

Redesigning and Prototyping a Micro Scissor for Micro-Anastomosis Post-Mastectomy

(Technical project)

Reconstructing Equity: A deep dive into the factors that influence African American women's

decision to pursue breast reconstruction

(STS project)

A Thesis Prospectus

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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## **Introduction:**

Breast cancer is a disease that plagues many homes and families, with around 240,000 cases diagnosed in women and 2,100 in men each year in the U.S. (CDCBreastCancer, 2023). A mastectomy can be performed to remove the tumor or abnormal tissue from the breast; however, the appearance, shape, and function of the breast will be damaged. Breast reconstruction has been a popular choice for women since the 1980s, providing them an option to replace the tissue lost after mastectomy to restore the physical appearance of the breast (Cordeiro, 2008). The outside tissue is connected to the breast tissue through micro-anastomosis, a surgery that connects the two veins or arteries to restore blood circulation. Most breast reconstruction surgeries are extremely complex procedures that require a high level of skill and expertise, and a study observed that 31.4% of women suffered from deep vein thrombosis, or blood clotting, post-operation which results in a failed surgery (Konoeda et al., 2017). According to Dr. Christopher Campbell, surgeons must remain above a certain fail rate or they suffer the consequences of being banned from performing the surgery (Personal Communication, September 7, 2023). Microscissors, a tool often used in breast cancer surgeries, are directly related to deep vein thrombosis after breast reconstruction due to poor cutting of the vein tissue. In order to improve the breast reconstruction success rate and decrease the risk of deep vein thrombosis (DVT), a new micro scissor needs to be designed that makes a clean cut through the veins and arteries used in surgery.

Breast reconstruction is also often chosen by women following mastectomy because it is reported as an option that improves body image, and lowers depressive symptoms (Archangelo et al., 2019). However, a study done by UPenn Medicine showed that Black women are 17% less likely to pursue breast reconstruction as opposed to Caucasian women due to racial disparities in

the medical industry. This study expands on how discrimination by the medical industry among plastic surgeons is based on factors such as insurance status, referral challenges, and insufficient breast reconstruction literacy. A history of poor medical treatment combined with discrimination results in Black women experiencing discomfort with their doctors, fostering a sense of medical mistrust and apprehension towards surgery (Kennedy et al., 2007). These factors have negative psychosocial impacts on Black women and prevent them from having an option that is shown to improve patients' self-confidence and body image (Butler et al., 2021). In addition to racial disparities in the medical industry, the introduction of social media has shaped society's perception of beauty amongst different races and cultures, and with this a new genesis of psychosocial impacts on Black women's mental health, self-image, and femininity. Social media promotes expectations of Black women to have curvier body types in pop culture and social media platforms (McComb & Mills, 2022). This body type pushed by societal norms worsens the psychosocial impacts that Black women face and may have an influence on Black women's choice to undergo breast reconstruction.

In my technical project, I will be focusing on improving surgical success rates and decreasing the risk of thrombosis by designing and prototyping a micro scissor that is sterile, durable, and can cleanly cleave the vein with no ridges. In my STS project, I will focus on the psychosocial impacts that arise from numerous factors that could potentially influence Black women's decision to pursue breast reconstruction surgery.

**Technical Topic:**

From a database of breast cancer patients in the U.S. who underwent breast reconstruction immediately following mastectomy between the years 2009 and 2016, over 16% of women had an autologous procedure. An autologous procedure involves attaching a harvested

tissue flap in order to rebuild the breast shape. It typically costs over \$29,226 and is often chosen due to a 23% decreased likelihood of infection post-operation (Berlin et al., 2020);(Sawyer et al., 2022). However, thrombosis or blot clotting from poor attachment of veins is the main cause of a failed autologous reconstruction and results in skin or flap necrosis. Necrosis from thrombosis occurs when the blood supply to the newly attached skin flap is no longer secure and the tissue does not receive the oxygen it needs to survive, leading to loss of the harvested tissue.

Microscissors are important surgical tools for any surgery involving reconstruction with a patient's own tissue by creating a clean, precise cut in veins attached to harvested tissue. When the edge of the venous anastomosis is ragged due to dull scissor blades and the vein diameter is less than 2.5mm, surgical precision decreases and research has shown that patients have a much higher risk of thrombosis (Shimbo et al., 2022). Working alongside our advisor, Dr. Campbell, our team intends to redesign and prototype microscissors to have a blade that indicates when it is no longer sharp to ensure durability and maximize usable tissue around the vein circumference in its cut. By testing the efficacy of the modifications in each prototype, the final design will improve cutting and therefore reconstructive success.

Our team plans to research prior art and literature to aid in developing a prototype of a micro scissor that is both durable and creates a clean cut, using CAD software. Once issues in prior art are acknowledged, our team will start the initial steps of the design process by using the information collected to create numerous designs of micro scissor blades and shafts using CAD (computer-aided design) tools such as Autodesk Fusion 360 and SolidWorks. After the designs are completed, prototypes will be printed using a 3D printer and assembled with a pivot screw to evaluate the preliminary size and movement of the redesigned blade and scissor shaft.

