Surgical and Radiologic Anatomy (2022) 44:1193–1199
https://doi.org/10.1007/s00276-022-02974-z

ORIGINAL ARTICLE

Students' perspective on the interactive online anatomy labs during the COVID-19 pandemic

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Received: 25 January 2022 / Accepted: 9 June 2022 / Published online: 9 July 2022

Abstract

Purpose New training methods sprung up using communication technologies after the suspension imposed on Greek Universities due to restrictive measures against the COVID-19 pandemic. The current questionnaire-based study evaluates the efficacy and utility of the interactive online anatomy labs (ONALs) in assisting the assimilation of anatomy and substituting dissection labs during the pandemic.

Methods ONALs consisting of video recorded demonstrations of dissected cadavers were developed so that real-time dialogue and interaction between tutor and students was feasible. First- and second-year medical students who were taught neuroanatomy and splanchnology and first-year dental students who were taught head and neck anatomy evaluated the ONALs.

Results One hundred and sixty students participated. The 61 students (38.13%) attended the splanchnology, 58 (36.25%) the neuroanatomy, and 41 (25.63%) the head and neck anatomy course. 86.9% of the participants found the ONALs beneficial for their study. The 75.5% with previous experience of a "face-to-face" dissection replied that the ONALs cannot substitute satisfactorily "face-to-face" dissections. 63.8% replied positively to the ONALs maintenance after the pandemic.

Conclusions The study's novelty is based on the maintenance of the greater possible interaction between tutors and students during the ONALs, in contrast to the previously described usage of dissection educational videos in anatomy. Our findings reinforce the established statement that "a teaching dissection is an irreplaceable tool in anatomy education". However, the ONALs were well-received by the students and can be kept on as a supplementary teaching modality and can be proven quite useful in Medical Schools that lack cadavers.

Keywords Online labs · Anatomy teaching · Remote teaching · COVID-19 · Distance anatomy · Gross anatomy · Online anatomy · Interaction · Education

Introduction

Learning anatomy is considered quite tough for a major part of the students [5, 28], as they should overcome difficulties, including the plethora of provided information, the complex terminology, and the psychological impact of experiencing the cadaver's dissection, a key element of the training at the laboratory [10, 11]. Given those special difficulties, a multimodal approach to anatomy teaching is necessary, especially using technological facilities that have been proven beneficial for most students [2]. However, both anatomists and health professionals agree that "hands-on" anatomy training and contact with cadavers is a prerequisite for the comprehension of the teaching object, and thus, teaching through dissections has remained a prominent position [12, 14, 23, 25, 31].

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The need for a multimodal approach to anatomy teaching became more prominent last 2 years [26, 28] with the COVID-19 pandemic. The suspension imposed on Greek Universities due to the SARS-CoV-2 spread hindered the students' learning. As for anatomy, teaching dissections and "hands-on" training were also suspended. Given this situation, and the need for distance anatomy teaching, two main goals had to be achieved: (1) The maintenance of the students' training on cadaveric specimens, as well as their familiarization with human tissues, and (2) The maintenance of the interaction between tutor and students to achieve the greatest possible learning gains. After the consideration of the use of dissection educational videos [20, 21] that have already been proven supplementary educational tools [4, 6, 13, 19], we intended to develop a novel kind modality of remote anatomy teaching, the online anatomy labs (ONALs), based on the continuous interaction between tutor and students.

The current questionnaire-based study evaluates the students' opinions on the efficacy and utility of these ONALs. This novel-kind teaching modality could be established as a preliminary stage before the "hands-on cadavers" teaching and practice, after the end of the pandemic.

Materials and methods

Participants

The volunteer participants were first- and second-year medical and first-year dental students. The object of their anatomy curricula was neuroanatomy for the first-year medical students (group 1), anatomy of visceral organs–splanchnology for the second-year medical students (group 2), and head and neck anatomy for the first-year dental students (group 3). Neuroanatomy group (1) had no previous experience in dissection, while splanchnology (2) and head and neck anatomy (3) groups had a previous experience in face-to-face dissection, a semester before with 15 and 3 dissection labs, respectively.

