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Learners' Responses to a Virtual Cadaver Dissection Nerve Course in the COVID Era: A Survey Study

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Abstract

Background Virtual education is an evolving method for teaching medical learners. During the coronavirus disease 2019 pandemic, remote learning has provided a replacement for conferences, lectures, and meetings, but has not been described as a method for conducting a cadaver dissection. We aim to demonstrate how learners perceive a virtual cadaver dissection as an alternative to live dissection.

Methods A virtual cadaver dissection was performed to demonstrate several upper extremity nerve procedures. These procedures were livestreamed as part of an educational event with multimedia and interactive audience questions. Participants were queried both during and after the session regarding their perceptions of this teaching modality.

Results Attendance of a virtual dissection held for three plastic surgery training institutions began at 100 and finished with 70 participants. Intrasession response rates from the audience varied between 68 and 75%, of which 75% strongly agreed that they were satisfied with the virtual environment. The audience strongly agreed or agreed that the addition of multimedia captions (88%), magnified video loupe views (82%), and split-screen multicast view (64%) was beneficial. Postsession response rate was 27%, and generally reflected a positive perspective about the content of the session.

Conclusions Virtual cadaver dissection is an effective modality for teaching surgical procedures and can be enhanced through technologies such as video loupes and multiple camera perspectives. The audience viewed the virtual cadaver dissection as a beneficial adjunct to surgical education. This format may also make in-person cadaver courses more effective by improving visualization and allowing for anatomic references to be displayed synchronously.

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- education
- learning
- anatomy

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Introduction

Cadaveric dissections have long served as the foundation of medical training. John Hunter, a prodigious, brilliant, and brash surgeon-anatomist of the late 1700s, notoriously built his reputation through unsanctioned private anatomy dissections in a London rental apartment.[1,2] Although he was an expert lecturer, the allure of Hunter's underground course was that he guaranteed individual hands-on experience with cadavers.[1] This concept facilitated learners to visualize the anatomy, feel the tissues, appreciate the odors, and practice surgery on authentic tissue. In current surgery training, cadaveric dissections continue to be of critical importance, especially when familiarizing learners with hardware and implant technologies.[3] These tactile experiences make cadaveric dissections the standard training prior to live surgery.[4] Furthermore, with newly introduced work-hour restrictions for trainees and an emphasis on patient safety and quality of care metrics, interest in cadaveric simulation training has grown.[5]

Unfortunately, modern dissection experiences have become less practical. In contrast to historically spacious theaters, trainees have been relegated to learn in crowded, underfunded laboratories with limited cadavers, poor acoustics, and castaway instruments. It is often difficult for observers to even hear and see the procedure and narration. Moreover, the current coronavirus disease 2019 (COVID-19) pandemic has mandated the need for social distancing, making in-person dissections temporarily obsolete. This has placed an impetus on alternative educational methods such as simulation training and virtual learning. Virtual surgical education has been around since the 1990s and has been shown, in medical students on surgical subspecialty clerkships, to provide equivalent outcomes to in-person lectures.[6–8] Translating a traditional cadaveric dissection into the virtual environment for teaching surgical procedures has not been applied fully. The availability of advanced technologies like video-mounted loupes make this endeavor feasible.[9,10] Moreover, free virtual meeting environments (e.g., Zoom) facilitate the dissemination of educational experiences possible at a low cost to a large audience and without geographic limitations. While we have innovated education more rapidly in the current pandemic environment, these changes may last beyond our mandated social distancing. Virtual education serves to span geographic and economic constraints expediently.

A virtual cadaver dissection introduces advantages over in-person learning that can prove valuable even when social distances restrictions ease.[11,12] Remote access permits participation of multiple institutions through broadcasting on media platforms to facilitate interactions between hosts and viewers. Additionally, video cameras improve viewing for participants not close to the dissection and enhanced visual experience with digital content like schematics, anatomic drawings, and clinical scenarios. To determine best methods to deliver this content and its value to learners, we conducted a virtual surgical dissection with multiple camera technologies and various interactive multimedia to assess attendee's experience.

