals

- **Team**: Decide on the final design for the incline plane and the software- most likely GeoMagic. Start a fabrication plan.

- **Ethan** - Find ways to more efficiently make dimensions and scales on blender for specific parts of the design.

- **Parker** - Work with 200s and Ethan to print two pieces and then make edits on new dicom

- **Amy** - Figure out way to stress test in SolidWorks

- **Justin**- Continue to update the website, talk about dimensions of the new device

- **Sanam**- Continue working back and forth with the 300s to make sure the edited stl file fits with the jaw model in Blender.

- **Sammie** - Continue working in MeshMixer to edit original design into 2 piece design

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed
Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20
Design Matrix and Design Ideas	9/25	All	100%	9/24/20
Preliminary Presentations	10/2	All	100%	10/02/20
Preliminary Deliverables	10/7	All	100%	10/07/20
Obtain Dental for Blender	10/28			
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	Description	Manufacturer	Part Number	Date	QTY	Cost	Total	Link
Blender for Dental	**An module add-on to the free Blender software**	**Blender for dental international**	**1**	**10/27/20**	**1**	**$79.00**	**$79.00**	**https://www.blenderfordental.com/**

Conclusion:

Work with new two-piece stl file in Blender to attach to skull model.

11/19 Progress Report 11

SANAM JHAVERI - Dec 08, 2020, 2:11 PM CST

Title: Progress Report 4

Date: 11/19/20

Content by: Ethan Frohna

Present: All

Goals: 3D print the new two-piece device

Content:

Team Vets

Client: Graham Paul Thatcher

Advisor: Dr. Walter Block

Team: Parker Callender - pcallender@wisc.edu - Team Leader

Ethan Frohna - ejfrohna@wisc.edu - BSAC

Sanam Jhaveri - snjhaveri@wisc.edu - Communicator

Sammie Gilarde - gilarde@wisc.edu - Co-BPAG

Amy Cao - ahcao@wisc.edu - Co-BPAG

Justin Grudem- grudem@wisc.edu - Co-BWIG

Date: 11/19/2020

Problem Statement

The protocols for materialized software used upon orthodontic procedures in veterinary situations struggle to adapt to each patient specifically. Therefore, the team will attempt to design a new workflow that is adaptable to a wide range of dogs and cats.

Brief Status Update

Parker and Ethan have met with Dr. Thatcher to discuss different parts of the Blender software and how they can be used to alter the sizing of the device. The 200's are working on editing the stl of the initial design so the bridge can be deleted and more edits can be made to the device.

Small Update- The 200 team was able to work on the device model and split up the design using MeshMixer, a 3D editing software.

Summary of Weekly Team Member Design Accomplishments

- **Team**: Team met with Dr. Thatcher to answer crucial questions and get feedback on mechanical design.

- **Ethan** - tried working with the new stl design on blender with little success on scaling on dimensions. Working out a way to use solidworks or another software to add dimensions

- **Parker** -Research: scaling abilities in blender, dimension change abilities in blender, mesh mixer (new software). Used mesh mixer to sculpt and fix the design

- **Amy** - Working in Meshmixer to manipulate design, filling in holes in the mesh.

- **Justin**- Continued working in meshmixer to further manipulate the design, worked on dimensions

- **Sanam** - Continued to work with MeshMixer to see how the STL file can be edited for dimensions

- **Sammie** - Continued working on 2 piece design in MeshMixer.

Weekly/Ongoing Difficulties

Blender is able to scale individual parts of a model, but it is extremely difficult to scale the right part without interfering with matrices and receiving a distortion. Solidworks might be a good way to add dimensions to the part, but I do not know if it is possible considering the complex geometry of the stl.

Upcoming Team and Individual Goals

- **Team**: Decide on the final design for the incline plane and the software- most likely GeoMagic. Start a fabrication plan.

- **Ethan** - Find ways to more efficiently make dimensions and scales on blender for specific parts of the design, as well as perform mechanical testing using Solidworks

- **Parker** - Develop a method to add dimensions to the piece and assist in the mechanical testing of the piece

- **Amy** - Attempt dimensional analysis on the design.

- **Justin**- Work on testing in SolidWorks and keep updating website

- **Sanam**- Mechanical testing and figuring out how to change the dimensions of the STL file.

- **Sammie** - Work on changing dimensions of design and start thinking about testing

Project Timeline

Project Goal	Deadline	Team Assigned	Progress	Completed

Study Basics of Malocclusions	9/13	All	100%	9/13/20
Product Design Specifications First Draft	9/18	All	100%	9/18/20
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Preliminary Presentations	10/2	All	100%	10/02/20
Preliminary Deliverables	10/7	All	100%	10/07/20
Obtain Dental for Blender	10/28			
Show and Tell	10/30	All		
Poster Presentations	12/4	All		
Final Deliverables	12/9	All		

Expenses

N/A

Item	Description	Manufacturer	Part Number	Date	QTY	Cost	Total	Link
Blender for Dental	**An module add-on to the free Blender software**	**Blender for dental international**	**1**	**10/27/20**	**1**	**$79.00**	**$79.00**	**https://www.blenderfordental.com/**

Conclusion:

Contact Graham to 3D print the two-piece device.

Malocclusions in Dogs

ETHAN FROHNA - Sep 13, 2020, 6:50 PM CDT

Title: Malocclusions in Dogs

Date: 9/13/20

Content by: Ethan Frohna

Present: N/A

Goals: To learn specifically about the physiology of malocclusion and how it arises in veterinary patients

Content:

Malocclusion in Dogs

- Tooth to tissue contact is the most common problem that stems from malocclusions
    - Causes painful wounds and recurring health issues
- Certain breeds of dogs have a genetic susceptibility to different malocclusions
    - Many breeds have natural genetic deformities
- Treatment of occlusions depends on a variety of different factors
    - Type of malocclusion
    - Genetic or acquired over time
    - Pets overall health status
- Extraction of teeth, performing endodontic therapy, and using orthodontics are all treatments for malocclusion
- Class II malocclusion (Mandibular Distoclusion)
    - Lower jaw or mandible is too short
    - Mostly a genetic skeletal deformity
- Lower teeth protrude into the upper palate

https://www.sacvds.com/forms/malocclusions-orthodontic-treatment.pdf

Conclusions/action items:

Team Vets' client, Dr. Thatcher, gave the team a great deal of information about what he is trying to fix about class 2 malocclusions. The lower two teeth of a dogs jaw have a tendency to puncture the roof of the mouth due to a class II malocclusion. The teeth need to be pushed back towards the outside of the mouth to reduce further injury, which takes roughly 6-8 weeks. A device will need to be created that fixes this issue.

Torque in Teeth

ETHAN FROHNA - Sep 21, 2020, 9:59 PM CDT

Title: Torque in Teeth

Date: 9/21

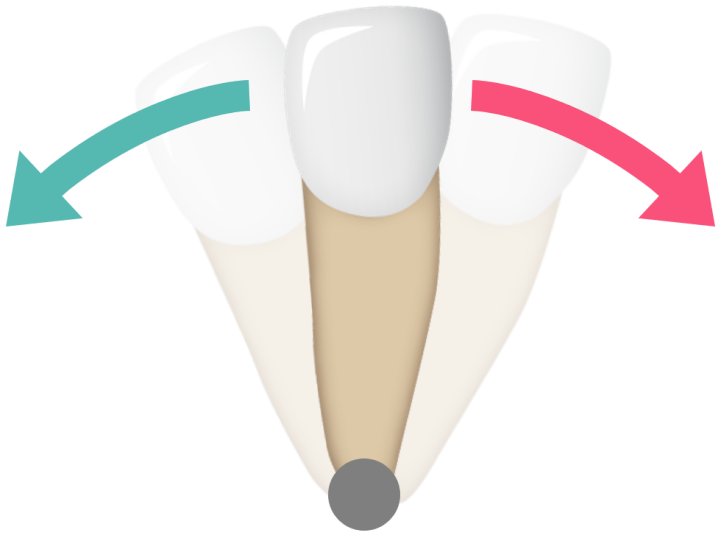
Content by: Ethan Frohna

Present: N/A

Goals: To learn about what type of movement occurs when a tooth like the bottom canines needs to be moved with an orthodontic device

Content:

- The definition of torque refers to the twisting of a structure along its longitudinal axis
    - Shear movement that causes rotation
    - In orthodontics, torque is defined as the x-axis of the tooth following the curve of a dental arch
- An orthodontic device may try to cause toruqe on a tooth by causing an axial moment
- A sagittal movement of the teeth would be used to return the teeth back to a normal occlusion
- Magnitude of torsion depends on a variety of factors
    - Strength of brace that causes a moment
    - Bracket placement
    - Degree of torque rotation that needs to happen about the longitudinal axis



https://meridian.allenpress.com/angle-orthodontist/article/80/1/201/58936/Torque-Expression-in-Stainless-Steel-Orthodontic

Conclusions/action items:

Using engineering terms to define biomechanical movements is extremely important when creating any medical device. Mechanical tests can be completed to see if the final device that is created in this project is capable of providing enough torque to be

Dr. Thatchers Design

ETHAN FROHNA - Oct 07, 2020, 11:28 AM CDT

Title: Dr. Thatchers Design

Date: 10/7/20

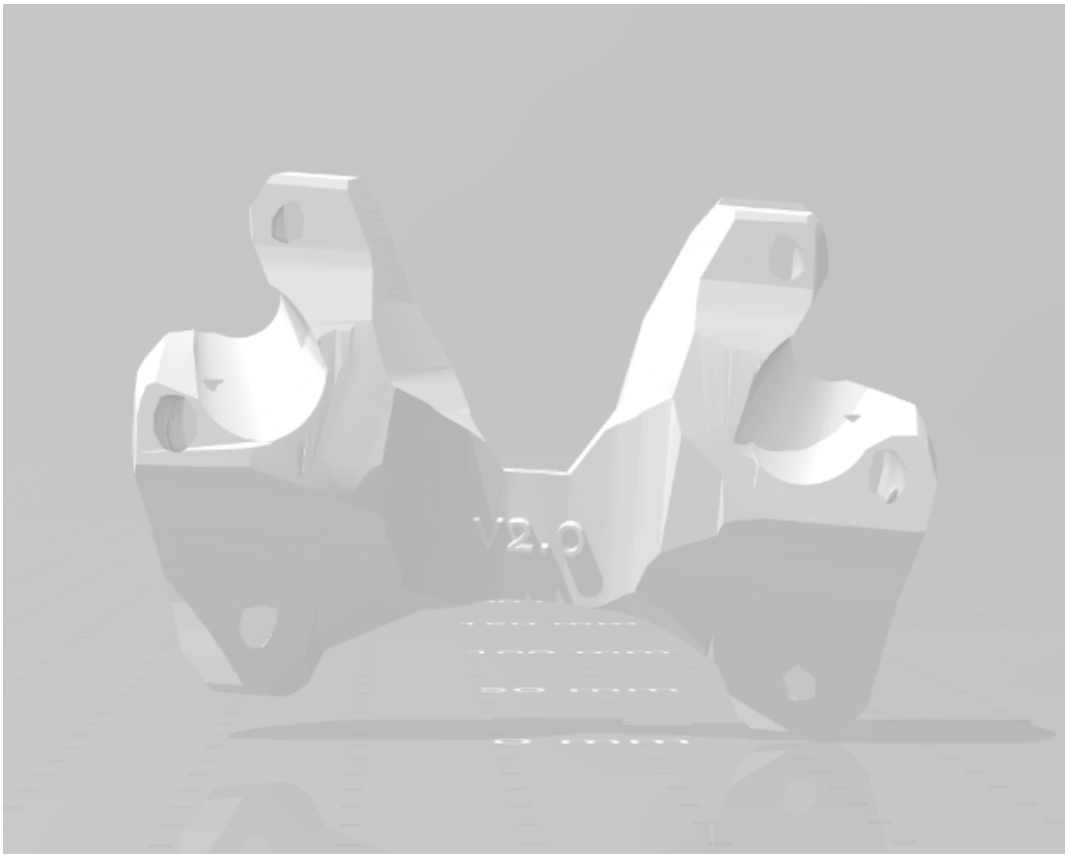
Content by: Ethan Frohna

Present: N/A

Goals: To explain the concept of Dr. Thatcher's design and how it was used to create different design concepts.

Content:

The client, Dr. Thatcher, has used the help of a software engineer to create several versions of an orthodontic brace meant to push the lower canines back to a normal occlusion. This picture below is an stl file of the second version of this design. While this design has worked successfully in the past with other clients, Dr. Thatcher did say that the team could explore new designs that eliminated some of the problems that the initial design. The team devised three different designs and ended up moving forward with a separate brace design. This design builds off of Dr. Thatchers, but instead of a bridge connecting the two sides of the brace together, each side is a separate brace. In Dr. Thatcher's initial client runs, he was having issues with the tissue of the upper jaw being inflamed from being in contact with the bridge of the brace. The new separate piece design eliminates this issue while still applying the same mechanical properties that the initial design has.



Conclusions/action items:

Using Dr. Thatchers first design helped the team derive a brand new design that eliminated some previous issues.

What is a Malocclusion?

ETHAN FROHNA - Sep 13, 2020, 6:42 PM CDT

Title: What is a Malocclusion?

Date: 9/8/20

Content by: Ethan Frohhna

Present: N/A

Goals: To learn about what type of medical ailment we will be addressing in this project. Malocclusions, how it develops in dogs, and what is being done to address malocclusions are all going to be researched to figure out our initial designs for our client.

Content:

What is Malocclusion?
https://www.uofmhealth.org/health-library/tn1000

- In simple terms, a malocclusion is crooked teeth
    - The upper and lower teeth are not lined up with each other, known as a “poor bite”
- Malocclusion is cosmetic but can affect speech and eating if severe
    - Mostly caused by growing development in jaw
    - In humans, can be caused by early developmental tendencies such as thumb sucking and tooth loss
- There are many different types of malocclusions
    - Underbites and overbites

https://www.uofmhealth.org/health-library/tn1000

- An example of a jaw without malocclusion is one where the upper teeth fit slightly over the bottom teeth
    - Points of the molars should fit grooves of other molars
- Malocclusion is mostly heredity and can be passed down in generations
    - Facial and cranial injuries are also a cause of malocclusions as they can cause a misalignment of the jaw bones
- Causes overcrowding and possibly debilitating bite patterns
- 3 different types of malocclusion
    - Class 1:Bite is normal but the upper teeth overlap the lower teeth
    - Class 2: Upper jaw severely overlaps the lower jaw (Overbite)
    - Class 3: Lower jaw protrudes forward and overlaps the upper jaw

https://medlineplus.gov/ency/article/001058.htm

Malocclusion in Dogs

- Tooth to tissue contact is the most common problem that stems from malocclusions
    - Causes painful wounds and recurring health issues
- Certain breeds of dogs have a genetic susceptibility to different malocclusions
    - Many breeds have natural genetic deformities
- Treatment of occlusions depends on a variety of different factors
    - Type of malocclusion
    - Genetic or acquired over time
    - Pets overall health status
- Extraction of teeth, performing endodontic therapy, and using orthodontics are all treatments for malocclusion
- Class II malocclusion (Mandibular Distoclusion)
    - Lower jaw or mandible is too short
    - Mostly a genetic skeletal deformity
- Lower teeth protrude into the upper palate

https://www.sacvds.com/forms/malocclusions-orthodontic-treatment.pdf

Conclusions/action items:

Malocclusions are a very common type of deformity found in the jaws and teeth of dogs. Our client, Dr. Thatcher, wants us to create a smooth workflow and aid in the creation of a device that will assist with a class 2 malocclusion. This type of malocclusion is most commonly referred to as

an overbite and causes the lower two canines to puncture the upper part of the jaw. Based on the research conducted, malocclusions can affect patient comfort and can even cause long term injury, so creating a device that will be able to revert the two bottom canines to their original position will help greatly with all types of veterinary patients

How to treat Malocclusions

ETHAN FROHNA - Sep 13, 2020, 7:37 PM CDT

Title: How to Treat Malocclusions

Date: 9/13/20

Content by: Ethan Frohna

Present: N/A

Goals: To learn about treatment options that may help our team come up with designs to treat this type of malocclusions

Content:

Treatment of Malocclusions

- Removal of certain teeth is taken into consideration
    - Extraction of the mandibular canine teeth is common, but with this project, the goal is to figure out way to push these teeth off to the side
- Strategically placed crown extensions can be inserted by a veterinary doctor
    - These crown extensions cause the canines to move back to a more suitable position
    - Can take longer than a direct surgical procedure but no teeth need to be removed
- A retention period is needed after orthodontic treatment is done to prevent repetitive movement of the canines
- Inclined planes are a passive force metho of moving mandibular canines
    - Made of composite-based orthodontic materials such as bisacryl composite
- Crown extensions are a new common way to decrease injury within the mouth
    - These extensions are placed on the upper teeth and "guide" the lower canines away from the upper jaw over time

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563895/

Conclusions/action items:

There are several different treatment options with varying levels of intrusiveness when it comes to dealing with malocclusions. However, the treatments that seem less invasive are the inclined planes and crown extensions that slowly move the teeth back to a normal occlusion over time, which is similar to the way the client is currently handling their patients.

