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Review Article

A Comparative Analysis of Cadaver and Virtual Dissection in Anatomy Education: Global Vs Sri Lanka

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Abstract

Introduction: Traditional cadaver dissection remains the cornerstone of anatomy education, yet virtual dissection tools (3D simulations, VR, AR) are emerging as scalable alternatives, particularly in regions like Sri Lanka where cultural and logistical barriers restrict cadaver access. This review evaluates their comparative efficacy, student perceptions, and implementation challenges across global and Sri Lankan context.

Methods: A narrative literature review analyzed peer-reviewed studies from MEDLINE, ScienceDirect, and Google Scholar. Search terms incorporated MeSH headings and keywords, restricted to English language human anatomy studies (excluding animal research). Boolean operators refined the search. Data extraction focused on comparative efficacy, student experiences, and regional implementation challenges, with particular attention to Sri Lankan contexts.

Results: Globally, 84.5% of students favor cadaver dissection for tactile feedback and clinical preparedness, while 64.3% report improved comprehension with virtual tools. In Sri Lanka, 89.2% of students recognize the value of 3D software but prioritize hands-on dissection despite cultural sensitivities. Virtual tools enhance accessibility, repeatability, and spatial understanding but lack tactile feedback and face adoption barriers in low-resource settings. A hybrid model emerges as the preferred strategy, balancing the strengths of both methods.

Conclusions: The integration of cadaver dissection and virtual tools optimizes anatomy education, combining tactile experience with technological flexibility. While virtual tools address logistical and cultural challenges, cadaver dissection remains indispensable for surgical training. Future curricula should adopt a hybrid approach, tailored to regional needs, to ensure comprehensive anatomical education.

Keywords: Anatomy education, Cadaver dissection, Hybrid learning, Sri Lanka, Virtual dissection tools

Introduction

Anatomy education is integral to medical training, with traditional cadaver dissection long regarded as the gold standard for developing essential clinical skills (Ghosh, 2015).

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However, advancements in virtual dissection tools, such as 3D simulations, virtual reality (VR), and augmented reality (AR), offer interactive, scalable alternatives (Patra *et al.*, 2022). While cadaver dissection provides irreplaceable tactile feedback and exposure to anatomical variations (Dissabandara *et al.*, 2015), virtual tools enhance visualization, accessibility, and adaptability, particularly in resource-limited settings (Bogomolova *et al.*, 2021; Said Ahmed, 2023).

Globally, 84.5% of medical students favor cadaver dissection, while 64.3% report improved comprehension with virtual tools (Edmund Atta Asante *et al.*, 2021; Funjan *et al.*, 2023) In Sri Lanka, cadaver access is often limited due to cultural and religious considerations, however, 89.2% of students recognize the value of 3D software but still prioritize hands-on dissection (Edirisinghe *et al.*, 2022; Wickramarathna *et al*., 2024). These disparities underscore the need for a context-specific approach to anatomy education, particularly in countries with limited cadaver access.

This literature review was undertaken to critically examine the efficacy and student perceptions of cadaver dissection versus virtual dissection tools in anatomy education. The review integrates historical perspectives, contemporary practices, and an analysis of the methodological advantages and limitations of both approaches (Ghosh, 2015; Boscolo-Berto *et al.*, 2021). By including both global and Sri Lankan viewpoints, this review explores how cultural, logistical, and resource factors influence anatomy education, which is crucial for understanding the educational dynamics in diverse contexts (Li *et al*., 2019; Janaka *et al*., 2023).Ultimately, this review aims to evaluate the potential for a hybrid approach, leveraging the strengths of both methods to optimize anatomical training and ensure comprehensive educational outcomes (Patra *et al.*, 2022).

Methods

This narrative literature review was conducted by analyzing peer-reviewed studies retrieved from MEDLINE, ScienceDirect, and Google Scholar. The search strategy integrated relevant MeSH (Medical Subject Headings) terms, along with a combination of keywords related to anatomical education and learning outcomes. Boolean operators were employed to identify articles related to human anatomy, while excluding those pertaining to animal studies or non-human anatomy, and studies not published in English. Inclusion criteria focused on empirical studies, meta-analyses, and systematic reviews specifically addressing the efficacy, student experiences, and perceptions of both cadaver dissection and virtual anatomy education.

Data extraction followed predefined criteria. A total of 55 studies were included, and a critical, logical synthesis was applied to evaluate and compare the findings. This approach facilitated the identification of patterns and trends in student preferences, learning outcomes, and implementation challenges across both international and Sri Lankan contexts. The review acknowledges limitations, including potential publication bias and the underrepresentation of virtual dissection studies from certain regions.

