Althea Medical Journal
ISSN Online: 2337-4330
https://doi.org/10.15850/amj.v12n2.3790

Original Article

Effectiveness of Cadaver Compared to Plastination as Anatomy Learning Media: Medical Student Perspective

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Abstract

Background: Anatomy is a fundamental component of medical education, playing a pivotal role in understanding the structure and function of the human body. Cadaver-based anatomy learning remains widely used in many medical faculties; meanwhile, plastination as an alternative method, offering efficiency and practicality. This study aimed to evaluate the effectiveness of cadaver and plastination learning media in improving anatomical understanding among first-year medical students.

Methods: This was a cross-sectional quantitative study with a pretest-posttest control group design conducted in November-December 2023. The study included 69 first-semester medical students from the Universitas Pertahanan, Republic of Indonesia who had not previously received musculoskeletal anatomy lectures. Participants were divided into cadaver and plastination groups. A questionnaire was distributed before and after the anatomy class. Data were analyzed with the Mann-Whitney, Wilcoxon, and paired sample t-test.

Results: Both cadaver and plastination groups showed a significant increase in post-test scores ($p<0.05$), indicating that each method effectively improved students' anatomical understanding. However, there was no significant difference between the two groups (p-value=0.253), suggesting comparable effectiveness between cadaveric and plastinated teaching media.

Conclusions: Cadaveric and plastinated learning media are equally effective in improving anatomical knowledge among first-semester medical students. A thorough understanding of human anatomy is essential not only for clinical competency but also for advancing knowledge related to wellness, healthy aging, and the management of degenerative diseases.

Keywords: Anatomy education, cadaver, plastination, medical students, learning media

Althea Medical Journal. 2025;12(2):140–146

Received: April 30, 2024
Accepted: October 22, 2024
Published: June 30, 2025

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Introduction

Anatomical understanding forms a fundamental component of preclinical medical education, serving as a critical foundation for competent clinical practice and safe patient care.[1] The selection of effective learning media is therefore essential. Prior studies have demonstrated comparable effectiveness between cadavers and teaching videos in enhancing students' understanding of neuroanatomy.[2] The appropriate use of instructional media can significantly improve both anatomical comprehension and practical skills.[2]

Traditionally, human cadavers have been the primary medium for teaching anatomy. However, with rapid technological advancements, several institutions in Indonesia have adopted modern alternatives such as plastination, augmented reality, and radiological imaging.[3] The main advantage of cadaver-based instruction lies in its close approximation to the actual human body in terms of structural detail and tissue texture, including anatomical variations.4 However, the use of cadavers presents several challenges, including high costs, limited availability, and safety concerns. Procuring and maintaining cadavers involves ethical considerations, reliance on voluntary body donation or institutional authorization, and requires specialized preservation facilities.[5–7] Additionally, the health risks associated with formaldehyde exposure pose further limitations.[7]

In response to these challenges, plastination has emerged as a promising alternative. In this method, biological tissues are preserved using polymeric materials, maintaining anatomical structure while eliminating the need for refrigeration or chemical preservation.[8,9] Plastinated specimens offer reusability and ease of maintenance. However, the absence of tissue moisture and texture similar to that of living tissue may limit their effectiveness in providing a fully immersive learning experience.[10]

At the Faculty of Military Medicine, Universitas Pertahanan Republic of Indonesia, cadavers have been used as the sole medium for anatomy instruction since its founding in 2021. However, since the 2021–2022 academic year, approximately 30% of cadets have failed the anatomy module examination, prompting concerns regarding the effectiveness of the current approach. Recently, plastinated specimens have been introduced as an additional teaching tool. This study aimed to evaluate and compare the effectiveness of cadavers and plastination as media for learning anatomy among medical students. By assessing the strengths and limitations of both methods, this research seeks to inform curriculum development and enhance the quality of anatomical education.

