Original Article

Exploring the Educational Outcomes of Traditional Cadaveric Dissection Compared to 3d Virtual Dissection Models.

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ABSTRACT

Traditional cadaveric dissection has been a cornerstone of anatomy education for a long time while modern 3D virtual dissection tools have emerged as an innovative alternative. This study aimed to compare perceptions of traditional dissection and 3D dissection among a broad medical community. A cross-sectional study was conducted using a structured questionnaire via Google Forms. The survey included 977 participants comprising medical students, dental students, nursing students, interns, residents and practicing professionals across various medical colleges. The questionnaire assessed participants' preferences, perceived effectiveness and attitudes toward both traditional cadaveric dissection and 3D virtual dissection. The majority of respondents indicated that while each method had its individual strengths, a combination of both traditional cadaveric dissection and 3D dissection was most effective for learning anatomy. The findings support the integration of both traditional and 3D dissection methods in anatomy education. Combining the cadaveric dissection with the technological precision of 3D tools may provide a more holistic and effective learning experience for medical learners across different stages of training.

Keywords: Traditional cadaveric dissection, 3D dissection tools, human anatomy, medical students, cross sectional study, educational outcomes.

INTRODUCTION

Background of Human Cadaveric Dissection

Ancient:

Hippocrates is credited with establishment of foundational concepts of human anatomy. Dissection of animals by Galen of Pergamon was the basis for anatomical knowledge in Europe for thousands of years[1].

Medieval:

Dissection as an educational tool began to gain prominence during the Renaissance, particularly in the works of Andreas Vesalius (1514–1564). Vesalius' book, De humani corporis fabrica (1543), revolutionized the understanding of human anatomy by promoting direct dissection of human cadavers, rather than relying on Galen's animal-based studies.

In this period, the dissection of human bodies became more common in European medical schools and it was seen as an essential part of learning. Medical schools, especially in Italy, began to acquire cadavers for dissection, and dissection became a public event in some cities[2,3].

Ethical Issues:

Throughout history, access to cadavers has often been controversial.

In the 19th century, cadaver thefts (e.g., the case of Burke and Hare in the UK) led to public outrage and legal reforms. The Human Tissue Act and other legislation around the world now regulate the use of cadavers for medical and educational purposes[4,5].

Environmental Issues:

The preservation of cadavers involves the use of chemicals such as formaldehyde, which can have harmful environmental effects and health risks for those working with them.

Resource intensity:

Maintaining a cadaveric dissection lab requires considerable space, equipment, and financial resources. It also limits the number of students who can be trained simultaneously, as cadavers are finite and costly to acquire and preserve.

Background of Virtual Dissection

During the early stages of computer science development, researchers began exploring ways to use computer graphics for medical purposes. Early attempts at creating 3D models of the human body were relatively primitive but marked the first steps toward creating virtual representations of human anatomy.

1970s: The emergence of CT (Computed Tomography) scans and MRI (Magnetic Resonance Imaging) opened new possibilities for creating highly detailed, layered representations of the human body.

These imaging techniques allowed for non-invasive views of internal anatomy and, eventually, the development of 3D models based on imaging data[6].

1990s: the first virtual anatomy programs were developed to assist medical students in learning human anatomy. One of the pioneering software applications in this field was Visible Body, which started as a digital atlas of human anatomy in 1994. It allowed users to view detailed 3D models of the human body, layer by layer, providing an early glimpse into what virtual dissection could look like.

Some universities and medical institutions began experimenting with 3D imaging technologies to create digital cadavers. for example: Body Viz system, developed in the late 1990s, used CT and MRI scans to create 3D representations of human bodies[7,8,9].

early 2000s: technologies like Virtual Reality (VR) and Augmented Reality (AR) began to be integrated with anatomy education

2000: Anatomage Table was introduced. This is a highly interactive, touchscreen 3D table that allows students to explore human anatomy by dissecting virtual cadavers. The Anatomage Table is still in use today and is widely recognised as a significant breakthrough in virtual dissection. Software platforms like BioDigital Human and Zygote Body provided VR and AR-based applications for anatomy learning, allowing students to explore anatomical structures from various angles and perspectives. These tools offered students the ability to "peel away" layers of the body to reveal deeper structures, just like a real dissection[10,11,12,13].

