

A One-Handed Knee Aspirator Medical Device to Aid in Arthrocentesis

(Technical Paper)

Actors of Telemedicine Virginia: A Response to Regional Health Disparity

(STS Paper)

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Patrick Murphy
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Technical Project Team Members
Julia Donlon
Sarah Zagorin

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

Introduction

There is a regional disparity of healthcare access in the state of Virginia, and as a result, citizens are not receiving equal treatment based on socioeconomic status and geographic location. Based on resource allocation and different socioeconomic regions, Virginia healthcare infrastructure differs regionally (“Hospital & Healthcare Preparedness – Emergency Preparedness,” n.d.). There are different initiatives in place to address this issue, but the issue is a question of equality as to if these citizens are receiving comparable treatment (“State Office of Rural Health – Health Equity,” n.d.). Telemedicine is one of the programs introduced in Virginia to combat the inequality in treatment. Telemedicine is a concept that employs the use of medical information and communication technology to provide and support health care when there is a distance between the patient and health care professional (Telemedicine & Field, 1996). Specifically, telemedicine employs audio and visual information between patient and physician for the purposes of diagnosis and treatment planning. Application of Actor Network Theory (ANT) reveals different actors and relationships in telemedicine that introduce various social factors contributing to enforced inequality (Rees et al., n.d.). In order to assess whether telemedicine is effectively addressing regional healthcare disparities in Virginia, actor network analysis will serve as evidence in this STS paper.

The device proposed in the technical section addresses complications associated with the medical procedure of knee aspiration, like telemedicine is an improvement in healthcare related to use and access. Motivation for the device is driven by the need for a more efficient procedure and an increase in patient and physician comfort. As knee aspiration is a common procedure in orthopedics, there are potential applications for implementation in other similar procedures that involve joint effusion.

Technical Topic (Capstone)

An effusion is an abnormal buildup of fluid in the body (Gerena & DeCastro, 2019). Knee effusion is a painful condition resulting from trauma, overuse, or underlying disease (Johnson, 2000). Knee aspiration, or *arthrocentesis*, is a process in which a physician aspirates synovial fluid build-up from the knee. This fluid removal not only has therapeutic benefits, but is used for diagnostic purposes; detecting infection or trauma. The current clinical protocol for arthrocentesis involves using a 60cc syringe to draw up the fluid. This process is inefficient in that it requires one hand of the physician to hold the syringe and one to draw back the fluid. Physicians in the University of Virginia(UVA) Sports Medicine Department expressed the need for a more efficient method of aspirating synovial fluid at the knee joint that would only require one hand. The physician's other hand is needed for maneuvering the fluid in the patient, and holding the patient's knee.

This technical proposal describes a device to be used in conjunction with a 60cc syringe that will allow the physician to stabilize the syringe and draw back fluid with only one hand. The mechanism involves a trigger that incrementally pushes back a rod with each pull. The rod is locked into the syringe plunger, and pulls back the plunger with each increment. The proposed design addresses the goal of a single-hand procedure while also increasing the speed and efficiency. In addition, physician and patient comfort will increase. The knee aspirator project consists of a team of biomedical engineering undergraduates Julia Donlon, Sarah Zagorin, and myself, Patrick Murphy, along with our advisors in the UVA Department of Orthopaedics; Dr. Miller and Dr. Backlund. This device apparatus also builds on the foundations of prior art and example of the ratcheting mechanism used to spread can be seen in Figure 1 below. Although the ratchet clamp spreader in Figure 1 provides a basis for a concept, it does not exactly achieve the

mechanism this project aims to address. Our team plans to reverse engineer this design in order to hack the necessary components and modify for knee aspirator purposes.

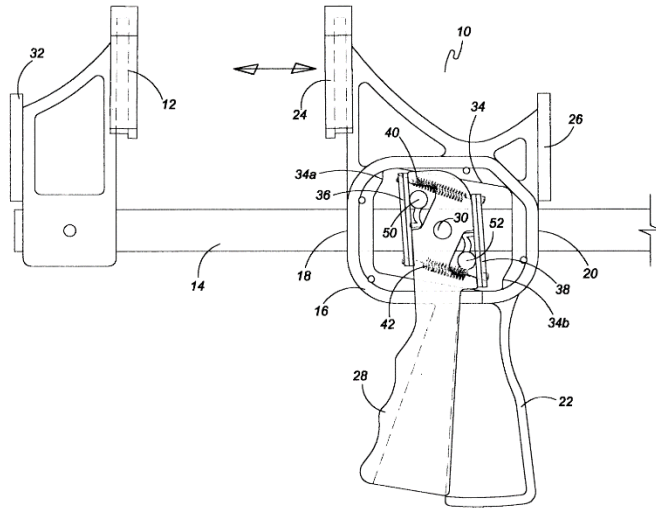


Figure 1 demonstrates the ratcheting mechanism that this proposal aims to emulate. From (United States Patent No. US6382608B1, 2002).

As a preliminary timeline for the technical project, a primary goal is to observe the procedure and note where procedural struggle occurs. At this time, these observations have for the most part taken place. Sequentially, the design phase is currently where the project stands. The knee aspirator team is currently designing and drafting measurements, with plans of prototyping with 3D printing before the end of the semester. Next semester will consist of testing and modifying prototypes, gathering data on efficiency and procedure time, and hopefully applying for a patent.