Methods

This study employed a quantitative, cross-sectional design with a pretest-posttest control group format conducted in November–December 2023 at the Faculty of Medicine, Universitas Pertahanan Republic of Indonesia, Bogor, Indonesia. The study population comprised all first-semester medical students enrolled in the 2023 academic year who had not previously received lectures on the musculoskeletal system. Ethical approval for this study was granted by the Ethics Committee of the Faculty of Medicine, Universitas Pertahanan Republik Indonesia, with approval number 202310072.

Participants were randomly assigned into two groups, namely a cadaver group and a plastination group, using simple randomization to minimize selection bias. However, no stratification by gender was applied, resulting in an unequal gender distribution between the groups, an expected limitation in small-sample studies using simple randomization.

Inclusion criteria were students in good health during the study period and willingness to participate voluntarily. Exclusion criteria included students who withdrew from the study, did not complete the learning session, or failed to return the questionnaire

A pretest questionnaire was distributed before students received material on the musculoskeletal anatomy of the humerus region. After the instructional session, using either cadaver or plastination media, students completed a posttest questionnaire. The instrument used in this study was adapted from previously validated and reliable research tools.[11] It contained 15 multiple-choice questions covering osteology, musculature and ligaments, and neurovascular structures (Table 1).[11]

Each correct response was awarded 1 point, while incorrect answers received 0 points, yielding a maximum raw score of 15. To enable comparative analysis, the raw scores were converted to a 0–100 scale using the formula: Final Score=(Number of Correct Answers / 15) × 100.[11]

Data were analyzed using both parametric and non-parametric statistical tests. Paired sample t-tests were used to assess within-group differences, while Wilcoxon and Mann–Whitney U tests were applied for between-group comparisons, depending on data distribution.

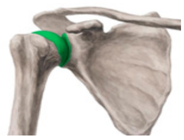
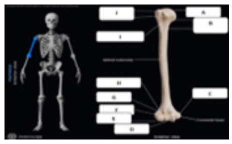
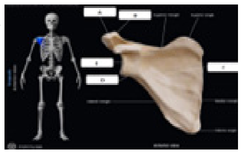
Results

A total of 69 first-semester medical students from the 2023 academic year participated in this study. Participants were aged between 17 and 19 years, consisting of 29 males and 40 females (Table 2).

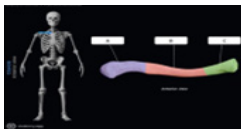
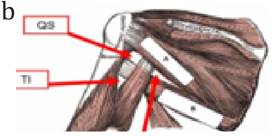
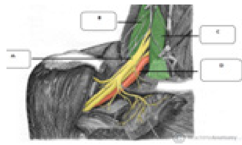
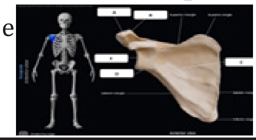
Analysis of prior exposure to anatomy learning materials revealed that 46% of students had never studied anatomy textbooks. Meanwhile, 31% had used various references, such as Campbell Biology, high school biology textbooks, medical anatomy mini notes, Netter's Atlas of Human Anatomy, and Yokochi's Anatomy Atlas (Table 3).

There was a statistically significant improvement in students' scores after the intervention in both groups. The plastination group showed a significant increase in the median pretest and posttest scores (p=0.000), while the cadaver group demonstrated a significant increase in the mean pretest and

Table 1 Pretest–Posttest Questionnaire on Musculoskeletal Knowledge

No	Question	Answer Choices	Correct Answer*
1.	The green-colored area in the image is innervated by:	a. Humeral nerve b. Glenohumeral nerve c. Brachial nerve d. Pectoral nerve e. Subscapular nerve	e 
2.	The muscles responsible for adduction of the shoulder joint are:	a. M. Supraspinatus and M. Deltoid medius b. M. Infraspinatus and M. Teres major c. M. Subscapularis and M. Teres major d. M. Teres major and M. Latissimus dorsi e. M. Deltoideus posterior and M. Infrascapularis	d
3.	The medial epicondyle in the image is part of the humerus known as:	a. D b. G c. E d. C e. F	d 
4.	The muscles that form the rotator cuff include:	a. M. Infraspinatus and M. Teres major b. M. Teres major and M. Teres minor c. M. Subscapularis and M. Supraspinatus d. M. Supraspinatus and M. Scapularis e. M. Suprascapularis and M. Infrascapularis	c
5.	The subscapular fossa is indicated in the image by the letter:	a. D b. B c. A d. E e. C	e 
6.	The superior trunk of the brachial plexus originates from:	a. C8–T1 b. C5–T1 c. C5–C8 d. C7 e. C5–C6	e
7.	The total number of rotator cuff muscles is:	a. 2 b. 5 c. 4 d. 3 e. 6	c
8.	The muscles responsible for abduction of the shoulder joint are:	a. M. Infraspinatus and M. Teres major b. M. Deltoideus posterior and M. Infrascapularis c. M. Subscapularis and M. Teres major d. M. Supraspinatus and M. Deltoid medius e. M. Teres major and M. Latissimus dorsi	d

(Continue)

No	Question	Answer Choices	Correct Answer*
9.	Rotator cuff muscles are innervated by the:	a. Coracoacromial nerve b. Subscapular nerve c. Scalenus nerve d. Deltoid nerve e. Infraspinatus nerve	b
10.	The structure labeled 'A' in the image is directly adjacent to:	a. Vertebrae b. Scapula c. Acromion d. Sternum e Radius	c 
11.	In the rotator cuff, the axillary nerve innervates the muscle:	a. Teres minor b. Infraspinatus c. Supraspinatus d. Teres major e. Subscapularis	a
12.	The quadrangular space is bordered by:	a. M. Biceps brachii b. M. Teres major c. M. Infraspinatus d. Deltoideus e. M. Teres medius	b 
13.	The muscles responsible for external rotation of the shoulder joint are:	a. M. Latissimus dorsi and M. Teres minor b. M. Pectoralis major and M. Latissimus dorsi c. M. Infraspinatus and M. Teres minor d. M. Subscapularis and M. Pectoralis minor e. M. Pectoralis major and M. Infraspinatus	c
14.	The brachial plexus is formed by the anterior rami of spinal nerves:	a. BSSD b. C1–C7 c. C5–T1 d. C2–T2 e. C5–T2	c 
15.	The glenoid cavity in the image is indicated by the letter:	a. E b. D c. C d. B e. A	e 

Note: *Correct answers were verified using standard anatomical references

posttest scores (p=0.000).

Interestingly, there was no statistically significant difference in posttest scores between the cadaver and plastination groups, suggesting that both media were similarly effective in improving students' understanding of musculoskeletal anatomy.

Discussion

Given their complementary strengths, integrating cadaveric and plastinated methods in anatomy education is recommended to provide a comprehensive learning experience. Cadavers offer an authentic representation of soft tissues and anatomical variations, allowing students to develop practical clinical skills by observing the texture, consistency, and spatial relationships of anatomical structures.[2] Conversely, plastinated specimens are durable, odorless, and resistant to decomposition, enabling repeated, long-term use without the need for preservation protocols. The combination of cadaver dissection and plastinated models may enhance anatomical learning by reinforcing long-term concept retention through plastination and clinical relevance through cadaveric exposure.[2]

Table 2 Characteristics of Respondents Included in the Study by Gender

Gender	Cadaver Group (n=35)		Plastination Group (n=34)	
	n	%	n	%
Male	17	49	12	35
Female	18	51	22	65

Table 3 Anatomy Textbook References Previously Read by Respondents (n=69)

Textbook	Frequency	Percentage
Sobotta	16	23
Never read any textbook	32	46
Other references*	21	31
Total	69	100

Note: * Includes Campbell, high school biology books, medical mini notes, Netter, and Yokochi.

Table 4 Knowledge Scores Before and After the Use of Plastination and Cadaver

Group	Mean ± SD / Median (Min–Max)	P-value
Plastination		
Pre-test score	33 (13.33 – 66.67)	0.000
Post-test score	47 (33.33 - 93.33)	
Cadaver		
Pre-test score	34.09 ± 18.13	0.000
Pos-ttest score	50.85 ± 15.08	

In the study of anatomy, cadaver-based learning has been regarded as the gold standard in anatomy education, enabling direct observation of human tissues, organs, and systems. However, technological advancements have introduced plastination as a viable alternative. This technique replaces body fluids with polymers, producing dry, durable specimens suitable for education. As plastination gains popularity, research has increasingly evaluated its effectiveness in anatomy instruction.

In this study, both plastination and cadaveric teaching methods significantly improved students' anatomy test scores. While students in the plastination group showed a significant improvement in posttest scores, the cadaveric group also demonstrated statistically significant gains. However, no significant difference was found between the two groups in post-intervention knowledge scores, indicating that both methods were equally effective in enhancing understanding of musculoskeletal anatomy.

These findings are consistent with prior research suggesting that plastination can support anatomy learning by improving students' comprehension of structures and facilitating repeated exposure without the need for specialized storage or safety measures.[8,12] Although plastination is not considered superior to cadaveric dissection, it serves as a practical complement and may enhance accessibility to anatomy learning resources.

A study measuring student satisfaction with the combined use of cadavers and plastination found that 97.7% of students reported enhanced understanding through plastination, and 100% recommended its continued use, particularly alongside cadaveric dissection in small-group tutorials.[13] Similarly, another study comparing plastination with video-based instruction found no significant differences in learning outcomes, supporting plastination as an effective supplementary tool.[11]

Other studies have also reported no significant differences between virtual dissection and cadaveric methods, indicating that both are effective for knowledge acquisition.[14] These findings align with our study's results, where significant pre- to post-test improvements were observed in both the plastination and cadaveric groups. Moreover, cadaver dissection remains highly valued by students and educators alike. It is still widely used in surgical training and is regarded as essential for developing spatial awareness and detailed anatomical knowledge.[15–17] Interestingly, previous studies have also shown that cadavers and other instructional tools, such as videos, are equally effective for improving neuroanatomy comprehension.[2] This supports the continued use of cadavers in medical faculties, both as a primary teaching method and in combination with newer technologies. A recent study comparing plastination and cadaver use among 60 medical students found no significant differences in performance, reinforcing the conclusion that both methods are equally effective.[18] Although plastinated models have limitations, such as lack of tissue texture, they are valued for their ease of use and do not require maintenance, making them practical for self-study and preparation.[18]

Further studies have suggested that replacing cadavers with plastination in surgical education can lead to increased laboratory performance scores, although cadaver use still dominates due to its realism in surgical simulations.[19] Up to 70% of trained dentists still prefer cadaver-based training, highlighting its enduring value.[19] Among 268 students surveyed in another study, plastinated specimens were preferred for differentiating complex structures, reinforcing the importance of multimodal learning.[20]

This study has several limitations that may influence the findings. Variability in student engagement, cognitive abilities, motivation, and learning styles may have affected the results. Differences in instructional quality and availability of teaching resources could also have impacted learning outcomes across groups. Additionally, prior exposure to anatomical resources, particularly among students who had previously studied Sobotta, may have introduced bias. Although pretest scores showed no significant differences between groups, familiarity with certain textbooks could have contributed to post-intervention performance. A subgroup analysis of students' prior exposure to anatomy materials could yield more nuanced insights into how baseline knowledge affects learning outcomes

In conclusion, both cadaveric and plastinated teaching media effectively enhanced medical students' understanding of musculoskeletal anatomy. These findings support the integration of both modalities into anatomy education to maximize the benefits of each and improve student learning experiences. A thorough understanding of human anatomy is essential not only for clinical competency but also for advancing knowledge related to wellness, healthy aging, and the management of degenerative diseases.

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