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Evaluating the Impact of a Dedicated Dissection Course on 3-D Anatomical Understanding in Senior Medical Students

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ABSTRACT

International changes in the focus of medical school education have led to a decrease in the time allocated to anatomy education, with human specimen dissection particularly affected. This study evaluates whether a dissection-based course facilitates the retention of three-dimensional (3-D) anatomical relationships in senior medical students who previously completed anatomy training without dissection. Fifteen year 4 or 5 medical students, who had completed preclinical anatomy instruction and 1 or 2 years of clinical training, were competitively selected to undertake a Clinical Anatomy Intercalation programme that included a 16-week full body human specimen dissection course. Participants completed four assessments administered before, midway through, at the end, and 1 month after the dissection course. Each assessment had 24 questions based on six prosection images representing major body regions. Half of the questions assessed anatomical identification, while the reminder evaluated 3-D understanding of anatomy. A post-course Likert scale questionnaire captured participants' perceptions of dissection as a learning tool. Overall test scores improved across the first three assessments, with questions relating to 3-D anatomical understanding showing a statistical improvement with each sequential in-course test. No statistically significant difference was observed between end of course and one-month post-course tests, indicating knowledge retention. Performance was significantly lower in head and neck anatomy compared to thoracic, abdominal, and pelvic regions ($p < 0.001$). Likert scale questionnaire responses indicated strong participant support for dissection as an education tool. This study demonstrates that a dissection-based anatomy course significantly enhances 3D anatomical knowledge gain and supports retention, which senior medical students can apply in clinical practice. Participants highly valued the experience, suggesting that dissection is still a vital component of medical education.

1 | Introduction

Recent medical school graduates demonstrate insufficient anatomical understanding, prompting the exploration of more effective teaching modalities during clinical training (Smith and Mathias 2011; Estai and Bunt 2016; Rehman et al. 2022; Tandon et al. 2025; Al-Antary et al. 2025). This is concerning, as anatomy is an essential part of medical education and poor anatomical knowledge has been linked to clinical errors that subsequently result in increased defense union claims and poorer patient outcomes (Turney 2007; Arráez-Aybar et al. 2010; Smith et al. 2022).

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Traditionally, human specimen dissection was central to anatomy education, but its use has declined globally due to financial and time constraints (Grković et al. 2009; Ramsey-Stewart et al. 2010; Drake et al. 2014; Ghosh 2017; Selcuk et al. 2019; Huynh et al. 2021; Feigl and Sammer 2022). Despite this, many studies have shown that students and clinicians view dissection-based courses as the gold standard in anatomical teaching in that they offer unique experiences which improve anatomical knowledge and understanding (Fillmore et al. 2016; Pais et al. 2017; Ghosh 2017). Such courses serve to develop and consolidate anatomical knowledge and its clinical applications by improving the students' three-dimensional appreciation of anatomical structures as well as aiding their confidence and motivation to learn anatomy (Patel and Moxham 2008; Eppler et al. 2018; Meguid and Khalil 2017; Feigl and Sammer 2022).

Dissection as a method of "kinesthetic learning" enables students to build upon their pre-existing anatomy knowledge acquired through two-dimensional modalities such as lectures or small group teaching, or the observation of pre-prepared prosection specimens (Hernandez et al. 2020; Diaz and Woolley 2021). The higher-order cognitive processes involved in integrating this knowledge into their continued learning while physically manipulating and dissecting human specimens are believed to result in a more efficacious learning method, yielding greater educational gains for the learner (Dennick 2016; Gangata and Vigurs 2023). More modern attempts to provide computer-based three-dimensional teaching methods appear to be enjoyed by participants; however, the reports of objective improvements in performance remain mixed (Wang et al. 2024; Kiliç et al. 2025).

Students frequently report dissatisfaction with the amount and depth of anatomy teaching, which is often limited to the early years of medical school and averages only 149 h—well below the 300+ h suggested for adequate training (Ahmad et al. 2020; Smith et al. 2022). This perceived deficiency contributes to low confidence, particularly in complex areas such as neuroanatomy and head and neck anatomy (Bergman et al. 2008; Fitzgerald et al. 2008; Hall et al. 2018; Ahmad et al. 2020), raising concerns about preparedness for clinical roles, especially in anatomy-intensive specialties like surgery and radiology (Turney 2007; Ahmad et al. 2020; Singh et al. 2022).

