Thesis Project Portfolio

A Patient-Specific Computational Model for Optimizing Surgical Planning to Treat Patellar Instability

(Technical Report)

Assessing Factors Attributing to Gender Disparity in Orthopedic Surgery

(STS Research Paper)

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Sociotechnical Synthesis

The field of medicine, including orthopedic surgery, is constantly striving for innovation to create the best treatment and care for patients. One of the ways in which they drive forward innovation is through diversity, so to provide different points of perspective in development. Nevertheless, while gender diversity increases altogether in the physician workforce, orthopedic surgery lags, continuing to have the lowest female representation of all medical specialties. My technical project will discuss a common orthopedic musculoskeletal disorder that could have lowered rates of post-surgical reoccurrence with new surgical planning methods. Such need for innovation is also discussed in my research, where I seek the reasoning behind low female representation in orthopedic surgery and its significance. Both projects are plainly connected through the same surgical specialty. Also, both show the importance of driving forward progress in medical development for the treatment of orthopedic disorders.

Patellar instability is an orthopedic disorder characterized by the reoccurring sliding of the patella out of its intended position within the femur's trochlear groove during knee flexion and extension. Forces generated by muscles and ligaments, including the quadriceps muscles and medial patellofemoral ligament (MPFL), stabilize the patella as it tracks longitudinally through the trochlear groove. If there is a force imbalance, it can result in subluxation of the patella, otherwise known as a partial dislocation. Because of the wide variety of comorbidities and presentations of patellar instability, current procedural planning methods rely on the surgeon's subjective opinions. To address this subjectivity, my team worked to create a patient specific computational model of the knee to then quantify the lateral force vector acting on the patella. First, segmentation was performed on the MRI images of the patient's lower extremities, and then bone and muscle geometries and volumes were imported into nmsBuilder. Anatomical

landmarks were placed on the quadricep muscles and patellar tendon to create the paths needed for the OpenSim model. Within OpenSim, the moment acting on the patella in the coronal plane was plotted, with particular interest in the moment at full leg extension and thirty degrees flexion, as it is most relevant in dislocation. This data could be used in conjunction with the moment arm to find the force vector acting on the patella. This information can be helpful to inform surgical approaches.

Orthopedic surgery has the lowest female representation of any surgical specialty, a composition which has remained true despite the growing numbers of women joining the surgical field. After a thematic analysis of American and Canadian healthcare systems over the past fifteen years, I concluded which characteristics of orthopedics are dissuading to female physicians. There are factors which contribute to both a lack of women applying to orthopedic programs and a high number of women leaving the specialty during residency or in their career. Some factors include underemphasis of medical school orthopedic rotation, barriers to residency application and interviews, disproportionate incentives to women, stereotypes of orthopedic surgeons and subsequent harassment, lack of mentorship, and physical risk. The resulting combination creates a non-diverse atmosphere which will require an intentional and significant combative strategy. If there is no change to the representation of women in the field, the specialty will be denied the benefits which gender inclusivity brings, such as increased innovation and better patient care.

Working on both my technical project and my research paper simultaneously helped me to see the significance of gender diversity in the treatment of musculoskeletal disorders. Walking through the research and development of surgical techniques to treat patella instability gave me the ability to stop and evaluate how the inclusion of a female perspective could benefit patient

care. My specific disorder presents in both men and women, but there are sex differences which lead to variance in comorbidities. Women generally present with a wider pelvis and lower muscle mass. These differences are less significant in pre-adolescence, when most patella instability cases occur, but remain factors which influence the lateral force acting on the patella. Doing my research at the same time, I could appreciate how a female physician perspective could help treat this variance in presentation among sexes. For example, with higher female representation, there is increased sex-based reporting; this could help add information to subjective surgical planning of patellar instability across different sexes. In conclusion, doing my research and technical work concurrently gave me a greater appreciation for the role which women play, and deserve to have, in the orthopedic surgical field.