Analyzing Osseointegration of Tetranite in Dental Implants

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WeARE Research Area

Dr. Sergio Montelongo mentored me throughout this study and helped me improve my computational and analytical skils, specifically with regards to bone. We worked in Dr. Teja Guda's lab in UTSA's Biomedical Engineering Department in the AET building.

Motivation or Background

Most visits to the dentist can be quite costly and lengthy, especially for operations that require a longer time for bone reparation. Dental implants, for example, usually require a follow-up visit three months after the surgical bone graft procedure so that the implant can be attached. Tetranite is an injectable bone adhesive which can potentially be applied to the area of implantation in a patient at the same time as the graft. Its creators claim that the application of the drug vastly reduces the waiting time for a follow-up visit from three months to approximately three days due to its high capability in repairing bone faster. This computational study was conducted to evaluate the findings from canines, who went through the dental implantations with Tetranite and the current gold standard in the field BioOss [1]. This data is part of an FDA study to see the efficacy and safety of the treatment prior to advancing to clinical trials. Tetranite has the potential of reducing complications with the bone grafts prior to implantations on top of reducing financial burden and time [2].

Objectives

1. Evaluate the effectiveness of Tetranite *in vivo* in a canine model undergoing a dental implant operation by comparing it to market leader product BioOss and to the BloodClot control (no product added).
2. Use microCT-analysis-based-data-imaging-software to isolate the dental implant from the microCT scans of canines in controlled animal studies. Then calculate the amount and quality of bone in the region surrounding the implant, thus quantifying osseointegration.

Methodology

Computational analysis can be a lengthy process, given the large amounts of data needed to be configured. Slices of CT images had to be individually inspected in order to ensure that no gaps were present and that portions of bone were not missing. With the Ctan software, we were able to find the centroids of implants in canines performed in a previous animal study [1]. Centering the implant allowed for us to accurately create ROIs around each implant in successive slices of a scan. Templates that perform various morphological operations were specifically designed to isolate the implant by extracting it from the scan. The Batman tool from CTan was later used to collect data of the surrounding bone and tissue for data analysis, demonstrating the extent of osseointegration with the application of Tetranite.

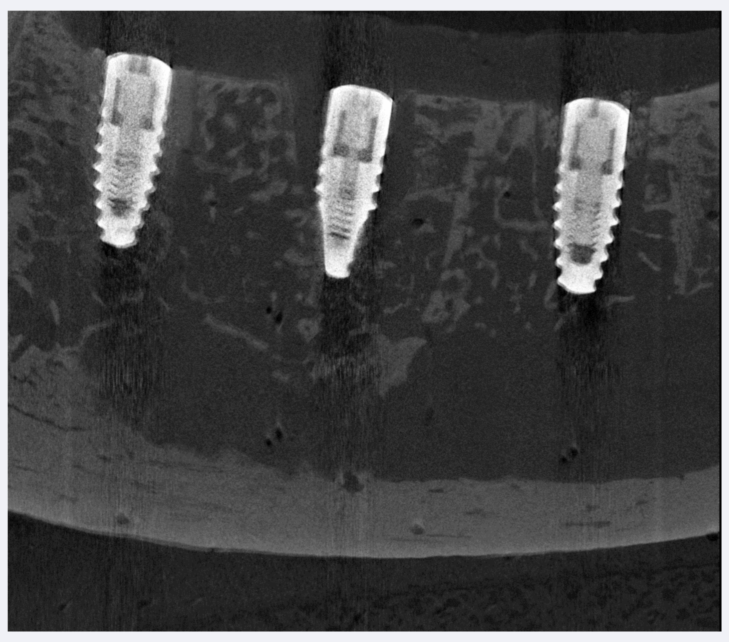

Fig. 1 microCT reconstruction of the implants *ex vivo Implants in canine mandible*