Methods

Participants

Three academic plastic surgery institutions with integrated residency programs were invited to participate in a 2-hour interactive, virtual surgical dissection course. The course was advertised a week in advance, held during protected conference time, and attendance was encouraged by individual programs. The course was broadcasted through a password protected Zoom (Zoom Video Communications, Inc., San Jose, CA) meeting, and the audience was informed the interactive questions were to be used for research purposes. All responses collected were anonymous and no demographic information was collected. The Zoom meeting attendance limitation was capped at 100, and participants included medical students, residents, fellows, and attending surgeons. The moderator for the session, who is the senior author of this paper (K.C.C.), was remote from the site of dissections as well as the audience. This study was approved and deemed exempt from the local Institutional Review Board.

Surgical Dissection Course

A comprehensive virtual upper extremity nerve course lasting 2 hours was performed over 1 day in fall of 2020. Preparation for this innovated anatomic dissection begin 3 months in advanced and was a collaborative effort involving surgeons, surgical trainees, and a communication broadcasting team (►Fig. 1). Development of the course required a preplanning, planning, and execution phase. After developing a robust curriculum to the target audience of surgical learners, substantial effort was dedicated to delivering a high-quality broadcast in the virtual environment. Several mock dissections were performed to coordinate the audio-video-Internet needs that facilitated seamless demonstration of anatomy and simultaneous interaction with an

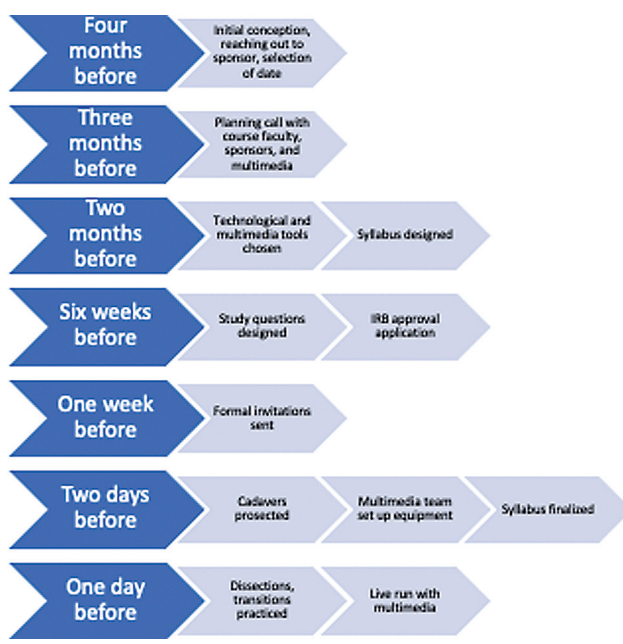

Fig. 1 Schematic of the planning process leading up to the event.

Compressive neuropathy

- Carpal tunnel release
- Revision carpal tunnel release + hypothenar fat pad flap + nerve wrap
- Pronator Release
- Guyon canal release
- Cubital tunnel release and transposition
- Radial tunnel decompression

Nerve transfer

- Digital nerve repair + allograft + radial sensory to digital nerve transfer
- AIN to ulnar nerve transfer
- ADQ motor branch to terminal branch of median nerve transfer
- Supinator to PIN (SPIN) transfer
- Brachialis to AIN transfer
- Double fascicular transfer

Fig. 2 Syllabus of procedures performed during the session.

audience. A final, preparatory prosection of the cadaver extremities was performed 2 days prior to the date of production to demonstrate the anatomy. On the day of the course, several common and uncommon upper extremity nerve procedures were reviewed and additional anatomical exposure was performed to demonstrate important anatomy and anatomical relations. The course syllabus is reflected in ►**Fig. 2**. Five to ten minutes were spent on each procedure, with planned breaks for interactive questions and questions from the audience.

