Original Article

Comparison of Teaching Aids and Learning Styles in Anatomy: A Cross-Sectional Study Among Medical and Dental Students

Amrat Ijaz,[1] Aysha Saleem,[1] Raafea Tafweez,[1] Zahra Haider[1]

[1]*Department of Anatomy, Azra Naheed Medical College, Superior University, Lahore*

How to cite: Ijaz A, Saleem A, Tafweez R, Haider Z. Comparison of Teaching Aids and Learning Styles in Anatomy: A Cross-Sectional Study Among Medical and Dental Students. J Lahore Med Dent Coll. 2026;3(1):29-35

DOI: 10.70384/jlmdc.v3i01.100

Abstract

Background: Anatomy education has evolved significantly, incorporating multimodal teaching approaches to balance traditional cadaveric dissections with emerging technological tools.

Objective: To assess students' perceptions regarding the effectiveness of anatomical teaching aids and tools like anatomage table, plastic models and cadaveric specimens in facilitating their learning and to explore students' perspectives on their preferred learning styles.

Methodology: This cross-sectional study was conducted via a questionnaire distributed among first- and second-year MBBS students and first-year BDS students at Azra Naheed Medical and Dental College. All data was processed using SPSS v26.0. Descriptive statistics including mean and standard deviation were calculated for effectiveness rating scores. One-way ANOVA test was used to compare effectiveness rating scores of anatomical learning resources for soft tissue across different learning styles. P-value ≤ 0.05 was considered significant.

Results: Plastic models were the most highly rated learning resource for both soft tissue and bone anatomy, with most participants rating them as Excellent (52.1% for soft tissue, 51.1% for bone) and Good (37.9% for soft tissue, 40.5% for bone). Similarly, plastic models were the preferred time-saving resource, while anatomage was perceived as less efficient than other methods. The most preferred learning style was Reading/Writing (41.1%), followed by Visual (24.7%), Kinesthetic (24.2%), and Auditory (10.0%).

Conclusion: It was concluded that plastic models were perceived as the most effective resource for anatomy learning, primarily due to their time efficiency and ease of use. Reading/writing was identified as the predominant learning style among students, highlighting the importance of aligning teaching strategies with learner preferences.

Key words: Anatomy, Learning, Students, Perception

Introduction

Teaching anatomy has changed significantly to accommodate a variety of student-specific learning styles and to stay up with technological advancements. More progressive methods that promote active learning are in competition with traditional instructive methods that promote a more passive learning style. Traditional techniques of teaching anatomy, such as cadaveric dissections and prosections, have grown more challenging because of a shortage of donated bodies, growing safety concerns, and high costs.[1,2] Furthermore, tertiary anatomy courses have steadily moved away from rote memorizing and toward comprehension of the material, which is fueled by concept-based, problem-solving methodo-

Correspondence:
Dr Amrat Ijaz, *Department of Anatomy, Azra Naheed Medical College, Superior University, Lahore* **Email:** *amrat.kamran@gmail.com*

Submission Date: January 24, 2026
1st Revision Received: February 23, 2026
2nd Revision Received: March 17, 2026
3rd Revision Received: April 1, 2026
Copyedited and Corrected: April 20, 2025
Final Revision Accepted: April 25, 2026

logies.[3,4] These developments have been complemented by dynamic technological advancements that have improved the quality and accessibility of medical imaging methods, models, and simulations.[3] As a result, mixed, or multimodal, learning methodologies have been used, giving pupils access to a range of conventional and innovative sources of information. Traditional dissections and didactic lectures are frequently supplemented (and occasionally replaced) by commercial models, computer simulations, clay modeling, body painting, and other living anatomy teaching techniques.[5,6]

The anatomage creates a 3-dimensional (3-D) reconstruction of the various human body components by combining software with stereoscopic pictures of the entire body. To enable virtual dissection and reconstruction of the human body, these pictures were obtained from two cadavers, have been frozen and divided into pieces.[5] The anatomage has proven to be an effective tool in teaching anatomy, as it provides students with hands-on experience without the need for a cadaver. This shift towards alternative learning tools is part of a broader discussion in anatomy education, with some research exploring if models and simulations can replace cadavers altogether.[7]

Given the variability in available resources and institutional constraints across medical schools, there is a need to evaluate and adapt anatomy teaching methods to ensure effective learning. Furthermore, understanding students' preferred learning styles is essential for informed curriculum remodeling and optimization of teaching strategies. In-order to compare teaching aids and learning styles in anatomy, the current study was planned with aims to assess students' perceptions regarding the effectiveness of anatomical teaching aids and tools like anatomage table, plastic models and cadaveric specimens in facilitating their learning and to explore students' perspectives on their preferred learning styles. The results of this study will add to present literature regarding preferred learning style among students in curriculum remodeling.