While several studies have demonstrated short-term gains in anatomical knowledge following dissection-based courses (Huynh et al. 2021), but findings on its superiority over other teaching modalities remain mixed (Hasan et al. 2010; Wilson et al. 2018; Lackey-Cornelison et al. 2020; Thompson and Marshall 2020). The perceptions of dissection in both trainees and senior medical practitioners were also studied by many researchers (Sharma et al. 2016; Flack and Nicholson 2018; Selcuk et al. 2019; Huynh et al. 2021; Kalthur et al. 2022). In general, doctors across various specialities and of varying seniority valued the ability of human specimen dissection to improve their anatomical knowledge acquisition as well as improving their surgical skills (Sharma et al. 2016; Selcuk et al. 2019). This is also reflected at a junior level, with medical students reporting improved confidence in both anatomical competency and surgical skills following dissection courses, as well as ranking them higher than other learning opportunities for perceived impact on anatomical knowledge (Pais et al. 2017; Eppler et al. 2018; Huynh et al. 2021).

This study aimed to quantitatively assess the impact of a 16-week dissection-based course on both superficial and deep anatomical knowledge acquisition and retention in senior medical students. All participants had completed pre-clinical anatomy education using anatomical models and prosections but without dissection. Secondary objectives included evaluation of students' perceptions of dissection as a learning tool and identifying any regional weaknesses.

2 | Materials and Methods

This prospective cohort study was conducted during the 2021–2022 academic year within the intercalated BSc Clinical Anatomy programme.

2.1 | Ethical Approval

This project was submitted to the ethical committee at the School of Medicine, who provided approval for the project to be completed without the need for full application to the University Postgraduate Ethics Committee based on responses in the submitted Postgraduate Ethical Review Questionnaire. The study adhered to the principles outlined in the Declaration of Helsinki, with all participants given a participant information sheet and signing a consent form prior to commencing the study.

2.2 | Participants

Fifteen medical students were recruited from the intercalated BSc Clinical Anatomy programme with entry requirements via a competitive selection process based on academic performance, including prior anatomy examination results. All participants had completed 2 years of pre-clinical anatomy education covering the entire human body delivered through lectures, small-group tutorials, and prosection-based sessions, but had not previously undertaken human specimen dissection.

Eligibility criteria included enrolment in the Clinical Anatomy programme and full participation in the dissection course. No additional inclusion or exclusion criteria were applied. All participants provided written consent and were assigned anonymized identifiers by an independent staff member to ensure confidentiality. Participants were able to withdraw at any stage, up to 3 months after the completion of the final test.

The dissection course spanned over 16 weeks (September—December), with participants engaging in 7 h of human specimen dissection per week. Working in teams of four, participants dissected the same human specimen throughout the course under the supervision of a senior dissection technician and academic staff. Instruction on dissection techniques was provided at the beginning, and all participants maintained a reflective logbook documenting their progress and learning experience. The region of the body to be dissected each week was pre-determined by faculty, while students planned specific objectives for each session with the help of a senior technician. Students worked together as a group of four to dissect the same region of the body each week as outlined by the weekly region-wise plan, ensuring that all students covered the desired content each week. The course was supplemented by embryology teaching and an independent research project.

2.3 | Assessment of Anatomical Knowledge

Participants completed four assessments: pre-course (Week 0), mid-course (Week 8), post-course (Week 16), and follow-up (Week 20). Week 20 was decided for the follow up test as participants were busy with their research project in those 4 weeks after they completed their dissection course and did not have any exposure to dissection or any relevant resources as this test was conducted to ascertain the degree of knowledge retention.

Each assessment comprised 24 questions based on prosection images from six regions, with four questions from each region in every test (head and neck, thorax, abdomen, pelvis, upper limb, lower limb). Each image as shown in Supporting Information was assessed by two identification questions assessing superficial knowledge and two application/relationship questions assessing deeper understanding, in order to assess the potential benefit of dissection based education on 3-D relationship knowledge gain. These images were printed on A4 paper, with participants providing written answers on this.