STS Topic

The Virginia Department of Health has expressed the need for initiatives with goals of bridging gaps in healthcare access in Virginia. Not only do people in these regions face geographic barriers to getting adequate healthcare needed, statistics show a decrease in life expectancy as a result of these socioeconomic and regional differences (Countries, Crimmins, Preston, & Cohen, 2011). Telemedicine was introduced to Virginia as a possible technology for addressing the issues of healthcare resulting from geographic barriers. For example, regions in Virginia with respect to healthcare infrastructure are largely disparate based on development, as represented by Southern Appalachian regions when compared to Northern Virginia (McGarvey, Leon-Verdin, Killos, Guterbock, & Cohn, 2011). Telemedicine is a concept that employs the use of medical information and communication technology to provide and support health care when there is a distance between the patient and health care professional. Specific to telemedicine is the use of imaging and sound to diagnose. Image quality is of utmost importance, but it is an expensive technology. Due to the expense of this technology, some of the less developed regions cannot support this technology (Minh et al., 2012).

In telemedicine there are stakeholders that are overlooked when considering who is affected by the implementation of such a system. Directly involved as stakeholders are the patients, most likely from a region with less access to healthcare, and the physicians at an established hospital. Also involved are regulatory and supportive members-- such as insurance companies, system administrators, healthcare staff, and pharmacists (Troshani, 2013). All of these roles are stakeholders in the system of telemedicine, and are affected by outcomes in this healthcare infrastructure. Cybersecurity and other communication technology stakeholders are also involved in telemedicine through the support of operations. Looking further into the ramifications of telemedicine, providers previously involved may lose their role with the introduction of

telemedicine. Studies have shown the effect telemedicine has had on nurse practitioner, who commonly serve the role as more readily available as opposed to a slightly less accessible medical doctor (Balestra, 2018). Conversely, there is a reallocation of responsibility which results in some healthcare actors to take on more efforts to support patients outside of their region.

Actor-Network Theory (ANT) focuses on the effects of technologies and humans on social processes. Through tracing associations between the various actors, account for such social effects as power are revealed (Cresswell, Worth, & Sheikh, 2010). In the case of a healthcare systems such as telemedicine, there are many actors involved as previously discussed, and also nonhuman actors, like IT systems. Constructionist critique ANT for its failure to assert that everything is socially constructed, rather ANT assumes social phenomena are the result of network interactions. ANT has also received critique for dismissing fundamental social factors such as race, class, and gender (Pages, 2011). I hope to address these critiques by shedding light on other social factors.

Not only does this topic frame analysis that has potential to identify issues and benefits of current implementation of telemedicine in Virginia, but it also serves as a predictor to how this paradigm shift in healthcare (“The Paradigm Shift in Medicine and How it Affects Technology,” n.d.) may serve as a predictor to future application of technology in healthcare. With the goal of identifying positive results and healthy relationships in the system, the possibility of solidifying these relationships will improve the system of telemedicine. Conversely, identifying corruption in the network will allow policy makers to provide support for marginalized actors and guidance for those in power.

Research Question and Methods

As an attempt to address the regional healthcare disparity in Virginia (McGarvey et al., 2011), telemedicine has been employed as a technology (“Telehealth – Health Equity,” n.d.), but involved in the implementation of telemedicine are actors who may undermine enforce power and corruption in such a system. This STS paper focuses on the question of what social factors come into play with implementation of telemedicine, and determining through ANT if the technology of telemedicine is bridging the gap of healthcare access. Telemedicine provides alternative ways of connecting health care providers to those in regions lacking necessary access, but has the potential to introduce other systemic inequalities, as identified by actor network theory (Rees et al., n.d.). Through the employment of network analysis, I plan to study the various actor networks involved in telemedicine. The method of Network Analysis and employing ANT will provide a framework which reveals relationships between actors in telemedicine that will lend insight to other social factors that may influence effectiveness of telemedicine as a bridge towards healthcare equality.

By first identifying crucial actors involved in telemedicine, both human and non-human, the framework for mapping relationships is established. Looking into these network relationships, the plan is to identify social factors present and how different actors are marginalized. Some actors identified thus far include, doctors, nurse practitioners, patients, cybersecurity. There is literature available to demonstrate unsatisfied actors as result of the system (Balestra, 2018) and non-human actors that contribute corruption to the system (“Telemedicine Breach Highlights Database Vulnerabilities,” 2018).

Conclusion

The technical deliverable will result in more efficient knee aspirator design will improve procedural efficiency for physicians performing knee aspirators, and decrease the amount of time required in clinic for patients with knee effusions. A mechanical design has potential for cheaper implementation that makes the device more accessible. The goal of the improved knee aspirator device is a procedure that only requires one hand, that is faster and more comfortable for physician and patient than the current procedure. Additionally, there is possibility for use of the proposed design in other joint fluid aspiration procedures.

Analysis of telemedicine in Virginia and the actors involved will reveal the various actors, human and non-human, in addition to actor relationships involved in telemedicine. Historical case studies may serve as a resource for identifying actors and also precedent ANT analysis of telemedicine in other areas. Applying the method of network analysis will reveal this network and reveal the efficacy of telemedicine implementation. This information will guide identification of social factors that are involved in telemedicine implementation and aid in uncovering potentially marginalized populations. Further, telemedicine analysis of this nature will help address issues in telemedicine in Virginia, so that it can more effectively serve as bridging the regional healthcare gap.

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