Online anatomy labs (ONALs) development

Concerning the ONALs, two formalin-fixed cadavers were dissected in the Dissections' Hall of our Department, by expert staff. After dissection (the step-by-step procedure was not recorded), the demonstration of the dissected structures was recorded by a Nikon d7100 DSLR camera (*Nikon, Tokyo, Japan).* Seven 2-h-lasting ONALs for each course were scheduled. During the ONALs, videos were streamed (timeframe from 30th March 2020 to 2nd June 2020) and a member of the Department (narrator) was describing the dissected structures. The tutor was visible to the students through a webcam and encouraged them to have their webcams turned on. The interactive procedure included the tutor's ability to pause the video, re-explain the critical points, and reply to students' questions. The tutor also asked the students to ensure they had assimilated the teaching objectives and further promote the dialogue and interaction. This interaction between tutor and students was one of our primary goals, while planning these ONALs, given that the learning gains for the students are significantly greater when they are actively engaged in the teaching procedure, as already reported in the data literature [17, 26, 27, 30, 32]. In total 49 short videos (12 for group 1, 16 for group 2, and 11 for group 3) were created.

Concerning the "Neuroanatomy" course (group-1), a formalin-fixed human brain, cadaveric brain sections (transverse and coronal), and a dry human skull (after its craniotomy) were used. The seven ONALs (12 videos) consisted of the demonstration of (1) the cerebral (sulci, gyri, lobes, and lobules), and cerebellum cortex anatomy, (2) the corpus callosum and white matter structures' anatomy, (3) the midbrain, pons, and medulla oblongata anatomy, (4) the basic ganglia, the hippocampus, and the cerebral ventricles in forebrain transverse sections, (5) the nuclei of the cranial nerves, the substantia nigra, the fourth ventricle, the cerebral aqueduct in brainstem transverse sections, (6) the neurocranium (bones, fossae, and foramina), the origin and course of the cranial nerves and (7) the dura matter with venous sinuses, and the brain arterial supply. Regarding the "splanchnology" course (group 2), the 7 ONALs (16 videos) consisted of the demonstration of (1) the thorax anatomy (*pleura, pericardium, trachea, bronchi, lungs, heart, pulmonary arteries and veins, and the aortic arch*), (2) the anatomy of the esophagus, stomach, duodenum, and pancreas, (3) the anatomy of the liver, spleen, and the biliary tract, (4) the anatomy of the small and large intestines, the peritoneum, and its reflections, (5) the anatomy of the urinary tract (*kidneys, ureters, and bladder*) and the adrenal glands, (6) the anatomy of the male and female genital system and (7) the abdominal aorta branching pattern, superior and inferior vena cava, and the anatomy of the azygos veins' system. As for the *"head and neck anatomy" course* (group 3), the 7 ONALs (11 videos) consisted of the demonstration of (1) the head and neck surface anatomy and anatomical landmarks, (2) the anatomy of the neurocranium, viscerocranium, and of the 7 cervical vertebrae, (3) The head fasciae and muscles, (4) salivary glands and superficial innervation of the face (*facial nerve's peripheral branches and cutaneous innervation of the trigeminal nerve*), (5) The neck fasciae and muscles, (6) vessels and nerves of the head and neck, and (7) anatomy of the oral cavity (lips, teeth, gingiva, mucosa, tongue, hard and soft palate, floor of the mouth). For the final video editing, iMovie software (*version 10.1.12*) was used. The ONALs were scheduled using Skype for Business

software (*Microsoft® Corp, Redmond, WA*) and the relevant URLs were e-mailed to students. This software was selected for its simplicity to use and accessibility to the students, as every student at our university had free access to this software via the institutional account. Skype for Business was also used by other Universities during the pandemic period [1, 9]. No other specific application nor online education program was used.

Data collection

A web questionnaire was mailed to the students attending the last ONAL on 02 June 2020. The questionnaire was available as a Google® form spanning the first 2 weeks (2–22 of June 2020) just after the end of the modality process. Only the students who attended at least 5 out of the total 7 ONALs (71.4% of the total time, 10 out of 14 h) had the right to participate. The participation was voluntary and anonymous, and no motivation was offered for it. The questionnaire consisted of 6 questions (Q): Q1–Q3 referred to the overall students' satisfaction with the ONALs and Q4–Q6 concerning deficiencies and probable improvements for the educational method. In addition, Q1, Q3, and Q5 targeted mainly the beneficial impact the ONALs had on students' anatomy learning, while Q2 and Q4 compared ONALs to the live methods. Q1–Q5 were designed as Likert scale [15] survey questions with one eligible reply, while Q6 had more than one eligible reply (Appendix 1). The internal consistency of the questionnaire was evaluated by Cronbach's alpha coefficient for the 5-item scale (Q1–Q5) [16].