Images were sourced from the University of Michigan Medical School Bluelink image database, with appropriate permissions (University of Michigan Medical School 2023). Questions were reviewed by a senior anatomy academic for accuracy and relevance, and to ensure that question structures were analogous between tests and that no repeat questions were included. This senior academic also acted to ensure the internal validity of the assessments, and to ensure that questions asked were at the correct level for intercalation BSc students. The Anatomical Society's core syllabus (Smith et al. 2015) was used to randomize test images used in this study. Specific numbers were assigned to each point on the syllabus for each of the six body regions. The numbers were randomly selected using computer software for each of the six regions, and the test images chosen based on the syllabus point selected.

2.4 | Perception of Dissection

At the final assessment, participants completed a structured questionnaire evaluating their perceptions of dissection, as shown in Figure 4. The survey included questions on the perceived importance of anatomy, educational value of dissection, student perception of dissection, and comparison of dissection with other teaching modalities. This questionnaire was reviewed by senior academics to ensure validity. Responses were recorded using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

2.5 | Statistical Analysis

Data were compiled in Microsoft Excel and analyzed using SPSS version 28. The Shapiro–Wilks test was used to test the data for normality. For parametric data, repeated measures ANOVA with Bonferroni post hoc correction was used to compare mean scores across time points. For non-parametric data, Friedman's test with Bonferroni-adjusted post hoc comparisons was applied.

A Chi square test with a post hoc Bonferroni correction when appropriate was used to analyze changes in the proportion of correct responses between identification and application questions across the tests. To evaluate performance across six anatomical regions, 14 participants completed four tests, each comprising 24 questions. Scores were aggregated per region across all tests to yield a total regional score for each participant. A repeated measures ANOVA was conducted to compare performance across regions, accounting for within-subject variability. Assumptions of normality and sphericity were tested, with corrections applied as needed. Post hoc pairwise comparisons were performed using Bonferroni adjustments to control for multiple testing. This approach enabled robust identification of statistically significant differences in regional performance. Likert scale analysis of participants' perception of dissection is illustrated as stacked bar charts. All data are presented as mean ± standard deviation. A p-value of < 0.05 was considered statistically significant in all cases.

3 | Results

Of the 15 participants initially recruited, 14 completed all parts of the study. One participant withdrew after the first test and was excluded from subsequent analysis.

3.1 | Whole Group Analysis

Test scores were normally distributed across all four time points (Shapiro–Wilk test > 0.05 for all). The mean scores attained in the four tests are shown in Figure 1, with a significant progressive increase from Test 1 to Test 2 ($p = 0.045$), and from Test 2 to

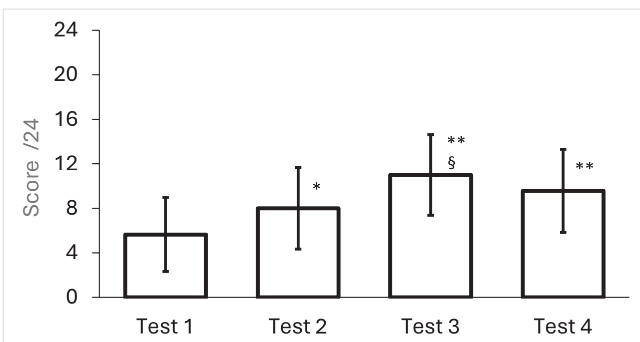

FIGURE 1 | Mean scores achieved in tests 1–4. Each column shows mean ± SD. *, ** indicate different from Test 1: $p < 0.05$, $p < 0.001$, respectively, § indicates difference from test 2: $p < 0.05$. Figure shows a significant difference in the scores achieved in test 1 and test 4.

TABLE 1 | Absolute difference and percentage change between test scores across four tests.

Test	Absolute difference in test score	Percentage change in test score (%)	*p*
Test 2–Test 1	2.36 (0.75)	41.84 (+/−13.30)	0.045
Test 3–Test 1	5.36 (0.71)	95.04 (+/−12.59)	< 0.001
Test 4–Test 1	3.93 (0.58)	69.68 (+/−10.28)	< 0.001
Test 3–Test 2	3.00 (0.78)	37.50 (+/−9.81)	0.013
Test 4–Test 2	1.57 (0.94)	19.63 (+/−11.70)	0.702
Test 4–Test 3	−1.43 (0.56)	−13.00 (+/−5.09)	0.147

Note: Changes in mean test score between tests given as absolute value out of 24 and as percentage change. Each value is mean (SD). *p*-values indicate differences between pairs of tests.