Preliminary Design Idea

ETHAN FROHNA - Sep 23, 2020, 11:36 PM CDT

Title: Preliminary Desgin

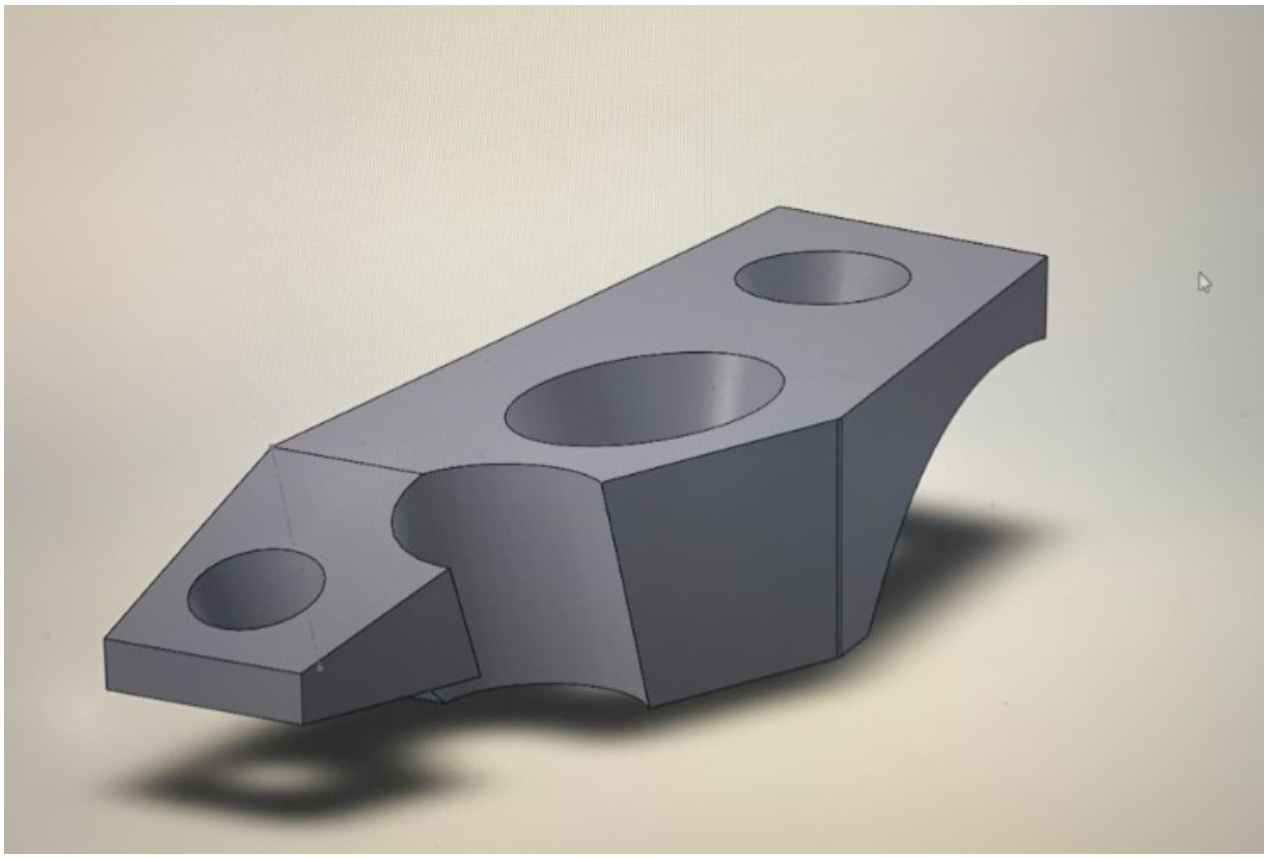
Date: 9/23/20

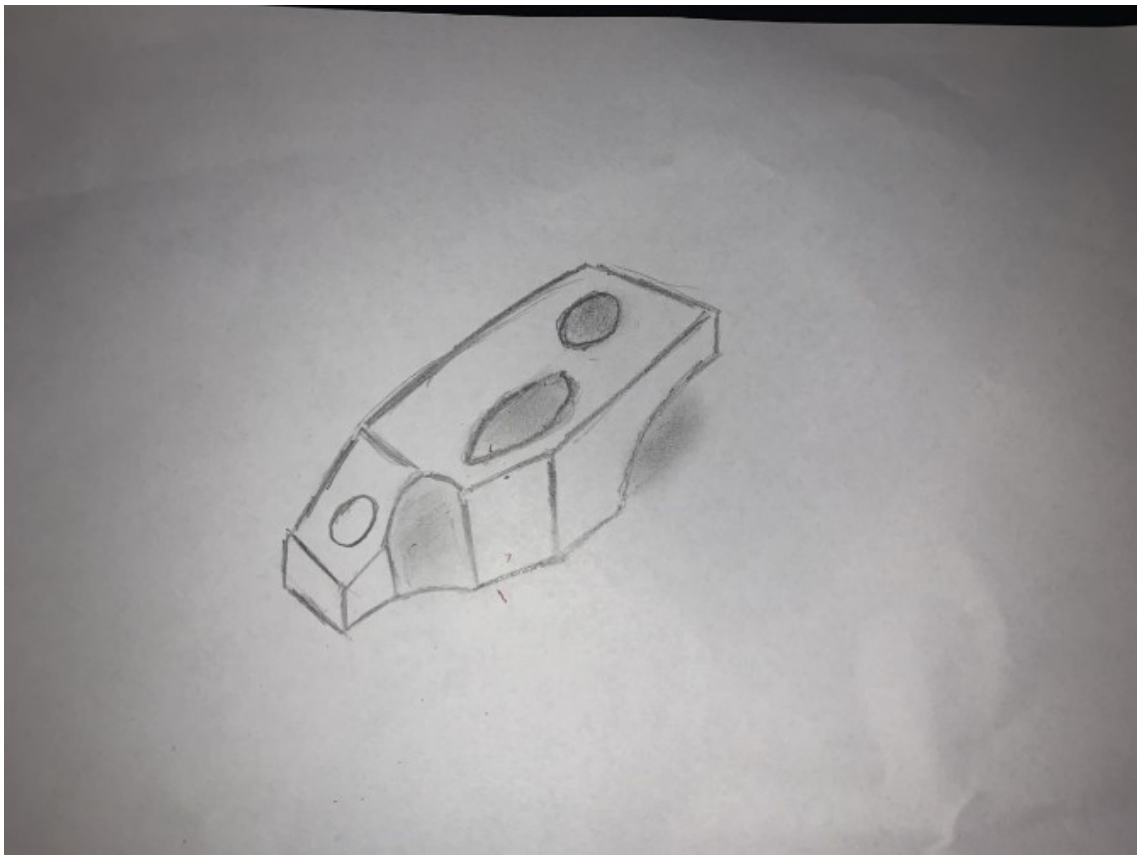
Content by: Ethan Frohna

Present: N/A

Goals: To create an initial design that builds upon the design of Dr. Thatcher.

Content:





Above is the first Initial Design for the orthodontic device. The design is similar to Dr. Thatchers' original model, but there is no bridge that connects two pieces to both sides of the upper jaw. Instead, this design featured two individual pieces that individually move the lower canines into the correct position.

Conclusions/action items:

Preliminary Report Designs and Matrices

ETHAN FROHNA - Oct 05, 2020, 12:12 PM CDT

Title: Preliminary Report Designs and Matrices

Date: 10/5/20

Content by: Ethan Frohna

Present: N/A

Goals: The purpose of the design matrices is to weigh each of the preliminary designs against each other and see which one has the best attributes

Content:

Design Criteria	Design One: Adjustable Bridge 	Design Two: Separate 	Design Three: Rubber Inclined Plane 
Effectiveness (30)	25	20	25
Adaptability (20)	15	20	15
Ease of Manufacturing (15)	5	15	10
Durability (15)	10	15	5
Safety (10)	5	5	10
Cost (10)	10	10	10
Total(100)	70	85	75

The first design is called the adjustable bridge design. Similar to Dr. Thatcher's original design, this brace has a bridge in the middle connecting the two parts together, but this iteration has an extendable bridge in the middle made out of a separate material. The second design also builds off of Thatcher's but instead of a bridge connecting the two parts together, the braces are split up into two individual symmetric pieces. The pieces go on each side of the mouth and reduce the amount of upper jaw tissue inflammation that occurred in the initial bridge design. The third design is similar to Thatchers but instead of using dental LT as the base resin, the brace is made out of rubber-like 3D printed material. Either Nylon or PLA has been chosen as the base material for this design.

Conclusions/action items:

By weighing each other the designs against certain criteria, it has been chosen that the group will move forward with the design of the separate pieces. This design features the most adaptability out of all the categories, and decreases the need to heal the upper roof of the mouth, which was an issue in Dr. Thatcher's initial client trials.

Geomagic for Solidworks

ETHAN FROHNA - Sep 29, 2020, 10:12 PM CDT

Title: Geomagic for Solidworks

Date: 9/27/20

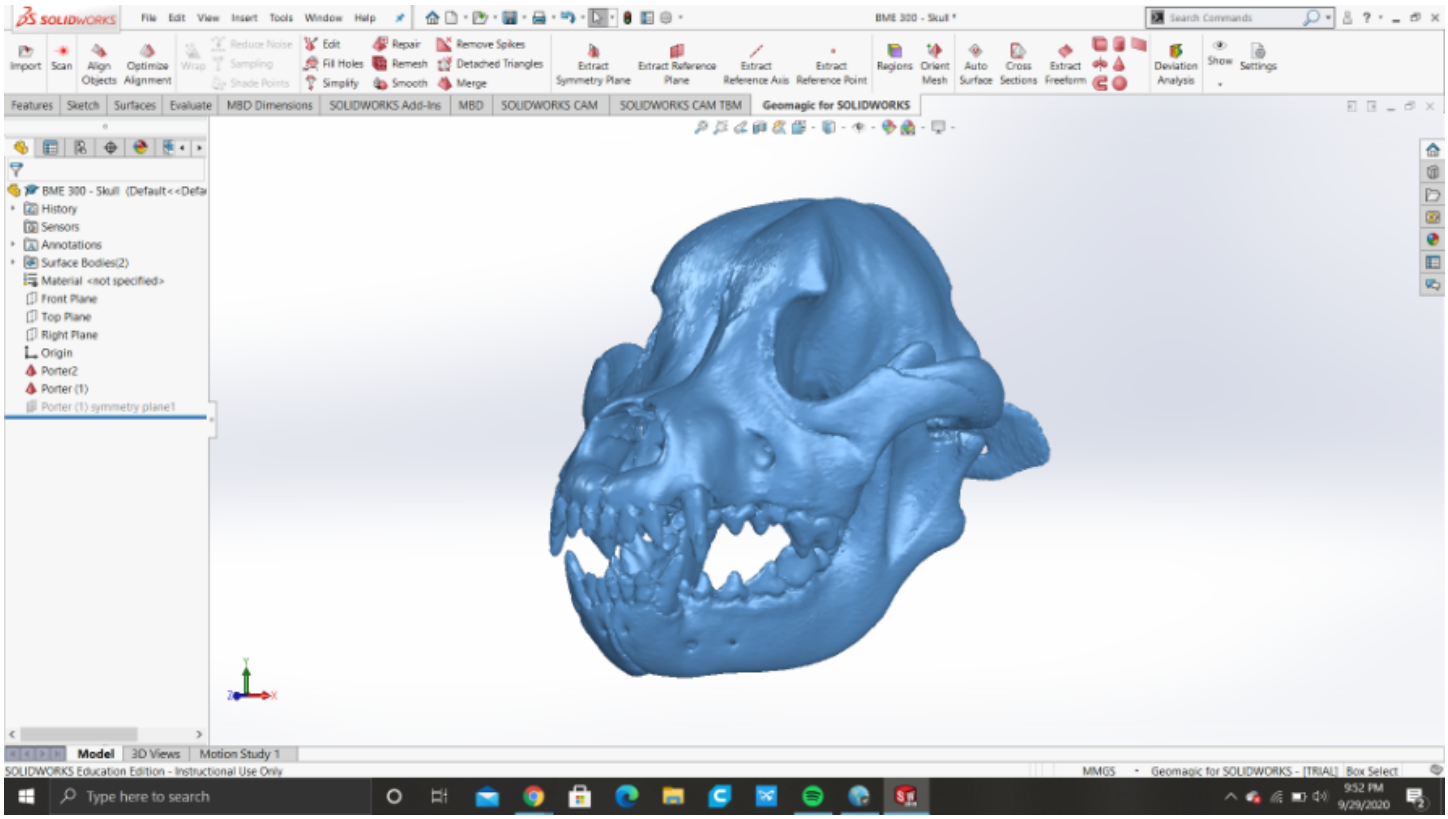
Content by: Ethan Frohna

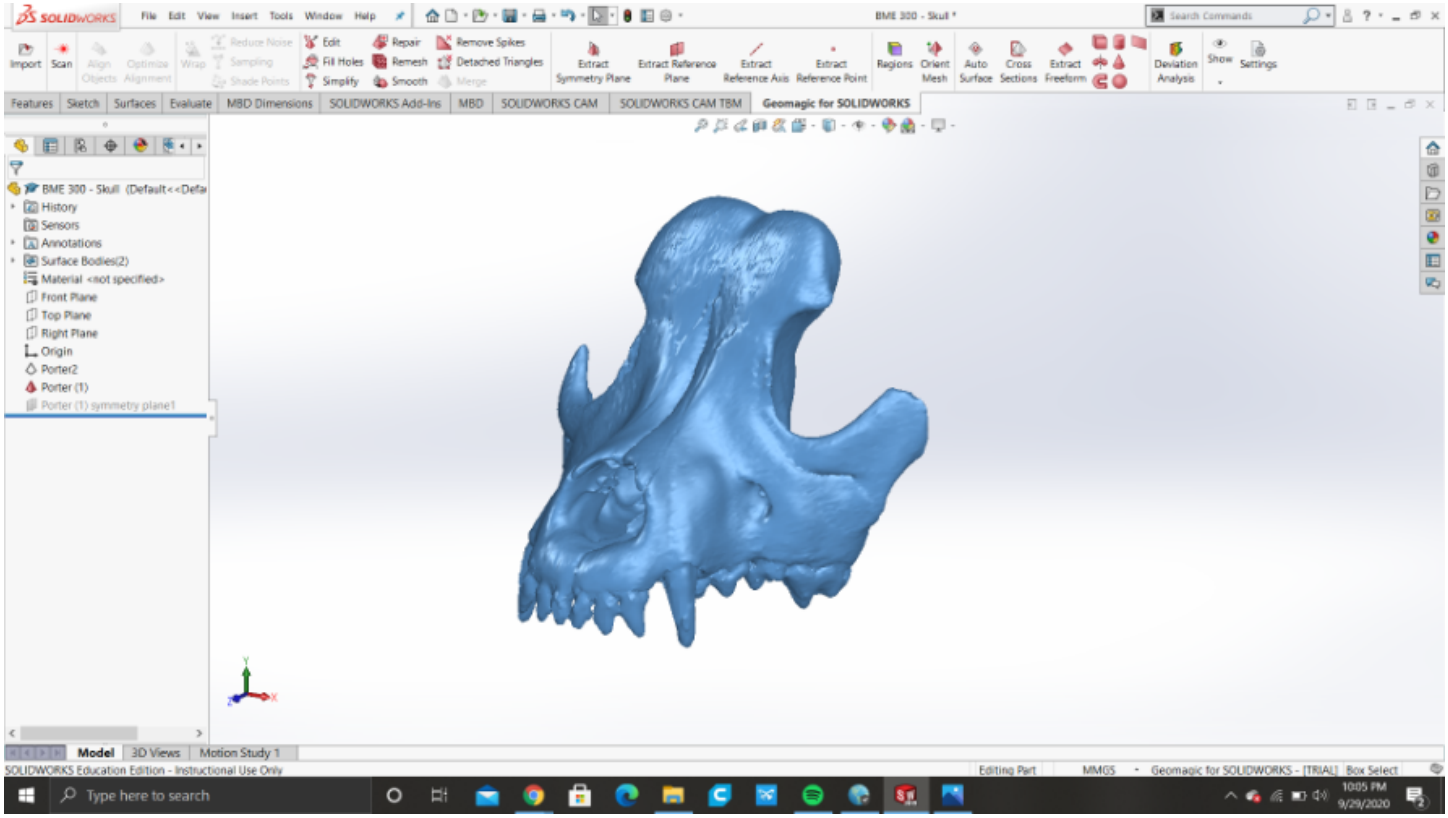
Present: N/A

Goals: To learn how to use Geomagic for SolidWorks and see if it can help make the workflow for creating orthodontic devices easier.

Content:

Geomagic for Solidworks is an add on to the SolidWorks design software that makes 3D scanning and modeling easier to utilize. Through this software, the DICOM model for the dog skull was easily imported into the SolidWorks part editor. It is very easy to window off particular sections of the model, as seen below. Since this scab can be integrated into the assembly tab of SolidWorks, matching specific parts of the original stl file for the orthodontic device could be extremely simple. There are options for remeshing parts of the scan and symmetry planes that can be inserted for smoother modeling. The second picture shows the model after being spliced, showing the only part of the model that will be worked on during the process.





Conclusions/action items:

Geomagic will enable the team to perform easy SolidWorks manipulation to make the workflow for Dr. thatcher as simple as it can be. The software makes use of SolidWorks and makes the modeling simple to manipulate and integrate with other pieces. Hopefully the team will be able to extend the free trial on this software and use it for the rest of the semester.

