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Analysis, Design, and Simulation of Clamp System

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Analysis, Design, and Simulation of Clamp System Used in Neurosurgical Procedures

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Abstract

The goal of this independent study was to prepare for the construction of modifications to the clamp system used during Neurosurgical procedures following consultation with neurosurgeons at the department of neurosurgery at Washington University in St. Louis's School of Medicine. This consultation established the necessary adaptations to be made, and the work proceeded in coordination with a Professor in Washington University in St. Louis's Department of Mechanical Engineering and Materials Science.

1. Introduction

The context in which this study was undertaken is the application of the mechanical engineering discipline to the medical field, specifically in consultation with neurosurgeons in the design and construction of modifications to the clamp system used during neurosurgical procedures. Medical devices are often standardized across the medical field, and both their high cost and the pervasively conservative culture of the medical field de-incentivize modifications or adaptations which could potentially improve the use of the device for the role in which it serves. These combined influencing factors provide ample opportunities for improvement and modifications per user specifications.

As a step towards this, I interviewed two neurosurgeons in the Washington University School of Medicine's Department of Neurosurgery in regard to the clamping system used most frequently during neurosurgical procedures. Such clamping systems are utilized in the immobilization of the patient's head and spine, and is typically integrally combined with the surgical bed upon which the patient is secured.

Figure 1 Top-down view of a patient secured in a prone position using a radiolucent neurosurgical clamp system [1]

Figure 2 Side-view of patient secured in a supine position to a surgical bed using a non-radiolucent clamp system [2]

In this report, I present the design process which I underwent to design, model, and plan to construct a prototype which displayed potential modifications to a commonly used radiolucent neurosurgical clamping system.

2. Methods

The study was conducted by first interviewing two neurosurgeons in the Washington University School of Medicine's Department of Neurosurgery in regard to current issues involved in the regular use of a commonly utilized radiolucent version of the neurosurgical head clamping system. Following this interview, consultation was made with a professor in the Washington University Department of Mechanical Engineering and Materials Science pending modifications to the system's design.

The multiple components of the clamping system were then analyzed individually, and modeled using Solidworks to have a virtual model with which to work with.