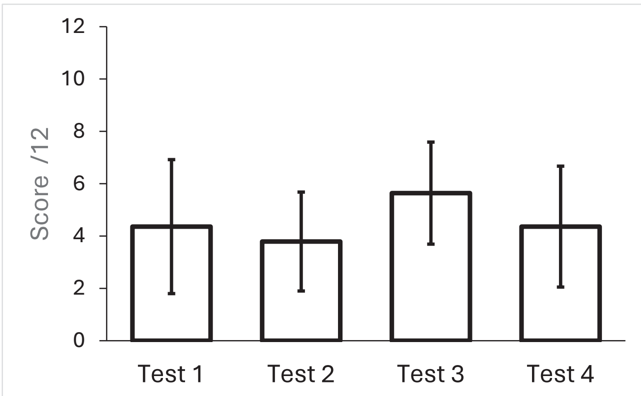

FIGURE 2 | Mean scores for simple identifying questions achieved in test 1–4. Each column shows mean ± SD. This figure shows no significant change in test score across the four tests for simple identifying questions.

Test 3 ($p = 0.013$). Although a slight decline was observed in Test 4 (one-month post-course), scores remained significantly higher ($p < 0.001$) than baseline (Test 1), suggesting retention of learning (Figure 1, Table 1).

3.2 | Simple Identifying Questions

A peak in scores for simple identifying questions was observed at Test 3 (Figure 2); but Friedman's test revealed no statistically significant difference between the scores across the four tests ($p = 0.06$), so post hoc tests were not undertaken.

3.3 | Application and Relationship Questions

Scores for application and relationship questions were normally distributed for all tests (Shapiro–Wilk test > 0.05 for all). The performance improved progressively across Tests 1–4 with a statistically significant increase between Tests 1–2, Tests 1–3 and Tests 1–4 ($p < 0.001$ for all), indicating strong retention of deeper anatomical understanding (Figure 3 and Table 2).

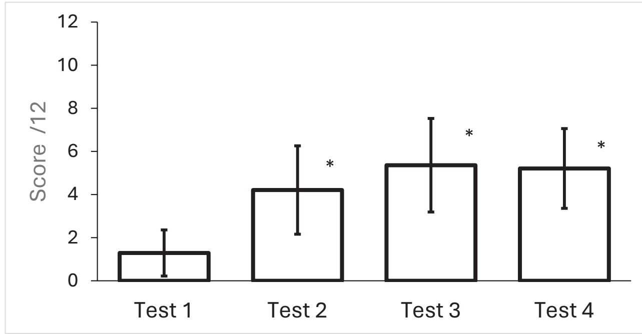

FIGURE 3 | Mean scores for application and relationship questions achieved in tests 1–4. Each column shows mean ± SD. * indicates different from Test 1: $p < 0.001$, respectively.

TABLE 2 | Absolute difference and percentage change between test scores across four tests for application and relationship questions.

Test	Absolute difference in test score	Percentage change in test score (%)	*p*
Test 2–Test 1	2.93 (0.54)	227.13 (41.86)	< 0.001
Test 3–Test 1	4.07 (0.43)	315.50 (33.33)	< 0.001
Test 4–Test 1	3.93 (0.43)	304.65 (33.33)	< 0.001
Test 3–Test 2	1.14 (0.52)	27.08 (12.35)	0.286
Test 4–Test 2	1.00 (0.45)	23.75 (10.45)	0.255
Test 4–Test 3	−0.14 (0.49)	2.61 (9.14)	1.000

Note: Changes in mean test score for application and relationship questions between tests given as absolute value out of 12 and as percentage change. Each value is mean (SD). *p*-values indicate differences between pairs of tests shown in Figure 3. This table shows a significant difference between test 1 and the other tests, with no significant difference between the remaining tests.

3.4 | Subgroup Analysis Between Regions of the Body

Regional subgroup analysis revealed significantly lower scores in head and neck questions compared to thorax ($p < 0.001$), abdomen ($p < 0.001$) and pelvis ($p < 0.001$). Thorax scores were also significantly higher than upper limb ($p = 0.001$). No other regional comparisons reached statistical significance.