Methodology

This was a cross-sectional study conducted over a period of six months at Azra Naheed Medical and Dental College. The sample size of 190 was calculated by assuming the proportion of preferred learning style is equal to 40% with a confidence level equal to 95% and a margin of error equal to 7%.[3]

Ethical consideration: The study was approved by the ethical review board (Reference No. FRB/BMS/13/ 03/ 2025, Dated: 13-03-2025). Informed written consent was obtained from the participants, and the confidentiality of their data was clearly explained.

Data was collected by a questionnaire that was distributed among first- and second-year MBBS students, as well as first-year BDS students at Azra Naheed Medical and Dental College. Non-probability convenience sampling technique was used. Plastic models, specimens and anatomage were used as learning tools for anatomy (soft tissue and bones). The questionnaire consisted of 25 questions, pertaining to the comparison, benefits and drawbacks of different teaching aids: blackboard, PowerPoint, overhead projectors and video animation. The questions were styled in multiple-choice format, with two sections based on the 04-point Likert Scale. In the first section their perception regarding these aids was categorized as unsure, fair, good and excellent in form of marks from 0-3 as used in other studies previously.[8,9] On the other hand, in the second section, learning style was categorized into Reading/ Writing, Visual, Kinesthetic and Auditory.[10] Learning styles were given a score from 1-4 according to preference by students. Score of 4 was regarded as excellent while 1 was marked as unsure. A pilot study was conducted to check the reliability and Cronbach alpha revealed a value of 0.79.

Inclusion Criteria: All willing male and female first- and second-year MBBS students, as well as first-year BDS students, were included.

Exclusion Criteria: Students who were unwilling or not interested in providing their feedback were excluded.

Statistical Analysis:

Statistical Package for Social Sciences (SPSS) version 26 was used for statistical analysis. Mean and standard deviation were calculated for effectiveness ratings score. Normality of the data was checked by Shapiro Wilk test. A one-way ANOVA test was used to compare the effectiveness ratings score of anatomical learning resources for soft tissue across different learning styles. Frequency and percentage were given for gender, predominant learning style and responses to the perceived effectiveness of anatomical learning Resources. A p-value of ≤ 0.05 was taken as statistically significant.

Results

The study sample consisted of 190 participants, with a nearly equal gender distribution. There were 96 (50.5%) male and 94 (49.5%) female students. The most preferred learning style was Reading/Writing, followed by Visual, Kinesthetic, and Auditory as shown in Figure I.

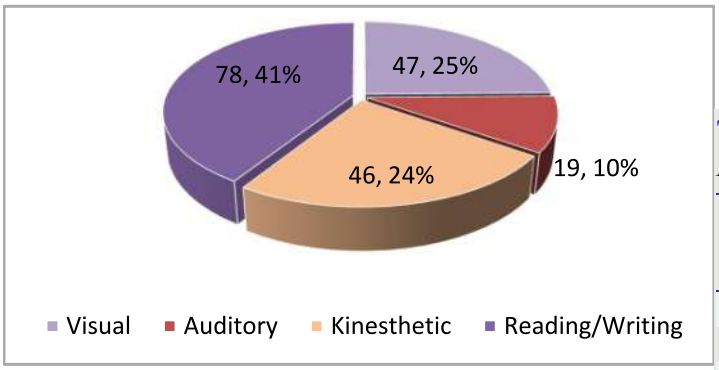

Figure-I: *Frequency Distribution of Predominant Learning Style*

The results indicated that plastic models were the most highly rated learning resource for both soft tissue and bone anatomy, with most of the participants rating them as Excellent and Good as shown by Table I. Specimens received more varied responses, with Excellent ratings of 36.8% for both soft tissue and bone, while a significant proportion rated them as Fair. Anatomage models, however, received the lowest ratings, with the highest percentage of participants rating them as Fair (40.0% for soft tissue, 35.3% for bone), and only 22.6% (soft tissue) and 25.3% (bone) rating them as Excellent. A small proportion of participants were Unsure about Anatomage (4.7% for soft tissue, 3.7% for bone), whereas none were uncertain about plastic models or specimens for bone anatomy. Overall, plastic models were perceived as the most effective resource, followed by specimens, while Anatomage was rated less favorably, particularly for soft tissue learning.

