VetMed: 3D Printed, Patient Specific Incline Plane for Management of Class II Malocclusion

Executive Summary: Tong BME Design Award, BME 301

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Class II malocclusions are a common genetic skeletal deformity that affects 10% of purebred dogs. With this condition, the dog's lower jaw is relatively shorter than the upper jaw which diminishes the functionality of the bite. Not only is this painful, but if it is not corrected, it can lead to dental attrition, gum diseases, oronasal fistula, and the destruction of the gum pallet and tissue. To safely correct class II malocclusion, veterinarians use tipping orthodontics. An inclined plane device is used to guide the misaligned teeth to the correct position by utilizing controlled tipping mechanics via the force of a dog's bite. The current procedure to create a patient-specific incline plane requires anesthesia to take a CT scan of the patient's jaw, conversion of DICOM files to produce a 3D printable model of the patient's jaw, and manual carving of an incline plane on this model by the veterinarian which is sent to a software engineer to create a computer model to be 3D printed. This fabrication and workflow is time-consuming and complex, making the procedure expensive and unrealistic for some pet owners. Our new workflow and fabrication process increases the speed of production and reduces costs to create this device, making the treatment more accessible.

The design we developed was inspired by an expired patent, US5151027A. It was created in SolidWorks and the model features two rings that will be secured to the upper maxillary canines of the patient. Attached to these two rings is an incline plane which will be used to tilt the lower mandibular canines into place. Supporting the pressure experienced by the upper maxillary canines from the contact with the lower mandibular canines will be a supporting bridge running along the roof of the patient's mouth, connecting the upper canines. Through the development of a simplified workflow involving the modification of 4 easily measurable dimensions within the patient's mouth taken with a handheld caliper, our SolidWorks model creates a client-specific product. Because of the simplification in design, the design eliminates the need for CT scans and anesthesia, ranging anywhere from $100-500 and $90-200 respectively, and allows the client to simply take measurements in the patient's mouth, alter a base 3D model, and print the device, which in total cuts the cost of fabrication down to only $120 for the device itself. The time required from the veterinarian is cut from 2-3 weeks involving the CT scan, time for the client to carve out a model incline plane (1 week), and time for an external software engineer to develop and print a 3D model incline plane (1-2 weeks), to about 30 minutes with the improved workflow, allowing the client to work independently. The final design will be made out of 3D printable Titanium (Ti64) and sourced from Materialise.

The new workflow process has been tested by other biomedical engineering students. Most students were able to complete the entire workflow in 15 minutes. The device will not break with a dog's bite force. The team compression tested the titanium piece and it repeatedly withstood about 926 N, the maximum force from a canine tooth. The team's workflow was also disclosed to WARF as intellectual property and the team is pursuing a patent. If this design were commercialized, it would be able to help the 4 million dogs affected by Class II malocclusions. Additionally, the profitability of our device can be maximized to 200% by setting the product to cost $500, making it a promising device in the field of veterinary orthodontics.