3.5 | Perception of Dissection

Participants strongly endorsed the value of dissection in enhancing anatomical understanding, clinical relevance, and skill development. Likert-scale responses are summarized in Figure 4, showing high levels of agreement above domains.

4 | Discussion

This study demonstrates that a dissection-based course significantly enhances anatomical knowledge in a small group of senior medical students with prior anatomy education. Whole-group analysis revealed a progressive improvement in test scores from

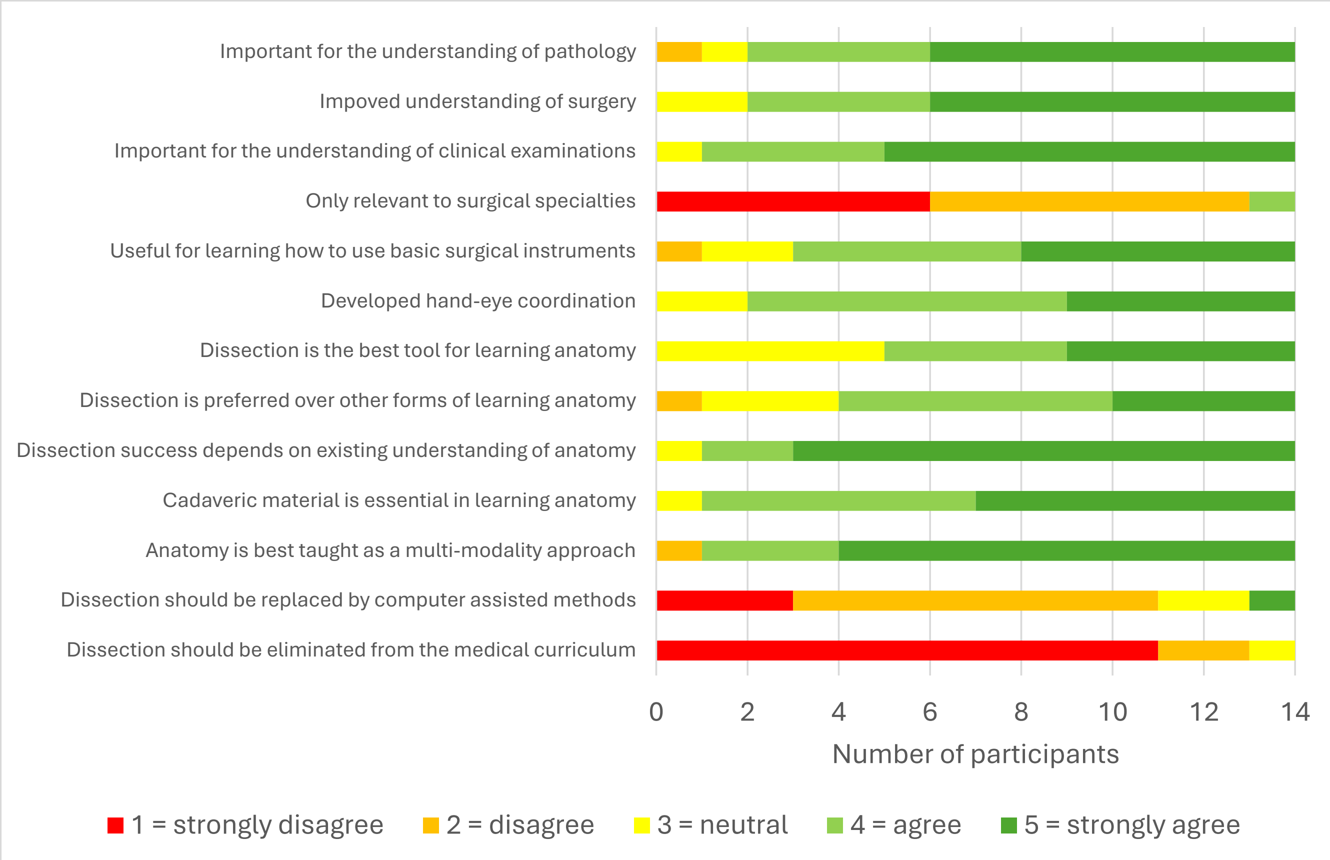

FIGURE 4 | Bar chart of student's perceptions of dissection. Student perceptions of dissection in anatomy education (top), to other skills developed by dissection (middle), and the importance of dissection for future clinical practice (bottom). This highlights that participants rate dissection as a highly efficacious and valued educational tool.