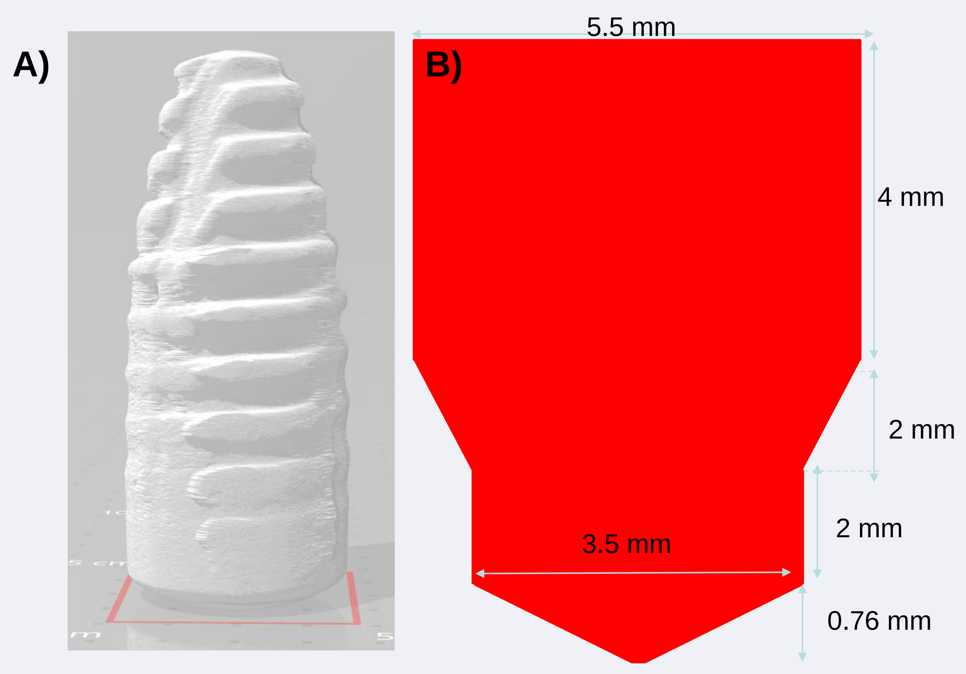

Fig. 2 A) 3D reconstruction of an implant, made from VOI B) *Dimensions of the Region of Interest analyzed*

Results

Using different segments of bone and the dental implant, we were able to quantify information from caudal, middle, and rostral portions of the mandible (corresponding to the samples implanted using Tetranite, BioOss or BloodClot as the control). Based on the morphometry results of the 3D analysis of the scans, we were able to derive data for over fifteen implants of an animal study conducted in the span of twelve months in order to quantify the resulting bone and tissue after the application of Tetranite versus the application of competitor products demonstrated below. Tetranite outperformed in the categories of Percent Bone Volume and Bone Surface Area and performed equally in Implant Volume and Tissue Volume.

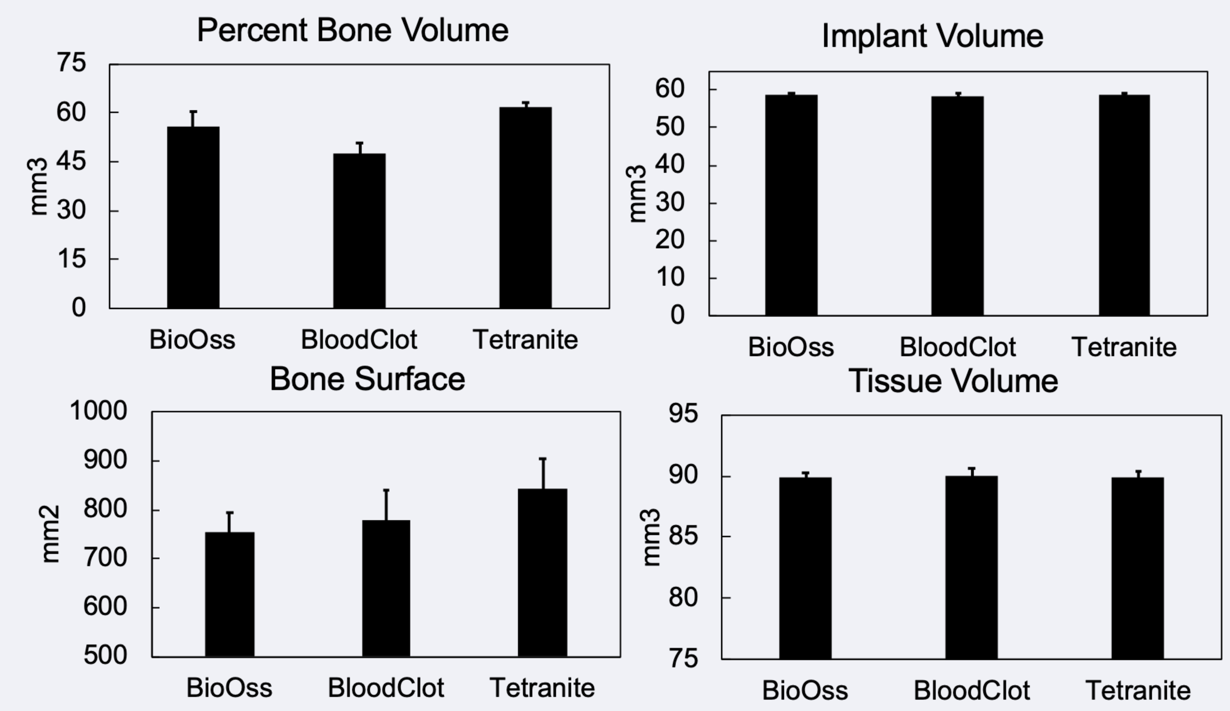

Fig. 3 *Comparing Tetranite to other products*

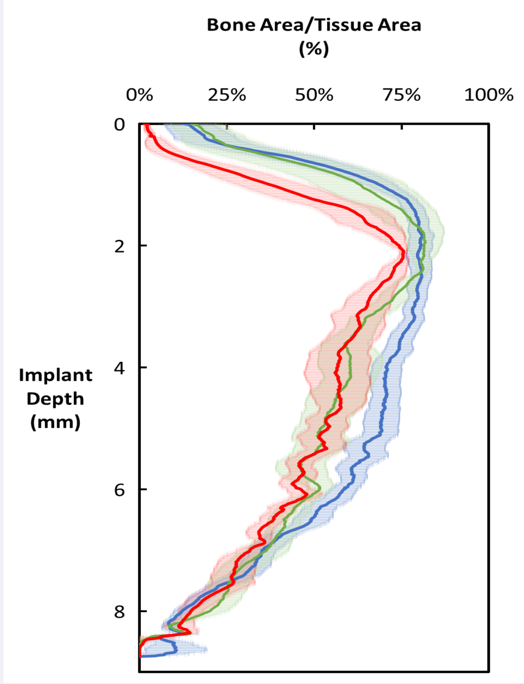

Fig. 4 *2D Mineralization Profile*

Skills and Experience

The initial challenge in the computational aspect of the project was reorienting the microCT images and using DataViewer to gauge the coordinates of the centroid of each implant. Given that this did not translate well into the CTan software, we decided to approximate four slices of the implant and take the average of their coordinates. This allowed for an easier transition in extracting the implant in the software when creating the ROIs and VOIs of each scan. Developing a good template that was able to fully remove the dental implant in order to analyze the surrounding bone, also posed a problem that required a creative solution. Through trial and error of running different variations of templates, my group was able to settle with one. An important component of the template is the threshold, which is the maximum grayscale value that is interpreted by CTan. Any data found outside of the threshold value is not read and is discarded when performing other morphological operations, such as dilations and erosions.

What I Learned

I learned how to use software, such as DataViewer, and CTan to model bone in canines. Due to some of the limited capabilities of imaging technologies, software, such as Dataviewer can be used to reorient a scan and CTan can be used to isolate structures within the scan. For example, I learned how to isolate a dental implant within the mandible, so that the surrounding structures can be observed and analyzed in Excel. Using Excel to store hundreds of gigabytes of data improved my ability in understanding large amounts of information and how to quantify it. I was also exposed to concepts from programming language R, and I developed a greater interest in learning computer programs with an application to the biosciences and bioengineering.

Future Plans

The Boston based company, LaunchPad Medical claims that this injectable and synthetic biomaterial allows for faster osseogenic integration between the mandible and a dental implant [2]. We attend to further assess the results obtained from the application of their product by improving upon the image analysis techniques used in this project. It is also entirely possible to develop machine learning programs that can automate some data analysis procedures due to its repetitive nature.

Acknowledgments

This work is supported by the USDA National Institute of Food and Agriculture, Interdisciplinary Hands-on Research Traineeship and Extension Experiential Learning in Bioenergy/Natural Resources/Economics/Rural project, U-GREAT (UnderGraduate Research, Education And Training) program (2016-67032-24984).

References

1. Geddes, A., Thatcher, G., Hetzel, S., McCabe, R., Vandereby, R., & Snyder, C. (2020, February 27). Biomechanical Testing of a Calcium Phosphate-Phosphoserine-Based Mineral-Organic Adhesive for Non-invasive Fracture Repair of Mandibular Fractures in Dogs. Retrieved May 12, 2020, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7058112/

2. LaunchPad Medical, LLC. (2019). Retrieved May 12, 2020, from http://www.launchpadmedical.com/