Virtual Multimedia Broadcast

The course livestreamed to the audience of surgical learners using Zoom. Video equipment included Panasonic 4K HD video cameras (Panasonic Corporation, Kadoma, Japan) as static cameras (with the ability to provide a macro or microscopic view) and a magnified "video loupes" using a Designs for Vision Nanocam HDi (Designs for Vision, Bohemia, NY) camera mounted on the proceduralist's loupes to provide video with 2.5x magnification from the perspective of the surgeon. Images projected to the viewers included a macro view, micro view, loupes view, or a combination of these views with split screens. An example of the participants' view is shown in ►**Fig. 3**. Prior to each new procedure, multimedia captions were used to provide a case vignette and identify the procedure being performed for the audience. Audiovisual professionals assisted in the video broadcasting and coordination of the different cameras. Dissections were performed by teams consisting of a hand surgery fellow and a junior plastic surgery resident; didactic lecture and expert commentary were provided by the senior author (K.C.C.) for each procedure.

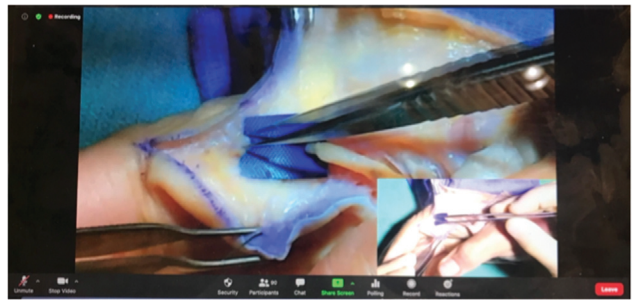

Fig. 3 Example image of a procedure under video loupe magnification (main) and normal video magnification (bottom right), as seen on a participant's Zoom screen.

Learner Experience Assessment

Learners answered multiple choice questions during the session and were also requested to participate in an online questionnaire after the session. Questionnaire was designed by the authors of the study group, all of whom have an MD degree (the senior author, K.C.C., also has an MS) and practice or train as plastic or hand surgeons and had according training. The questionnaire was not validated; the questions may be seen in ►**Tables 1** and **2**. Participants knew that the questions were to study the teaching techniques employed. No characteristics of the researchers, beyond those commonly known, were reported to the participants. All of the audience were invited to participate and were approached by pop-up questions that appeared to them during the teaching session. Reasons for ceasing to reply questions or for leaving the educational session were not assessed. Participant location was not recorded. The audiovisual team and the course facilitating staff were also present in the location of the dissections, but not with the participants. Repeat interviews were not relevant and were therefore not assessed; the surveys lasted the 2-hour duration of the course, plus whatever time was needed to complete the postcourse survey. We did not stop the survey at any point for

Table 1 Responses to intrasession questions

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	% Response
The video conferencing environment is user friendly	53%	46%	1%	0%	0%	75%
The addition of multimedia captions is beneficial	37%	51%	10%	10%	1%	73%
The video loupes provide a clear view of the procedure being demonstrated	30%	52%	12%	4%	2%	68%
I prefer the split screen view (video loupes and video camera together to either view on its own)	34%	30%	18%	14%	4%	68%
I am satisfied overall with this educational session	75%	23%	2%	0%	0%	69%

Table 2 Responses from postsession Likert questions

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
My knowledge was improved by this educational session	70%	30%	0%	0%	0%
The material presented was comprehensive	78%	22%	0%	0%	0%
The virtual cadaver dissection format provided a realistic representation of the anatomy/procedure demonstrated	48%	48%	0%	4%	0%
The educational material was at an appropriate level	64%	32%	4%	0%	0%
The session was interactive enough to remain engaging	41%	48%	7%	4%	0%
I felt comfortable asking questions of the presenters	27%	19%	42%	12%	0%
The format was more stimulating that an in-person session	19%	19%	44%	15%	4%
The format was more enjoyable than an in-person session	19%	22%	44%	11%	4%
The format was better overall than an in-person session	22%	19%	48%	11%	0%
I am satisfied overall with this educational session	70%	30%	0%	0%	0%

data saturation. Transcripts were not returned to participants for comment or correction nor were they asked to provide feedback on the findings.