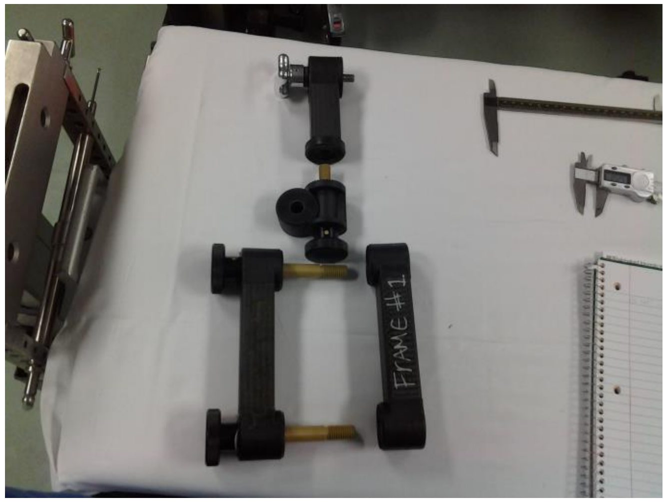

Figure 3 Disassembled radiolucent clamp system laid out for dimensioning

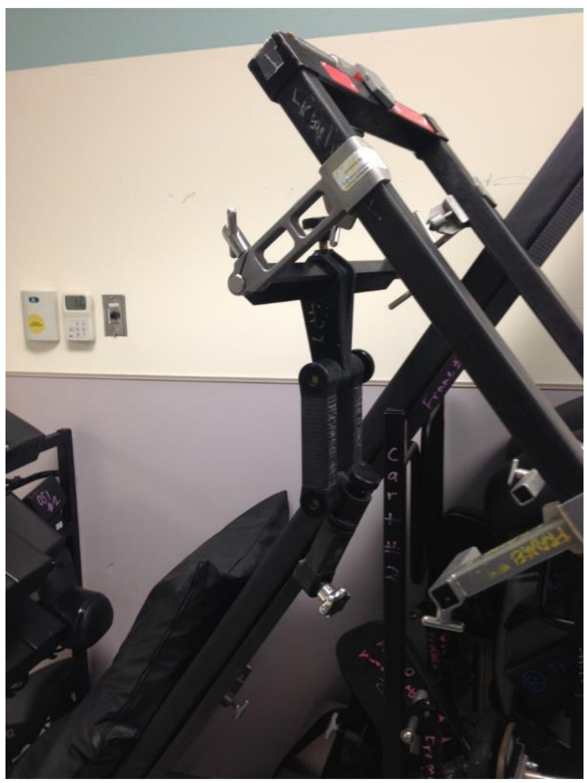

Figure 4 Assembled clamp system integrally mounted to the underside of the frame of the surgical bed

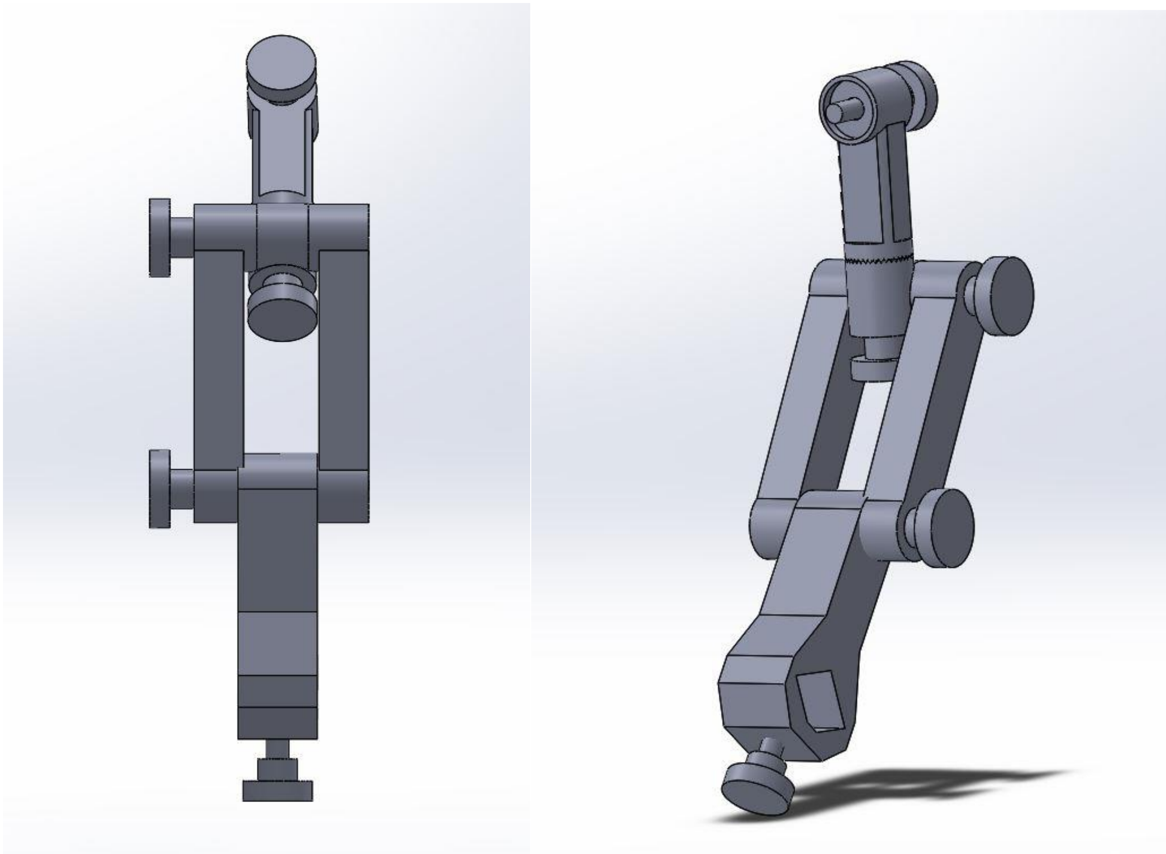

Figure 5 Back and isometric views of the modeled clam system made using Solidworks

The components of the model were dimensioned per specifications laid out in the Standard Preferred Tolerance Limits Fits ANSI B4.1 RC 8 and RC9 definitions of loose running fits [3]. The consistent use of this dimensioning allowed for prospective imperfections in the making of a physical model with which to demonstrate the modifications to the clamp system.

