THESIS PROJECT PORTFOLIO

Design of an Alternative Method to Create Custom Ocular Prosthetics

(Technical Report)

Ocular Prosthetics: The Socioeconomic Properties of Medical Technology

(STS Research Paper)

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There are over 2 million medical devices available globally; some of them are complex and life-sustaining, while others are small and more common items. The ocular prosthetic is an example of such a device; it is a small apparatus that patients who have lost an eye wear in their socket to restore their normal appearance. Although its main function is aesthetic, it also protects the socket from foreign bodies and infection. Around 5 million people worldwide wear ocular prosthetics, and patient reports show that they help individuals to live comfortably and re-integrate into their communities after losing an eye, which is a traumatic event. While these prosthetics offer great functional and aesthetic benefits to patients, they are not always accessible. They cost thousands of dollars and have to be replaced every few years; the fitting process is also uncomfortable. Ocularists, the specialists who make prosthetic eyes, are few in number, and patients may have to travel long distances for 3-4 appointments before receiving their eye. This problem relates to the much bigger issue of accessibility to medical devices and healthcare in the United States, but that is outside the scope of this specific project. This thesis project seeks to understand how accessibility to ocular prosthetics can be improved for patients.

The technical project centers on the physical design process of creating the ocular prosthetic, and how it could be changed to improve patient accessibility. The project outlines an alternative method to streamline creation, reduce resource and time use, and improve patient comfort and financial burden. Instead of the traditional mold cast method ocularists use, it combines photogrammetry, digital imaging, and 3D modeling. The final product is a manual describing the detailed steps required to go from a patient with an enucleated socket, to a 3D model of a prosthetic that would fit him or her. It involves first using pictures of the face to generate a 3D mesh reconstruction, and then using the mesh in 3D modeling software with boolean subtraction to deduce the shape of the prosthetic. This prosthetic model could then theoretically be printed using 3D stereolithography and used, after some biocompatibility modifications. Using root mean square error values, it was shown that this method can accurately reproduce the dimensions of a face and prosthetic. An important aspect of this proposed method is that it eliminates the contact and patient discomfort during the mold cast process through shifting production digitally. It would also streamline creation through reducing resource use and time, which would theoretically lower the cost of the prosthetics and allow ocularists more time to see new patients.

In contrast to the purely technical project, the STS project explores the social implications of problems in accessibility for ocular prosthetics, the effects these problems have on patients, and how the field of ocularistry may have to change in order to correct these issues. In its current state, the technological development of the custom ocular prosthesis is inherently biased towards particular social groups, mainly those who are in good health, wealthy, and with flexible work schedules. The project highlights the monopolistic nature of the ocularist industry and how this has led to stagnation within the technological advancement of the practice. It also examines the patient experience, and how socioeconomic bias in prosthetic creation has particularly devastating social consequences for excluded users, considering how improving the appearance of a lost eye is vital to improving patient quality of life. The results of this analysis suggest that the ocularist industry should expand and differentiate if it wishes to meet the needs of all users. Overall, the STS project aims to highlight the necessity of examining the technological politics of medical devices and the importance of accounting for all stakeholders during technological development.

There was great value in working on the technical and STS projects simultaneously; analyzing these two complementary proposals to the problem of accessibility in ocular prosthesis design has offered significantly more insight than working on one of the projects alone. In particular, the STS project influenced many aspects of the technical project through encouraging consideration of how certain parts of the new design process would affect accessibility. On the other hand, working on the technical project revealed many aspects of the design process that have social implications that were not previously recognized. The results of both the technical and STS projects were successful and led to a greater understanding of how patient accessibility to ocular prosthetics can be improved. Together, the results of this thesis emphasize the responsibility engineers have to account for the social work of their designs during technological development. Possible future work for the technical thesis might include investigating the actual printing of the prosthetic, or how 3D technology could be incorporated into other parts of the design process (e.g. scanning molds, scanning old prosthetics to use as references, etc.) Future work for the STS thesis could involve exploring difficult issues like how to increase insurance coverage of prosthetics by the FDA, or connecting how barriers to prosthesis accessibility relate to the more overarching issue of healthcare access in the U.S.

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