Statistical analysis

All data were expressed as absolute frequency and percentage. Data were firstly analyzed in the total sample and a subgroup analysis (according to the attended course) was performed to identify the possible differences. Q1–Q5 were treated as existing in the questionnaire, while Q6 was evaluated by categorizing the replies into 3 main categories: (i) lack of physical interaction with the cadaver (Q6i), ii) lack of physical interaction with the tutor (Q6ii), (iii) technical problems (Q6iii). Three different Scores were created by matching the questions according to their main target point; Score_1 evaluated the impact of the ONALs on students' education, Score_2 targeted the comparison of the ONALs to the traditional labs and Score_3 evaluated the problems affecting the efficacy of the ONALs. As for the Score_1, Q1, Q3, and Q5 were evaluated, and a one-way ANOVA was performed to assess possible differences between the three different study topics. The Score_2 was created by the evaluation of Q2, Q4, Q6i & Q6ii variables, and a difference between students who had participated in a traditional lab (groups 2 and 3) vs those who hadn't (group 1) was investigated by the Wilcoxon test. The difference in Score_2 between the two groups of students (2 and 3) who had participated in a traditional anatomy lab for the different periods was also evaluated. Q6i & Q6ii were evaluated at Score_2, given that students who had participated in a traditional lab could actually tell the difference between ONALs and physical presence procedures, speaking in terms of interaction with the cadaveric material or the tutor. Table 1 summarizes the exact way each reply was evaluated for Scores_1 &_ 2. For both Scores, neutral replies were treated as missing values. As for Q3 the reply "in a major degree" was also treated as a missing value. Score _1 ranged from 0 to 5 points and Score_2 from 0 to 4 points. Median interquartile range (IQR) knowledge Scores were calculated. A 5-point Score_1 means that the ONALs were highly beneficial, while a 4-point Score_2 means that regardless of their educational benefit, they are not able to substitute the traditional method. Score_3 was estimated by adding one point for each mentioned studied disadvantage (Q6i or/and Q6ii or/and Q6iii). Non mentioned disadvantage did not affect Score_3. Score_3 ranges from 0 to 3 and his association with Scores_1 &_2 were evaluated. Statistical analysis was performed using STATA MP13 and non-parametric tests were used. A statistically significant difference was set at the level of 0.05.

Ethics

Dissected cadavers derived from the body-donation program after written informed consent according to the relevant legislation [18]. Approval for the research protocol was obtained from the Ethics Committee of our Faculty.

Results

One hundred and sixty (63 male and 97 female) medical and dental students participated. Among them, 61 students (38.13%) attended the splanchnology (group-2), 58 students (36.25%) the neuroanatomy (group-1), and 41 students (25.63%) attended the head and neck anatomy (group-3) course (Fig. 1). Most participants (61.3%) were in the 2nd semester of their study (groups 1 and 3) and 38.7% (group 2) were in the 4th semester. The majority of the students were female (Table 2). Replies to individual knowledge questions are summarized in Appendix 2. At Q1 replied 160 participants. Among them, 139 (86.9%) found the attendance of the ONALs beneficial for their study. Concerning the Q2 replies, only the participants ($n=102$) who had a previous experience of participation in dissection labs were evaluated. Descriptive analysis of Q2 showed that the majority of the students ($n=77$, 75.5%) with previous experience of a "face-to-face" dissection replied that the ONALs cannot substitute

Table 1 Evaluation of the questions (Q) for the Scores_1 & _2

Questions (Q)	Replies' scoring	
	Score_1 (Maximum 5 points)	Score_2 (Maximum 4 points)
1. Was the attendance of the online labs beneficial to your studying anatomy?	A little—> +1 A lot—> +2	
2. Do you think that the online labs' attendance substituted satisfactorily the traditional (face-to-face) teaching dissections?		No—> +1
3. In your opinion, if you had not attended the online labs, you would have assimilated the teaching objectives of the course	In a minor degree—> +1	
4. Would you prefer online labs with synchronous explanation and cadaveric demonstrations over the video recorded and simultaneously narrated demonstrations?		Yes—> +1
5. Do you think that this kind of teaching (the online labs with video-recorded demonstrations on cadaveric material) could be used after the pandemic?	Yes, as auxiliary element—> +1 Yes, as main educational element—> +2	
6. What was, in your opinion, the main disadvantage of this teaching approach? (each reply was evaluated separately)		Lack of physical interaction with the cadaver—> +1 Lack of physical interaction with the tutor—> +1