The answer choices for all Likert questions were strongly agree, agree, neither agree or disagree, disagree, and strongly disagree. The postsession questionnaire also included the free text short response questions. The postsession questionnaire was left open for 1 month after the session, at which point responses had ceased. Reminder emails were sent twice over this month for participants to reply to this questionnaire. Descriptive statistics were used to evaluate the responses to these questionnaires and were calculated in Microsoft Excel (Microsoft, Redmond, WA).

Results

One-hundred audience members attended the session at the start, which was the maximum allowable by our software. Responses and response rates to the in-session questions are listed in ►**Table 1**. The majority of participants found the environment user-friendly, the addition of multimedia beneficial, and were overall satisfied with the educational session. Participants were varied as to preference for split-screen versus either screen on their own: 64% were favorable to split screen, whereas 36% expressed to preference or preferred the single-screen at a time.

We had a response rate of 27% for the postsession questionnaire. Responses to the multiple-choice questions are summarized in ►**Table 2**.

Responses to free text question 1 “Did you prefer viewing the procedures through video loupes or the fixed camera? Why?” were mixed. Of the 20 who responded to this free text question, 25% expressed a preference for loupes, 35% preferred the fixed camera, 20% preferred both, and 20% replied “N/A.” Those who preferred the loupes cited the close-up views, high quality of the video definition, and surgeon’s perspective as helpful features. Those who preferred the fixed camera cited the perspective and sharp focus, and the less shaky, more stable image.

In response to free text question 2 “Is this virtual cadaver dissection format more effective than watching (not performing) an in-person cadaver dissection? Why?” those who answered generally expressed preference for virtual cadaver dissections over live. Forty percent of those who replied to this question preferred the virtual cadaver dissection to viewing (not performing) an in-person dissection. Twenty percent of those who replied gave a mixed response, and 40% of respondents replied “N/A” or had not observed a live cadaver dissection.

To the third free response question “How can we improve the virtual cadaver dissection format?” responses had some recurrent themes. One request was that dissections be performed from start to finish, rather than starting the course with a prosected cadaver. Most of the other responses were thematically unique. Responses are listed in ►**Table 3**.

Discussion

A cadaver dissection broadcasted in the virtual environment can provide an excellent anatomical learning experience that advances knowledge of participants. This study found that a well-organized, comprehensive course can demonstrate surgical procedures in detail and adequately emulate a live dissection. Audience members overwhelmingly found the virtual format to be user-friendly and the addition of dynamic multimedia to be beneficial. Based on the structural delivery of this course, participants felt engaged but desired more opportunities for host–viewer interaction. An optimal class size for better interaction is yet to be determined, but a slower pace may have been beneficial based on our observations. Furthermore, half the audience neither agreed nor disagreed that the virtual course was more stimulating or enjoyable than an in-person experience. Collectively, the survey results suggest that a live, virtual cadaveric dissection is a productive learning format for training institutions, but

Table 3 Responses from postsession free-test questions

How can we improve the virtual cadaver dissection format?
Let us ask questions
More questions. Longer questions that allow for start to finish dissections
Show a full dissection starting from the incision. Often the most challenging part of these types of procedures is identifying the correct surgical interval an initial dissection to locate the nerve of interest
Do more of them
For being virtual, this was incredibly well done. The video quality (especially through the video loupes) was fantastic and the anatomy was explained well and in an efficient way. However, there is the interactive aspect that is still lost with basically any virtual format
Better identify and tag structures
It is easier to see things in this format. During an in-person session, I often am not able to see because there are too many person around one cadaver
Better lighting so that structures are distinguishable and figures alongside the camera view to demonstrate what's going on
More extensive dissections that show start to finish
Instead of dissecting everything ahead of time, may be nice to do some procedures in real time to better define structures before they have been dissected out for us. Thanks for the hard work
I think it was very well run with great dissections and I was able to see everything very clearly. It was a great session

that an in-person dissection holds value that cannot be replicated.