Table I: *Frequency Distribution of Perceived Effectiveness of Anatomical Learning*

	Medium you think clears your concepts	Unsure n (%)	Fair n (%)	Good n (%)	Excellent n (%)
Soft Tissue	Plastic Models	0 (0.0)	19(10.0)	72 (37.9)	99 (52.1)
	Specimens	6 (3.2)	53(27.9)	61 (32.1)	70 (36.8)
	Anatomage	9 (4.7)	76(40.0)	62 (32.6)	43 (22.6)
Bone	Plastic Models	0 (0.0)	16(8.4)	77 (40.5)	97 (51.1)
	Specimens	0 (0.0)	57(30.0)	63 (33.2)	70 (36.8)
	Anatomage	7 (3.7)	67(35.3)	68 (35.8)	48 (25.3)

n: number of participants

Plastic models were perceived as the most time-saving medium for learning anatomy, with most of the participants rating them as Excellent (63.2%) and Good (29.5%), while very few rated them as Fair (6.8%) or were Unsure (0.5%) as presented in Table II. Specimens, on the other hand, received more mixed ratings, with the highest proportion rating them as Good (37.4%), followed by Fair (33.7%) and Excellent (25.3%), indicating moderate effectiveness. Anatomage models had the lowest proportion of Excellent ratings (16.3%), with a significant percentage of participants rating them as Fair (39.5%) or Good (41.1%), and a small proportion (3.2%) expressing uncertainty. Overall, plastic models were the preferred time-saving resource, while Anatomage was perceived as less efficient compared to other methods.

Table II: *Frequency Distribution of Perceived Time Efficiency of Anatomical Learning*

Time-Saving Medium for Learning Anatomy	Unsure n (%)	Fair n (%)	Good n (%)	Excellent n (%)
Plastic Models	1 (0.5)	13 (6.8)	56 (29.5)	120 (63.2)
Specimens	7 (3.7)	64 (33.7)	71 (37.4)	48 (25.3)
Anatomage	6 (3.2)	75 (39.5)	78 (41.1)	31 (16.3)

n: number of participants

Significant variations were observed in the perceived

Table III: *Effectiveness of Anatomical Learning Resources for Soft Tissue Across Different Learning Styles*

Soft Tissue	Learning Style	Mean ± SD	p-value
Plastic models	Visual	2.7 ± 0.5	0.000*
	Auditory	2.1 ± 0.8	
	Kinesthetic	2.1 ± 0.7	
	Reading/writing	2.5 ± 0.6	
Specimens	Visual	2.1 ± 0.7	0.002*
	Auditory	2.2 ± 0.8	
	Kinesthetic	2.4 ± 0.8	
	Reading/writing	1.8 ± 0.9	
Anatomage	Visual	1.8 ± 0.9	0.589
	Auditory	1.7 ± 0.9	
	Kinesthetic	1.8 ± 0.8	
	Reading/writing	1.6 ± 0.9	

**p-value ≤ 0.05 statistically significant; p-value calculated by one way ANOVA, SD= Standard Deviation.*

effectiveness of different anatomical learning resources across learning styles (Table III). Plastic models for soft tissue were rated the highest overall, with visual learners showing the strongest preference and kinesthetic learners giving the lowest rating. Specimens for soft tissue had a lower overall rating, with kinesthetic learners rating them the highest and reading/writing learners the lowest. In contrast, Anatomage for soft tissue received the lowest ratings, with no significant variation across learning styles.

Table IV: *Effectiveness of Anatomical Learning Resources for Bone Across Different Learning Styles*

Bone	Learning Style	Mean ± SD	p-value
Plastic models	Visual	2.7 ± 0.5	0.000*
	Auditory	2.3 ± 0.8	
	Kinesthetic	2.1 ± 0.7	
	Reading/writing	2.5 ± 0.6	
Specimens	Visual	2.1 ± 0.7	0.008*
	Auditory	2.2 ± 0.8	
	Kinesthetic	2.4 ± 0.8	
	Reading/writing	1.9 ± 0.8	
Anatomage	Visual	1.9 ± 0.9	0.627
	Auditory	1.8 ± 0.8	
	Kinesthetic	1.9 ± 0.8	
	Reading/writing	1.7 ± 0.9	

