Technical Note

The Use of Telesurgery Mentoring and Augmented Reality to Teach Arthroscopy

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Abstract: Surgical teaching methods may be enhanced with telesurgery mentoring technology through virtual, visual, and audio interactions in the operating room, irrespective of geographic restrictions. The use of telesurgery mentoring carries the potential for accelerated learning in arthroscopic and surgical education. A telesurgery platform enables the establishment of a global network of surgeons with the goal of bridging gaps in surgical training via an accessible, cost-effective communication pathway. Specifically, such a platform allows a local surgeon to deliver real-time and live virtual assistance to a remote surgeon over a standard internet connection and removes the geographic barriers that prevent the practice of high-quality surgical care, thereby expanding virtual surgical collaboration. The purpose of our study is to describe our technique of telesurgery mentoring using a telesurgery internet platform (SurgTime; www.surgtime.com) and its applicability to teaching arthroscopic surgery skills both within the United States and in developing countries across the globe.

Remote surgical education or telesurgery mentoring is the process by which a remote surgeon can interact in real time with the operating surgeon via an accessible, cost-effective communication pathway. Using a telesurgery platform, the remote surgeon is able to give or receive live virtual assistance from another surgeon over a standard internet connection.

In orthopaedic surgical training programs and in developing countries, arthroscopic surgical skills are not often emphasized. The use of telesurgery mentoring has the potential to accelerate the learning curve in arthroscopic and surgical education. The reduction of surgical training to 80 hours per week also reduces the volume of cases US orthopaedic residents perform. Telesurgery mentoring can facilitate the collaborative efforts of improving both arthroscopic and open surgical teaching methods through virtual, visual, and audio interactions in the operating room, regardless of geographic boundaries. Stetson et al.[1] (2021) determined that telementoring using augmented reality was a reliable and effective tool for teaching shoulder arthroscopy to remote surgeons in Romania, Serbia, and Bosnia.

We describe a telesurgery internet platform (SurgTime; www.surgtime.com) that connects the operating room to other surgeons, students, and industry representatives regardless of their geographic location and allows real-time and live interaction and surgical instruction (Video 1). The purpose of our study is to describe the technique of telesurgery mentoring and its usefulness in teaching arthroscopic surgical skills both domestically and in developing countries.

Technique

Telesurgery Equipment

The telesurgery tower is a standalone cart (Ergotron Neo-Flex Monitor Cart) that can easily be wheeled into any operating room theater and connected to a standard arthroscopic tower. The tower consists of a
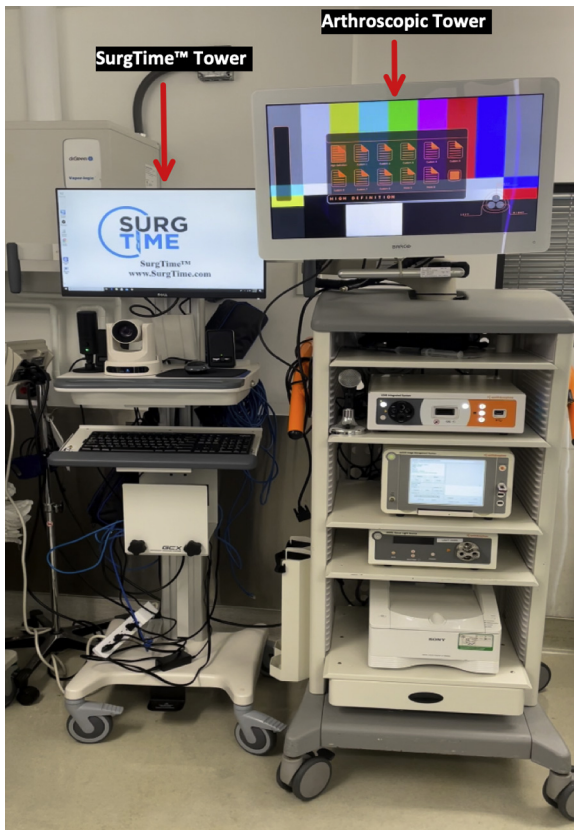
Fig 1. SurgTime tower adjacent and connected to arthroscopic tower.