The need for robust virtual learning environments has been expedited during the COVID-19 pandemic.[13] Training programs across the country rapidly adopted the virtual meeting environment to conduct typical conference activities (lectures, morbidity and mortality meetings, research collaborations, etc.), and many surgical disciplines engaged a multi-institutional collaborative approach to provide weekly didactics from leaders in surgical fields.[14] Although these endeavors have been successful, surgery is a craft specialty that mandates the development of skills and dexterity that are not replicable in the virtual envirnonment.[4] In the absence of the ability to conduct this in-person, our virtual dissection was designed to provide exposure to this important component of surgical training.

The virtual delivery was successful, given that 96% of the audience found the cadaver dissection to be a realistic representation of procedures, and therefore we have shown that surgical techniques and anatomy can be conveyed in the virtual environment. Surprisingly, only 11% of respondents "disagreed" that the video format was better overall than an in-person session, suggesting that many participants preferred the virtual cadaver course to the traditional in-person course. The potential reasons for this are myriad. A hands-on cadaver experience is invaluable, but in the absence of one-on-one mentorship, a virtual cadaver experience provides several benefits including better visualization for all participants (not just those immediately next to a demonstration table), more rapid progression through dissections/procedures, and the ability to simultaneously project schematics, anatomical images, and clinical vignettes.

Kirkpatrick and Kirkpatrick describe four levels at which learners can evaluate a training program, the most basic being the *reaction* of learners to the perceived qualities of the program.[15] In previous studies of computerized, simulation-based medical training in trauma and emergency medicine, learners have rated their experience as favorable in terms of their satisfaction and perception of learning.[16,17] This is particularly true in younger generations who are more comfortable with technology and computerized learning platforms than their predecessors.[18] This study supports a favorable *reaction* from the attendees, but further research is required to know how effective participants learned, how their intraoperative behaviors changed, and how patient outcomes were influenced to capture the *learning, behavior,* and *results* of the Kirkpatrick evaluation model. The positive *reaction* by participants was attributed to the comprehensive content, and specifically relevant to an anatomical course, the use of high-quality video technologies to improve learners' visualization of procedures.

The use of advanced video technology that provided clear anatomical detail was imperative to successfully supplant the experience of an observatory in-person cadaver dissection. A vast majority found the video loupes to be an accurate representation of the surgeons view of the dissection, but postsession free text responses reported that the image was periodically "shaky" and induced feelings of motion sickness. The dissector minimized this affect by wearing a soft neck brace and operating with 2.5x magnification rather than 3.5x. This shortcoming may be overcome with future technology equipped with better image stabilization technology. Alternatively, Vara et al showed that video recording of hand surgery procedures with head-mounted action cameras (e.g., GoPro) is an excellent method to assess performance, provide education, demonstrate operative techniques, and compile a video library for research.[19] These action cameras typically provide a macroscopic (non-zoomed in) viewer experience, which make head movement less of an issue, but may fail to capture the fine detailed needed to demonstrate some hand surgeries.