the start to the end of the course, with no significant decrease in mean test score one-month post-completion. These findings suggest that dissection not only facilitates knowledge acquisition for a specific small cohort of clinical medical students but also supports retention, particularly of complex anatomical relationships. Students also expressed strong support for dissection as a learning modality, aligning with previous literature that highlights its educational value (Sarkis et al. 2014; Whelan et al. 2018; Abdellatif 2020; Lackey-Cornelison et al. 2020; Huynh et al. 2021; Feigl and Sammer 2022).

Importantly, while no significant difference was observed between the end-of-course (Test 3) and follow-up test (Test 4) scores, both were significantly higher than baseline, especially for the "application and relationship questions." Retrospective power calculation indicated that over 700 participants would be needed to detect a statistically significant decrease in performance between Tests 3–4 in the "application and relationship questions." Taken together these findings suggest that the dissection course was particularly effective in fostering long-term retention of the 3D anatomical understanding, although the low numbers of participants involved in this project limit the generalizability of the results. These findings contrast with some studies reporting poor retention following dissection-based teaching (Jurjus et al. 2014; Doomernik et al. 2017; Kooloos et al. 2020) which may be due to participants in those studies being earlier in their medical school training than those in this project. However, this study aligns with many other studies showing that dissection can support durable learning, particularly when students are motivated and have a strong foundational knowledge (Sarkis et al. 2014; Burgess et al. 2022; Baker 2022).

The distinction between superficial and deep learning was clearly demonstrated. While scores for simple identification questions did not significantly change across the study period, performance on application and relationship questions improved markedly. The proportion of marks on each test from "application and relationship" questions increased from 23.5% at baseline to 48.7% post-course despite the fact the same number of this question type was included in each test, indicating a shift toward deeper understanding for this cohort of 14 medical students. This supports the notion that dissection is particularly effective in developing spatial awareness and relational anatomy, as reported in prior studies (Huynh et al. 2021; Flack and Nicholson 2018). The relatively stable performance on identification questions may reflect a ceiling effect from prior teaching, although baseline scores in this study (4.36/12) suggest room for improvement.

When comparing region wise knowledge and understanding, participants scored better in thorax questions compared with most other areas of the body. This is consistent with previous studies stating student perception of cardiovascular anatomy as the simplest to learn (Lieu et al. 2018). A notable finding was the consistently lower performance in head and neck questions compared to other regions. This aligns with previous UK-based studies identifying head and neck anatomy as particularly challenging (Hall et al. 2018), likely due to its structural complexity and dissection difficulty (Williams et al. 2018; Cheung et al. 2021). Interestingly, this contrasts with the study in Pakistan, where students reported abdomen (19%), head and neck (19%) and upper limb (16%) anatomy as equally difficult (Qamar et al. 2021). These differences may reflect variations in curriculum design and teaching emphasis, suggesting opportunities for targeted improvements in UK anatomy education. Previous literature has highlighted some potential explanations for the comparative difficulty in learning head and neck anatomy with a large number of muscles, nerves and vessels that are found in a relatively small anatomical space. This can be conceptually difficult for students to grasp, and the added complexity of considering how the fascial and anatomical planes interact places further stress on learning (Rehman et al. 2022). Compounding this, UK medical schools are reducing the number of hours dedicated to otolaryngology, meaning that pre-existing clinical knowledge that may help anatomy learning is reduced (Sharma et al. 2006; Ferguson et al. 2016; Rehman et al. 2022).

The results of the Likert-questionnaire in the present study reinforced the educational value of dissection. Participants reported that dissection enhanced their understanding, manual dexterity, confidence and preferred it over other modalities such as prosection or digital tools. These findings are consistent with prior research highlighting dissection's role in consolidating theoretical knowledge and developing practical skills (Lempp 2005; Ali et al. 2015; Harper and Birch 2017; Flack and Nicholson 2018; Jeyakumar et al. 2020; Asante et al. 2021; Huynh et al. 2021).

