



VetMed: 3D Printed, Patient Specific Incline Plane

PRELIMINARY PRODUCT DESIGN SPECIFICATIONS

BME 200/300

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Function:

Class II malocclusion is a common genetic skeletal deformity among a variety of animal breeds [1]. Specifically in canines, this type of mandibular distocclusion refers to the misalignment of the teeth; the canines lower jaw is shorter than the upper jaw[1]. This condition leads to destruction of the palate and gum tissue of the upper jaw. This negatively affects the canine's quality of life by inhibiting necessary instincts, such as eating and defense. The current design scope of our project is to further develop the current design, Dr. Thatcher's incline plane, by creating a design that is easier to manufacture and is more adaptable for each specific patient. In addition, to design a more efficient workflow by creating a general SolidWorks file that can be easily altered to create a patient specific 3D printable model of the device.

Client Requirements:

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

Design Requirements:

Physical and Operational Characteristics:

A. Performance requirements:

The goal of the incline plane is to slowly, over time guide the mandibular (lower) canines into the correct positioning. The incline plane will be positioned comfortably using dental glue on the maxillary palate (upper jaw) in the canine's mouth. It will need to withstand a bite force of the canine teeth ranging from 147-926 N [2]. In addition, the device will be easily manipulated in SolidWorks to be patient specific, using measurements taken with calipers.

B. Safety:

The incline plane should not impede the canine's wellbeing. The device should adjust to the mouth without causing sores and pain. The device also must be made of a non-toxic material, it must follow the standard, "ISO 13504" Dentistry requirements and related accessories used in dental implant placement and treatment [3]. The device should be strong enough to withstand the force of the dog's bite, for 6-8 weeks without breakage. The initial veterinary examination should follow the AAHA-AVMA canine preventive healthcare guidelines [4]. In addition, the following implant and implant materials should follow, "ISO 13504."

C. Accuracy and Reliability:

The device will be patient specific in order to minimize error. To get an accurate, personalized fit, a canine measurement using calipers is required to input into the SolidWorks file. The SolidWorks files will be used to 3D print a model that fits around the patient's teeth. In human orthodontics dimensional errors for the incline plane must be under 300-500 micrometers to be considered acceptable for treatment use [3].

D. Life in Service:

The inclined plane should last 6-8 weeks, depending on the circumstances of the malocclusion [1]. The device will be placed on the maxillary arches, and therefore will need to last in the mouth of the patient for the stated amount of time.

E. Shelf Life:

The plane needs to have a shelf life of up to 10 weeks to consider the time between manufacturing the device and putting the device into the mouth of the patient. After the correction cycle is complete, the device will not need to operate anymore as it is specific to one patient and it is then removed and disposed of.

F. Operating Environment:

The inclined plane will be worn 24 hours a day- 7 days a week and so the patient's day-to-day environment will be its operating conditions because the device will be attached to the patient's mouth, which is a moist environment and so the device needs to withstand the bacteria that is present in the mouth. For temperatures the device will need to be able to withstand a range of -32°C to 50°C to accommodate extreme weather conditions the patient may encounter. The device will need to withstand bite forces of a dog bite that ranges from 147-926 N [2] so the device is not loosened from the mouth or is not cracked or fractured. The device should not interfere with the patient's food consumption, so it should not have food stick to it or cause the device to peel off. The device should also withstand normal interactions with toys and other

other objects. The software used should be accessible to the veterinary orthodontist to use. The software should also be easy to follow and can be used on most computers.

G. Ergonomics:

The plane will be placed on the mandibular canines of the patient. When the patient closes their mouth, force from the mandibular canines will be applied to the inclined plane. Over time, this repeating motion combined with the angle of the inclined plane will slowly guide the canines into the desired position. The device should be non-intrusive to the rest of the patient's mouth with a height and size that is patient specific. The angle of the incline plane will be patient specific; it will be determined by the degree of distoclusion, size of teeth, and time needed for correction, which typically falls into a range of 45-60 degrees.

H. Size:

The size of the inclined plane will vary from patient to patient and therefore should be size adjustable to accommodate for each patient and the varying Class II Malocclusions. Typical canine width to consider in the design is a 11 mm width of crown as percentage compared with widest crown [5].

I. Weight:

The inclined plane should weigh 170 grams or less. This will ensure that the patient does not notice the device and is able to use it comfortably for 6-8 weeks. The optimum weight would be around 85-113 grams, depending on the size of the patient.

J. Material:

The device will be 3D printed with Ti64 using a Lens MR7 printer. 3D printable resins such as Formlabs Dental LT Resin should not be used due to weaker mechanical properties.

K. Aesthetics:

Color is relatively unimportant for the functionality of the inclined plane, and therefore this aspect of aesthetics is not the focus of the design. The shape of the inclined plane will be that of the maxillary arches of the patient [2]. The design will have two rings for the maxillary canines. As for texture the devices should be smooth to negate any lacerations and to maximize comfort for the patient.

Production Characteristics

A. *Quantity:*

Units are designed specifically for each individual patient, so quantity depends on the number of patients with Class II Malocclusions. One device is used per patient.

B. *Target Product Cost:*

The cost of production will be based on the specific material used for 3D printing the incline plane, which is around ~\$100 [6], as well as the size of it as each incline plane will vary from each patient.

3. Miscellaneous

C. *Standards and Specifications:*

The incline plane would go under the category of Orthodontic appliance and accessories, in which the device is affixed on a tooth so that pressure can be exerted on teeth for orthodontic treatment, which is a Class 1 classification. This means the incline plane is low to moderate risk of injury [7].

D. *Customer:*

The client would like an incline plane that would be able to fit on any size canine with Class 2 Malocclusion. This would be achieved by having a general SolidWorks model that can be altered patient by patient through the use of calipers to take measurements of canines to create the patient specific incline plane.

E. *Patient-related concerns:*

Before the device is placed in the mouth of the patient, the owner will be explained how the incline plane is supposed to work to fix the Class 2 Malocclusion. Each individual patient will be sedated so that measurements of the teeth and jaw structure can be taken. An incline plane will be created specifically for that patient, resulting in no need for sterilization between uses. Furthermore, the owner of the patient will be explained how the incline plane should be monitored when the patient eats or plays. If the device breaks, the owner of the patient needs to return to get another incline plane implanted.

F. *Competition:*

There exists a patent for an orthodontic fixture intended for use with animals to correct lingually displaced canine teeth [8]. This device uses non-toxic metal which can be costly

and difficult to manufacture. This product can be improved by adding support, such as a thicker bridge and thicker crowns, to prevent this design from breaking upon usage.

References:

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