The subsequent actions following the printed prototype will be testing the efficacy of micro scissor prototypes through Finite Element Analysis (FEA) and conducting experimental trials to assess durability and precision of the cut. Our team plans to conduct FEA in Autodesk Fusion 360/SolidWorks with Titanium and other metals to figure out which metal has the best durability and strength under tensile and compressive stresses felt when cutting tissue. After the analysis is completed, the most promising designs will be constructed using metal based on results from the 3D printed prototypes and FEA. The newly constructed prototypes will then be subjected to trials with multiple criteria such as ease of use, ease of manufacturing, clean cleaving of vein, surface area of usable tissue around vein circumference, and diameter size of vein once cleaved. The prototype will first be tested on tubing similar to the vein diameter sizes, then tested on cadaverous veins provided by Dr. Campbell. After each cut, the cleaved vein will be observed under a microscope to measure the amplitude of the microscopic ridges in the tissue after cutting using ImageJ software. The prototype that is tested will then be evaluated after the first trial to assess how many repetitions the blade can withstand before passing marginal durability parameters.

By redesigning the blade and shaft of the microscissors used by surgeons in anastomosis procedures, we expect not only surgeon precision to be improved but also vein diameter to be increased. By improving both of these factors, we believe this redesigned surgical tool can be used to improve surgical outcomes and patient happiness not just in breast reconstructive procedures but any surgical operation that requires the use of microscissors.

**STS Topic:**

Countless women navigate the difficult journey that is breast cancer, and often women underestimate the emotional toll of losing a breast after undergoing a mastectomy. Black women

with breast cancer who undergo a mastectomy fall victim to these emotions, as a study reported that 40% of Black women showed symptoms of anxiety and 20% showed symptoms of depression post-treatment (Lake et al., 2022). Many of these emotions stem from social media. The advent of social media has produced a new age of expectations for idealized and unrealistic body standards (McComb & Mills, 2022). Social media and contemporary pop culture have contributed to the popularization of a cultural preference for a curvier body amongst Black women (McComb & Mills, 2022). With a diverse range of body types in the Black community, this can sometimes be unattainable. As Black women are constantly held to this standard by society, Black women who have undergone a mastectomy feel extreme psychosocial impacts on their mental health from dealing with feelings of low self-esteem or beauty. A study concluded that 22.2% of women experience depression and emotional changes after mastectomy and mourn loss of breast (Padmalatha et al., 2021). Breast reconstruction after mastectomy is introduced as a solution to this issue by providing an option that may help the patient feel more comfortable with how they look after a mastectomy (Breast Reconstruction After A Mastectomy, 2023). In the same study that focused on depression in women with breast cancer, the rate of depression for women who undergo breast reconstruction decreased to 15.7% (Padmalatha et al., 2021).

As Black women continue to suffer from harmful societal norms influenced by social media, it would correlate that they would pursue breast reconstruction to improve self-image. However, a study done by UPenn Medicine discovered that minorities, specifically Black women, are less likely to receive breast reconstruction compared to Caucasian women. Where 59% of Caucasian women underwent breast reconstruction surgery, only 42% of African Americans underwent breast reconstruction. It was later discovered in the study that this is due to

racial disparities in the medical field, specifically concerning plastic surgeons not accepting private or public insurance from Black women (Penn Medicine, 2017). Although the Women's Health and Cancer Rights Act requires insurance coverage for postmastectomy breast reconstruction, there is still evidence that disparities are noted in referrals from surgical oncologists to plastic surgeons for breast reconstruction (Butler et al., 2021). These disadvantages paired with the Black community's historical mistrust of the medical industry could dissuade Black women from pursuing breast reconstruction surgery (Butler et al., 2021).

### **Research Question and Methods:**

The question that I aim to answer with this STS project is as follows: What are the variables that have psychosocial impacts on Black women and influence their decision to undergo breast reconstruction surgery? The focus of this search will be on literature research and conducting interviews with breast cancer survivor group organizers. I plan to review literature to gain insight and facts on the psychosocial impact of social media on both Black women and breast reconstruction, to understand how their relationships all intertwine. One piece of literature that I intend to expand on is an excerpt from Ruha Benjamin's book *Race After Technology*, "The New Jim Code" as it explores the relationship between African Americans and social media. This piece of literature along with the other material that I will collect will be analyzed using critical race STS theories that examine race as a technological phenomenon and social determinism theory and the influence of technology on society. Furthermore, I plan to obtain more information about racial disparities that Black women face in the medical industry, specifically with plastic surgeons and oncologists, and assess if there is a connection to fewer percentages of Black women undergoing breast reconstruction compared to Caucasian women. Following this, I plan to conduct multiple interviews with breast cancer survivor group

organizers in both Charlottesville, VA, and Fairfax, VA. In doing this, I hope to gain multiple perspectives from the women who have seen the impacts of breast cancer and breast reconstruction. Lastly, I plan to set up a meeting with my advisor, Dr. Christopher Campbell, to gauge his insights on why Black women choose to undergo breast reconstruction surgery based on consultations he's had and patients with whom he has interacted. It would also be helpful discussing with him his thoughts on racial disparities in the medical industry on Black women to receive insight from someone who is actively practicing medicine.

**Conclusion:**

In my technical project, I will create a prototype of a new design of micro scissor that is durable, user-friendly, and has improved cleaving abilities. As Black women choose to undergo breast reconstruction in the years to come, the surgery will be improved with the use of a new tool that consistently makes a clean cut and lessens the risk of thrombosis. In my STS deliverable, I will investigate why Black women undergo breast reconstruction after mastectomy, and if factors such as psychosocial impacts of social media and racial disparities in the medical industry influence this decision. By understanding the relationship between psychosocial impacts and racial disparities that Black women face and their reasoning for pursuing breast reconstruction, this research can help bring awareness and drive society and the medical industry to find solutions that can improve Black women's mindsets and relationships with their doctors.

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