television monitor connected to a computer (Dell) with an internet connection, in addition to an outside microphone and audio speakers with audio input-output capabilities. The tower connects SDI (serial digital interface) or HD-DVI (high-definition digital visual interface) cables to an adjacent arthroscopic tower to display the same image the arthroscopic surgeon is seeing intra-articularly (Fig 1). There is also an outside camera (PTZOptics 20X-NDI Broadcast and Conference Camera) attached to the telesurgery tower that displays the outside picture of the operative field so that there is a split screen enabling the viewer to see the outside field and the arthroscopic view of the joint at the same time (Fig 2).

Operating Room Setup

The telesurgery tower is brought into the operating room and connected to the standard arthroscopic tower. The telesurgery tower equipment allows the video picture from the arthroscopic tower to be transmitted to any computer, tablet, or mobile device via a standard internet connection. The telesurgery platform does not interfere with or hinder the surgeon's view of the arthroscopic tower. In addition, the connection to the telesurgery platform does not interfere in any way with the quality of the arthroscopic image projected onto the surgeon's regular surgical tower.

Telesurgery Platform (SurgTime)

The telesurgery platform (SurgTime) is a secure, Health Insurance Portability and Accountability Act (HIPAA)−compliant internet platform that uses proprietary, cloud-based software that is licensed on a subscription basis and is centrally hosted. Access to the SurgTime platform can be established on the company's website (www.surgtime.com). Once a surgeon or other health care professional creates an account, he or she then has the ability to view surgery generated from the platform and to share surgical videos with other surgeons and health care professionals. If a surgeon wishes to become a broadcaster, he or she is required to purchase a telesurgery tower that can then be placed in his or her operating room with technical support from the company to facilitate the installation. Next, the broadcasting surgeon can schedule a surgical procedure and invite up to 100 viewers simultaneously. Skilled surgeons can then stream their surgical procedures live in real time to a global audience. This is an intraoperative, live video platform that can be transmitted across the hallway or across the world via a standard internet connection. It provides an audiovisual communication portal for surgeons, students, and industry members to engage with each other, irrespective of geographic location. The broadcasting surgeon has the ability to interact with all of his or her viewers in real time and participate in direct dialogue with the viewers asking questions. This in essence creates a "borderless operating room" where surgeons can share their knowledge with other health care professionals. The viewing surgeons have the capability to use the augmented-reality capabilities of the platform and the "telestration" feature to annotate the image with a 2-dimensional pen tool using their computer mouse (Fig 3).

The surgical procedures can then be saved on the surgeon's own telesurgery Health Insurance Portability and Accountability Act (HIPAA)−compliant website portal (www.surgtime.com) for other individuals to view in the future. This creates a valuable database of content to empower fellow surgeons with unprecedented resources to improve their surgical skills. It also creates a site on which surgeons, clinicians, and mentors can review and analyze their own performance with their peers and can virtually collaborate and interact in a peer-to-peer forum, providing an enhanced postoperative learning experience. This telesurgery platform eliminates the need for long-distance travel to partake in surgical collaboration. The hope is to establish a collaborative medical community that is committed to globalizing modern approaches to surgery through open dialogue and professional expertise.