3D Slicer

ETHAN FROHNA - Sep 29, 2020, 10:31 PM CDT

Title: 3D Slicer

Date: 9/29/20

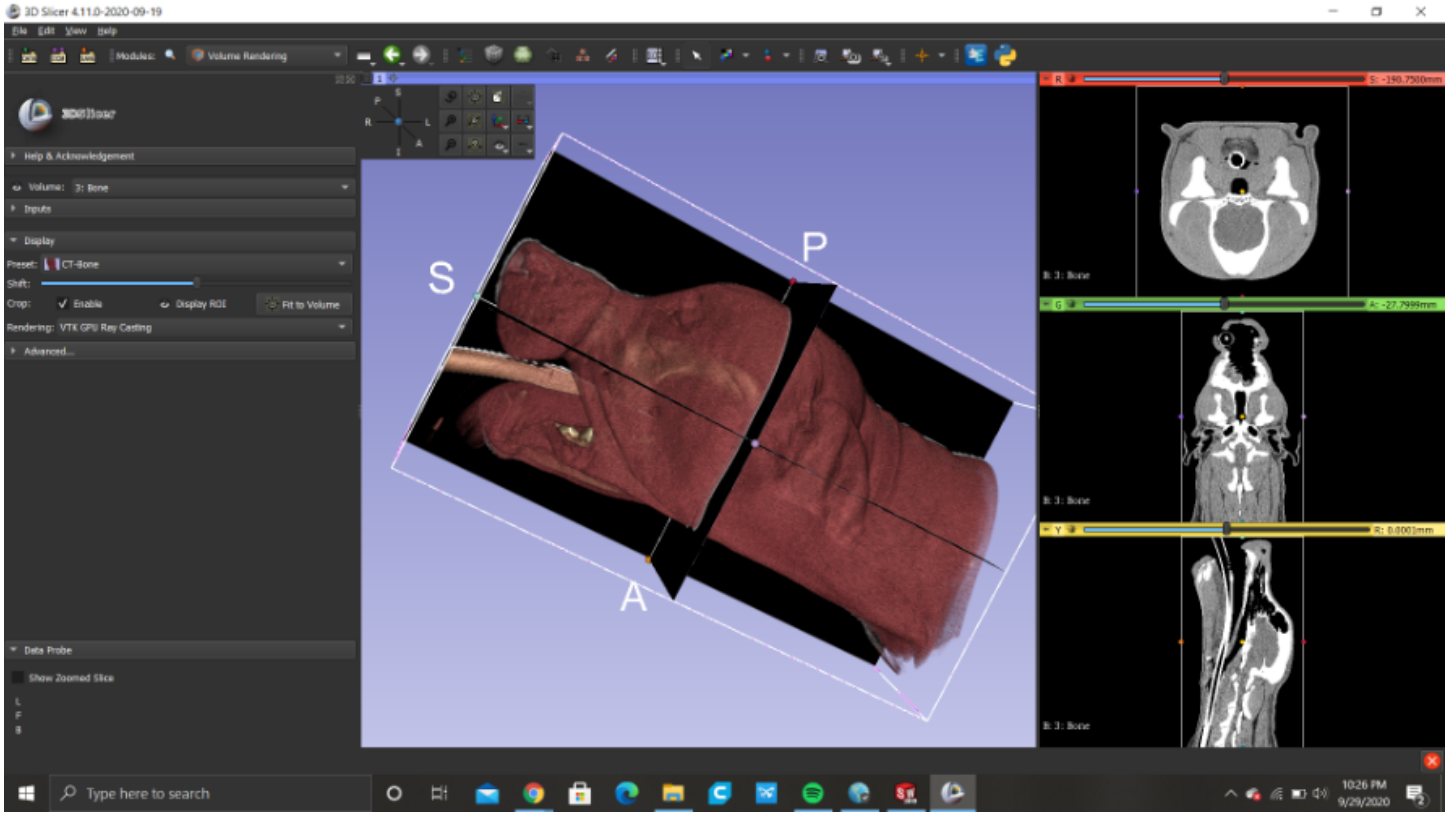
Content by: Ethan Frohna

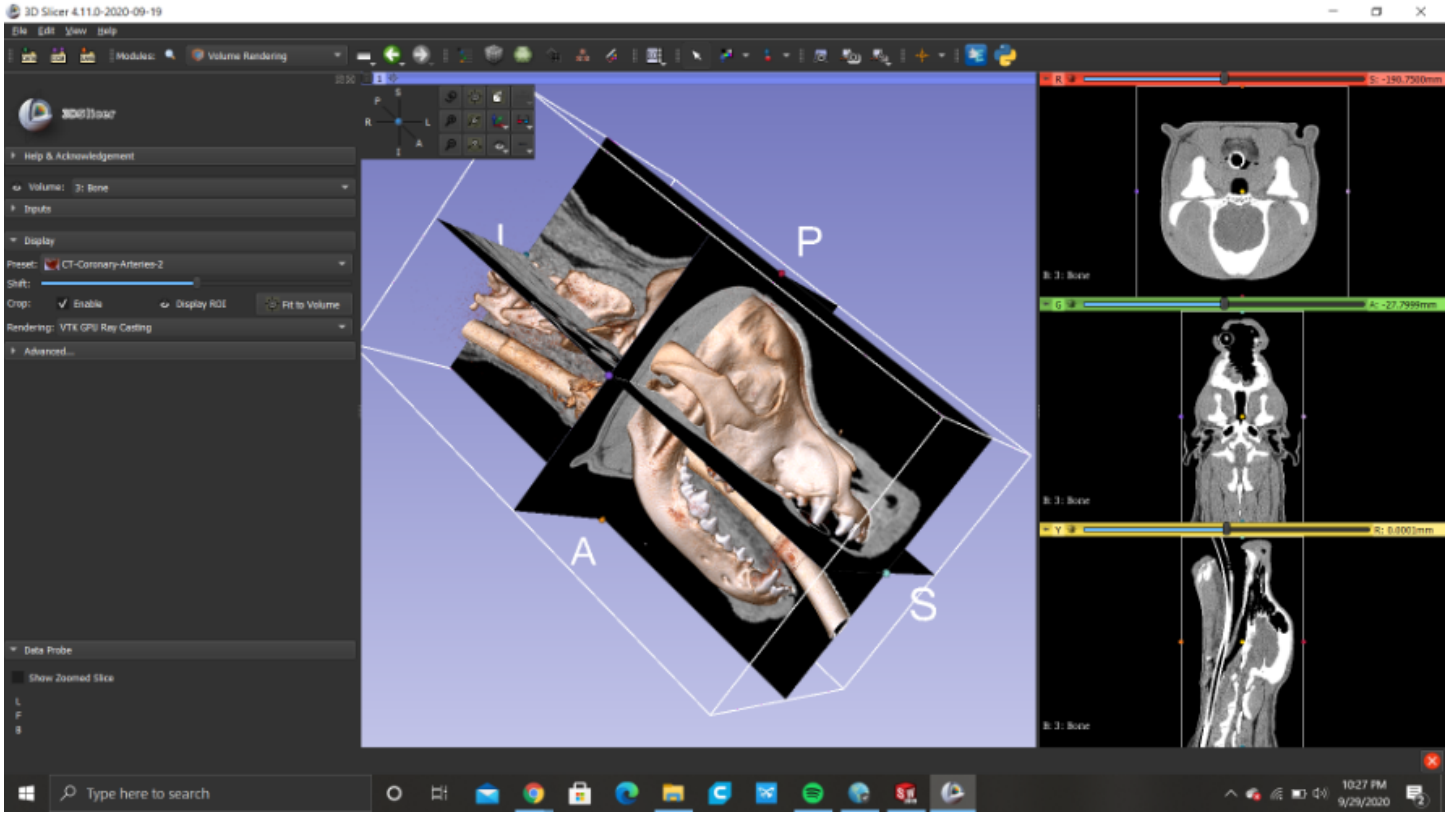
Present: N/A

Goals: To learn the basics of 3D slicer and how it can be used to view a DICOM file

Content:

3D slicer is a free software that is mainly meant to view DICOM and CT scan files only. One can render the scan into a 3-dimensional layout that allows you see to the different layers of tissue, bone, and other organic material. ANgle measurements can be taken that could be helpful to seeing how far the angle of torque needs to be on teeth, but this software is mainly just used for visual use. The first picture is a view of the scan that shows the surrounding skin while the second photo shows the main skeletal structure of the dog.





Conclusions/action items:

3D slicer is useful for viewing certain DICOM files, but does not give the team to same range of ability that Geomagic for Solidworks can give us in terms of manipulating models.

Blender for Dental

ETHAN FROHNA - Nov 01, 2020, 1:08 PM CST

Title: Blender for Dental

Date: 11/1/20

Content by: Ethan Frohna

Present: N/A

Goals: To describe the processes and learning that went into the Blender Software

Content:

The link below details the steps to download the Module designer add-on for blender. The link also gives great tutorial videos that have been instrumental in learning the Blender software and how to edit parts of a scan or model.

https://www.blenderfordental.com/modeldesigner28pc

Conclusions/action items:

The Blender for Dental software is going to be instrumental for simplifying the workflow for the client, Dr. Thatcher. These basic tutorials have enabled the team and Dr. Thatcher to edit the orthodontic brace design using the scaling and editing features found on the Blender Software.

11/13/20 - Tong Entrepreneurship Lecture

ETHAN FROHNA - Nov 13, 2020, 12:52 PM CST

Title: Tong Entrepreneurship Lecture

Date: 11/13/20

Content by: Ethan Frohna

Present: N/A

Goals: To learn about entrepreneurship in the biomedical engineering space

Content:

- Started company that sold computer parts
- Need to have an international focus when feeling with healthcare and business
    - Think outside borders
- Globalization is a key factor in biomedical devices
- What is entrepreneurship?
    - Always take financial risk into consideration
    - Profit for the right reasons
    - Need to like the lifestyle of owning a business
        - More work and time put into it, but you get to make your own time and hours
- Original Thinker
    - Have an ability to think outside of the box and to see how things will turn out down the road.
- MBA is a great option that gives you the right education to run a company
- Understand how far you want to take your company
- Risk tolerance is an important part of business
- Knowing when to pull the plug on a business is important as it can save you a lot of hardship
- Oxygenated blood pump for the heart
    - Takes away from some of the load of the lungs and the hearts so it can take pressure off of the body
    - Makes surface biocompatible
    - Electrical part and software that helps run the pump
    - Multi-disciplinary projects
- Know your regulatory
- Know your funding options
- Hardware
- Know your market
- Go global
- Raising money is an art, not necessarily a science
- Buy the best advice you can afford
    - Corporate set up
    - IP
    - Regulatory
    - Selling
- Know the strings that come with funding
- Know the strings that come with funding
- Know your partners
- Find out what side of the business you enjoy
-

Conclusions/action items:

2020/08/17-Occlusion Comparison of Teeth

PARKER CALLENDER - Dec 08, 2020, 10:04 PM CST

Title: Occlusion Comparison of Teeth

Date: 08/17

Content by: Parker Callender

Present:

Goals: Understanding the condition of the dog that results in the necessary surgery.

Content:

each patient is different in their diagnosis; therefore, you need to be able to scan their skull first in order to make something that will work for that patient in particular

from their, the scans can be altered and re-evaluated the symmetry and maxillomandibular relationship

*maxillomandibula: a surgery done to advance the jaw and expand the airway of the patient

Normal Occlusion: describing how the jaw and teeth should be aligned – “the maxillary and mandibular premolars should appear as interdigitation with the maxillary premolars occluding distal to the mandibular counterpart”

Picture Evidence of the difference:

Not normal:

Conclusions/action items: The orientation of the teeth is a tilt to the outside so that the jaw can fold symmetry and correctly, avoiding injury to the gums and bones.

Connection to Greater Significance: The greater significance beyond this project is the patient or dog. Dogs suffer from misalignment frequently, making it difficult to chew and keep gums and mouth sterile.

Resources: Thatcher, Graham. “Diagnosis and management of Class II malocclusion.” *The Canadian veterinary journal = La revue veterinaire canadienne* vol. 60,7 (2019): 791-795.

2020/08/15-OsiriX

PARKER CALLENDER - Sep 17, 2020, 9:18 AM CDT

Title: Introduction to Using OrisiX

Date: 08/14

Content by: Parker Callender

Present:

Goals: Trying to understand how to upload a dicom file and alter it.

Content:

generating 3D models using Osirix

Import a DICOM file or folder

Viewer on the top window allows you to scan across between bone and tissue

Top horizontal sliding scale allows for cross sectioning through the body

Grow Region (2D/3D Segmentation)

Algorithm either lower threshold or higher in order to determine what is bone and what is not

Then, you can re-slice the image, creating an image that is primarily bone.

Can also select sections and change threshold in order to find the part that is bone.

Setting Pixel values to a specific value

In settings tab can select 3D Volume Rendering

Can use scissor icon to slice parts of the image

Questions for team to ask?

what pixels?

what threshold?

what section to cut?

Conclusions/action items: The conclusion is, using this software, one can convert to an stl file.

Greater Significance: The greater significance is using this software in order to figure out the information that the orthodontist needs in order to make the piece for the dog's mouth.

Resources: https://www.youtube.com/watch?v=WMDG_BL65kw

09/20 Osirix

PARKER CALLENDER - Sep 30, 2020, 1:09 PM CDT

PARKER CALLENDER - Sep 30, 2020, 1:16 PM CDT

Title: Osirix Application

Date: 09/20

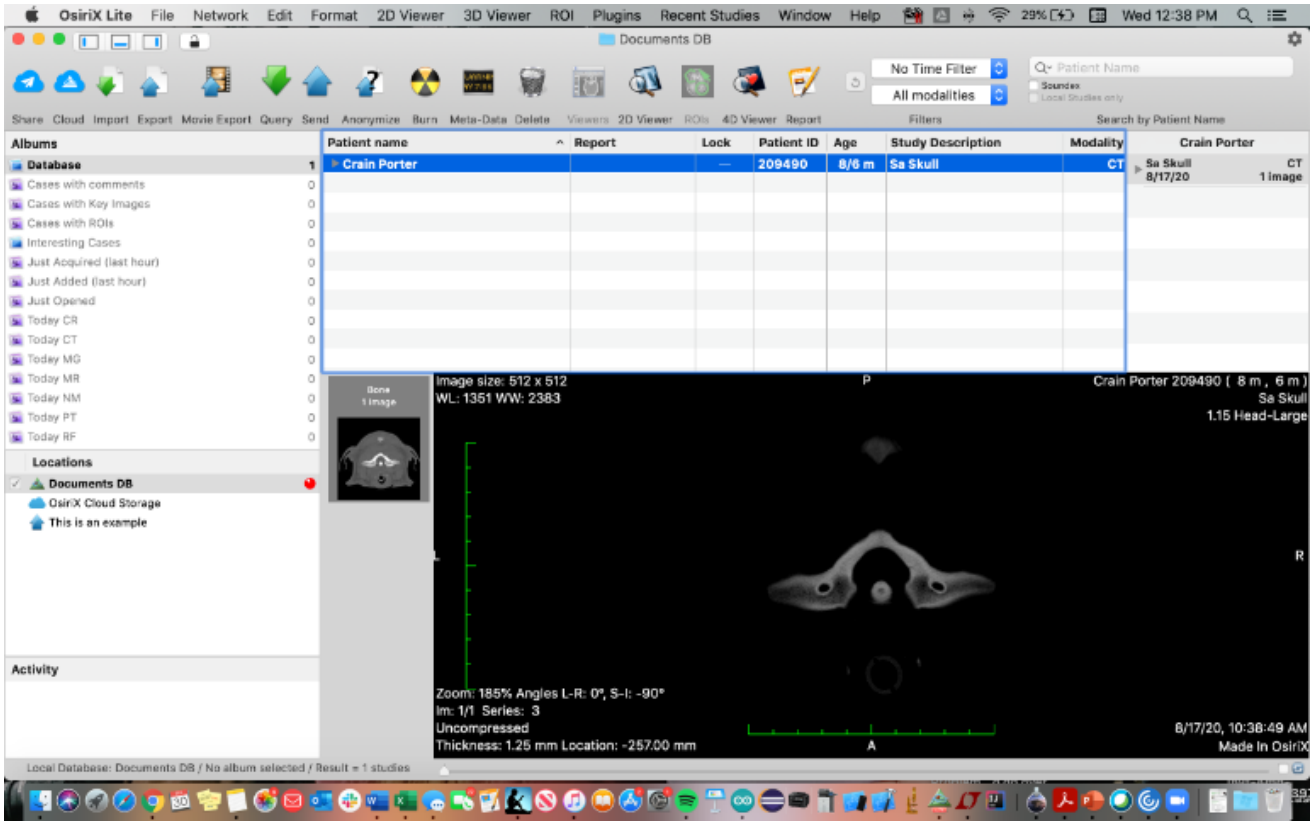
Content by: Parker Callender

Present:

Goals: Understanding the advantages and disadvantages of using Osirix.

Content:

This is the content that was gathered when using Osirix.



Advantages: can alter the program to change pixels, thresholds.

Disadvantages: uploading to an stl file is difficult and has many complications of what will be transferred over.

Conclusions/action items: Checking this workflow in comparison to other available software that are available.

Connection to Greater Significance: The greater significance beyond this project is the patient or dog. Dogs suffer from misalignment frequently, making it difficult to chew and keep gums and mouth sterile.

Resources:

2020/11/05 – Mesh Mixer

PARKER CALLENDER - Nov 05, 2020, 8:52 PM CST

Title: Mesh Mixer

Date: 11/05/2020

Content by: Parker

Present:

Goals: To understand the uses of mesh mixer and what it can be used for.

Content:

Team issue: The team wants to be able to adapt and change the model of the inclined piece that will go into the dog's mouth.

Blender does not seem to be able to change the already used model piece, but the software only allows for changes in spatial dimensions not specific to the piece.

Teams goal: The goal is to be able to find software that will be able to sculpt and edit the piece that is being used.

The idea is that the mesh mixer will be able to change the dimensions – have been used for prosthetics and other health projects in the past.

Conclusions/action items:

Use mesh mixer to be able to alter the model piece for a specific incline plane.

Resources:

https://www.meshmixer.com/health.html

Preliminary Research- Justin Grudem

JUSTIN GRUDEM - Dec 08, 2020, 10:11 PM CST

Title: Preliminary Research

Date: 8/18

Content by: Justin Grudem

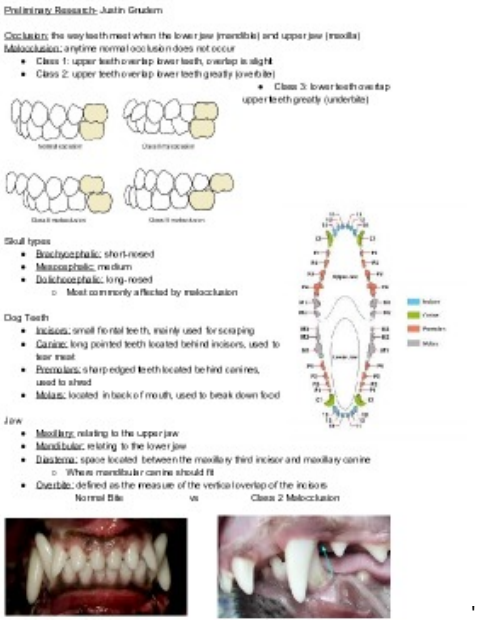
Present: N/A

Goals: To develop a thorough understanding of the problem our project is attempting to solve

Content: See below

Conclusion: I learned about class II malocclusions in dogs and how it affects them.