The timing of dissection within the curriculum remains a subject of debate. While some students prefer early exposure during pre-clinical years (Webb et al. 2022), others—and the present study's participants—suggest that prior anatomical knowledge enhances the value of dissection. This is supported by our findings and those of Huynh et al. (2021), who argue that senior students may better integrate dissection with clinical reasoning. Koh et al. (2023) reported significantly better performance by students after completing dissection than prosection-based courses. A hybrid approach combining dissection, prosection, and digital tools may offer the most effective strategy going forward (Wilson et al. 2018; Aziz et al. 2020; Lackey-Cornelison et al. 2020; Moro et al. 2021; Kalthur et al. 2022).

Participants in this study strongly favored dissection over other modalities but also supported a multimodal approach. They also opined strongly to keep dissection as part of the medical curriculum. This aligns with literature advocating integration of computer-assisted learning only to complement dissection and prosection-based learning (Papa and Vaccarezza 2013; Harper and Birch 2017; Naidoo et al. 2020; Baratz et al. 2022; Kochhar et al. 2022).

4.1 | Limitations

At the time of the "mid-course" test, participants had completed dissections of the thorax, abdomen and pelvis only, and therefore had limited exposure to the head, neck and limbs, potentially affecting comparability. Participants were self-selected and highly motivated to apply and secure a place on the competitive intercalation programme. This may limit generalizability and introduce selection bias. Future studies should include randomly recruited students from the broader medical cohort to ascertain wider applicability.

The sample size, constrained by programme capacity, limits statistical power and the generalizability of these results. Larger, multi-centre studies or a longitudinal prospective design would help validate these findings. The lack of a control group within this study design limits the generalizability of the results, and future research should ensure this is included. Future studies' reliability could be improved through the use of Cronbach's alpha analysis.

Additionally, the study did not include a 12-month follow-up, which would have provided further insight into long-term retention. The final test was completed at 4 weeks after the completion of the course due to the nature of the academic year for the participants, who begin revising for summative examinations at this point. In order to avoid confounding results, the final "retention" test was completed at the four-week point. Finally, concurrent embryology teaching may have influenced learning outcomes, although its impact was not directly assessed.

Questionnaire questions were heavily directed toward anatomy and surgery, with potential for missed benefits due to the nature of the questions asked. Further qualitative research would be required to ascertain the participants' opinions on wider applications, with a qualitative open-ended focus group being ideal for this in future.

Assessment tests utilized throughout this study involved participants answering questions based on images of prosection samples printed on A4 paper. The use of this modality, as well as the question type utilized, could be optimized in future research through the use of prosection samples in order to more efficaciously ascertain the effect of this dissection course on participant understanding. This is particularly relevant to the perceived gains in relation to participants' 3-dimensional understanding, with the use of live prosection samples for assessments in future research being a stronger method of assessing participants' understanding of the relationships of adjacent structures.

5 | Conclusion

This study supports the use of dissection as an effective method for teaching anatomy to senior medical students. Dissection improved deep anatomical understanding, enhanced 3D spatial awareness and supported knowledge retention in this cohort of motivated participants. Larger improvements were seen in the understanding of 3D relationships between structures when compared to simple ability to identify structures, highlighting a specific benefit of this teaching course. Students reported positive experiences of this teaching modality, reinforcing the value of dissection.

While dissection may not be feasible for all institutions or students, its inclusion as a short course for clinical-phase students can provide educational value, particularly for aspiring surgeons. Despite this, the correct timing for a dissection-based teaching course is unclear, with potential benefits whenever it is completed in the medical curriculum. In an era of reduced curricular time for anatomy, these findings advocate for the strategic retention of dissection integrating into a multimodal approach. In future, focus should be on optimizing the timing, structure and accessibility of dissection-based learning in medical education.

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The authors have nothing to report.

Data Availability Statement

The data that supports the findings of this study are available in the Supporting Information of this article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** Prosection images utilised during the tests. One image was utilised for each region of the body, meaning six images were used in each test. Questions A and B test 'simple identification' questions, whilst questions C and D test 'application and relationship' questions. Prosection images used in the test were acquired from the University of Michigan Medical School Bluelink image database, with appropriate permission obtained (University of Michigan Medical School, 2023).