Live Telesurgery Transmission

The ability to interact and discuss difficult surgical cases in real time, in the operating room, with other
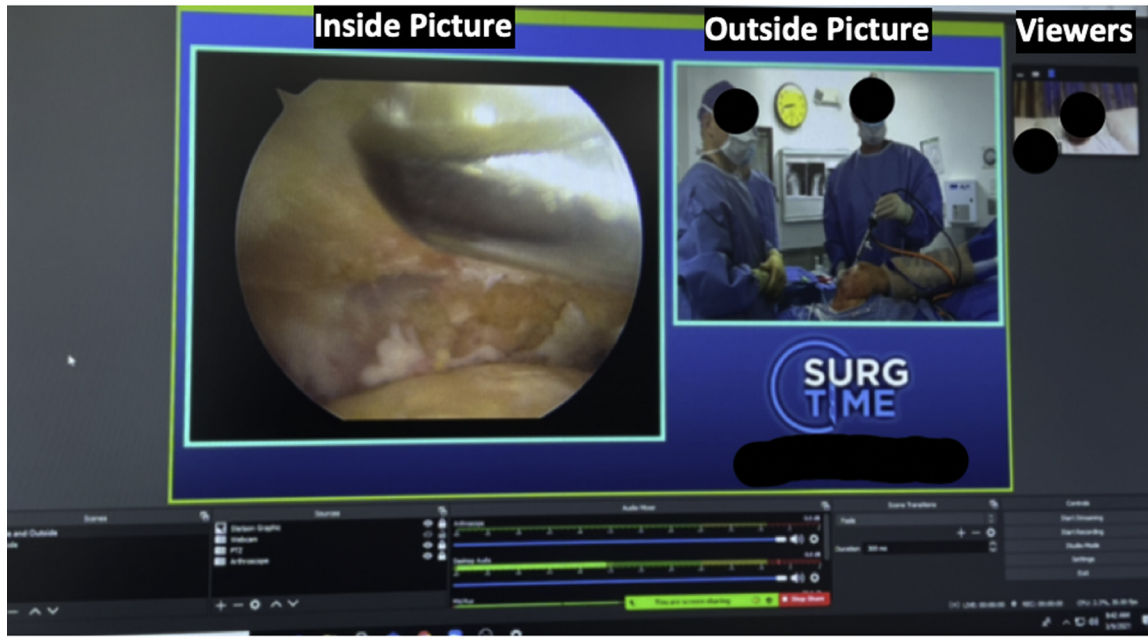
Fig 2. Tower monitor with split screen of inside and outside pictures with gallery view and viewing doctors on side.

experienced surgeons offers a valuable opportunity to enhance patient care. The telesurgery platform allows virtual communication for surgical collaboration, mentoring, and step-by-step instruction. The ability to virtually scrub in and give instructions from anywhere in the world connects clinicians and improves patient outcomes. The live telesurgery transmission can be used for one-on-one surgical instruction in a challenging case or for transmission to multiple surgeons simultaneously so that they can learn a new technique or refine their skills. Surgeons and other individuals can view surgical procedures and participate in real-time viewing from all parts of the world. The platform has been used successfully to transmit surgery to doctors in the United States, Romania, China, Bosnia, and Bali (Fig 2). Industry members can also log in remotely, and the virtual interaction through telesurgery gives representatives remote access to surgeons in the operating

Fig 3. Demonstration of monitor picture using "telestration" feature, depicted by blue oval overlying arthroscopic view.

Table 1. Pearls and Pitfalls

Pearls

    The reduction of surgical training to 80 h/wk reduces the volume of cases US residents perform.

    The telesurgery platform can bridge the gap in surgical training via an accessible, cost-effective communication pathway in the operating room.

    Remote surgeons can virtually scrub in and give instructions from anywhere in the world to provide instruction and improve patient outcomes.

    Industry representatives can be "virtually" present in the operating room to facilitate new product introduction and market penetration.

Pitfalls

    Arthroscopic and surgical skills are often not emphasized in US and other residency programs.

    Telesurgery mentoring cannot replace basic surgical skills.

    Telesurgery mentoring cannot replace good decision making in preoperative treatment.

room to aid in the development of new technology. This interaction is unique and has the ability to change the landscape of surgical education. By harnessing technology, surgeons can work collectively and collaboratively with each other and industry representatives to share their experiences and best practices, improving patient care. Tables 1 presents pearls and pitfalls for the use of the described platform, and Table 2 shows advantages and disadvantages.

Discussion

The telehealth market has grown exponentially and is expected to grow 30% during the period of 2019-2025.[2] The US telehealth market was expected to reach around $10 billion by the end of 2020, with high double-digit year-over-year growth of around 80%, owing to the recent COVID-19 (coronavirus disease 2019) pandemic. Ponce et al.[3] coined the term "virtual interactive presence" (or "VIP") as the ability to connect remote health care providers with patients or other providers through audio and video technology, without direct contact.[1] Tele-mentoring, a concept within telehealth, involves an expert physician guiding another physician at a different geographic location. Tele-mentoring has multiple real-world benefits but has undergone minimal evaluation in surgical training and education.[3] We have coined the term "telesurgery mentoring" and its use to bring a real-time interactive presence to the operating room from another geographically remote surgeon via a standard internet connection.

The need for specialized surgical expertise continues to grow despite an increasing shortage of practicing physicians.[4] This is especially true in underserved areas where approximately 80 million persons in the United States live.[5] In response, the United States has put governmental incentives in place to promote the use of telehealth.[6] This is particularly relevant in procedure-based medical fields such as surgery and is a driver of the growth of tele-mentoring[3] and telesurgery. In complex elective abdominal surgery, tele-mentoring of community surgeons by university surgeons has been shown to result in shorter hospital stays.[7] This technology can also serve as a bridge not only between junior and senior residency but also between residency and clinical practice.[3]

Providing quality surgical assistance and training locally and globally is a challenging task. The demand for health care and surgical skills training is outpacing the number of surgeons available to deliver care. Only about 6% of the world's surgical procedures occur in developing nations.[1] It is estimated that 18.6 million persons die each year from a lack of access to safe surgery, more than the number of deaths from human immunodeficiency virus, tuberculosis, and malaria combined. High-quality health care and surgical training are in demand everywhere. Telesurgery mentoring has the ability to transform surgical training by allowing surgeons to place themselves into any surgical setting in a live situation regardless of geographic location, the so-called borderless operating room. Telesurgery can break down these geographic barriers by delivering real-time and live surgical training and can help bridge the gap to surgeons unfamiliar with new surgical techniques.

Virtual interactions through telesurgery also allow industry representatives remote access to surgeons. This connection provides a virtual work space with increased work flexibility, as well as reduced costs, and adheres to hospital regulations. Digitizing a representative's physical presence in the operating room streamlines education and training. It can also accelerate new product introduction, allowing for faster and deeper market penetration.

In conclusion, the purpose of the telesurgery platform is to establish a global network of surgeons with

Table 2. Advantages and Disadvantages

Advantages

    Telesurgery mentoring allows real-time interaction with the operating surgeon from any location.

    Telesurgery mentoring can accelerate the learning curve in surgical education.

    Telesurgery mentoring can facilitate collaborative efforts in difficult cases.

    The telesurgery platform connects the operating room to other surgeons, students, and industry representatives, eliminating long-distance travel.

Disadvantages

    The telesurgery platform requires special equipment with a stable and broad internet connection.

    The telesurgery platform requires training on the patent-pending equipment and setup of the arthroscopic tower.

    Telesurgery mentoring cannot replace good, basic arthroscopic and surgical skills that must be learned through hands-on training.

the goal of bridging gaps in surgical training via an accessible, cost-effective communication pathway. The platform allows a local surgeon to deliver real-time and live virtual assistance to a remote surgeon over a standard internet connection. The platform can help surgeons both locally and globally improve their technical accuracy, thereby enhancing the treatment provided to their patients. New surgeons facing a difficult or challenging case can connect with mentors in real time in the operating room via the virtual platform. Experienced surgeons can connect anywhere around the world in real time to share their surgical expertise, eliminating the need for long-distance travel to partake in surgical collaboration. The platform also allows industry members to be virtually present, increasing their efficiency. The platform removes the geographic barriers that prevent the practice of high-quality surgical care and expands virtual surgical collaboration.

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