While the production model shown in figure 3 has a market cost of roughly $6,000, it was decided that a physical prototype could be manufactured utilizing 3D printing methods for less than $500. To this end, the components of the CAD model shown in figure 5 were processed individually using the slicing software Simplify3D.

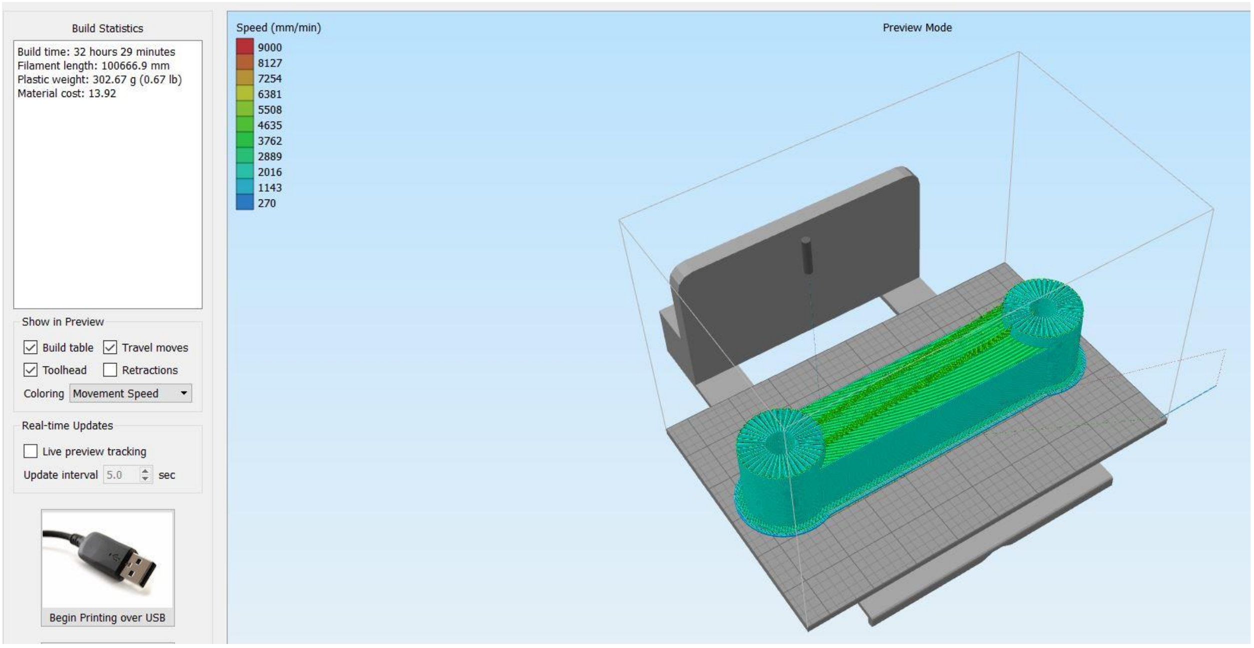

Figure 6 One component of the CAD model following analysis using Simplify3D

It was decided that polylactic acid (PLA) would be used to print the components of the prototype. This material was chosen over Acrylonitrile butadiene styrene (ABS) as the thermoplastic polymer to use due to its superior environmental impact and the comparative lack of warping observed in larger prints such as the one shown in Figure 6.

3. Results and Discussion

The virtual model is in place, and future work will consist of constructing an operable prototype for the demonstration of the modifications to the neurosurgical clamp system. This project greatly improved my familiarity with Solidworks, Simplify3D, and 3D printing methods, as well as my understanding of the various engineering tolerances used throughout the industry. I experienced the application of mechanical engineering skills to a problem in the medical field, which is one of the primary goals in my prospective career. I look forward to further work on the subject, which may include electrical circuitry and automation methods such as those provided by the Arduino platform.

4. Acknowledgments

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