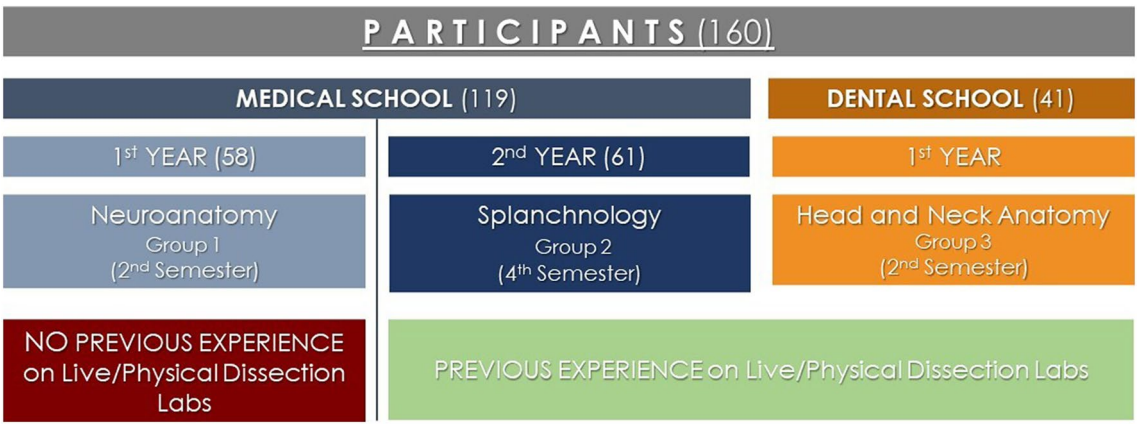

Fig. 1 Participants (160) of the study as categorized by course into three groups. Groups 2 and 3 had a previous experience with face to face ("live") dissection, while group 1 had not

Table 2 Demographics of the study participants according to their school, the course they attended, and their gender

	Males *n* (%)	Females *n* (%)	Total *N* (%)
School			
Medical	53 (44.54%)	66 (55.46%)	119 (74.38%)
Dental	10 (24.39%)	31 (75.61%)	41 (25.62%)
Total	63 (39.38%)	97 (60.62%)	160 (100%)
Anatomy course			
Splanchnology (group 2)	24 (39.34%)	37 (60.66%)	61 (38.13%)
Head and neck (group 3)	10 (24.39%)	31 (75.61%)	41 (25.62%)
Neuroanatomy (group 1)	29 (50%)	29 (50%)	58 (36.25%)

satisfactorily the "face to face" dissections. One-hundred and two out of 160 students (63.8%) replied positively to the maintenance of the ONALs after the pandemic. The internal consistency measured by Cronbach's alpha coefficient for 5 item scale (Q1–Q5) was 0.55.

Students' perspectives on the online anatomy labs (ONALs)

The median IQR total Score_1 was 3/5 (2/5, 4/5). Score_1 didn't significantly differ between males and females. One-way ANOVA revealed a significant difference in Score_1 among different courses. Further analysis by Pairwise Comparisons of Means Test indicated that Score_1 for group 1 was