JUSTIN GRUDEM - Dec 08, 2020, 10:12 PM CST



Justin-_Preliminary_Research.pdf(206.1 KB) - download

Design Brainstorming

JUSTIN GRUDEM - Dec 08, 2020, 10:14 PM CST

Title: Original Design Ideas

Date: 09/7

Content by: Justin Grudem

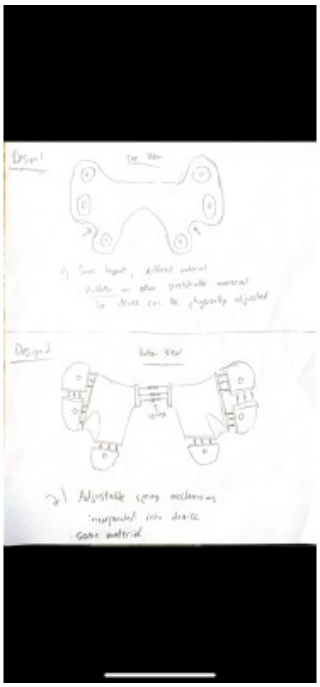
Present: N/A

Goals: Brainstorm ideas on how to improve the current inclined plane

Content: See below

Conclusion: I was able to generate 2 potential designs for a modified inclined plane

JUSTIN GRUDEM - Dec 08, 2020, 10:14 PM CST



DesignIdeas.pdf(1.6 MB) - download

3D printing process

JUSTIN GRUDEM - Dec 08, 2020, 10:20 PM CST

Title: 3D printing of inclined plane

Date: 11/24

Content by: Justin Grudem

Present: N/A

Goals: Successfully 3D print the inclined plane device

Content:

Things I learned from the 3D printing process:

1) How to use the slicing software Cura

a) Manipulating the device to minimize the support bodies needed to print

b) Generating proper support bodies

c) Transferring files to and from different devices

2) How to use a 3D printer

a) Choosing the correct thickness to print with based on the object being printed

b) Operating a 3D printer

Conclusion:

Through the 3D printing process, I gained more knowledge on how to correctly manipulate objects and generate support structures at the correct location in Cura. I also learned how to operate a 3D printer and developed a better understanding of how this process works.

JUSTIN GRUDEM - Dec 08, 2020, 10:21 PM CST

IMG_1500_2.HEIC(819.9 KB) - download

JUSTIN GRUDEM - Dec 08, 2020, 10:21 PM CST

IMG_1499_2.HEIC(924 KB) - download

Meshmixer

JUSTIN GRUDEM - Dec 08, 2020, 10:24 PM CST

Title: Meshmixer Learning

Date: 10/25

Content by: Justin Grudem

Present:

Goals: To learn how to use meshmixer

Content: See below

Conclusion:

I was able to make 2 individual cuts within the inclined plane, removing the bridge of the device.

JUSTIN GRUDEM - Dec 08, 2020, 10:25 PM CST

Screen_Shot_2020-12-08_at_10.25.10_PM.png(723.7 KB) - download

9/9 Project Overview and Malocclusion Info

SANAM JHAVERI - Sep 09, 2020, 2:32 PM CDT

Title: Project Overview and Malocclusion Info

Date: 9/9

Content by: Sanam Jhaveri

Present:

Goals: To understand the basis behind the BME design project. To learn about what Malocclusion exactly is and the current available treatments.

Content:

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

https://bmedesign.engr.wisc.edu/projects/f20/incline_plane

https://bmedesign.engr.wisc.edu/selection/projects/4bb7ce39-97cd-46a2-ba90-7ff1b8cf051d

Definitions of Medical terms:

Malocclusion

→ incorrect or misalignment of the jaw

→ many different types each regarding different teeth within a dog/cat's mouth

→ https://veterinarydentistry.net/defining-dental-malocclusions-dogs/

Class 2 Malocclusion

→ Mandibular Distoclusion

→ Lower jaw sits too distal (caudal) in relation to its normal alignment with the maxilla

→ Overbite

Occlusion

→ Alignment of the lower jaw and the upper jaw

→ How the teeth align/sit together

Mandible/Mandibular

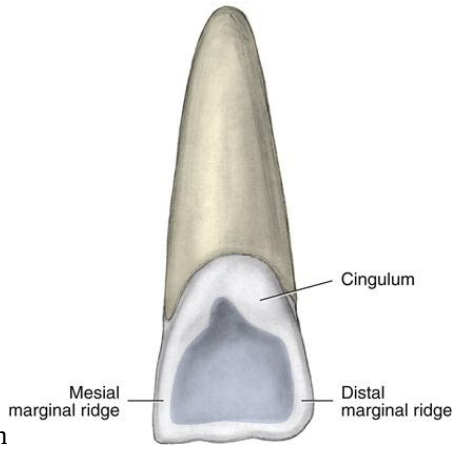
→ Refers to lower jaw

Maxillary/Maxillo-/Maxilla

→ Refers to upper jaw

Anisognathic jaws

→ maxillae are wider and longer in relation to the mandibles



Cingulum → a part of the tooth

Occluding

→ come in contact with

Distal

→ towards back side

→ back side of tooth

Buccal

→ cheek-side

Distocclusion (Mandibular)

→ Lower teeth are distal to the upper teeth

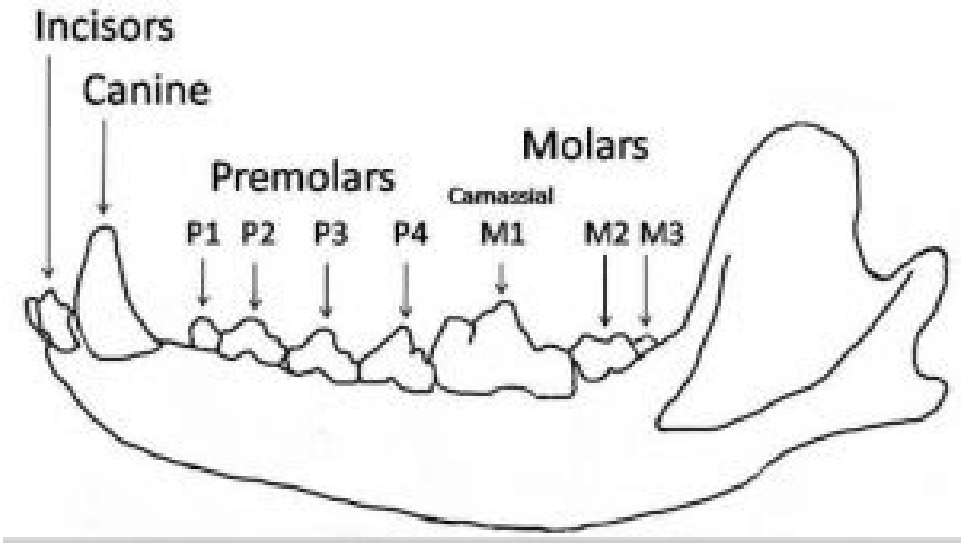


Diagram of canine mouth

Normal Occlusion (dogs/cats have a natural slight overbite)

1. Incisors of lower jaw touch the cingulum of the incisors of the upper jaw
2. Triad interlock between the 3rd upper jaw incisor, and both canines
    1. The lower canine should rest in the **diastema** (gap) between the upper canine and the 3rd incisor
    2. The tip of the lower canine should be completely visible in a closed bite
3. The premolars should be in a interlocked state (like two hands together) but without touching each other
    1. Upper premolars should be more buccal than the lower premolars due to the anisognathic jaws
4. Molars create a ‘crushing’ table
    1. Lower jaw molar 1 creates a shear with upper jaw premolar 4

Class II Malocclusion

→ Mandibular canine sits too distal from its normal position in the triad interlock with the maxillary canine and and maxillary 3rd incisor.

→ Mandibular canine cause irritation and pain on the maxillary palate/gums

INCLINE PLANE (current treatment)

→ way to direct mandibular canine teeth into correct occlusion

→ applied to the maxillary (upper jaw) arches

→ Material: bisacryl composite

→ bonded to maxillary canine teeth, incisors, and/or premolars

→ creates trough to guide mandibular canine tooth

→ 3D printed incline plane used Materialize (3-Matic) software

GOAL

→ Make it easier to design an inclined plane for specific malocclusion patients and easily adapt the software/plane for canines of all sorts.

Conclusions/action items:

Conclusion --> I have gained knowledge about what exactly the problem is and how an inclined plane is used to treat malocclusion in canines

Action --> Talk with Dr. Thatcher on Friday 9/11 to gain more insight into the project, what his perspectives are on the whole project, and what he wants us to do/aim for.

9/20 Dr. Thatcher's Inclined Plane Research

SANAM JHAVERI - Oct 07, 2020, 11:08 AM CDT

Title: Dr. Thatcher's Inclined Plane Research

Date: 9/20

Content by: Sanam Jhaveri

Present:

Goals: Analyze Dr. Thatcher's Design and see what can be improved

Content:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563895/

Notes:

The incline plane was successful in the first client canine for Dr. Thatcher

Although it was successful, part of the device was broken due to natural forces from the canine's bite

Palatitis occurred on the upper portion of the jaw- most likely was causing pain and irritation for the dog

Food was most likely being consistently stuck in the gap between the plane and palette

Dr. Thatcher used bisacryl material for his first inclined plane usage.

Conclusions/action items:

We understand what went wrong with the incline plane and have some ideas for brainstorming potential new ones.

9/24 Potential Design Matrix Drawings

SANAM JHAVERI - Sep 24, 2020, 4:01 PM CDT

Title: Potential Design Matrix Drawings

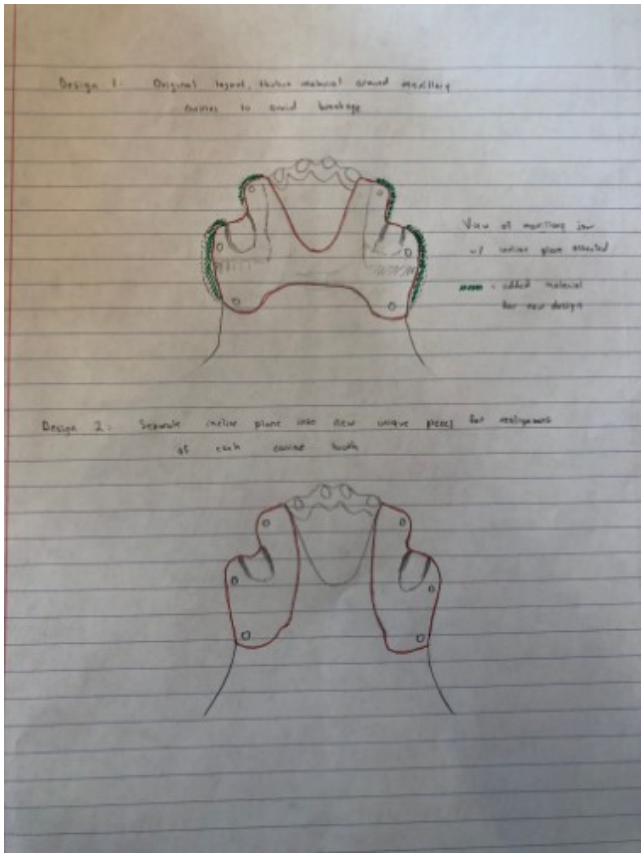
Date: 9/24

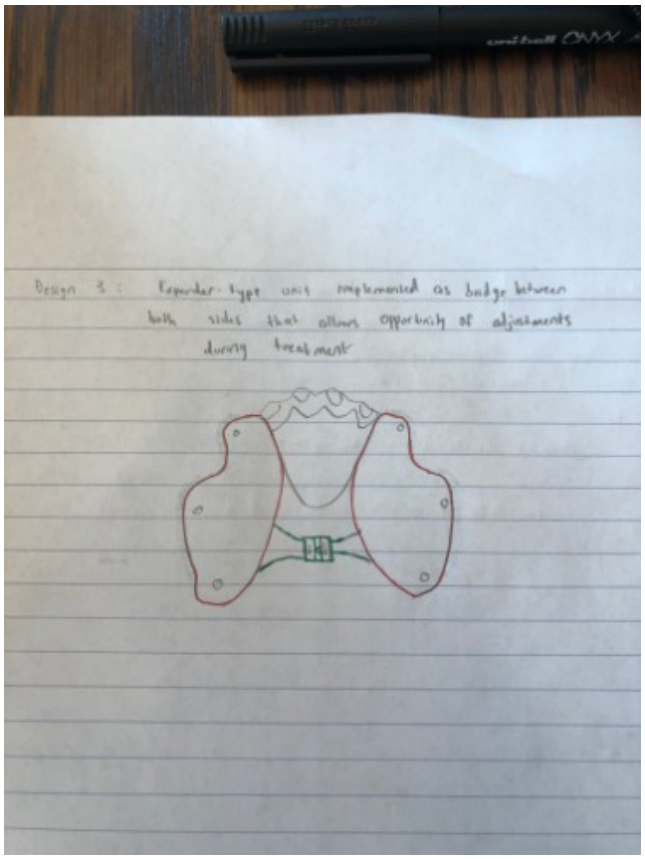
Content by: Sanam Jhaveri

Present:

Goals: Draw some rough sketches that can be used for the design matrix

Content:





Conclusions/action items:

Conclusion: I have some ideas to present when we meet to fo the design matrix

Action Items: I will present these ideas and make adjustments as needed.

10/5 Background/Prelim Design Portion of Report

SANAM JHAVERI - Dec 08, 2020, 9:49 PM CST

Title: Background/Prelim Portion of Report

Date: 10/5

Content by: Sanam Jhaveri

Present:

Goals: To layout my portion of the report and organize my research and ideas.

Content:

II. Background

1. Physiology and Biology

Class II Malocclusion

Just like humans, many canines have orthodontic problems that affect their ability to live and especially eat. Types of these orthodontic problems range similarly to those of humans. There is one specific orthodontic issue called Class II Malocclusion that is directly specific to the misalignment of three teeth within a canine's mouth. These three teeth involve the maxillary canine, the maxillary 3rd incisor, and the mandibular canine. In normal occlusion of the upper and lower jaws, the mandibular (lower) canine sits within a diastema between the upper canine and the upper third incisor, as shown in *Figure 1.* However, in Class II Malocclusion, the occlusion of the dog's jaws is distorted with an emphasis on the location of the lower canine. As shown in *Figure 2*, the lower canine will sit more distal

(towards the middle of the mouth) rather than the normal position up against the diastema [1].

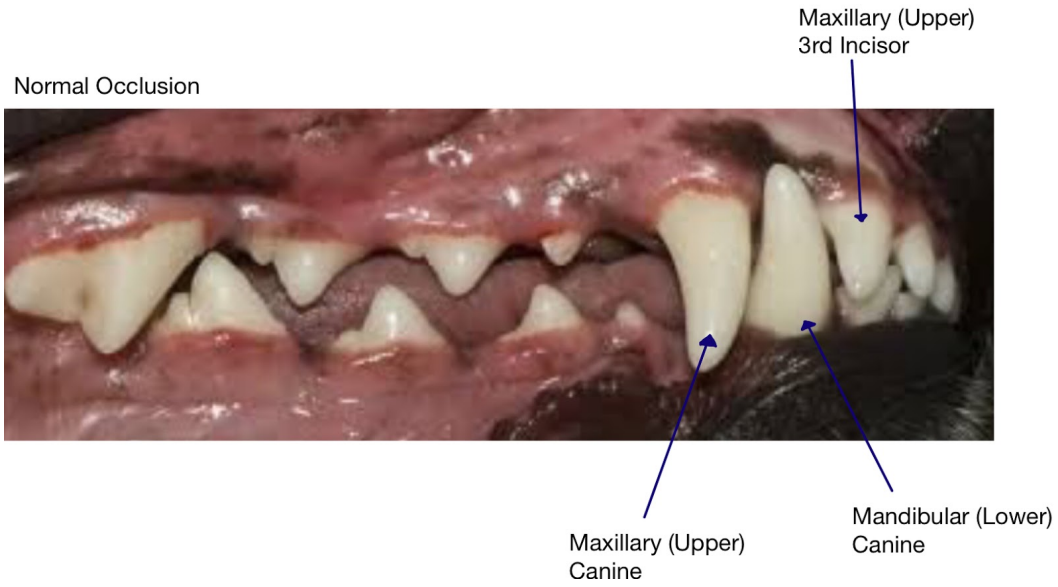


Figure 1: Normal Occlusion in a Canine. This figure shows a side view of a canine mouth with normal occlusion between the maxillary and mandibular jaws. The mandibular canine sits within the diastema (gap) between the maxillary canine and maxillary third incisor.

Class II Malocclusion is generally defined as "mandibular distoclusion" which is commonly referred to as an overbite [1]. The lower jaw sits entirely too far distal in the mouth causing the mandibular canines to not sit correctly in relation to the upper teeth. The reason this type of alignment is problematic for canines is due to the damage it can cause. A misaligned canine can cause irritation and damage to surrounding tissue and teeth. In addition, the misalignment can cause conditions such as dental attrition, periodontal diseases, and oronasal fistula [4]. As

well, dogs use their canines to both puncture, tear, and hold items so they are a crucial part of their lives and daily tasks [2]. Thus, there is a high importance to ensuring they are in the correct position and alignment.

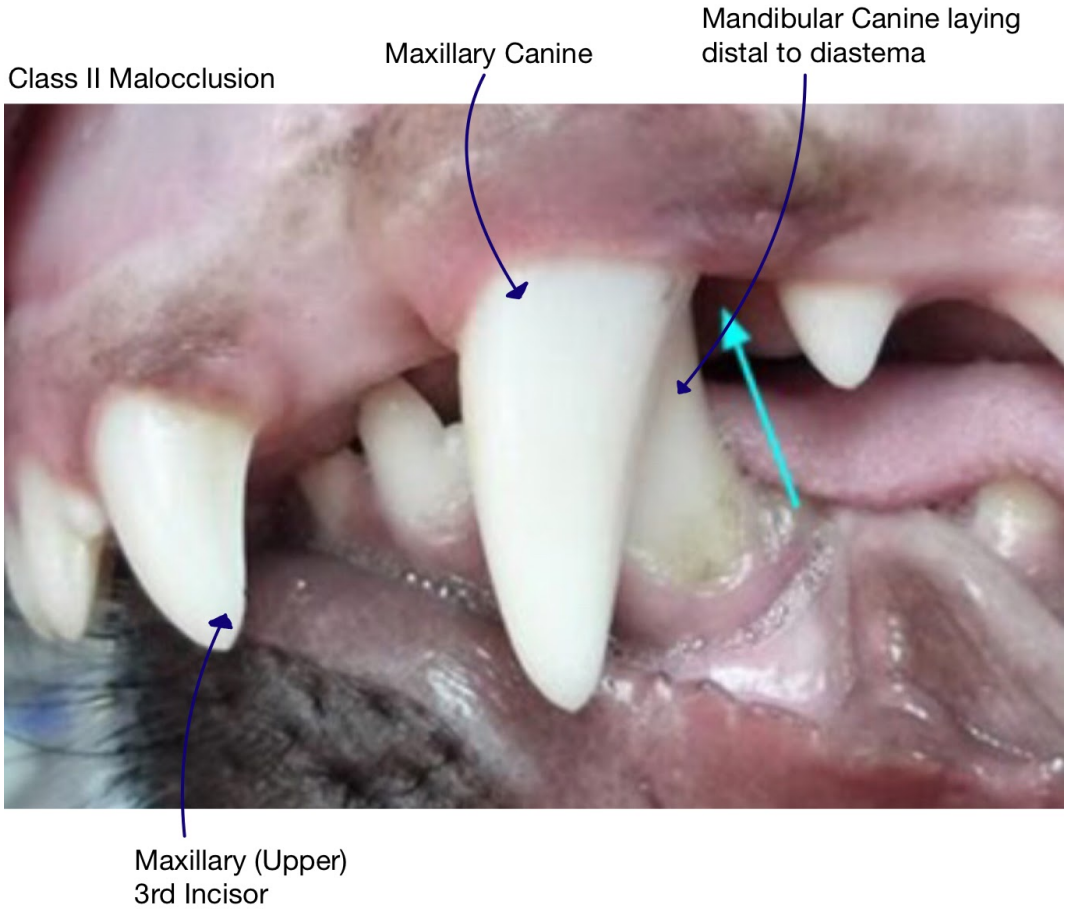


Figure 2: Class II Malocclusion. This figure shows a side view of a canine mouth with class II malocclusion. The mandibular canine sits distal to its normal position within the diastema.