**p-value ≤ 0.05 statistically significant; p-value calculated by one way ANOVA, SD= Standard Deviation.*

Table V: *Perceived Time-Saving Effectiveness of Anatomical Learning Resources Across Different Learning Styles*

Time-Saving Medium for Learning Anatomy	Learning Style	Mean ± SD	p-value
Plastic models	Visual	2.7 ± 0.6	0.057
	Auditory	2.5 ± 0.5	
	Kinesthetic	2.3 ± 0.8	
	Reading/writing	2.6 ± 0.6	
Specimens	Visual	1.8 ± 0.8	0.001*
	Auditory	2.1 ± 0.8	
	Kinesthetic	2.2 ± 0.8	
	Reading/writing	1.6 ± 0.9	
Anatomage	Visual	1.8 ± 0.8	0.158
	Auditory	1.7 ± 0.6	
	Kinesthetic	1.9 ± 0.7	
	Reading/writing	1.6 ± 0.8	

**p-value ≤ 0.05 statistically significant; p-value calculated by one way ANOVA, SD= Standard Deviation.*

Table IV shows that plastic models were rated highest for bone anatomy, followed by specimens, while Anatomage received the lowest ratings. Significant differences were observed across learning styles for plastic models and specimens, whereas no significant variation was noted for Anatomage.

For general learning and time-saving methods, plastic models were rated the highest, with visual learners giving the strongest preference and kinesthetic learners rating them the lowest but the results were not significant (Table V). Specimens received comparatively lower ratings, although kinesthetic learners rated them higher than other groups, with a significant difference across learning styles. In contrast, Anatomage received the lowest ratings overall, with no significant variation across learning styles. Overall, plastic models emerged as the most effective learning resource across all categories, followed by specimens, while Anatomage had the lowest ratings and no significant preference among learners.

Discussion

A comprehensive understanding of anatomy is essential for the practice of medicine therefore, it should not rely solely on a single teaching modality. This study evaluated different tools in relation to students preferred learning styles and it also dressed the student's perception on different teaching styles. Results of present study indicated that plastic models were the most highly rated learning resource for both soft tissue and bone anatomy, with the majority of participants rating them as Excellent and Good. Paradoxically, previous studies have demonstrated that cadaveric dissection has historically remained a fundamental method for teaching anatomy in medical schools world-wide.[7,11] Students have expressed a strong belief that engaging in cadaveric dissection enhances their under-standing of anatomy and fosters greater respect for the human body.[8] Furthermore, other anatomists have emphasized that cadaveric dissection cannot be replaced, although it can be effectively augmented with additional teaching tools to enhance anatomical learning..[9,12] However, in contrast to studies favoring cadaveric dissection, the present findings highlighting the effectiveness of plastic models are supported by previous research demonstrating that students taught using plastic models achieved significantly higher scores compared to those taught through cadaveric dissection.[13] It was reported that plastic models improved concept clarity, structured learning, repeated access and exam performance as these models provide a clear, tangible representation

of anatomical structures, which likely enhances understanding and retention. In the current study, visual learners rated plastic models highest, supporting the idea that visual representation is key to grasping complex spatial relationships in anatomy. Moreover, plastic anatomical models may demonstrate improved learning outcomes in certain contexts due to their ability to facilitate tactile and repetitive hands-on interaction, allowing students to repeatedly explore structures without the limitations associated with cadaver availability. Additionally, models provide clear, standardized visualization of anatomical relationships, which can reduce cognitive overload for novice learners and enhance spatial understanding. This combination of tactile engagement and simplified representation can, in some settings, lead to better short-term comprehension compared to cadaver-based learning.[14]

However, previous studies have reported that anatomical models were perceived as less useful in achieving intended learning objectives, with students demonstrating a preference for cadaver-based learning.[15,16] In contrast, advancements in digital technology have introduced three-dimensional (3D) anatomical models and texture mapping, which can effectively represent the morphological attributes of human tissues and structures. These tools are particularly valuable in visualizing complex anatomical relationships that are difficult to appreciate through conventional methods, thereby enhancing the effectiveness of anatomy instruction. Traditional anatomical models were initially introduced to compensate for the limited availability of cadaveric specimens.[17,18] Despite these advancements, the Anatomage table received comparatively lower ratings from students in the present study. This may be attributed to several factors, including limited training, lack of familiarity, reduced accessibility, and the high cost associated with the technology, making it less feasible for widespread institutional use.