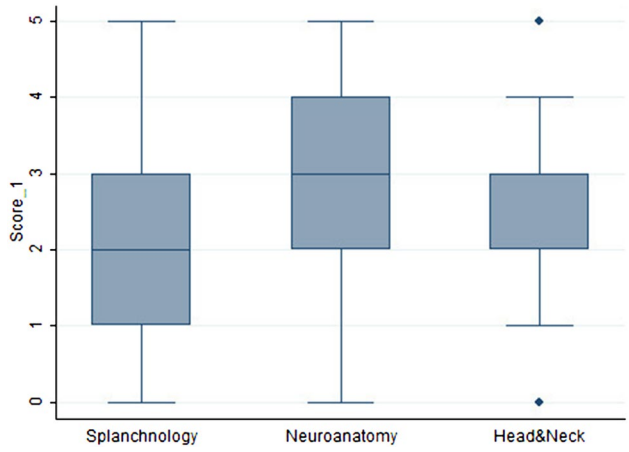

Fig. 2 Score_1 in the three study subgroups

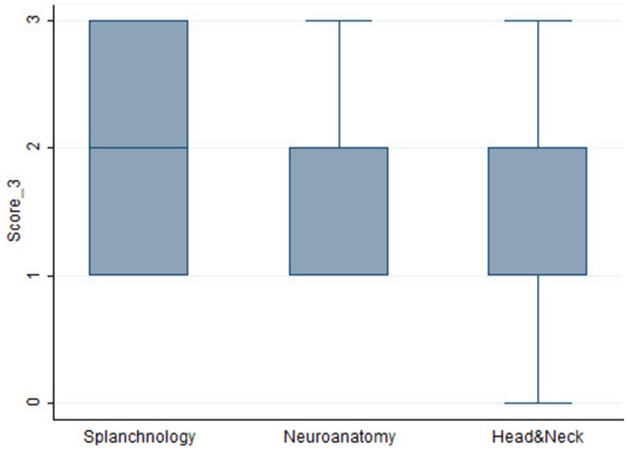

Fig. 4 Score_3 in the three study subgroups

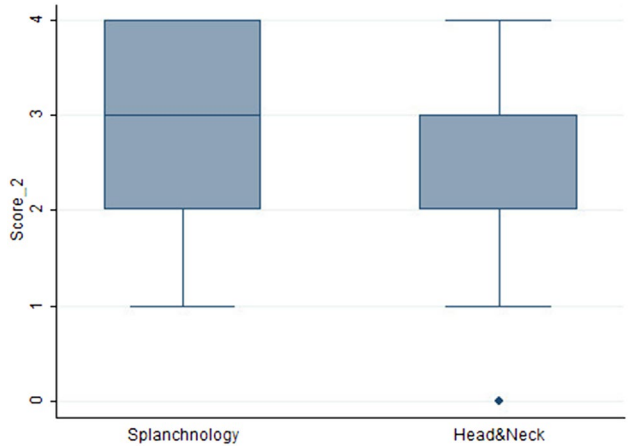

Fig. 3 Score_2 in the subgroups who had attended face-to-face dissection labs

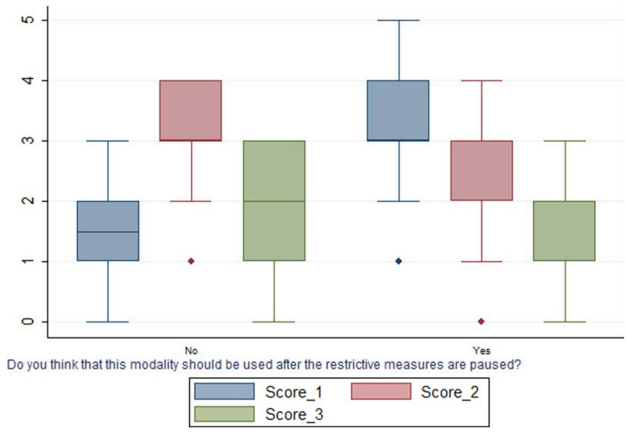

Fig. 5 Three scores after the classification of the Q5 replies (maintenance vs no maintenance)

0.7 points higher than Score_1 for group 2 (p value < 0.05) (Fig. 2). The median IQR Score_2 was 3/4 (2/4, 3/4) for those who had attended the traditional labs even at once (groups 2 and 3, $N = 102$). Score_2 didn't significantly differ between male and female students who attended the traditional lab in the past. Students of group 2 had a 0.4 points higher Score_2 than those of group 3 (p value $= 0.05$) (Fig. 3). No difference was detected between students of groups 2 and 3 who have attended the face-to-face labs in the past, and group 1. The median IQR total Score_3 was 2/3 (1/3, 2/3) and the Score_3 didn't significantly differ among the three subgroups (Fig. 4). Spearman correlation test revealed a high significant correlation between Score_1 and Score_2 ($\rho = -0.3$, p value < 0.01), and between Score_2 and Score_3 ($\rho = 0.6$, p value < 0.01), while no significant correlation was detected between Score_1 and Score_3. The students (102, 64%) who supported that the ONALs should be used in the future had a statistically significant difference in all three evaluated Scores (Fig. 5).

Discussion

Given the great significance of teaching dissections in anatomy education [12, 14, 25, 31], as well as the concern of medical students regarding their suspension due to the COVID-19 pandemic [8, 22], a more efficient mode of remote teaching had to be developed as a substitute to dissection labs, as soon as possible.

The creation of dissection educational videos enabled the continuation of laboratory teaching using cadaveric material during the pandemic. These videos use in anatomy teaching [4, 6, 7, 13, 21, 24] as a supplementary educational tool has already been described.