2. Existing Treatments/Device

Extraction:

One treatment type is to simply remove the misaligned canine. This may get rid of the misalignment, but, removing the teeth will bring up more lifestyle problems for the dog. This is due to the fact that dogs need their canines to eat food and hold things in their mouth. Thus, this is not a preferred method.

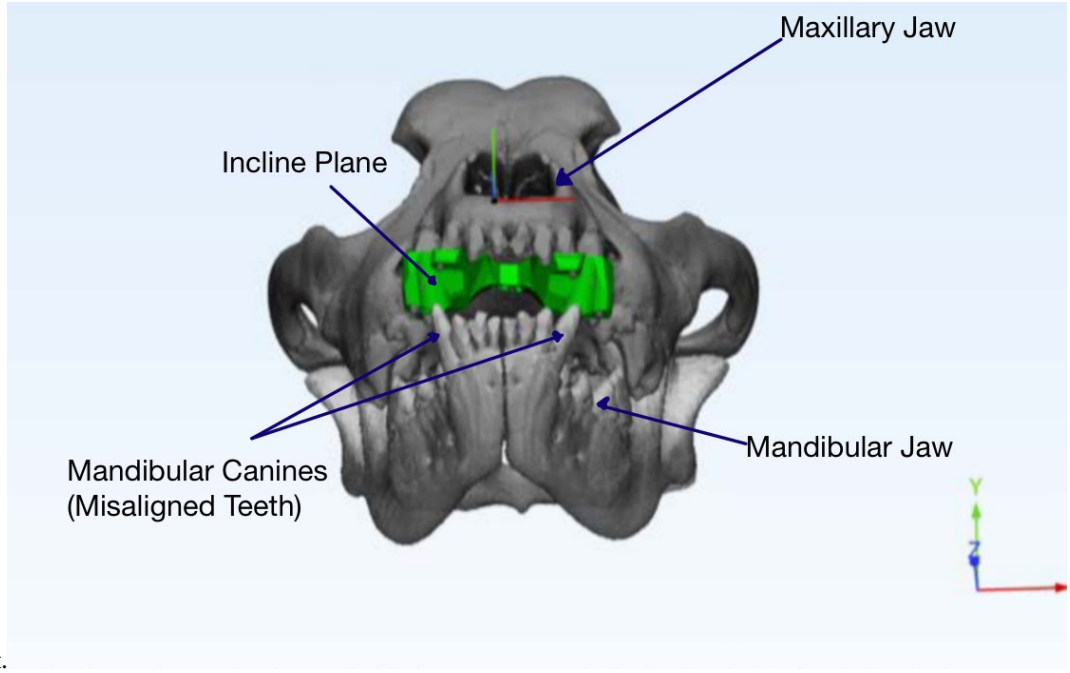
Shortening

Another treatment type is to shorten the tooth so the canine does not cause irritation to the palette. While this will cause some temporary relief, again, the canine is distorted and not being able to function normally for the dog.

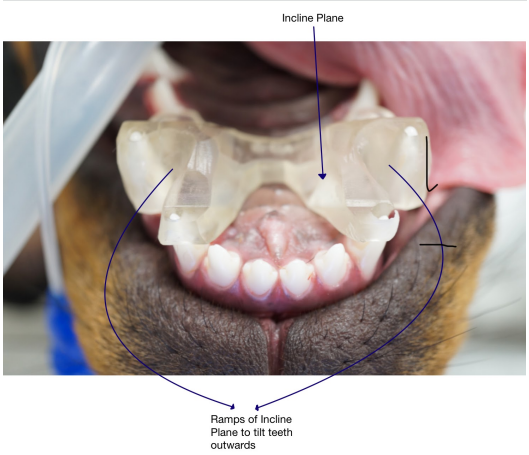
Incline Plane

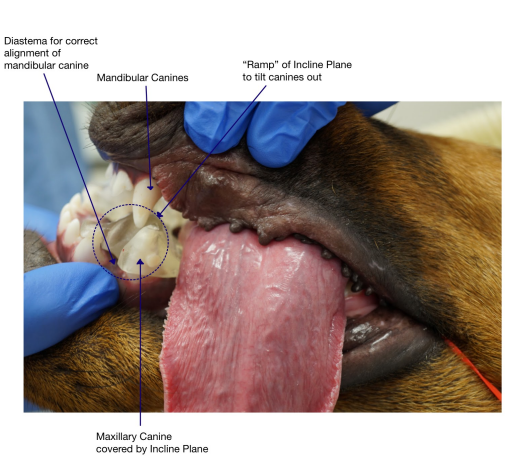
The last type of treatment was designed by client Dr. Graham Thatcher and involves dental orthodistry treatment for the dog. The incline plane is a 3D printed device made of FDA approved dental material. The device acts as a retainer for the dog and is attached to the mandibular jaw through hole attachments. As shown in Figure 3, the incline plane attaches to the mandibular jaw through holes that are placed on the mandibular canines and molars.

Figure 3 Incline Plane in stl file. This figure shows a CT scan of the dog's skull with the green portion indicating the incline plane device used to tilt the mandibular canines out.



The plane is essentially a combination of two ramps that are aligned to direct the mandibular canines into the correct position. Canine teeth, in dogs, are easily tilted without the need of major pressure so the use of the ramps within the inclined plane work effectively. As shown in Figures 4 and 5, the incline plane is designed so that the mandibular canines have no choice, when the dog closes their mouth, to tilt outwards towards the correct position in the diastema.





Figures 4 and 5 Client 01. These figures show the inclined plane attached to Dr. Thatcher's first client and how the ramps work to push the teeth outward.

Although the incline plane designed by Dr. Thatcher was successful in the first client, it poses many inefficiencies that are associated with negative consequences of the plane as well as the development of the plane itself.

3. Existing Development Process of Inclined Plane.

While Dr. Thatcher has succeeded in creating a physical inclined plane, his process for doing so is very inefficient and complicated. His process involves first taking a CT scan of a dog's mouth. He then 3D prints the skull of the mouth and uses a dental material to arbitrarily mold a potential design for the plane onto the skull model. Once he is satisfied with the design, he sends the CT scan (DICOM files) and the model to a software engineer who takes all the information and builds an stl file of the inclined plane in an engineering software. Dr. Thatcher and the engineer then work back and forth to perfect the design through adjustments, printing prototype designs, and trails. Ultimately, this process isn't

efficient nor timely. Resultantly, the second half of our project involves the development of an interface and software program that expedites and simplifies the process of designing the inclined plane.

4. 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. He is responsible for the management of dentoalveolar and orofacial diseases and trauma as well as is an educator to current veterinary students [5]. Dr. Thatcher is currently working on this project and has solicited our team's help to sophisticate and better his current designs.

5. Design Specifications

Inclined Plane:

The new inclined plane has several specifications that must be met to satisfy both Dr. Thatcher's requests as well as improve the product in general. Firstly, 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 inclined 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.

Software/Interface:

When designing the software program, many specifications must be considered when choosing the right pathway. For one, the process must be simple enough where a veterinary orthodontist can easily utilize the software without the help from a software engineer. The software must also be compatible with common computers found in veterinary hospitals and offices. Lastly, the main specification is that the software must be able to manipulate multiple cross sections of a DICOM file so the veterinary orthodontist can move the mandibular canines to the right position within the program..

[1] https://veterinarydentistry.net/defining-dental-malocclusions-dogs/

[2] **https://www.sacvds.com/forms/malocclusions-orthodontic-treatment.pdf**

[3] **https://www.purina.co.uk/dentalife/dental-advice/dog/article/canine-dental-anatomy#:~:text=Canines%20are%20the%20long%20and,a%20bone%20or%20chew%20toy.**

[4] **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563895/**

[5] **https://www.vetmed.wisc.edu/people/gthatcher/**

Conclusions/action items: I completed my portion of the research and background and will now help with the rest of the report.

11/12 Personal Two-Piece Design Cut Attempt

SANAM JHAVERI - Dec 08, 2020, 5:07 PM CST

Title: Personal Two-Piece Design Cut Attempt

Date: 11/12

Content by: Sanam

Present:

Goals: Make the cut of the original inclined plane to create the two-piece design.

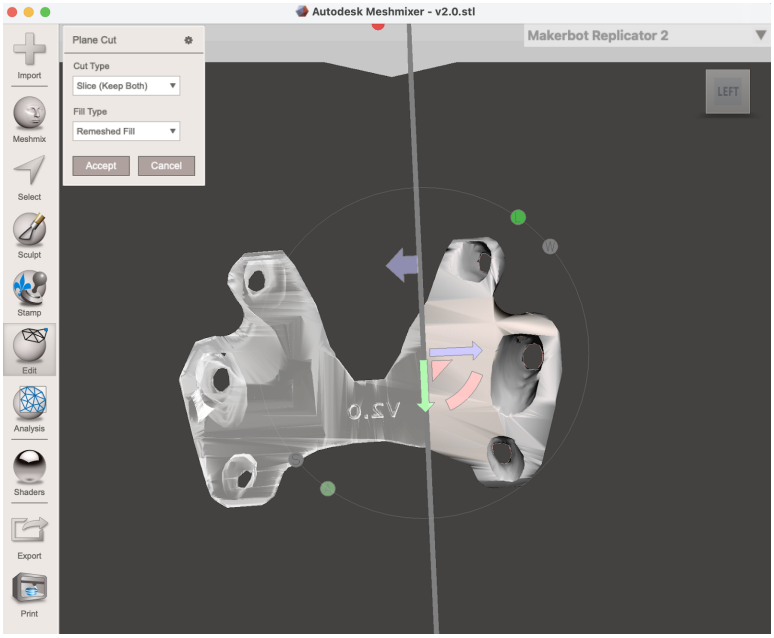
Content:

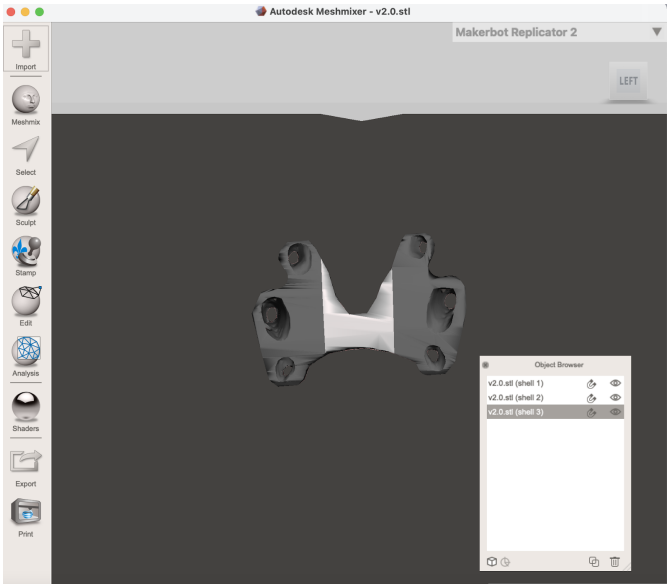
Process from Team Note on 11/12

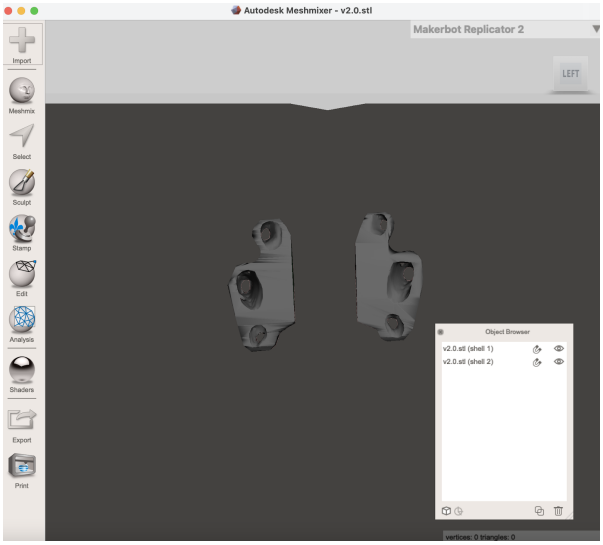
1) Make two Plane Cuts

2) Separate shells by removing the middle bridge piece

3) Test for weak points in SolidWorks







Conclusions/action items:

Cut was made and .stl file now contains two pieces. Send to Ethan and Parker.

11/5 MeshMixer Learning

SANAM JHAVERI - Dec 08, 2020, 9:57 PM CST

Title: MeshMixer Learning

Date: 11/05

Content by: Sanam Jhaveri

Present:

Goals: To learn the tools of MeshMixer so I can edit the .stl file

Content:

MeshMixer Tutorial Page:

https://formlabs.com/blog/meshmixer-tutorial-tips-to-edit-stl-files-for-3d-printing/#Tip%20%2315%3A%20Sending%20Models%20to%20a%203D%20Printing%20Software

Tools I can use:

Plane Cuts

Expand

Separate Shells

Measure

Sculpt

Testing

What I need to accomplish: Cutting the device into two pieces and ensuring that the product does not fail when printing.

Conclusions/action items:

I understand what tools to use in MeshMixer to edit the .stl file. Now it is time to make the two cuts and converse with Sammie, Justin, and Amy about what else to do with the file.

10/20 Preliminary Presentation Figures

SANAM JHAVERI - Dec 08, 2020, 9:51 PM CST

Title: Preliminary Presentation Figures

Date: 10/20

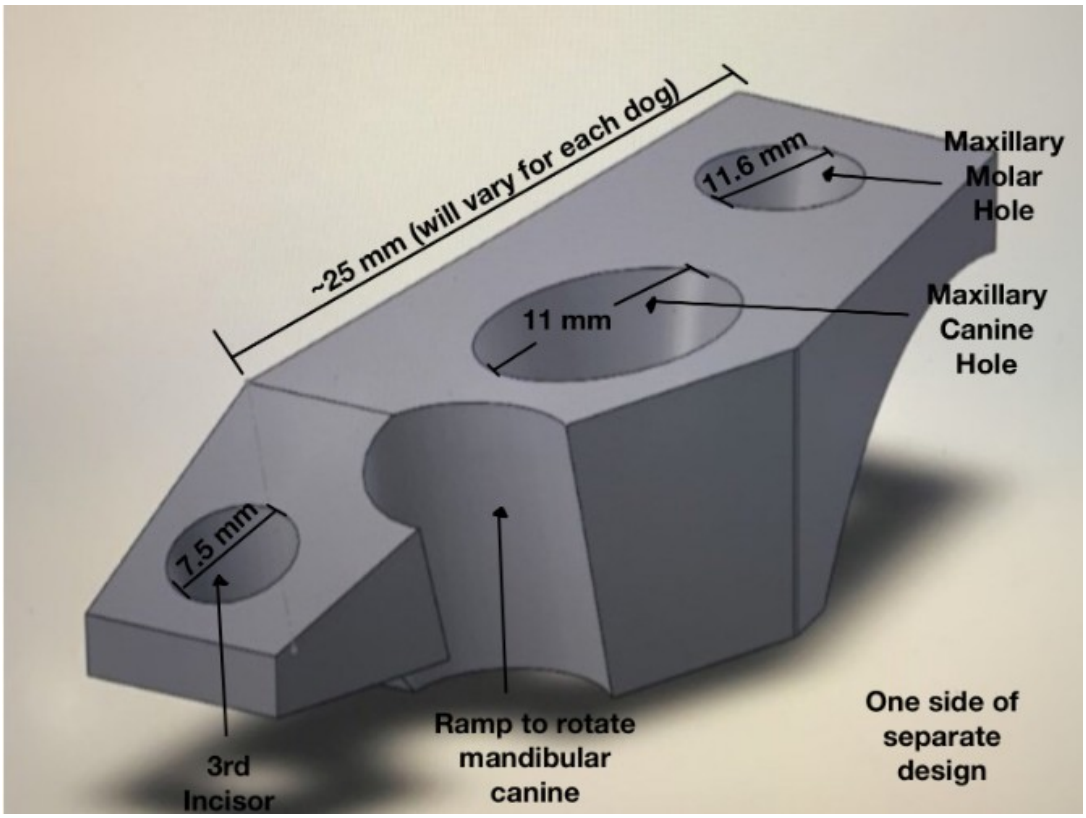
Content by: Sanam

Present:

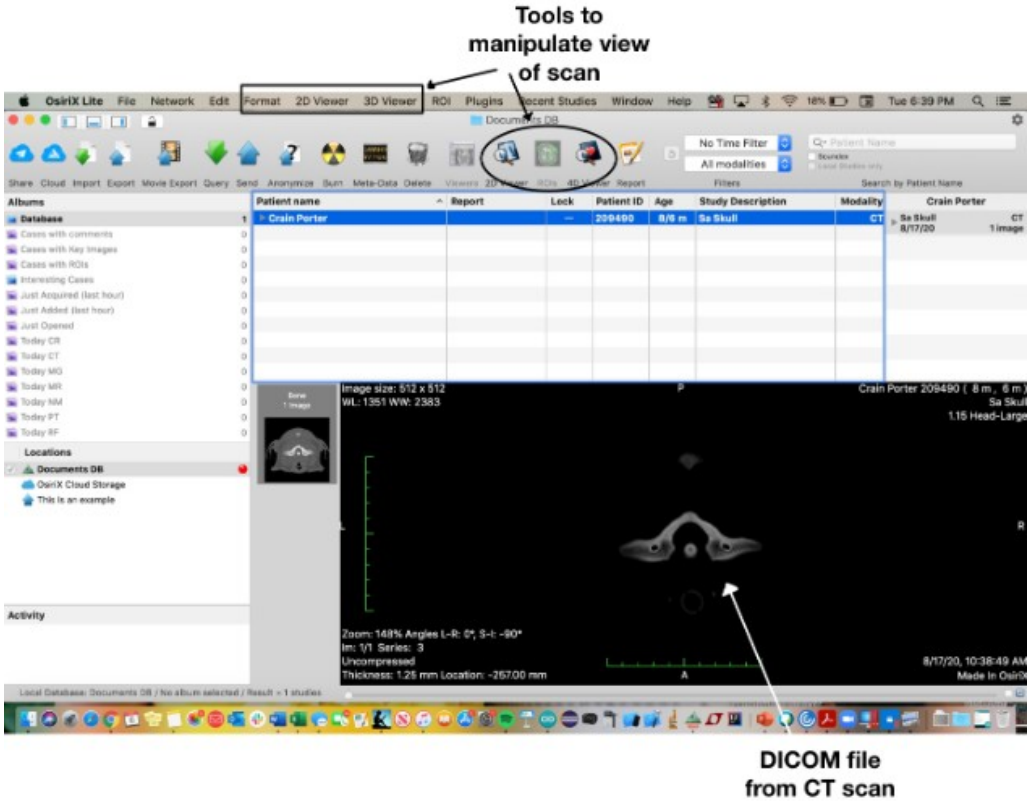
Goals: Make annotated figures that show background information and preliminary designs information

Content:

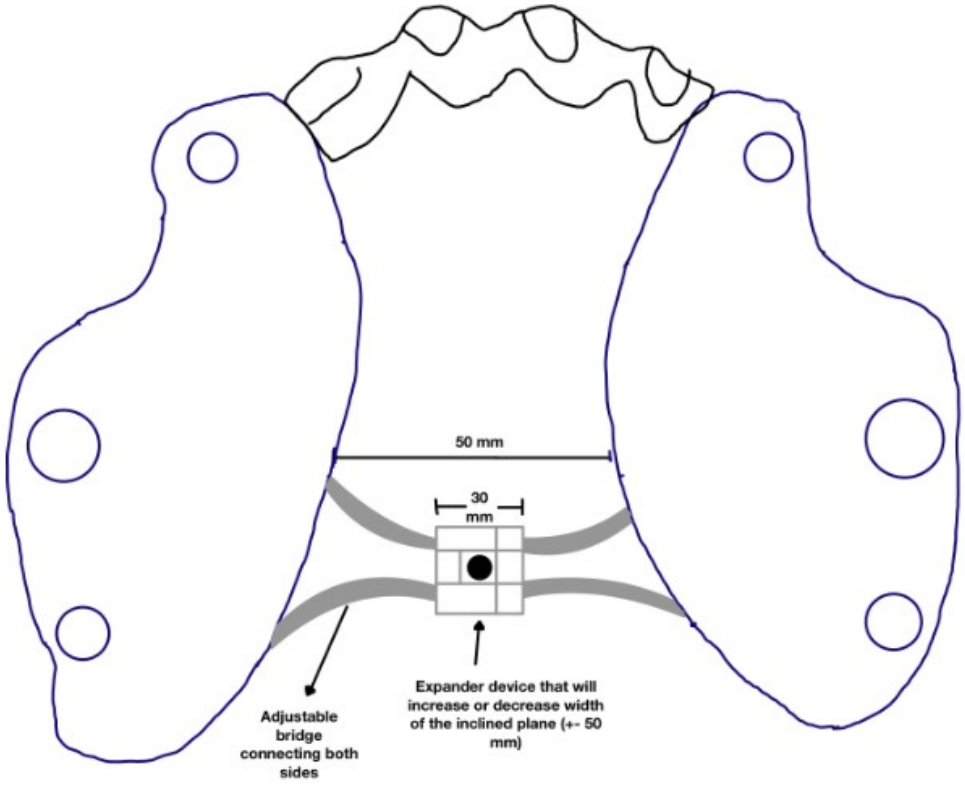
Two-Piece Design



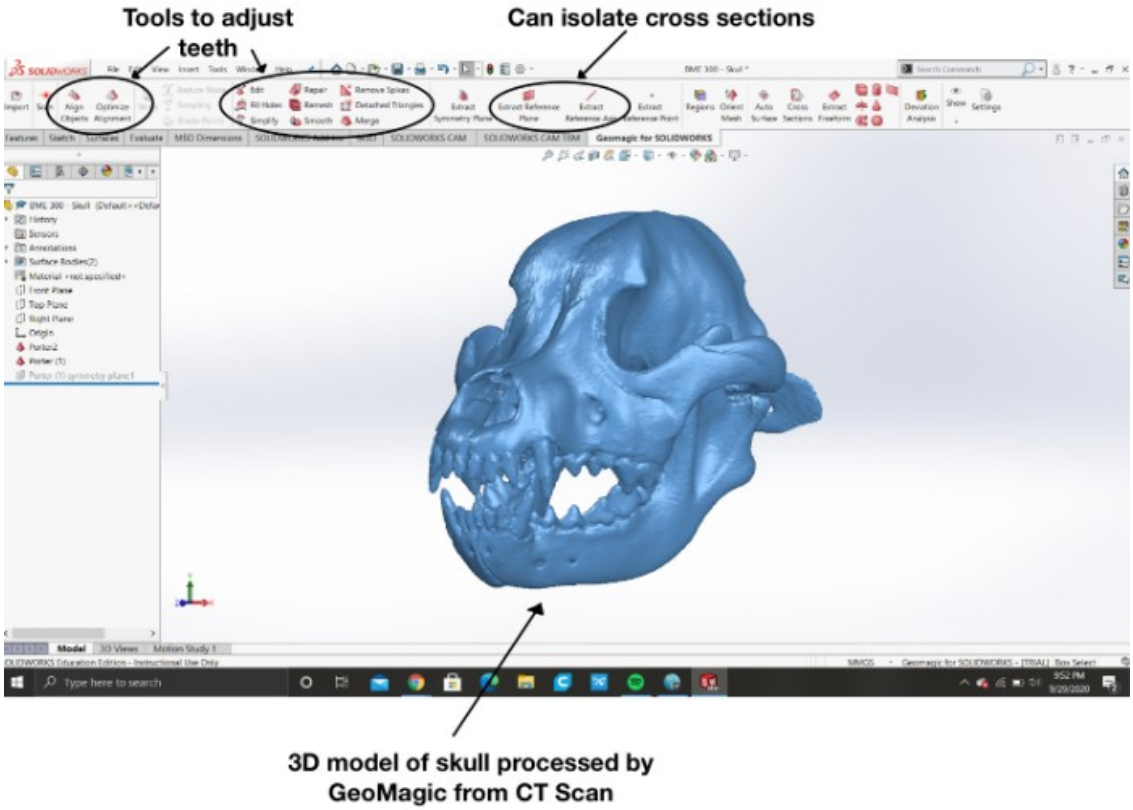
OsirisX



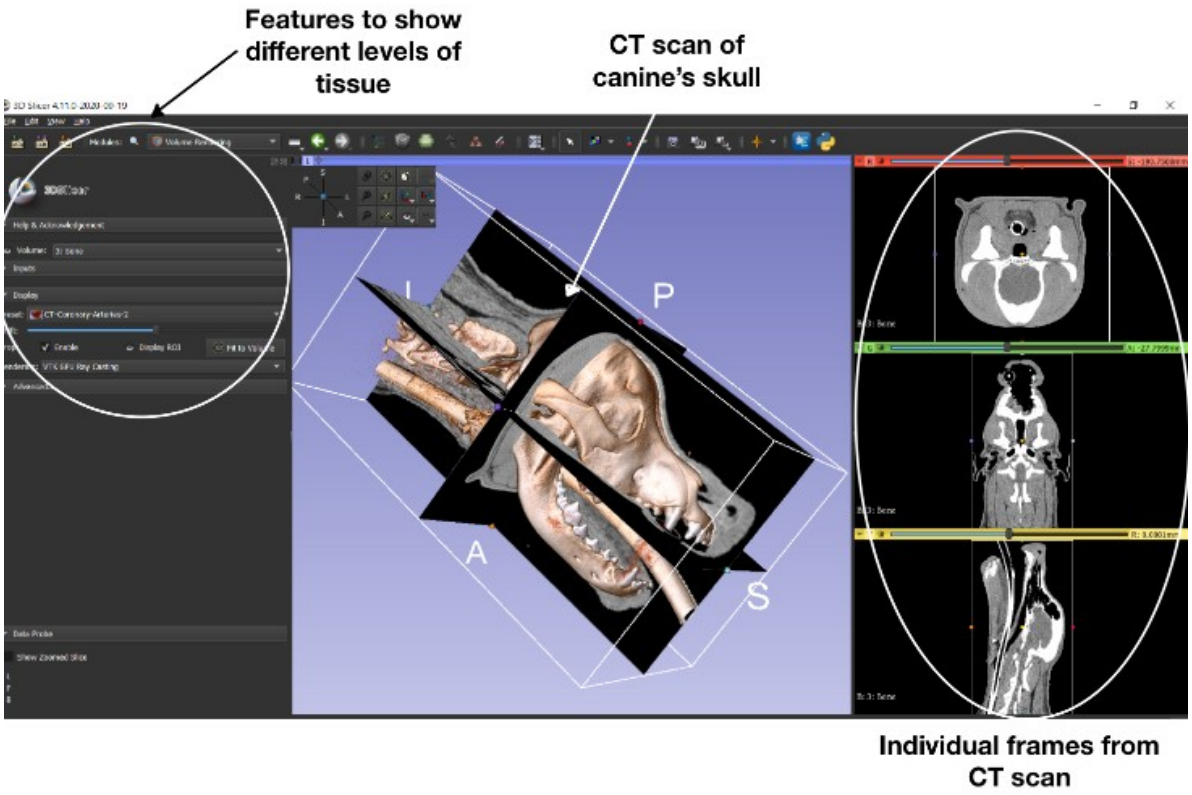
Adjustable Bridge Design



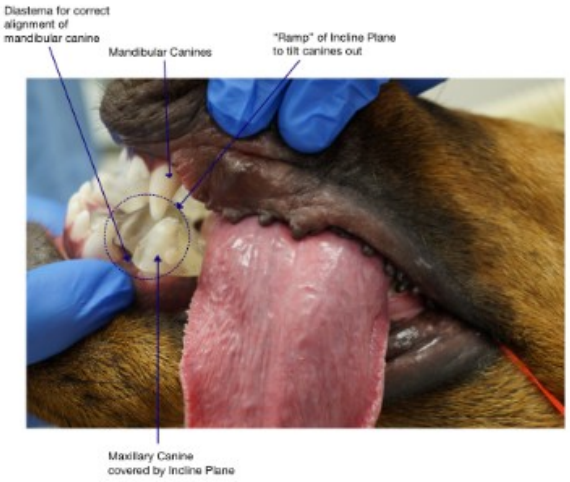
GeoMagic

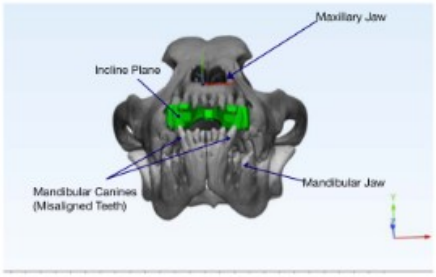


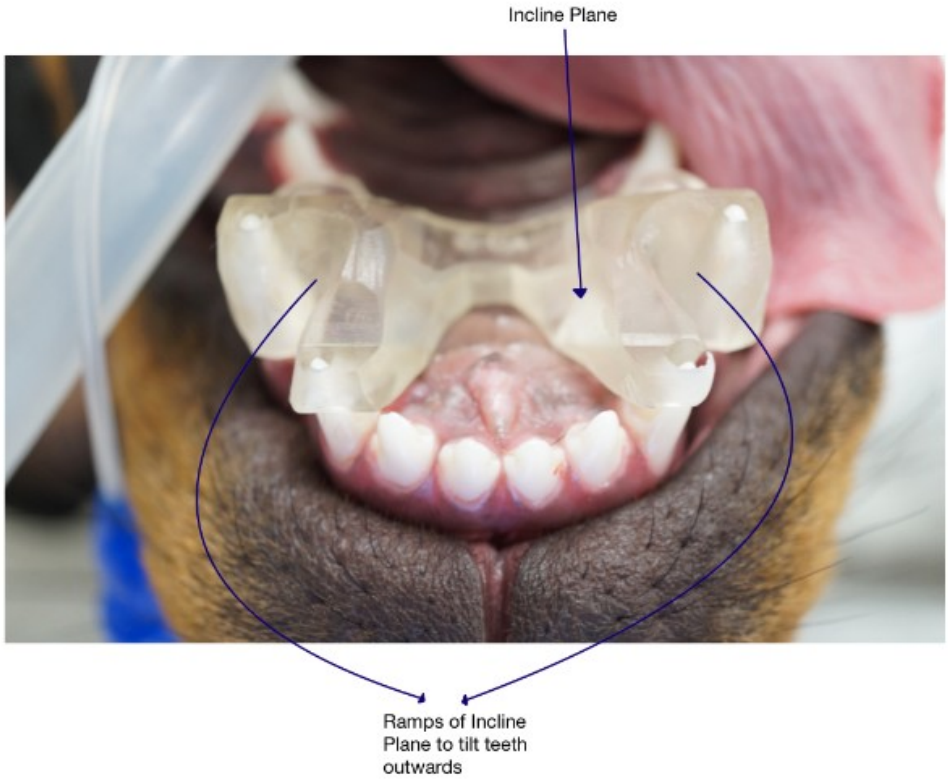
3D Slicer

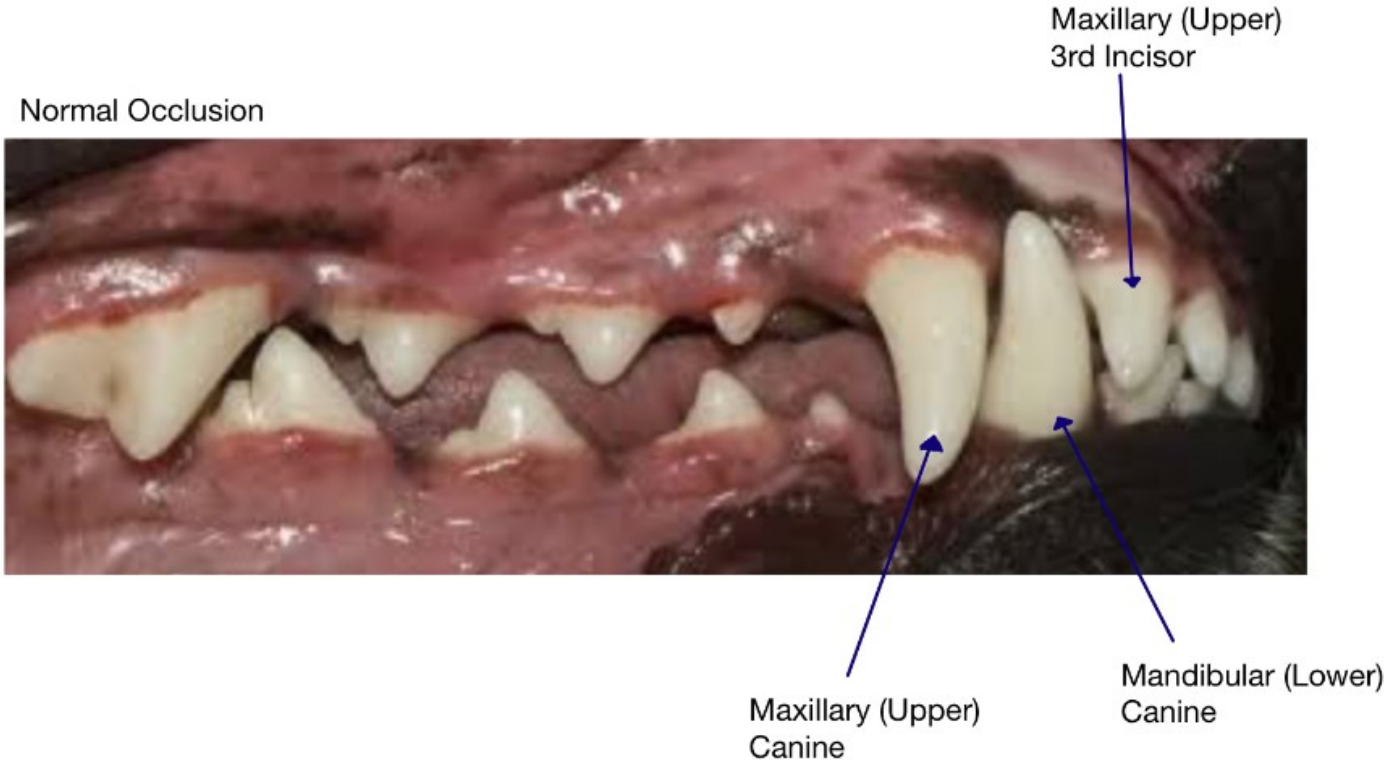


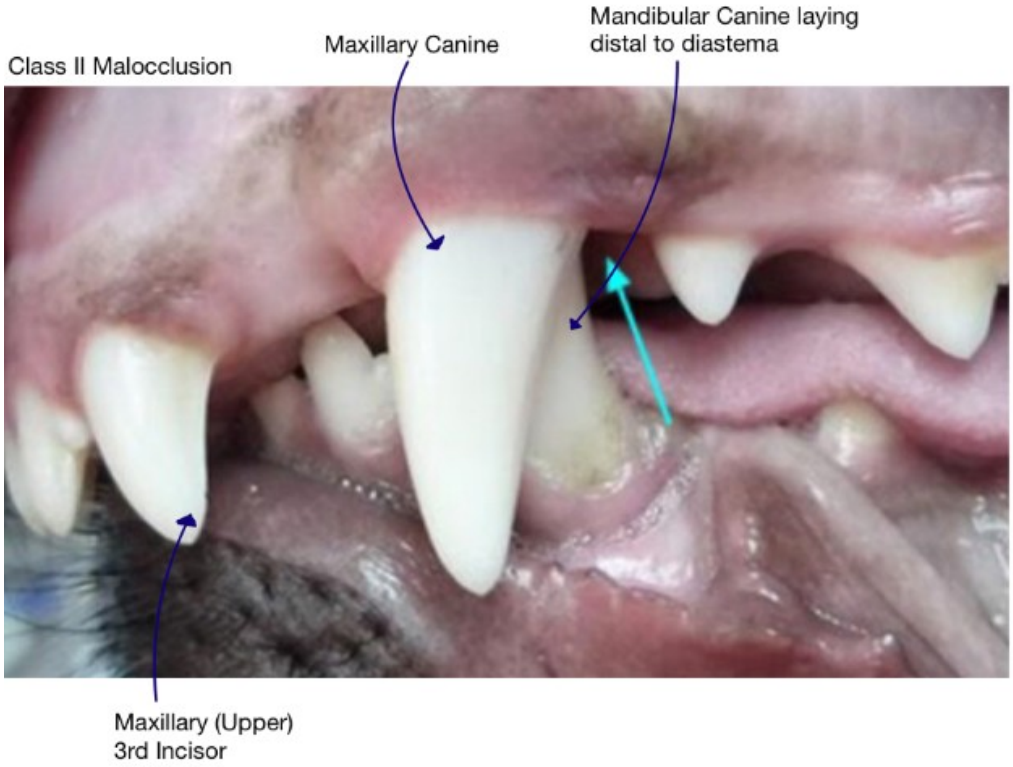
Background


Diastema for correct alignment of mandibular canine
Mandibular Canines
"Ramp" of Incline Plane to tilt canines out
Maxillary Canine covered by Incline Plane


Maxillary Jaw
Incline Plane
Mandibular Canines (Misaligned Teeth)
Mandibular Jaw


Incline Plane
Ramps of Incline Plane to tilt teeth outwards





Conclusions/action items:

The figures are fully annotated with the sufficient information. May need to change the colors of the arrows. Put into Preliminary Report/Presentation.