The Historical Evolution of Cadaver Dissection in Medical Education

The practice of cadaver dissection originated in the 3rd century BC, when Herophilus of Chalcedon and Erasistratus of Ceos conducted systematic dissections in ancient Greece, significantly advancing anatomical knowledge (Ghosh, 2015). However, religious and ethical opposition led to its decline in subsequent centuries, particularly in Christian Europe during the Middle Ages, where anatomical studies were largely confined to classical texts (Park, 1994). The resurgence of human dissection in the early 14th century, particularly at the University of Bologna under Mondino de Liuzzi, marked a paradigm shift in medical education (Rengachary *et al.*, 2009). This revival established the foundation for structured anatomical studies, institutionalizing dissection as a fundamental component of medical training.

By the late 13th century, universities across Europe, including those in Padua and Montpellier, integrated human dissection into medical curricula, reinforcing its role in anatomical education (Mc Ardle *et al*., 2010). The establishment of anatomical theatres in the 16th century formalized dissection, despite ongoing ethical concerns regarding the sourcing of cadavers (O'Malley, 2021). The escalating demand for bodies in the 18th and 19th centuries led to grave robbing and illicit practices, prompting

legislative reforms such as the UK's Anatomy Act of 1832, which ensured the ethical procurement of cadavers (Barr *et al*., 2020). These reforms solidified dissection as an indispensable practice in medical education, overcoming religious, ethical, and legal challenges to advance anatomical knowledge and surgical training.

Current Practices of Traditional Human Cadaver Dissection

Traditional human cadaver dissection continues to serve as a fundamental component of anatomy education, offering hands-on, three-dimensional learning that enhances spatial and clinical understanding (Bartoletti-Stella *et al*., 2021; Varner *et al*., 2021; Silén *et al*., 2022). Typically introduced in the first year of medical school, dissections are conducted in small groups under expert guidance, supported by lectures, textbooks, and imaging modalities such as MRI or CT to reinforce learning (Chapman *et al.*, 2013; Said Ahmed, 2023). Preservation of cadavers primarily involves formalin fixation, although alternative methods like Thiel embalming are used to maintain more lifelike tissue properties, thereby improving the educational experience (Thavarajah *et al.*, 2012; Balta *et al.*, 2015). While Western institutions often emphasize full cadaver dissection, many Asian medical schools utilize prosections or modified techniques due to cultural sensitivities and resource limitations (Ghosh, 2015). Despite regional variations, cadaver dissection remains an essential component of anatomy education in Sri Lanka, where it continues to provide hands-on learning, enhance spatial understanding, and prepare students for clinical practice (Arudchelvam, 2022).

Advantages and challenges of Traditional Human Cadaver Dissection in Anatomy Learning

Traditional human cadaver dissection remains a vital component of anatomy education, offering hands-on experience that enhances spatial understanding of organs and systems (Ghosh, 2017; Said Ahmed, 2023). It helps students develop essential surgical skills, boosts confidence in anatomical knowledge, and provides exposure to real tissue textures and variations (Johnson, 2002; Bartoletti-Stella *et al.*, 2021; Silén *et al.*, 2022). Unlike digital tools, cadaver dissection accurately reveals complex anatomical structures, tissue layers, and organ systems, reinforcing clinical preparedness (Dissabandara *et al.*, 2015; Geavlete *et al.*, 2023). It also supports collaborative learning by integrating with lectures and digital methods (Han *et al*., 2015; De Silva *et al*., 2017).

Despite its benefits, studies in Sri Lanka, Japan, and India have shown that body donations are limited due to cultural and religious beliefs (Li *et al*., 2019; Makowska and Wyleżałek, 2021; Wickramarathna *et al*., 2024). Ethical handling and respect for cadavers are emphasized to maintain public trust (Gangata *et al*., 2010; Makowska and Wyleżałek, 2021). Moreover, cadaver dissection can pose challenges such as student emotional distress, preservation costs, and health risks from chemicals like formaldehyde (Chang *et al*., 2018; Lakum *et al.*, 2023).

Virtual Cadaver Dissection and Its Technological Integration in Anatomy Education

Virtual cadaver dissection has become a prominent component of modern anatomy education, utilizing computer-generated simulations, interactive 3D models, and immersive environments to replicate the human body in detailed, manipulable formats (Patra *et al*., 2022; Wickramasinghe *et al*., 2022). These platforms are built on high-resolution imaging data, such as MRI and CT scans, allowing for accurate visualization of anatomical structures (Bogomolova *et al.*, 2021). Technological features commonly include the ability to zoom, rotate, and virtually dissect tissues in layers, supporting a comprehensive spatial understanding of human anatomy (Azkue, 2022; Titmus *et al.*, 2023).

Beyond anatomical visualization, many virtual dissection tools are integrated with complementary educational resources. These may include digital quizzes, case-based learning modules, and annotated clinical datasets, which aim to reinforce theoretical knowledge and align anatomical concepts with clinical applications (Abdellatif *et al.*, 2022). Certain platforms also incorporate histological images and patient-specific data to simulate real-world learning contexts and enhance interdisciplinary training (Patra *et al.*, 2022). These educational designs are intended to foster both conceptual understanding and clinical relevance in medical training.

As part of evolving curricula, virtual dissection systems are increasingly used alongside lectures, textbooks, and imaging modalities, reflecting a pedagogical shift towards technologically integrated and student-centered approaches in anatomy education (Bogomolova *et al.*, 2021; Neyem *et al.*, 2025). This integration marks a significant development in how anatomy is taught, supported by continual advancements in medical visualization technology.

Classification of Virtual Dissection Tools in Medical Education

Several types of virtual dissection tools are currently used in anatomy education, each providing unique features and levels of interactivity:

a) **Three-Dimensional (3D) Simulations -**
Allow manipulation of anatomical models with rotation, zoom, and layered dissection features. (Pujol *et al.*, 2016; Kazoka, Pilmane and Edelmers, 2021; Wang *et al.*, 2024).

b) **Virtual Reality (VR) Platforms -** Provide immersive, interactive experiences through head-mounted displays and controllers, supporting spatial understanding and engagement (Marougkas *et al.*, 2023; Sadeghi Esfahlani *et al.*, 2020).

c) **Augmented Reality (AR) Systems -** Overlay digital anatomy onto the physical environment, allowing real-time interaction and collaborative learning (Dhar *et al.*, 2021; Venkatesan *et al.*, 2021; AlGerafi *et al.*, 2023).

d) **Anatomage Table -** A life-sized, touchscreen dissection table offering detailed digital cadaveric images and integration of patient-specific data (Raja *et al.*, 2022; Said Ahmed, 2023).

e) **Mobile Applications -** Tools like *Complete Anatomy* and *Essential Anatomy* provide flexible access to high-quality anatomical models on smartphones and tablets (Meyer *et al.*, 2016; Said Ahmed, 2023).

By leveraging these tools, medical education can provide a more comprehensive, accessible, and interactive approach to anatomy learning.

Current Applications of Virtual Dissection Tools

With advancements in technology, virtual dissection tools have become integral to anatomy education worldwide, enhancing accessibility and providing alternatives to cadaver-based dissection. Their role became especially crucial during the COVID-19 pandemic, addressing educational and resource limitations (Sinou, Sinou and Filippou, 2023).

The Anatomage Table is widely recognized for its interactive 3D visualization, significantly improving students' comprehension and exam performance (Patel *et al.*, 2015; Cardoso *et al.*, 2023). Studies report that 78% of students found it engaging, reinforcing its effectiveness in medical training (Brown *et al.*, 2015). Additionally, DICOM data integration from MRI and CT scans allows students to explore detailed anatomical structures, benefiting

surgical and radiological education (Raja *et al.*, 2022).

Countries like the United States and Japan have successfully incorporated VR and AR into medical curricula, while low-income regions face challenges in technology access, limiting the widespread adoption of these tools (Sinou, Sinou and Filippou, 2023). However, ongoing research aims to improve accessibility and enhance the effectiveness of virtual dissection methods (Baratz *et al.*, 2019; Said Ahmed, 2023).

Rather than replacing traditional cadaver-based dissection, virtual tools are increasingly being integrated into a hybrid educational model, combining digital innovation with hands-on learning. The pandemic has accelerated the shift toward technology-driven medical education, shaping future strategies for sustainable learning solutions, particularly in resource-limited settings.

Advantages and Disadvantages of Virtual Dissection Tools in Anatomy Learning

Virtual dissection tools enhance anatomy learning by providing accessibility, repeatability, and multimedia integration. They allow students to explore 3D models anytime, ensuring flexibility and consistent learning. Studies indicate improved knowledge retention and spatial reasoning due to interactive features (Bogomolova *et al.*, 2021; Boscolo-Berto *et al.*, 2021). These tools cater to diverse learning styles, integrating videos and interactive elements for engaging experiences (Saltarelli, Roseth & Saltarelli, 2014).

However, limitations include the lack of tactile feedback, which affects manual dexterity; a crucial skill for surgical training (Patel *et al.*, 2015; Cardoso *et al.*, 2023). Virtual models may not fully capture the spatial complexity of real human structures, leading to potential gaps in understanding (Sharmin, Chow and King, 2023). Additionally, high costs and technical constraints, such as software expenses and internet reliability, pose challenges for widespread adoption, especially in resource-limited settings (Pottle, 2019; Senbekov *et al.*, 2020).

Despite these drawbacks, virtual dissection remains a valuable supplement to traditional methods, offering a scalable, consistent, and engaging approach to anatomy education.

Student Perceptions and Effectiveness of Virtual Dissection Tools Versus Traditional Cadaver Dissection in Anatomy Education

Global Perspectives

Traditional cadaveric dissection remains a cornerstone of anatomy education globally. Most students continue to favor this hands-on approach, citing its ability to engage attention and reinforce theoretical knowledge. Studies show that 84.5% of students find cadaveric dissection engaging, with 87% noting its impact on enhancing their understanding of anatomy (Edmund Atta Asante *et al.*, 2021). It is also regarded as crucial for clinical preparedness, with 74.5% of students supporting its continued inclusion in curricula (Edmund Atta Asante *et al.*, 2021). However, a growing preference for a hybrid learning model has emerged. Virtual dissection tools, such as 3D software, augmented reality (AR), and virtual reality (VR), offer valuable supplements by allowing repeated practice and visualizing complex anatomical structures. About 80.5% of students report a preference for combining virtual tools with traditional dissection for optimal learning (Funjan *et al.*, 2023). This integrated approach is seen as the most effective for reinforcing anatomical understanding while providing flexibility and accessibility that traditional methods alone cannot offer.

Sri Lankan Perspectives; Cultural and Emotional Barriers.

In Sri Lanka, medical students value cadaveric dissection for its role in understanding anatomical structures and clinical applications, reflecting global perspectives (Edirisinghe *et al.,* 2022). However, cultural and religious beliefs significantly limit body donations, even under voluntary consent programs, which

restrict cadaver availability for anatomy teaching (Edirisinghe *et al.,* 2022; Wickramasinghe *et al*., 2022). These limitations, considered within the broader context of ethical concerns, may also reduce students' opportunities to engage with concepts of death and dying, an important aspect of professional development (Wickramasinghe *et al*., 2022). Emotional responses, including anxiety, fear, or distress, are frequently reported during initial dissection experiences and can influence learning outcomes (Edirisinghe *et al*., 2022). Furthermore, the substantial financial and infrastructural demands of maintaining dissection facilities add practical challenges to sustaining cadaver-based education in Sri Lanka (Edirisinghe *et al*., 2022).

Comparison of Traditional Cadaver Dissection and Virtual Dissection Tools

Traditional cadaver dissection remains a critical method for learning anatomy, particularly for developing tactile skills, spatial awareness, and understanding human anatomical variations. This hands-on approach is crucial for students pursuing surgical or clinical careers (Edmund Atta Asante *et al.*, 2021). While it offers unique advantages, such as exposure to real human bodies and promoting teamwork, it also has limitations, including ethical concerns, emotional challenges, and the need for cadaver availability (Hussein *et al.*, 2016). In contrast, virtual dissection tools, such as 3D software, VR, and AR, provide engaging, flexible, and accessible ways to visualize and interact with anatomical structures (Funjan *et al.*, 2023). These tools are particularly beneficial for repeated practice and for understanding complex anatomical regions (Janaka, Hewapathirana and Karunathilake, 2023). However, they lack the tactile feedback necessary for developing manual skills, which remains a vital component of surgical training (Patel *et al.*, 2015; Cardoso *et al.*, 2023). Despite these differences, most students prefer a hybrid approach that combines the strengths of both methods, allowing for a comprehensive and well-rounded anatomy education (Funjan *et al.*, 2023). This integrated approach ensures students benefit from the tactile, hands-on experience of cadaver dissection while also leveraging the flexibility and accessibility offered by virtual tools.

Conclusion

A hybrid approach combining cadaver dissection with virtual tools is considered the most effective for anatomy education in both international and Sri Lankan contexts. Students value cadaver dissection for its tactile experience and insights into human anatomy, while virtual tools offer enhanced visualization and flexibility. While virtual tools assist in understanding complex structures, they are not a substitute for hands-on experience. This approach blends traditional and modern methods, providing the best learning outcomes. As virtual tools improve, they will likely become more integrated into curricula, yet the value of cadaver dissection remains irreplaceable.

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Competing Interests

The authors declare no competing interests.

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