In the current study, the majority of the total number of respondents found the ONALs attendance beneficial for their studying. Most of the participants with a previous experience of a face-to-face dissection replied that the ONALs cannot substitute satisfactorily face-to-face dissection. A major part of the total number of participants replied positively to the ONALs maintenance after the pandemic, as they found them beneficial. The participants with a previous experience in face-to-face anatomy labs stated they quite less benefited than students who lacked this experience and this might be explained by the greater expectations they potentially have had. The students who didn't support the ONALs for future use, experienced disadvantages, problems including the physical interaction with the tutor, and/or the cadaveric material, as well as technical difficulties that sprung up. These findings express that there is always space for ONALs improvement, and a potential optimization would possibly make these labs better received by the students. As to optimize the labs, technical improvements are needed, and changes in the teaching part, such as synchronous demonstration would be helpful.

The combination of asynchronous, recorded demonstration of dissected structures and synchronous teaching and description, with the possibility of real-time dialogue between tutor and student is a quite new teaching modality [23]. The preference of the participants for a synchronous description and demonstration on cadavers in combination with the greater assimilation of the educational object, resulting from students' interaction and active engagement in the learning procedure [17, 27, 32], indicates the ONALs development with real-time demonstrations, or even dissections, as the solution to the aforementioned problem. Natsis et al. [20, 21] analyzed the substitution of the dissection courses with online dissection educational videos after taking into consideration the auxiliary role of the videos in anatomy learning [6, 19, 29, 30]. The dissection educational videos (with the recorded narration) were available to download, to give students the opportunity to become familiar with the dissection steps [21]. They were characterized as supplementary educational material and as a modality to assist the dissection training, especially in complex areas [21].

The ONALs insertion into anatomy education could facilitate further explanation and clarification of the anatomy of complex areas, and the familiarization with the dissection process [8], by "prolonging" the interactive lesson on the cadaver out of the Dissection Hall. Such an approach would also be in accordance with the suggestion of the Anatomical Society Teaching Commission, which is "as much face-to-face teaching as possible and as much online teaching as necessary" [3].

The ONALs could be auxiliary, especially in Medical Schools that lack cadavers, as the students would have the opportunity to get familiarized with the anatomical structures as appeared in a dissected cadaver, but in a quite more interactive way. Under any circumstances, though, the ONALs could be a useful tool in cases of future need for remote anatomy teaching.

Study limitations

The videos used were created and edited by members of our department and not by professionals. The equipment used, provided high-quality videos and those that worked on this project ensured the appropriate lighting and background. During ONALs and real-time narration, no professional microphone was used by the tutor, and the room in which the narration took place was not soundproofed. In addition, the quality of each participant's local internet connection (problems in attending efficiently the ONALs) was out of the Department's control. Regarding data collection, the students were told to participate only if they had attended at least five out of seven ONALs in total, but it could not be verified if they had attended the ONALs, for the whole duration, even if the tutor throughout the whole course, encouraged the students to have their webcams turned on. Another limitation may also be the relatively small size of our sample and further application and evaluation of this modality are necessary to reach stronger conclusions. The internal consistency of the questionnaire was evaluated as poor; thus, it is recommended the questionnaire's improvement by adding a higher number of questions relevant to the research questions.

Conclusions

The novelty of the current study is based on the maintenance of the greater possible interaction between tutors and students during the ONALs. Our findings reinforce the established statement that "teaching dissections and hands-on cadaveric training are irreplaceable tools in anatomy education". However, the ONLAs were well-received by the students and can be kept on as a supplementary teaching modality and can be proven quite useful in Medical Schools that lack cadaveric material. However, if remote anatomy teaching is required in the future, a more interactive kind of online lab with synchronous demonstrations on cadavers should be attempted.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00276-022-02974-z.

Acknowledgements The authors would like to thank Dr. Panayiotis Yavopoulos, Dr. Alexandros Samolis, and Emeritus Prof. Alexandros Paraschos for their assistance in the demonstrations and preparation of the videos used in the online anatomy labs developed. The authors are also grateful to the body donors, who chose to offer their bodies and tissues for anatomy education and research.

Author contributions IA: conceptualization; IA, EVP, and TT: project development; IA, EVP, MP: manuscript writing, editing, and final revision; EVP: data analysis; MP, ElP, and DC: data collection; ED: visualization and technical support; TT: supervision. All authors approved the final draft of the manuscript.

Declarations

Conflict of interest The authors report no declarations of interest.

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