10/30 Preliminary Report Figures

SANAM JHAVERI - Dec 08, 2020, 1:39 PM CST

Title: Preliminary Report Figures

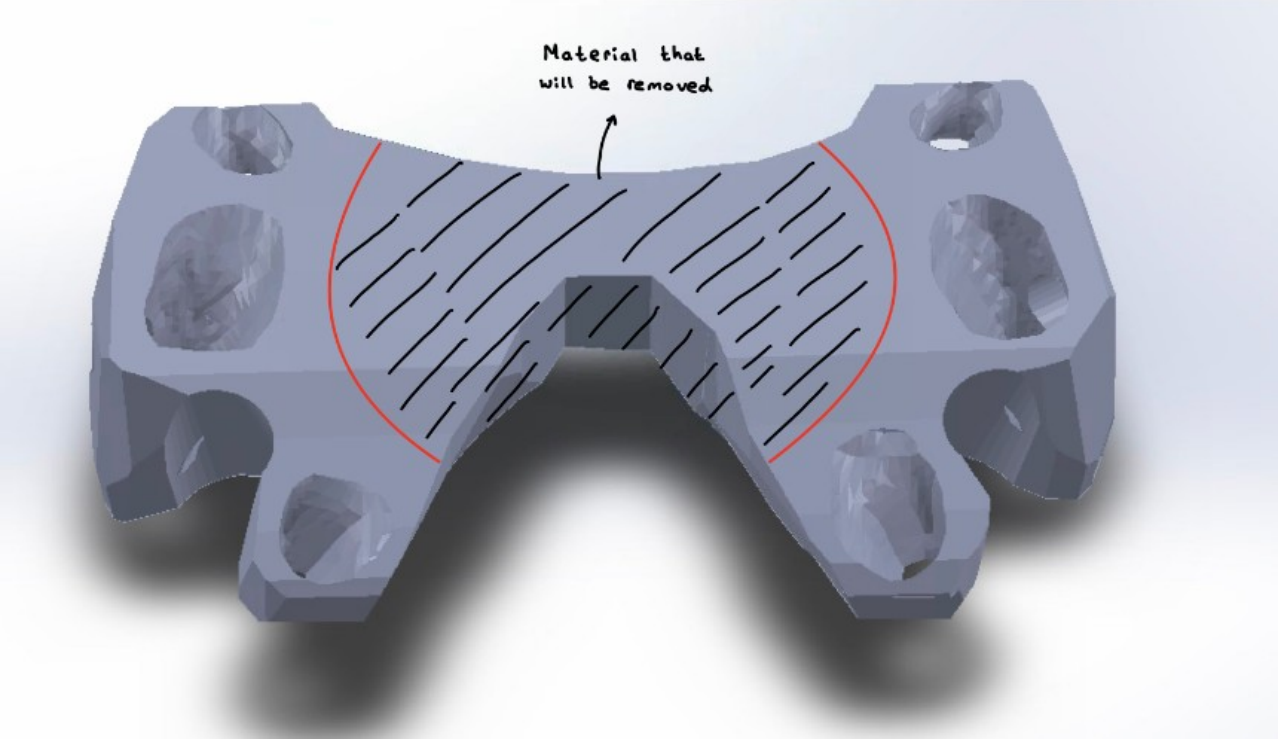
Date: 10/30

Content by: Sanam

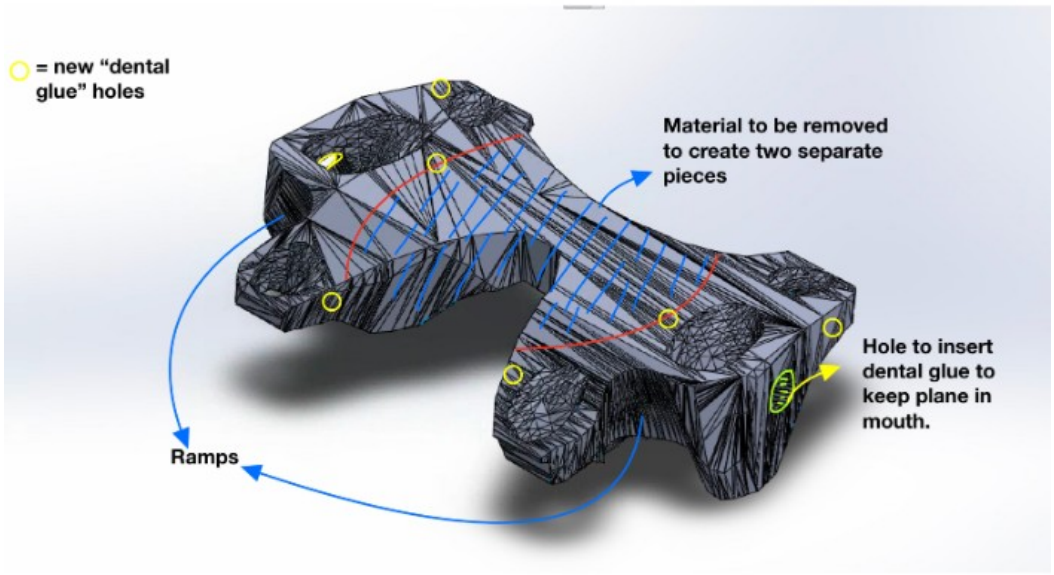
Present:

Goals: Make annotated figures for the preliminary report and Piazza post

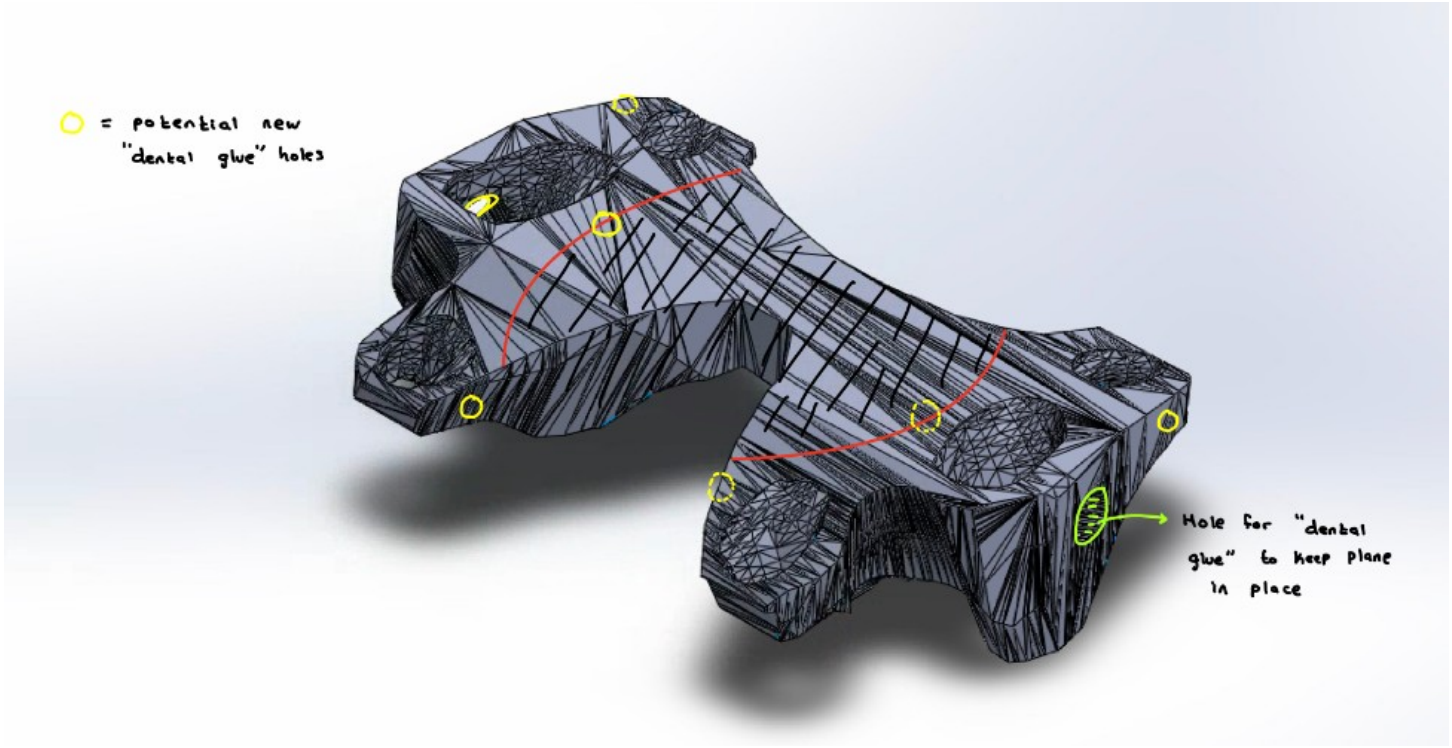
Content:



Inclined Plane Design in SolidWorks



This retainer-like device sits on the maxillary jaw. The 6 larger holes seen are locations for where teeth will sit. The ramps are used to push the mandibular canine into its correct position. The lines are SolidWorks surfaces.



Conclusions/action items:

Figures are well made and clearly show future edits. Make Piazza post and get started on the two-piece design.

12/1 Final Poster Figures

SANAM JHAVERI - Dec 08, 2020, 1:52 PM CST

Title: Final Poster Figures

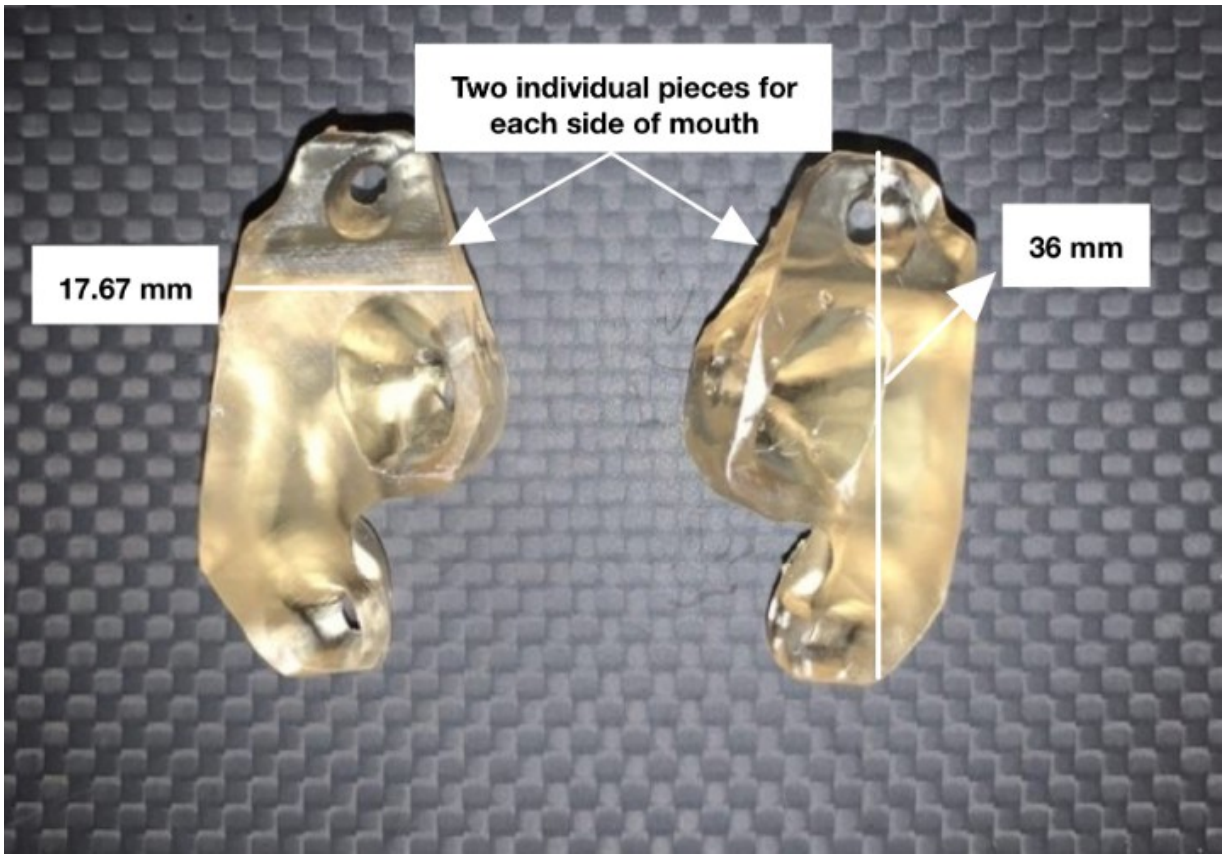
Date: 12/1/2020

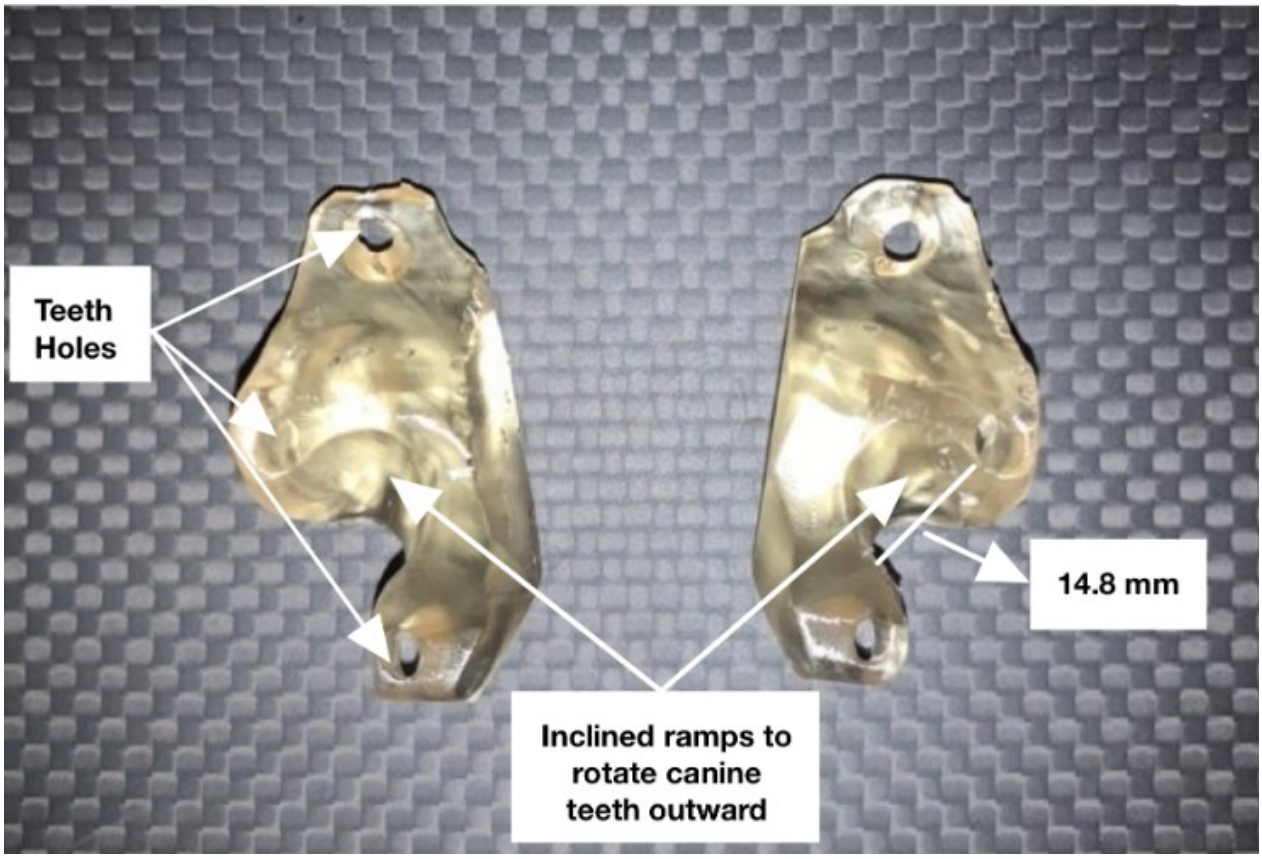
Content by: Sanam

Present:

Goals: Annotate over pictures of the 3D printed device

Content:





Conclusions/action items:

Figures were made and annotated with dimensions and labels. Work on Final poster and report.

9/9 - Preliminary Research

Sammie Gilarde (gilarde@wisc.edu) - Oct 06, 2020, 11:02 PM CDT

Title: Preliminary Research on Malocclusions

Date: 9/9/2020

Content by: Sammie

Present: N/A

Goals: To gain an understanding of what a malocclusion is and how it can be treated.