The present study showed that most preferred learning style was Reading/Writing, followed by Visual, Kinesthetic and Auditory. Similarly, previous studies on learning anatomy by different styles have reported that reading/writing was the priority of the students on any teaching tools followed by visual while auditory styles was least preferred.[15,19,20] These findings provide valuable insight for educators to better under-stand students' learning needs and adapt their teaching strategies accordingly. In terms of time efficiency, plastic models received the highest ratings, while specimens had mixed results and the Anatomage table lagged. The observation that visual learners consistently rated plastic models highest in both effectiveness and time-saving measures suggests that this method aligns well with the predominant learning style within the study population.[21] Plastic models were widely adopted because they are easy to handle, require minimal setup, and allow rapid repetition of learning tasks as reported by one study.[22] These features directly translate into higher time efficiency ratings by students. A previous study showed that plastinated specimens improved performance and clinical understanding. However, they involve handling complexity, preparation time, and limited availability. Consequently, they are less time-efficient and more variable in student preference.[23]

Overall, these findings suggest that plastic models remain the most effective and adaptable teaching tool for a majority of students, making them a strong candidate for continued and expanded use in the curriculum. Specimens, while less universally favored, still hold value for kinesthetic learners, supporting their continued inclusion alongside other resources. The comparatively lower ratings for the Anatomage table indicate that, despite its technological advantages, it may require improved integration, adequate training, or complementary instructional strategies to enhance its educational effectiveness.[15,24]

Conclusion

Plastic models were perceived as the most effective resource for anatomy learning, primarily due to their time efficiency and ease of use. Reading/writing was identified as the predominant learning style among students, highlighting the importance of aligning teaching strategies with learner preferences.

Limitations and Recommendations

This study has certain limitations. This was a single center study and cross-sectional design was used which limits the ability to establish causal relationships. Additionally, the use of convenience sampling may introduce selection bias and limit the representativeness of the study population, thereby affecting the generalizability of the findings.

Curriculum remodeling efforts should prioritize a balanced, multimodal approach that integrates traditional models and specimens with newer technologies like the Anatomage table but only if the technology can be adapted to better meet student learning needs. Further

research may be necessary to explore how the Anatomage table can be enhanced or paired with other methods to improve its effectiveness, particularly for visual and kinesthetic learners. By aligning teaching strategies with students' preferred learning styles, medical education can become more engaging, efficient, and effective, ultimately fostering a deeper understanding of anatomy.

Conflict of Interest: None

Funding Disclosure: None

Acknowledgement: None

References

1. Goubar T, Larach J, Hindmarch J, Bownes S, Sinha S. A pragmatic approach to effective anatomy teaching and learning to medical students: a ten-year experience using evidence-based principles. MedEdPublish. 2021; 10:147. Doi: 10.15694/mep.2021.000147.1.
2. Osorio-Toro S, Rodríguez-Campo A, Ramirez-Malule H. Bibliometric analysis of global research output on teaching and learning of human anatomy. Int J Morphol. 2022;40(3):789-797. Doi:10.4067/S0717-95022022 000300789
3. Bork F, Lehner A, Eck U, Navab N, Waschke J, Kugelmann D. The Effectiveness of Collaborative Augmented Reality in Gross Anatomy Teaching: A Quantitative and Qualitative Pilot Study. Anat Sci Educ. 2021;14 (5):590-604. Doi: 10.1002/ase.2016
4. Biswas S, Thosar NR, Srimani P. Self-Directed Learning Versus Traditional Teaching in learning gross anatomy among First-Year Medical students: a comparative study. Cureus. 2024;16(8):e66542. D o i: 10.7759/ cureus. 66542.
5. Asante EA, Maalman RS, Ali MA, Donkor YO, Korpisah JK. Perception and attitude of medical students towards cadaveric dissection in anatomical science education. Ethiop J Health Sci. 2021;31(4):677-686. Doi: 10. 4314/ ejhs.v31i4.3
6. Onigbinde OA, Chia T, Oyeniran OI, Ajagbe AO. The place of cadaveric dissection in post-COVID-19 anatomy education. Morphologie. 2021;105(351):259-266. Doi: 10.1016/j.morpho.2020.12.004.
7. Seth V, Upadhyaya P, Ahmad M, Moghe V. PowerPoint or chalk and talk: Perceptions of medical students versus dental students in a medical college in India. Adv Med Educ Pract. 2010;1:11-16. Doi: 10.2147/AMEP. S12154.
8. Naqvi SH, Mobasher F, Afzal MA, Umair M, Kohli AN, Bukhari MH. Effectiveness of teaching methods in a medical institute: perceptions of medical students to teaching aids. J Pak Med Assoc. 2013;63(7):859-864. PMID: 23901709
9. Pereira JA, Pleguezuelos E, Merí A, Molina Ros A, Molina-Tomás MC, Masdeu C. Effectiveness of using blended learning strategies for teaching and learning human anatomy. Med Educ. 2007;41(2):189-195. Doi:10.1111/j.1365-2929.2006.02672.x
10. Hafez SA. Design for assessment of dissection in anatomy laboratory based on group identification of structures and peer evaluation. Anat Sci Educ. 2022;15(6): 1045-1059. Doi: 10.1002/ase.2143
11. Alghamdi MA, Bu Saeed R, Fudhah W, Alqarni D, Albarzan S, Alamoudi S, et al. Perceptions of medical students regarding methods of teaching human anatomy. Cogent Educ. 2024;11(1):2340836. Doi:10.1080/ 23 31186X.2024.2340836
12. Abdullah E, Lone M, Cray JJ, Dvoracek P, Balta JY. Medical Students' Opinions of Anatomy Teaching Resources and Their Role in Achieving Learning Outcomes. Med Sci Educ. 2021;31(6):1903-1910. Doi: 10.1007/s40670-021-01436-2
13. Qamar K, Ahmad A, Ashar A. Comparison of learning anatomy with cadaveric dissection and plastic models by medical students. Pak Armed Forces Med J. 2014; 64 (2): 219-224.
14. Azer SA, Azer S. 3D anatomy models and impact on learning: a review of the quality of the literature. Health Prof Educ. 2016;2(2):80-98. Doi:10.1016/ j.hpe. 2016. 05.002
15. Almulhem MA, Almulhem JA. Evaluation of problem-based learning implementation in a college of medicine, Kingdom of Saudi Arabia: a cross-sectional comparative study. BMC Med Educ. 2022;22(1):311. Doi: 10. 1186/s12909-022-03347-1
16. Koh ZJ, Yeow M, Srinivasan DK, Ng YK, Ponnamperuma GG, Chong CS. A randomized trial comparing cadaveric dissection and examination of prosections as applied surgical anatomy teaching pedagogies. Anat Sci Educ. 2023;16(1):57-70. Doi: 10.1002/ase.2166
17. Lackey-Cornelison WL, Bauler LD, Smith J. A comparison of the effectiveness of dissection and prosection on short-term anatomic knowledge retention in a reciprocal peer-teaching program. Adv Physiol Educ. 2020; 44(2):239-246. Doi: 10.1152/advan.00031.2020
18. Burgess AW, Luscombe GM, Ramsey-Stewart G. An intensive anatomy by whole-body dissection elective: A longitudinal study. Clin Anat. 2022;35(5):550-559. Doi: 10.1002/ca.23861
19. Tan L, Wang Z, Jiang H, Han B, Tang J, Kang C, Zhang N, Xu Y. Full color 3D printing of ana-tomical models. Clin Anat. 2022;35(5):598-608. Doi: 10.1002/ca.23875

20. Alfarsi W, Elaghoury AH, Kore SE. Preferred Learning Styles and Teaching Methods Among Medical Students: A Cross-Sectional Study. Cureus. 2023;15(10):e46875. Doi: 10.7759/cureus.46875

21. Estai M, Bunt S. Best teaching practices in anatomy education: A critical review. Ann Anat. 2016;208:151-157. Doi: 10.1016/j.aanat.2016.02.010

22. Verma S, Sharma U. Alternatives to cadaveric dissection in medical education: an overview. Int J Adv Med Health Res. 2025;12(1):12-22. Doi:10.4103/ijamr.ijamr_316_24

23. Suharto MI, Hayati T, Hanifah H, Mozart M. Effectiveness of cadaver compared to plastination as anatomy learning media: medical student perspective. Althea Med J. 2025; 12(2):140-146. Doi:10.15850/amj.v12n2.3790

24. Fraher JP, Evans DJ. Training tomorrow's anatomists today: a partnership approach. Anat Sci Educ. 2009; 2(3):119-25. Doi: 10.1002/ase.81

Authors Contribution

All authors have approved the final revision of the manuscript and take responsibility for the integrity of the study.

AI & RT: Conceptualization of Project, Data interpre-tation, writeup and revision of the manuscript

ZH, AS, RT: Literature search, Data Collection, analysis and article writeup and revision