To capture both the surgeons view and a global perspective of the surgical procedure and anatomy, a split-screen view was employed. Akin to a multicast perspective of a sporting event, the split view offers multiple perspectives of the anatomy. This was well received as 64% of respondents reported during the session that they preferred this experience, with a static and dynamic (i.e., loupe) view option. More sophisticated future broadcast can provide the viewers the option to select their view preference. Regardless, the success of the videography ultimately relies heavily on the quality of equipment, technical considerations (i.e., camera placement, camera settings, lighting), and the aesthetics of the dissecting field (e.g., clean, monochrome background).[20] The optimal use of technologies such as video loupes is yet to be determined, though it may be a matter of personal preference or dependent on the type of procedure being demonstrated. Furthermore, it is valuable information to know that the split-screen option was not critical to the success of the virtual cadaver course, because this requires specialized video production software, and not needing it likely means more institutions can host virtual cadaver courses. Another modality that may be beneficial is the use of prerecorded dissections with real-time discussion; this format would be easier to facilitate, but loses the interactivity and ability to stop, clarify, and point out specific things during the dissection.

Although the cadaver dissection was rated very highly for its educational content and the realism of the cadaver dissection, challenges with the format were revealed. While 89% of respondents felt the session was interactive enough to remain engaged, a majority of respondents replied "neither agree nor disagree" to questions about feeling comfortable asking questions and respondents of the post-session questionnaire desired more interactive questions. Other responses suggested that the number of procedures was too ambitious, and many learners wanted to view dissections from start to finish (rather than prosected). Lastly, the audience neither agreed or disagreed that the format was more stimulating, enjoyable, and better overall than an in-person cadaver dissection course. Interestingly, none of the respondents to the posttest questionnaire stated that they preferred in-person cadaver dissections to our virtual format, without any other qualifications or stipulations. Several free text responses to the last question were reflective of audience members' positive views toward this format.

This study has some limitations. We have no assessment of the knowledge gained by learners during this course; this is a higher level of evaluation of a new learning modality, which we felt was better reserved for future study after we demonstrate the viability of the modality.[15] We also recognize the response rate to our postsession questionnaire to be low relative to the in-session questions, which may reflect differences in the two sets of responses. Moreover, thirty participants dropped out during the session. Although this is likely secondary to clinical related responsibilities (because this was conducted during typical work hours), this could have been due to lack of interest. The audience was heterogeneous, which we chose to optimize the educational experience for all of our plastic surgery service team members, though it does weaken the study somewhat. Lastly, we did not have granular data on responses based on learners experience level or experiences with live anatomical dissections, both which could heavily influence how the learner perceived the content and production. In total, this article is best viewed as a representation of how technology can be used to create a robust virtual learning environment for cadaver dissections.

Our undertaking was ambitious, but demonstrated what can be done with multimedia-enhanced virtual surgical education. We covered an enormous volume of surgery in 2 hours. This necessitated prosection, which could be avoided in a more abbreviated course. Preparation is everything. To execute a course such as this, one must anticipate problems and have solutions at the ready in real-time. Everything must be coordinated and practiced multiple times in advance to ensure seamless delivery. Our team was smoothing out glitches in a midnight trial run the night before the presentation. In short, we have demonstrated a novel and extremely useful technique for demonstrating surgical procedures to learners of multiple levels by applying new technologies in a way that we hope will set the standard for virtual surgical education now and in the future.

Authors' Contributions

Conceptualization: J.L.L., S.P.J., D.G., K.C.C. Data curation: J.L.L., S.P.J., D.G. Formal analysis: J.L.L., S.P.J., D.G. Methodology: J.L.L., S.P.J., D.G., K.C.C. Project administration: J.L.L., K.C.C. Writing-original draft: J.L.L. Writing-review & editing: J.L.L., S.P.J., D.G., K.C.C.

Ethical Approval

This study was approved and deemed exempt from our university's Institutional Review Board.

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Conflict of Interest

J.L.L., S.P.J., and D.G. have no financial interest to declare in relation to the content of this article. K.C.C. receives funding from the National Institutes of Health and book royalties from Wolters Kluwer and Elsevier. He is a consultant for Integra and Axogen. Cadavers and logistical and media support were provided by Axogen in the creation of this article. None of the authors has a financial interest in any of the products or devices mentioned in this discussion or the manuscript being discussed.

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