Content:

What is a malocclusion?

https://www.sacvds.com/forms/malocclusions-orthodontic-treatment.pdf

- abnormal alignment of teeth
- teeth are turned inwards and the roof of the mouth is impacted
- can be genetic, caused by trauma, or baby teeth that don't fall out

How are they treated?

https://www.sacvds.com/forms/malocclusions-orthodontic-treatment.pdf

- orthodontics - usually on younger dogs
- extraction of teeth
- however, if the orthodontics are done incorrectly this can cause more damage

Conclusions/action items:

Malocclusions are defined as abnormal alignment of the teeth. A class II malocclusion is when the teeth are turned inward which results in the teeth hitting the upper palette when the dog bites. This can cause trauma to the upper palette and can cause pain for the dog. The course of treatment is different depending on the severity of the malocclusion as well as the breed and age of dog. Treatments include orthodontics and removing the teeth. If orthodontics are not done properly they can cause more harm. In addition if the teeth are removed this can make it harder for the dog to eat due to the strength of their canine teeth.

11/12 - MeshMixer 2 Piece Design

Sammie Gilarde (gilarde@wisc.edu) - Dec 08, 2020, 9:46 PM CST

Title: 2 Piece Design in MeshMixer

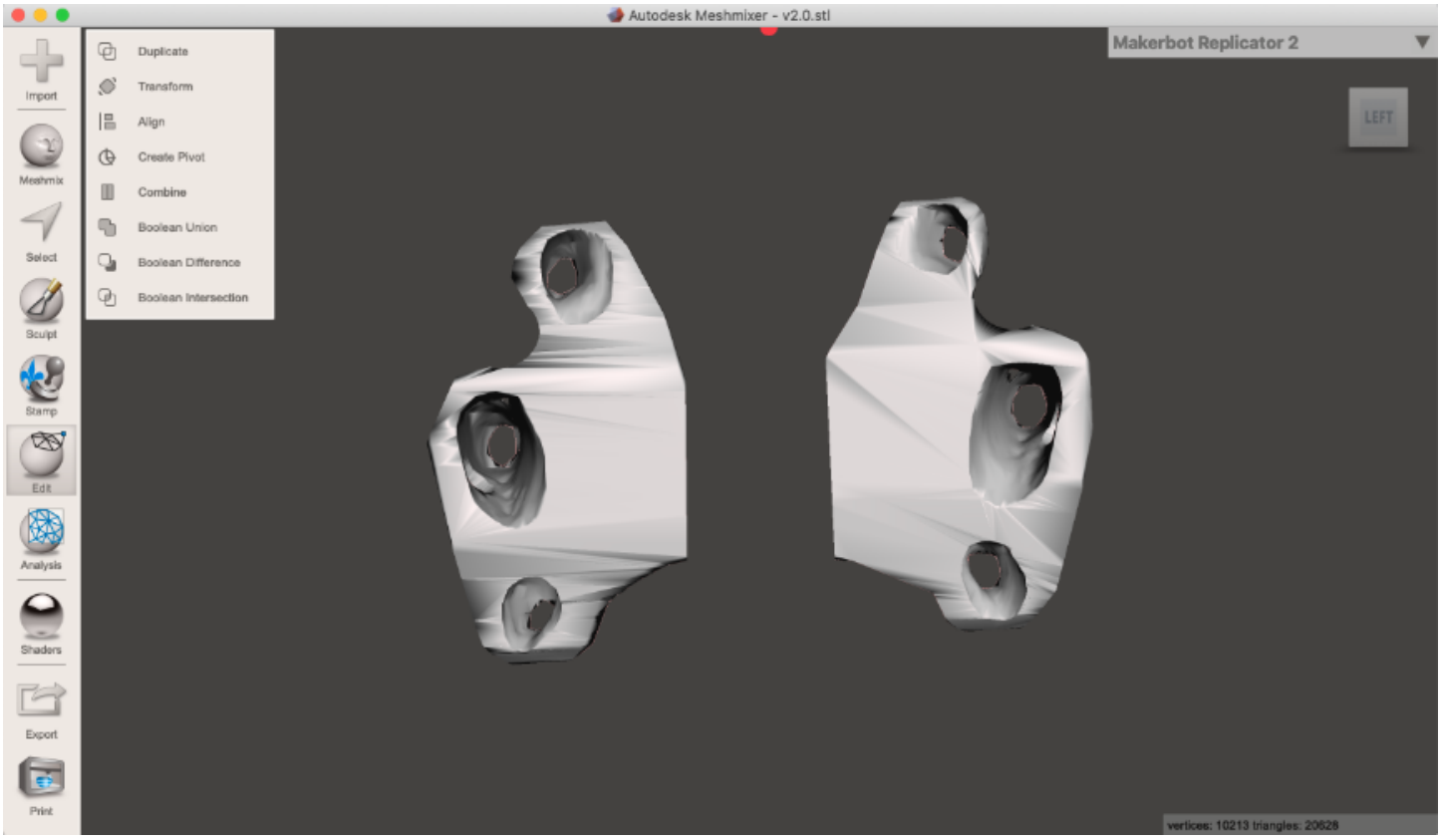
Date: 11/12/2020

Content by: Sammie

Present:

Goals: split original design into 2 pieces

Content:



Conclusions/action items: I was able to use MeshMixer to cut the piece and delete the middle portion of the original design. Now there are 2 halves to the piece which is exactly what our goal was. Next, I will send this to the rest of the team so that we can make any necessary adjustments and eventually we will be able to 3D print the pieces.

11/06 - Learning about MeshMixer

Sammie Gilarde (gilarde@wisc.edu) - Dec 08, 2020, 9:45 PM CST

Title: Learning How to Use MeshMixer

Date: 11/6/2020

Content by: Sammie

Present:

Goals: learn how to use the tools in MeshMixer in order to cut the original stl file of the one piece design into 2 separate pieces.

Content:

https://blog.prusaprinters.org/cut-stl-models-3d-printing-meshmixer_7652/

1. load STL file into MeshMixer

2. choose edit, then plane cut

3. make cut by making a slice through the design

4. select slice in order to keep both sides

5. now go back to edit and click separate shells

6. select portion that you want to delete and delete from menu on the right

Conclusions/action items:

After reading different articles and watching some videos on MeshMixer I am confident that I can now go in and make the cut. My goal is to be able to delete the middle portion of the original design so that the 2 pieces fit comfortably around the dog's upper teeth. The next step is to actually use MeshMixer to make the cut so that the physical design can be printed in the future.

Malocclusions Preresearch

AMY CAO - Sep 14, 2020, 7:13 PM CDT

Title: Malocclusion Research

Date: 9/9/2020

Content by: Amy Cao

Present: N/A

Goals: Basic research on class II malocclusions in dogs

Content:

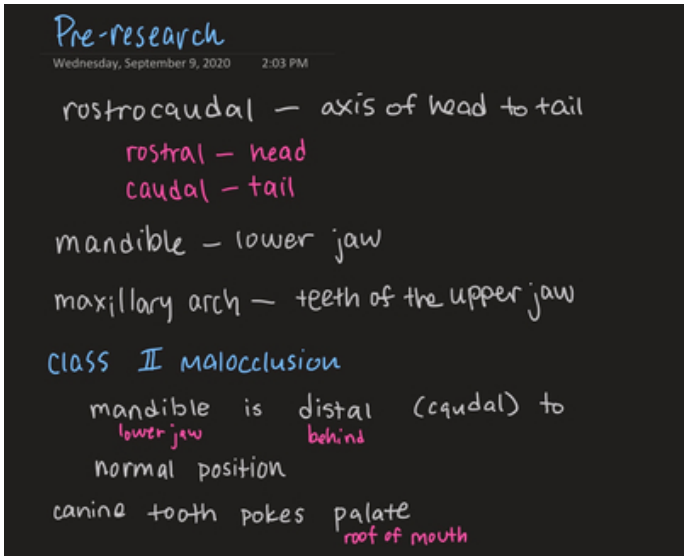
Below

Conclusions/action items:

Research incline plane treatment, softwares used

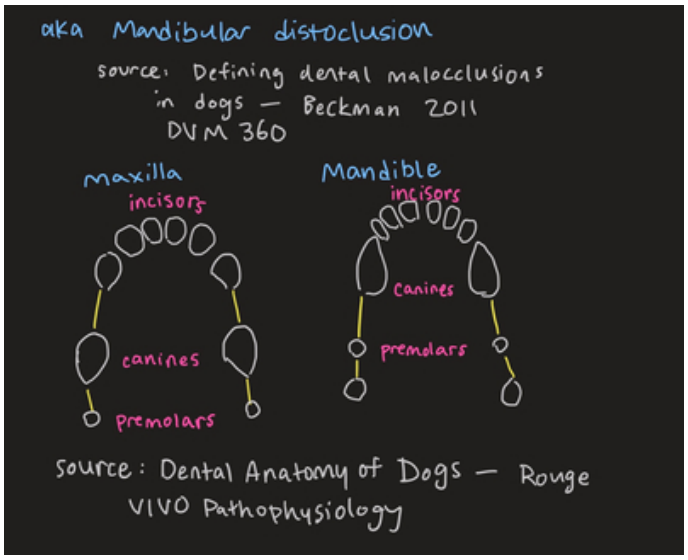
Meeting 9/14 8:15pm via Zoom

AMY CAO - Sep 14, 2020, 7:12 PM CDT



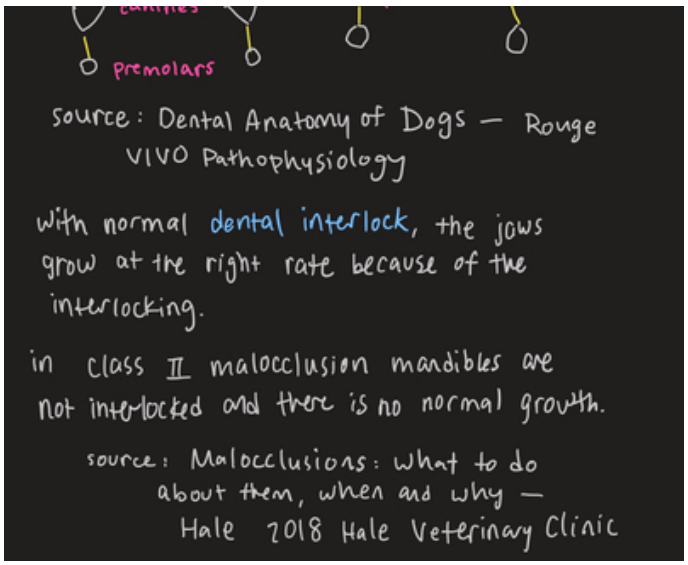
p1.jpg(415.1 KB) - download

AMY CAO - Sep 14, 2020, 7:12 PM CDT



p2.jpg(434.4 KB) - download

AMY CAO - Sep 14, 2020, 7:13 PM CDT



p3.jpg(429.5 KB) - download

MeshMixer Learning

AMY CAO - Nov 25, 2020, 5:05 PM CST

Title: MeshMixer Learning

Date: 10/30-11/18

Content by: Amy Cao

Present:

Goals: Modify .stl file of the inclined plane in MeshMixer for 3D printing, force testing, etc.

Content:

Beginner's Tutorial: How to Use Meshmixer Tutorial: Beginners Guide Part 1

Converting mesh to solid body

- Successfully used Edit > Make Solid

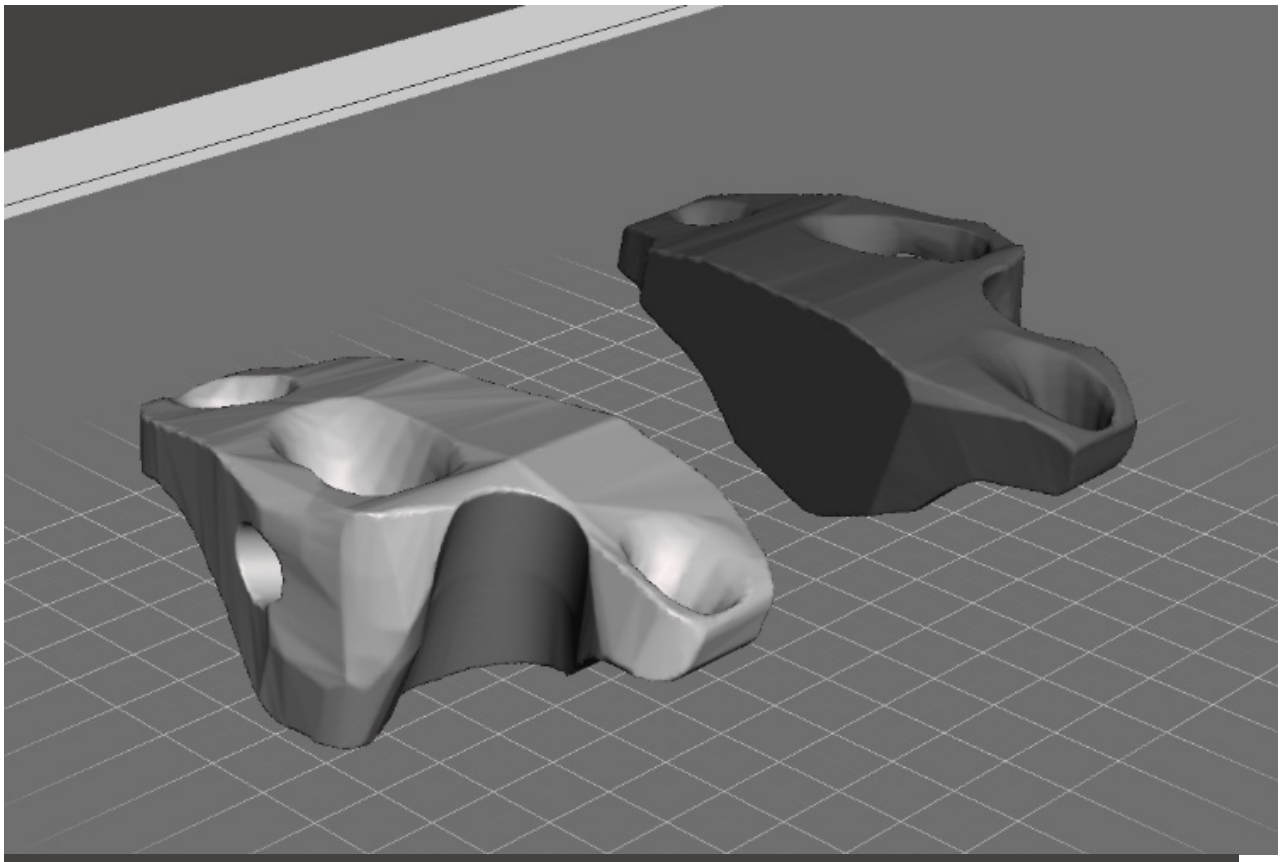
Cutting piece into two pieces

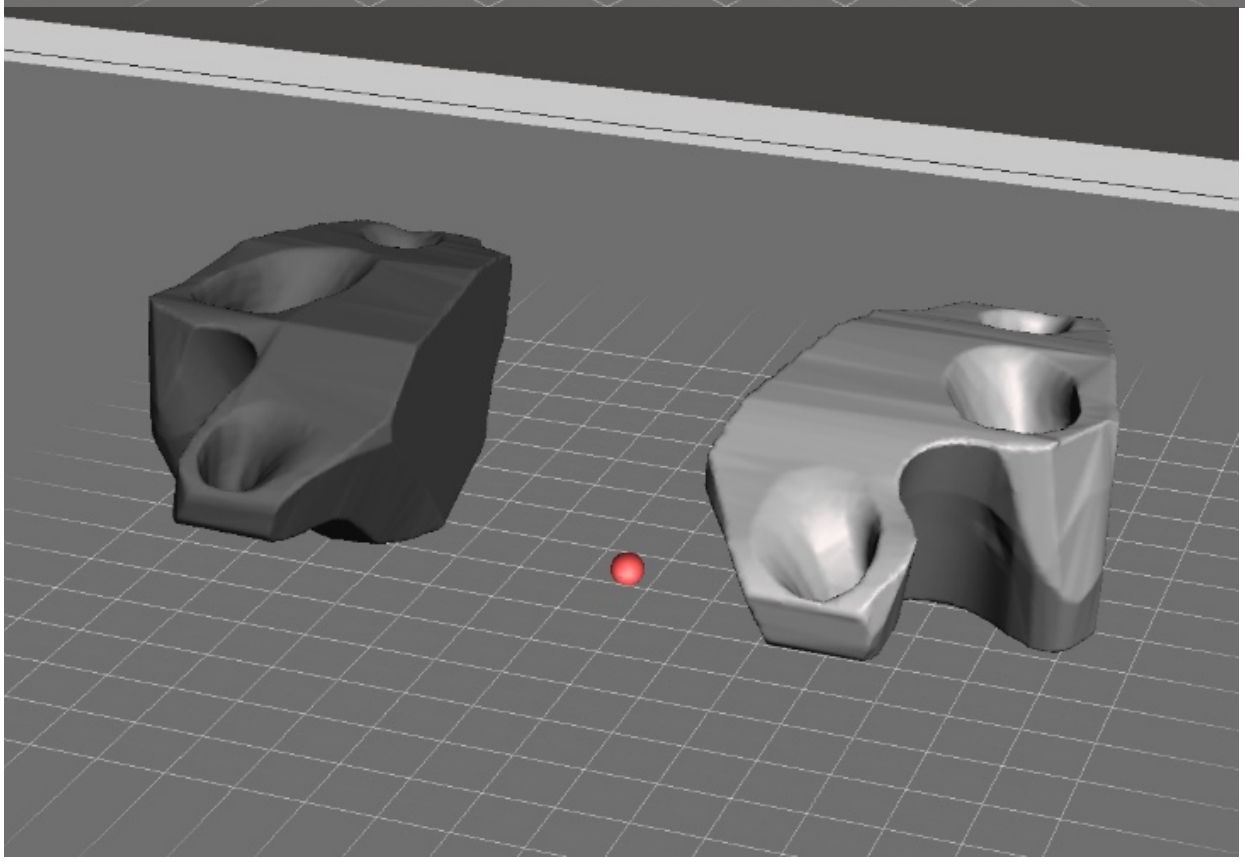
- Tutorial: How to cut STL models for 3D printing in Meshmixer
- Successfully used Edit > Plane Cut, Slice (Keep Both)

Model had some holes when the piece was made into a solid, due to mesh overlapping itself.

Cleaning holes

- Tutorial: Meshmixer Clean a Scan
- Successfully cleaned up holes





Conclusions/action items:

Sent .stl file to rest of the team for 3D printing and force testing

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: