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Original Research Article

Exploring the effectiveness of CADAVIZ in enhancing learning outcomes in undergraduate medical students

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ABSTRACT

Background: Cadaver-based learning is fundamental to mastering human anatomy. However, accessing delicate, deep-seated regions such as the cerebellum is challenging. In this regard the virtual dissection table (VDT) is a useful supplement. This study investigates the effectiveness of CADAVIZ, a VDT, in enhancing anatomical understanding among undergraduate medical students.
Methods: After obtaining ethical approval and informed consent, 250 participants attended a standardized lecture on cerebellar anatomy followed by a pre-test to assess their baseline knowledge. The participants were then randomly assigned to three Groups: Group A attended practical session with a cadaveric specimen of the human cerebellum, Group B participated in an interactive session on cerebellar anatomy using CADAVIZ, and Group C engaged in practical sessions with both a cadaveric specimen and CADAVIZ. Lastly, post-tests were conducted to assess knowledge retention after the respective practical sessions.
Results: The mean pre-test score for Group A was 4.88±0.17 and the mean post-test score was 7.35±0.21, registering a mean percentage increase of 60.68±5.41%. Group B obtained a mean pre-test and post-test score of 4.73±0.19 and 7.75±0.15, respectively, reflecting a mean percentage increase of 78.92±5.27% (p=0.127). Group C, on the other hand, recorded a mean pre-test and post-test score of 3.99±0.13 and 6.96±0.16, respectively, yielding a mean percentage increase of 81.84±4.81% (p=0.005).
Conclusions: As compared to Group A, the percentage increase in Group C was significantly (p=0.005) higher, indicating that the blended learning with both cadaveric specimen and CADAVIZ enhanced anatomical learning more than a practical session with cadaveric specimen alone.

Keywords: CADAVIZ, Cadaveric specimen, Virtual dissection table, Cerebellum, Anatomy

INTRODUCTION

Anatomy underpins the structural literacy essential for clinical assessment, diagnostic reasoning, and surgical precision. It forms the basis of competency in medical practice. Although textbooks and cadaveric dissection are two of the most enduring pillars of anatomy, each has its own set of load-bearing limits.[1] Textbooks, even the detailed anatomy atlases, are inherently static. Thus, despite the rich content, they often fail to convey the dynamic, three-dimensional complexity of the human body.[2]

Although cadaveric dissection is the long-standing gold standard for experiential learning, it is principally constrained by the paucity of cadavers, requiring one specimen to be shared among 10 to sometimes 20 students.[3] Additionally, dissection is an irreversible process; once a structure is dissected, it cannot be restored, pre students from repeating procedures for reinforcement and preventing deep learning through in-depth review.[4]

Furthermore, the rigidity of embalmed bodies and the difficulty in repositioning them reduce accessibility to deep-seated or obscured structures.[5] Not to mention that embalming, to some extent, diminishes anatomical realism by altering tissue texture, colour, and pliability.[6] The repetitive exposure to formaldehyde, coupled with psychological stress and anxiety among students during dissection, further adds to the challenges of learning anatomy with cadaver dissection.[7]

Then, there is the complexity of dissecting delicate organs such as the human brain. Deep-seated structures, such as the brainstem, thalamus, and basal ganglia, are difficult to access in situ without highly skilled and extensive dissection techniques.[8] These regions are composed of complex networks of interconnected nuclei and fiber tracts, whose spatial and functional relationships are difficult to preserve in cadaveric specimens. Moreover, the delicate nature of neuroanatomical structures makes them prone to fragmentation in post-mortem dissection, often obscuring fine anatomical details and disrupting their interconnectivity. As a result, learners are unable to visualize the neuronal crosstalk that underlies motor control, sensory integration, and higher cognitive functions.[9,10] Consequently, a thorough understanding of neuroanatomy often requires the use of expensive modalities such as magnetic resonance imaging (MRI), computed tomography (CT) imaging, or neurophysical recordings, resources that are typically unavailable in undergraduate anatomy laboratories.[11]

Thus, the need of the hour is to embrace integrated, student-centred, technologically enabled, innovative academic tools. One such promising advancement in this context is the virtual dissection table (VDT) CADAVIZ. It is a digital platform that offers an interactive, three-dimensional virtual representation of human anatomy, enabling students to explore every aspect of the human body in detail. This study aims to evaluate the efficacy of CADAVIZ in allowing students to visualize and understand the complex, deep-seated anatomical structures. To exemplify the challenge of such a structure, the cerebellum was selected as the instructional focus of the study.

Located in the posterior fossa, the cerebellum is intricately folded and comprises multiple lobes, lobules, peduncles, and nuclei. Its spatial relationships with adjacent landmarks, such as the cerebellopontine angle and structural delicacy, make it particularly vulnerable to damage during dissection.[13] Given these characteristics and its educational significance, the cerebellum serves as an ideal candidate to evaluate how CADAVIZ can enhance anatomical learning, particularly in the context where cadaveric dissection presents inherent constraints.

METHODS

Study setting

The current research was undertaken as a quasi-experimental study in the Department of Anatomy at Sree Balaji Medical College and Hospital, Chennai, during the academic year 2024-2025, with undergraduate medical students.

Ethical consideration

Ethical approval was obtained from the Institutional Ethics Committee (Ref. No. 002/SBMCH/IHEC/2025/2389) before the commencement of the study. Informed consent was obtained from all participants. The confidentiality and anonymity of the participants were ensured throughout the study, and no personally identifiable information was recorded.

Participants and sampling

A total of 250 undergraduate students from the MBBS course were initially enrolled in the study. Of these, 249 students completed all phases of the study-including the lecture session, practical intervention, and assessments.

Study design

All participants first attended a standardized lecture on cerebellar neuroanatomy, after which a pre-test was conducted to assess their baseline knowledge. Following the pre-test, students were divided into three Groups: Group A, Group B, and Group C using a stratified random sampling technique. Each Group then participated in a different type of practical session. The description of the practical exposure to each Group is summarised in Table 1.

Table 1: Participant demographics and Group allocation with intervention details.

Groups	Intervention	Sample size	Mean age	Males	Females	Phase of MBBS	Exposure to CADAVIZ/ cadaveric dissection
Group A	Lecture + cadaveric dissection	83	18	33	50	Phase 1	6 months
Group B	Lecture + CADAVIZ	83	18	37	46	Phase 1	6 months
Group C	Lecture + cadaveric dissection CADAVIZ	83	18	38	45	Phase 1	6 months

Group A had practical sessions with a cadaveric specimen of the human cerebellum (Figure 1a), Group B had interactive sessions with CADAVIZ (Figure 1b), and Group C had practical sessions with both a cadaveric specimen as well as CADAVIZ. After completing the practical sessions, a post-test was conducted to assess the increase in knowledge retention.

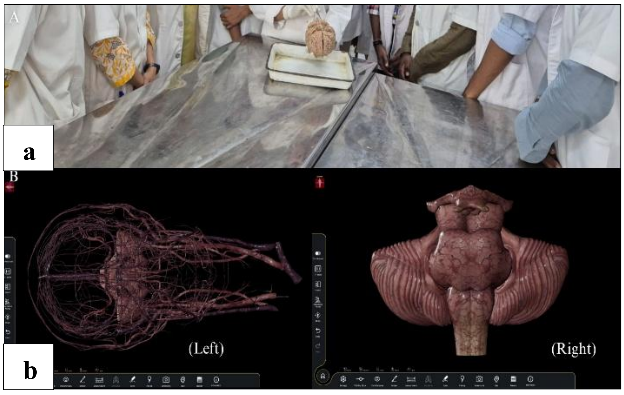

Figure 1: Cerebral anatomy as visualized with cadaveric specimen (a) Cerebral anatomy visualized using a cadaveric brain specimen during the practical dissection session for Groups A and C; (b) Interactive visualization of the human cerebellum using CADAVIZ. Participants in Groups B and C could explore the cerebellum both with the overlying cerebellar vasculature (left) and in isolation without vascular structures (right), enabling a detailed appreciation of its anatomical features.

Assessment

The pre-test and post-test assessments were designed to evaluate students' retention of knowledge as well as their conceptual understanding of the cerebellum. Beyond factual recall, the tests explored students' ability to analyse and contextualise anatomical structures within the broader framework of neuroanatomy. The assessments were pre-validated by anatomy experts and administered using Google Forms.

Data analysis

Descriptive statistics (mean±SEM) were used to summarize pre-test and post-test scores for each Group. The percentage improvement was estimated for each participant. To estimate the difference in learning outcomes between Groups, while accounting for baseline performance, ANCOVA was performed using Excel add-in Analyse-it, with baseline pre-test scores included as a covariate. Statistical significance was set at $p<0.05$.

RESULTS

The results of the study demonstrated measurable improvement in all three Groups following the practical session. The pre-test assessment scores served as a baseline indicator of prior knowledge, while the post-test scores reflect the learning outcomes achieved after practical exposure. A comparative overview of the pre-test and post-test performance across Groups is represented in Figure 2.

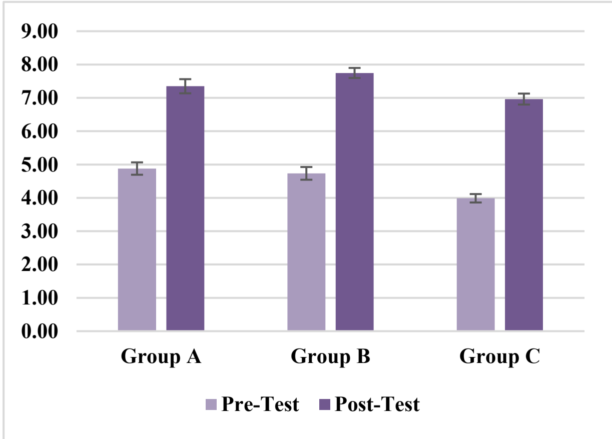

Figure 2: Comparison of pre-test and post-test scores among three Groups exposed to different instructional modalities.

The pre-test scores of Group A were found to be 4.88±0.17. After receiving practical demonstrations using cadaveric specimens, Group A scored 7.35±0.21 in its post-test. Similarly, the mean pre-test score for Group B was found to be 4.73±0.19. After an interactive session with CADAVIZ, the mean score achieved by Group B in the post-test was 7.75±0.15. Group C scored 3.99±0.13 in pre-test; however, after receiving both practical demonstrations with cadaveric specimen as well as having an interactive session with CADAVIZ, it achieved a post-test mean of 6.96±0.16. To better understand the magnitude of knowledge retained, we calculated the percentage increase in test scores for each participant (Figure 3).

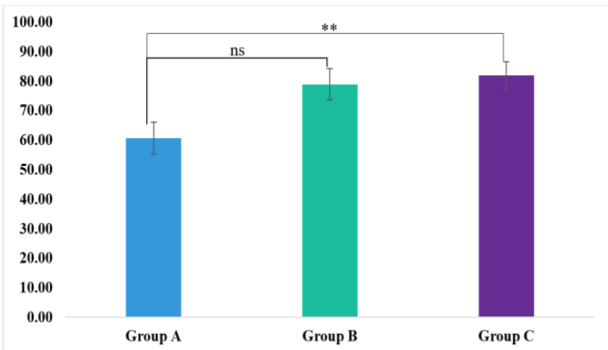

Figure 3: Comparison of percentage increase in pre-test and post-test scores among three student Groups exposed to different instructional modalities.

ns indicates $p=0.127$; **indicates $p=0.005$.

Group A exhibited a mean percentage increase of 60.68±5.41%. The percentage increase in scores for Group

B was 78.92±5.27, and although the registered increase was numerically greater than Group A, the difference was not statistically significant (p=0.127). Group C, on the other hand, showed the highest improvement among all three Groups, registering approximately 81.84±4.81% increase in scores. Furthermore, this improvement in scores from Group A was statistically significant (p=0.005), suggesting that substantially more learning benefits can be yielded by a blended instructional approach using both cadaveric specimens and CADAVIZ rather than using cadaveric specimens alone.

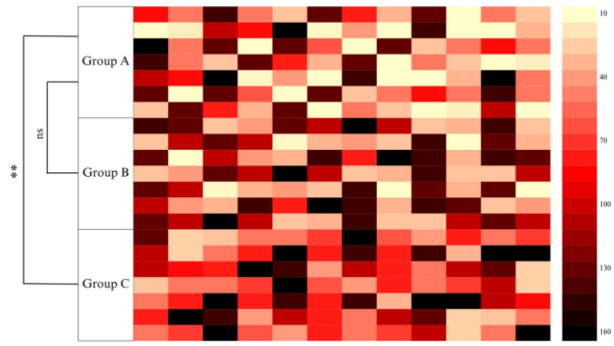

Figure 4: Heat map representation of individual percentage increases in test scores across the three study Groups following different instructional modalities.

ns indicates p=0.127; **indicates p=0.005.

The aforementioned findings are further reinforced in Figure 4. It is a heat map of individual-level percentage improvements in test scores across the three instructional Groups. The intensity of colour, ranging from yellow (lowest improvement) to black (highest improvement), visually depicts the magnitude of learning gain for individual participants.

As visualised in Figure 4, a Group A exhibits a wider spread of colours with more of lighter tones (yellow to light red), indicating lower and more variability in improvement across individual participants of the Group. Group B displays mostly intermediate tone (red to deep-red), indicating moderate but consistent improvement across individual participants. Group C, on the other hand, is dominated by high intensity shades (dark red to black) with fewer lighter tones, indicating a greater and more uniform percentage increase across individual participants of the Group.

Statistical annotations on the heat map further clarify these differences (**) denotes a statistically significant improvement (p=0.005) in Group C compared to Group A, whereas "ns" indicates the difference between Group A and Group B was not statistically significant. Thus, from the results of the study, it can be deduced that while CADAVIZ is a valuable tool on its own, its use alongside cadaveric specimens can help in significantly enhancing learning outcomes, in undergraduate medical students.

DISCUSSION

Amid the growing advocacy for blended learning in anatomy education, digital innovations such as the VDT is increasingly recognized as valuable complements to traditional cadaveric dissection-based pedagogy.[14] Yoon evaluated the impact of 3D virtual cadaver practice on first-year students and found notable enhancements in learning motivation, academic performance, and self-efficacy. The study supports the integration of virtual dissection tools as effective supplements to traditional methods in promoting deeper engagement and improved educational outcomes.[15] Evans et al analysed Group dynamics in virtual dissection learning. They found that structured collaborative sessions around a virtual table improved peer learning and problem-solving. Faculty noted increased student interaction and engagement, with the observation that social learning around technology fostered deeper comprehension of anatomy.[16]

Bokil et al conducted a feedback-based observational study among undergraduate students from a traditional system of medicine using CADAVIZ, in which 95% of respondents found the platform user-friendly, and 72% reported an improved anatomical understanding.[12] The study concluded that student perception strongly supports CADAVIZ as an effective and engaging tool for anatomy education. Oliveira et al assessed interprofessional anatomy labs with hybrid (virtual and in-person) delivery. Student participants reported enhanced learning efficiency and satisfaction in the blended format across professions. Virtual tools supported IPE engagement without reducing instructional quality. Faculty noted equivalence in competency outcomes between modes.[17]

Patil et al conducted a stratified cross-sectional study using CADAVIZ, among undergraduate students from a traditional Indian medical system. Participants were stratified into Groups based on their performance before the intervention. Post-intervention assessments showed significant improvements across all Groups, suggesting that CADAVIZ supports effective and inclusive anatomy learning regardless of baseline academic performance.[18]

Chytas et al implemented a blended learning model combining cadaveric dissection and virtual dissection tables. Students experienced better retention and clarity in spatial orientation, particularly in complex anatomical areas. The study concluded that integrating virtual dissection tables complements traditional methods and enhances anatomical understanding.[19]

Alasmari et al evaluated student perception in a cohort of 78 medical students using a virtual dissection table. Most students reported improved anatomical insight and valued the incorporation of radiological images. The study concluded that VDT enhances conceptual and clinical anatomy learning.[20] Stecco et al conducted a retrospective study exploring the feasibility of using a virtual dissection table in diagnosing and classifying Le Fort fractures. The study demonstrated that the tool effectively aided anatomical visualization and fracture classification, highlighting its potential utility in clinical diagnostics and medical education.[21]

While an expanding body of research has explored the value of the virtual dissection table in anatomy education, research quantifying its efficacy in supporting knowledge retention of deep-seated anatomical structures, which are typically challenging to access via conventional dissection, is still limited.

The current study explores the educational value of CADAVIZ, in enhancing student comprehension of complex neuroanatomy. By focusing on the cerebellum, a region recognised for its structural intricacy and spatial constraints, the study addresses the growing need for educational tools that foster deeper visual and spatial engagement in anatomy learning. As indicated in Figures 2 and 3, findings from the practical session underscore the effectiveness of CADAVIZ both as a standalone teaching modality and as a complementary tool alongside cadaveric dissection. Repeatability, reusability, and interactive, self-paced learning are among the defining features of CADAVIZ. Research in educational psychology consistently shows that repeated viewing and self-directed exploration significantly enhance learning retention and conceptual clarity.[22] Specifically, spaced repetition has been shown to improve memory consolidation more effectively than massed learning.[23]

Traditional cadaveric dissection or practical sessions with cadaveric specimens, while providing valuable tactile and spatial experiences, typically adhere to a massed learning format (Figure 1a), with limited, non-repeatable exposure during scheduled sessions. In contrast, CADAVIZ allows learners to revisit anatomical structures as often as needed and explore them at their own pace. This distinction may explain why students in Group B, who engaged exclusively with CADAVIZ, demonstrated greater post-test improvement than those in Group A, who learned through cadaver-based instruction alone, although the difference was not statistically significant (p=0.127).

Combining multimodal learning strategies-such as the tactile engagement of cadaveric dissection with the visual and cognitive reinforcement provided by digital tools like CADAVIZ, can produce synergistic effects that significantly enhance comprehension and retention.[24] The effectiveness of this integrative method is further supported by the substantial percentage increase from pre-test to post-test scores observed in Group C, which received instruction through a combined modality of cadaveric dissection and CADAVIZ.

CONCLUSION

In conclusion, this study reinforces the evolving pedagogical shift in anatomy education, one that values technological integration alongside traditional methods. While cadaveric dissection continues to be indispensable for hands-on tactile learning, challenges associated with accessing deep-seated, delicate structures such as the cerebellum are undeniable. The findings of the current study demonstrate that supplementing cadaver-based instruction with digital innovations such as CADAVIZ, can significantly enhance students' knowledge retention of complex neuroanatomy. Thus, by integrating the traditional practice of cadaver dissection with modern technology, medical academia can create a more holistic, accessible, and effective model of anatomical education, suited for the evolving era of medical science.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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