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NOVEL VIRTUAL MICROSURGICAL TRAINING PROGRAM DURING THE COVID-19 PANDEMIC

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Abstract
The COVID-19 pandemic has challenged the way microsurgery is taught. In response, a live online program was created for surgeons to improve their microsurgical skill set as well as for non-experienced students to be introduced to the field. The curriculum included recorded video modules and live online sessions with the instructor. Three different student workstation setups were analyzed for its microsurgery training efficacy. In this paper, we illustrate Columbia University's development of a virtual microsurgery course and why the "scope to scope" workstation set-up is the preferred method for microsurgical training.

Keywords:	*microsurgery, microsurgical education, remote learning, virtual training, curriculum, microvascular surgery, anastomosis.*
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НОВАЯ ВИРТУАЛЬНАЯ ПРОГРАММА ОБУЧЕНИЯ МИКРОХИРУРГИИ ВО ВРЕМЯ ПАНДЕМИИ COVID-19

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Аннотация
Пандемия COVID-19 бросила вызов многим сферам жизни, в том числе она повлияла на методики преподавания микрохирургии. В ответ на это была создана онлайн-программа для хирургов с целью улучшения их микрохирургических навыков, а также для ознакомления студентов с этой областью медицины. Учебная программа включала в себя записанные видео-модули и онлайн-занятия с инструктором. Были проанализированы три различные конфигурации рабочих станций студентов на предмет эффективности обучения микрохирургии. В этой статье мы представляем разработанный в Колумбийском университете виртуальный курс по микрохирургии и объясняем, почему установка рабочей станции «от масштаба к объему» является предпочтительным методом для обучения микрохирургии.

Ключевые слова:	*микрохирургия, микрохирургическое образование, дистанционное обучение, виртуальное обучение, учебная программа, микрососудистая хирургия, анастомоз.*
Конфликт интересов:	авторы подтверждают отсутствие конфликта интересов, о котором необходимо сообщить.
Прозрачность финансовой деятельности:	никто из авторов не имеет финансовой заинтересованности в представленных материалах или методах.
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INTRODUCTION

Microsurgical training has traditionally taken place within the confines of a simulation lab with in-person teaching being the gold standard. Since the 1980s, Columbia University has trained more than 4,000 physicians from 60 U.S. institutions and over 70 countries through its' microsurgery laboratory. In early 2020, the COVID-19 pandemic created a limitation. Microsurgical training could no longer be conducted in-person. Social distancing became a fact of life for many fields as society shifted to remote work and remote learning environments. This unanticipated development forced a new set of ideas to emerge in order for microsurgical education to continue.

With the aid of microsurgically trained medical students, Dr. Yelena Akelina, DVM (Director of the Columbia Orthopedics Microsurgery Research and Training laboratory) started an initiative to address the unforeseen circumstances that arose secondary to the COVID-19 pandemic. This initiative was to create a microsurgery curriculum that would allow students to effectively learn and enhance their microsurgical skillset outside of the laboratory environment.

This new curriculum needed to simulate the job of an operating microscope while also benefiting from the availability of an instructor regardless of the student's location. Upon further planning, it was decided that an online curriculum would be designed using three different types of student set-ups; each dependent upon the individual student's access to certain resources. We compared all three setups in order to determine their overall effectiveness. We wanted to know which of the three was most ideal for teaching microsurgery in a virtual setting.

The different workstation set-ups included the following:

1. *Scope to Scope Set-up* – Both the student and instructor had access to a microscope
2. *Pluggable Digital Microscope and Surgical Loupes Set-up* – The student utilized a USB digital microscope and surgical loupes while the instructor used an operating microscope
3. *Smartphone with Surgical Loupes Set-up* – the student utilized surgical loupes to visualize their work and a smartphone to transmit images of their work to the instructor; the instructor used an operating microscope.

The virtual curriculum consisted of instructional video modules and a three-day live online course.

Instructional video modules were produced and uploaded on Invivox, as an introduction into the microsurgery course. These briefing videos served to not only prepare the student for the live online course but also to serve as an opportunity for the student to go back and view these videos as many times as they felt comfortable. Included within these videos were the instructions showing how to set up the student's workstation as well as lessons involving the different surgical techniques used within the curriculum.

The live online course took place over the span of three days, each session lasting three hours in length. Hand positions and posture, microsurgical suturing techniques, and steps for performing end-to-end arterial and venous anastomosis were taught. The student and instructor connected with each other using the Zoom video conference software. This allowed the instructor to view the student's progress and provide adequate feedback.

METHODS AND DESIGN

Producing the modules

Five briefing modules were filmed for the course. The topics covered included:

1. Introduction to Virtual Microsurgical Training (VMT).
2. Introduction and setup of the surgical microscope.
3. Hand positions and posture.
4. Equipment needed before the start of the live online course.
5. Basic microsurgical suturing techniques.
6. Basic aspects of end-to-end arterial and venous anastomosis.

Equipment used for Video Module Production

- Camera connected microscope.
- Smartphone.
- Video Editing Software.

A camera was connected to the operating microscope to record high resolution footage of microsurgery being performed by the instructor. A smartphone was used to record audio and to film the instructor introducing the microsurgery course. Video editing software was used to help finalize the modules.

Instructor Workstation Set-up

- Operating Microscope.
- Computer with webcam and internet connection.
- Zoom Software.
- Nylon 8-0 and 9-0 sutures.
- Plastic Suturing board.
- Gloves.

○ Cutting board.
○ Colored Plastic background.
○ Chicken thigh.

An operating microscope with an attached camera was connected to a computer and used by the instructor. This would allow the student to see microsurgery being done in real time as well as for the instructor to be able to adequately demonstrate the microsurgical techniques. Internet connection was required to log on to the Zoom software and start the course. The computer webcam was used for face-to-face instruction and to help the student learn proper body posture and hand position.

Student Workstation set-up

Scope to Scope

○ Microscope.
○ Computer with webcam and internet connection.
○ Zoom software.
○ Microsurgical instruments.
○ Nylon 8-0 or 9-0 sutures.
○ Plastic suturing board.
○ Gloves.
○ Cutting board.
○ Colored plastic or latex background.
○ Chicken thigh.

A microscope with an attached camera connected to a computer was used for the "scope to scope" setup (Fig. 1A). Internet connection was required to log onto the Zoom software and start the course. The computer webcam was used for face-to-face instruction and to monitor the student's body posture and hand position. This simulated an in-person experience and allowed for constructive feedback to be given by the instructor.

Pluggable digital microscope with surgical loupes

○ Pluggable digital microscope.
○ Surgical loupes 2.5x or 3.5x.
○ Computer with webcam and internet connection.
○ Zoom software.
○ Microsurgical instruments.
○ Nylon 8-0 or 9-0 sutures.
○ Plastic suturing board.
○ Gloves.
○ Cutting board.
○ Colored plastic or latex background.
○ Chicken thigh.

A pluggable digital microscope was connected via a USB cable to a computer for the "Pluggable digital microscope with surgical loupes" set-up (Fig. 1B). Internet connection was required to log onto the Zoom software and start the course. The computer webcam was used for face-to-face instruction and to monitor the student's body posture and hand position. Surgical loupes were used by the student to perform the microsurgical exercises properly and comfortably.

Smartphone with surgical loupes

○ Smart phone.
○ Surgical loupes 2.5x or 3.5x.
○ Computer with webcam and internet connection.
○ Zoom software.
○ An object to be used as a platform (e.g. a small box).
○ Headlight or lamp.
○ Microsurgical instruments.
○ Nylon 8-0 or 9-0 sutures.
○ Plastic suturing board.
○ Gloves.
○ Cutting board.
○ Colored plastic or latex background.
○ Chicken thigh.

A computer with internet connection was required to be able to log onto Zoom and start the course. This was used for face-to-face instruction and to monitor the student's body posture and hand position. In addition to the computer, a smartphone was needed by the student to log on to the same Zoom session. The student was asked to position the smartphone face-up on a small box or object of choice with the rear camera facing the work area (Fig. 2).

The smartphone's camera was used to help the instructor observe the microsurgical techniques being performed by the student. This simulated an in-person experience and allowed for constructive feedback to be given by the instructor. Surgical loupes were used by the student to be able to see their work more clearly and at a higher magnification. A desk lamp or headlight was also required to illuminate the area.

Required Equipment for all three set-ups include:

○ Microsurgical instruments.
– Needle Holder.
– Jeweler Forceps.
– Scissors.
– Plastic Vascular Clamps.
○ Sutures 8-0 or 9-0 nylon.
○ Plastic suturing board.
○ Gloves.
○ Cutting board.
○ Colored plastic or latex background.
○ Chicken thigh.

Plastic Suturing Board

Before starting on the femoral chicken thigh, a plastic suturing board was used to practice suturing techniques. This was accomplished by cutting a piece of latex glove and adhering it to a plastic board with the use of masking tape. A slit was created in the middle of the latex material. The slit was then used to practice suturing skills by approximating the edges of the slit via the use of microsurgical suturing techniques (Fig. 1B).

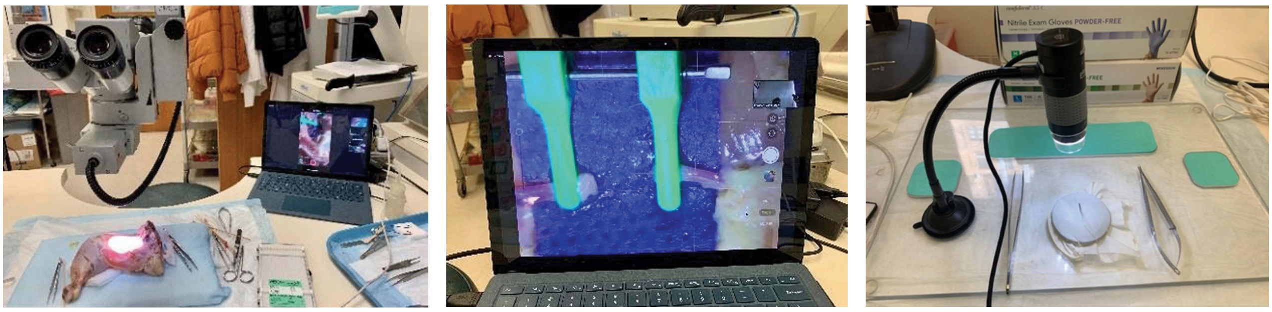
Chicken Thigh Model

A chicken thigh was used in place of a live animal model (Fig. 1A). This was both cost-efficient and easily attainable by the students. The chicken thigh was placed on a cutting board and dissected. Once the chicken thigh was dissected and the femoral vessels identified, a colored plastic or latex background was positioned to better visualize arterial and venous structures (Fig. 1C).

Curriculum

The curriculum consisted of three days of instruction, each session lasting three hours in length. A 30-minute practice session was scheduled before the official start of the course to ensure that technical difficulties were addressed if needed.

Day 1: The first session included the instructor introducing and setting up the operational microscope, teaching proper body posture and hand positioning, and practicing suturing techniques on the plastic suturing board.



A *B* *C*

Fig. 1. Chicken thigh model using scope to scope set-up (*A*). Plastic suturing board set-up using the pluggable digital microscope (*B*). Colored plastic or latex background (*C*)

Рис. 1. Модель куриного бедра с настройкой области воздействия (*A*). Установка пластиковой доски для выполнения швов с использованием цифрового микроскопа (*B*). Цветной пластиковый или латексный фон (*C*)

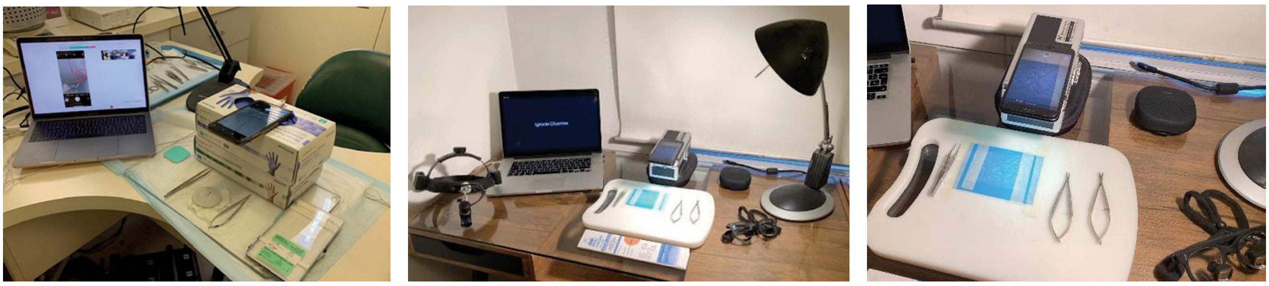


Fig. 2. Phone with surgical loupes set-up

Рис. 2. Телефон с хирургическими лупами

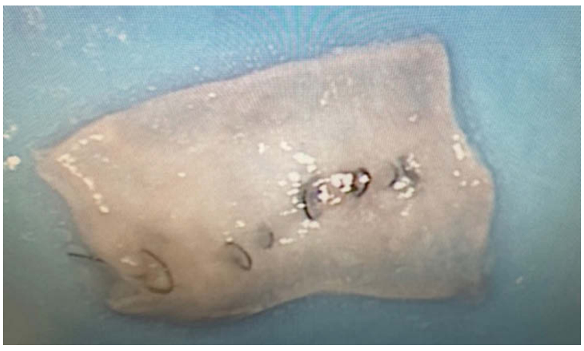


Fig. 3. Utilizing ALI scoring system

Рис. 3. Использование системы оценки ALI

Day 2: The second session comprised of dissecting the chicken thigh model, learning how to perform end-to-end arterial anastomosis using two different microsurgical techniques (two-stays conventional technique, one-way up technique), assessing the patency, and assessing the quality of the student's work with the use of the ALI scoring system.

Day 3: The third session consisted of the dissection of the chicken thigh model, learning how to perform end-to-end venous anastomosis, assessing the patency, and assessing the quality of the student's work with the use of the ALI scoring system (Fig. 3).

DISCUSSION

Student Workstation Set-up Comparison

Amongst the three different types of student workstation set-ups, we found that the "scope to scope" set-up was the most effective system for teaching the virtual microsurgery course (Fig. 4). The "scope to scope" set-up superiorly delivered in a wide range of aspects. Advantages to using the "scope to scope" set-up include the fact that it mirrors the laboratory setting more closely than both the "pluggable digital microscope with surgical loupes" and "smartphone with surgical loupes" setup. In addition, it also provided a wider field of view, better illumination, the ability to adjust magnification with ease and a higher level of accuracy as demonstrated by stronger ALI scores among students who used this method. Students reported superior visual comfort and clearer visualization.

Fig. 4. Instructor providing feedback using the scope to scope set-up.

Рис. 4. Инструктор обеспечивает обратную связь, используя устройство для настройки области воздействия

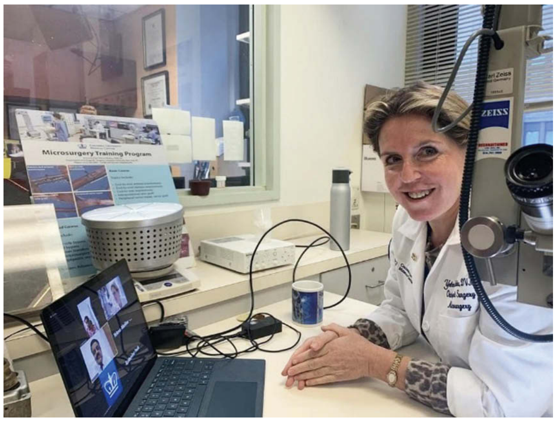
In comparison, the "pluggable digital microscope with surgical loupes" setup was much more cost-efficient than the "scope to scope" setup. However, we found that there was significant lag regarding transmitting video and images to the instructor. Students found that the shallow depth of field and suction cup attachment at the base were difficult to work with. There was also difficulty with focus and magnification. On the instructor's end, we found that the digital microscope did not provide enough lighting and created a lot of unwanted glares, which made the student's work difficult to visualize upon inspection. We also noticed that due to its flexible arm and suction cup base, the digital microscope was sensitive to vibration making it difficult to keep steady. Although not ideal, this set-up remains to be a great model to practice microsurgical techniques.

The "smartphone with surgical loupes" setup offered some of its own advantages as it was the most cost-effective and easily attainable setup in comparison to the "scope to scope" and the "pluggable digital microscope with surgical loupes" setup. The primary benefit of this setup is that most of the student population already have smartphones and surgical loupes in their possession. However, we found that the smartphone setup did not provide adequate magnification or illumination for the instructor to view the images as clearly. Students found the smartphone difficult to maneuver as it had to sit in a fixed position on an elevation. Similarly, to the "pluggable digital microscope with surgical loupes" setup, the "smartphone with surgical loupes" setup is still nonetheless an excellent model to practice microsurgical techniques.

Overall, the "scope to scope" method is preferable for microsurgical education.

Limitations

Under ordinary circumstances, a live rat femoral artery and venous model is utilized. However, due to its easy attainability and cost-efficiency, the chicken thigh model was used as a substitute in this curriculum. This in itself places some limitations due to the fact that it is easier to visualize patency in a live animal model versus a raw chicken thigh model. Other limitations included the disparity between each individual student's socioeconomic class (surgeons from all over the world participated in the virtual microsurgery program), and thus the quality of the equipment each student was able to obtain somewhat varied.



MOVING FORWARD

The COVID-19 pandemic has significantly changed the way in which we approach education, although it should not serve as a replacement to in-person learning, distance education can truly serve as an asset to microsurgery training. This program has allowed students to develop and increase their surgical skill-set and become more comfortable with their microsurgical abilities. In fact, qualitative feedback from students indicated a successful program. Students reported an improvement with their fine motor movements, dexterity, and hand-eye coordination.

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