AIMS & OBJECTIVES

Aim: To develop, validate, and evaluate human virtual dissection tools that enhance the understanding of human anatomy, improve medical education outcomes, and provide a cost effective, ethical, and scalable alternative to traditional cadaver dissection.

Objectives:

1. Collect qualitative feedback on the ease of use, clarity, and engagement of the models.
2. Seek reviews from surgeons or clinicians who regularly interact with human anatomy in practice.
3. Explore the potential of virtual dissection to reduce reliance on cadavers, preserving resources and addressing ethical concerns.
4. Conduct comparative studies between virtual dissection and traditional cadaver-based learning.

MATERIALS AND METHODS

This is a cross-sectional study conducted via Google Forms. 977 people participated in this study consisting of medical students, dental students, nursing students, interns, residents and medical professionals from various medical institutions across India. Each participant was allowed to submit the form only once. The participants were mostly from the 18-24 age group. The results of the survey indicate that participants favored a combination of traditional cadaveric dissection and 3D dissection tools for learning anatomy. This hybrid approach was seen as the most effective way to understand human anatomy, allowing students to gain hands-on experience while also benefiting from digital tools. Although, 3D tools are valued for their interactivity and visualization, the tangible experience of working with real cadavers remains the preferred method for mastering the complexities of anatomy during exams.

Ethical consideration:

The research was reviewed and approved by the Institutional Ethics Committee.

Study design:

This is a cross-sectional study conducted through Google Forms.

Duration:

December 2024-March 2025

RESULT

1. Sample characteristics

A total of 977 participants were included in this study, consisting predominantly of medical students (94.7%) with the remaining 5.3% comprising dental students, physiotherapy students, nursing students, doctors and other medical professionals from various medical colleges and hospitals across India.

The participants were mostly young adults, with 94.1% falling within the age range of 18 to 24 years, 2.5% were above 40 years, a small percentage of 1.8% were under 18 years, 1.1% were aged between 25 to 30 years, and 0.5% were aged between 31 to 40 years.

Among the students, the majority were first-year students (70%), followed by second-year students (17.5%). 7.8% of the participants were fourth year students. A smaller proportion of participants were from the third year (0.9%) with 0.6% being residents.

2. Exposure and Preferences

In terms of experience with traditional cadaveric dissection, 88.5% of participants reported having performed cadaveric dissection, while 8.7% had observed but never performed it. 2.8% had neither observed nor performed traditional dissection.

Regarding the use of virtual dissection tools, 72.1% of participants had used them, while 27.9% had no experience with such tools.

When asked about preferences for dissection methods, 77.1% of participants preferred a combination of both traditional cadaveric dissection and virtual dissection tools, while 26.5% preferred traditional dissection only, and 6.1% favored virtual dissection only.

Participants highlighted several benefits of traditional cadaveric dissection over virtual dissection, including:

- Exposure to real anatomical variations, which provides a more accurate and authentic representation of the human body.
- A better understanding of 3D anatomy, which enhances spatial awareness and the ability to visualize anatomical structures in three dimensions.
- Improvement in retention and recall, as hands-on dissection helps to solidify anatomical knowledge through physical interaction and direct experience.

On the other hand, several benefits of virtual dissection were also noted by participants:

- The ability to repeat the dissection process multiple times, providing unlimited opportunities for practice and review.
- Its usefulness for visualizing complex structures, as virtual tools allow for better clarity and detailed exploration of intricate anatomical features.
- Accessibility and cost-effectiveness, with virtual tools being more readily available and more affordable compared to traditional cadaveric dissection.

In terms of the role of virtual dissection in medical education, 55.8% of participants expressed interest in more virtual dissection tools in anatomy education, though they emphasized the importance of reviewing traditional cadavers first. 12.1% of the participants were not interested in virtual dissection tools in anatomy education.

When assessing the comfort level of participants in handling cadaveric specimens, only 31.2% of the respondents reported being very comfortable (rating of 5 on a scale of 1 to 5).

Additionally, 30.2% of participants rated their comfort level as 4, indicating they were fairly comfortable, while 24.9% rated their comfort level at 3, suggesting a moderate degree of comfort. Lower comfort ratings (levels 1 and 2) were much less commonly reported.

3. Educational Outcomes

Regarding the understanding of anatomical variations among individuals, 52.4% of participants felt that a combination of both traditional cadaveric dissection and virtual dissection provided the best understanding. Meanwhile, 46.1% believed that traditional cadaveric dissection alone was sufficient for appreciating anatomical variations, and 11.5% felt that virtual dissection alone could achieve this.

When asked about repetition and review of anatomical structures, 55% of participants believed that a combination of both traditional cadaveric dissection and virtual dissection allowed for better repetition and review. In comparison, 23.2% of participants felt that virtual dissection alone was sufficient for this purpose, while 18.2% believed that traditional dissection alone could effectively support repetition and review. The remaining opted for the use of textbooks and diagrams.

In terms of the learning curve, 58.1% of participants believed that traditional cadaveric dissection allows for a steeper and more rapid acquisition of anatomical knowledge.

Furthermore, 62.3% of participants believed that virtual dissection is more scalable for larger class sizes, making it a more feasible option in large-scale medical education.

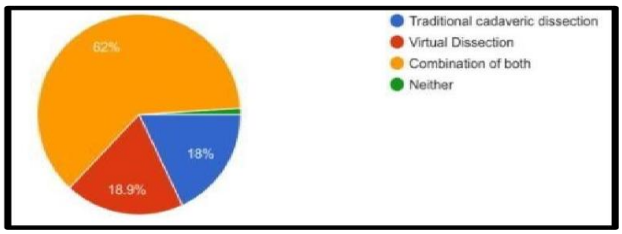

Figure 1: For the purpose of exam preparation, 62% of participants believed that a combination of both methods would lead to better outcomes, 18.9% believed that virtual dissection methods would be sufficient and 18% opted for the use of virtual dissection methods.

Regarding the stimulation of critical thinking skills, 46.2% of participants felt that a combination of both traditional and virtual dissection tools is more effective in this regard, while 45.4% believed that traditional dissection alone also stimulates critical thinking effectively.

When evaluating the impact of interactive features in virtual dissection tools — such as zooming, undoing, rotating, and cross-sectional views — on their learning experience, 26.1% of participants rated these features at the highest level (5 out of 5). Additionally, 24.7% rated their impact at 4, while 33% rated them at 3, indicating a moderate to high perceived enhancement in their learning experience through these interactive functionalities.

Regarding the retention of anatomical knowledge over time, 79.8% of participants believed that traditional cadaveric dissection significantly helps in retaining anatomical knowledge for a longer duration. In contrast, only 40% felt that virtual dissection alone could achieve long-term retention. A portion of participants indicated that the use of diagrams or a combination of both methods was more effective, while others expressed that the ability to retain anatomical knowledge varied from person to person.

A significant majority (78.6%) of participants believed that virtual dissection should be made mandatory alongside traditional cadaveric dissection methods in anatomy education. However, when asked whether virtual dissection alone could produce competent healthcare professionals, only 8.7% of participants strongly agreed (rating 5 on a scale of 1 to 5), and 9.9% rated it 4. The majority of participants (31.8%) rated it 3, indicating a neutral or moderately supportive stance.

When considering the overall approach to medical education, 59.6% of participants favored a hybrid model

combining both traditional and virtual dissection methods. Meanwhile, 34.4% of respondents believed that traditional cadaveric dissection remains irreplaceable, and only 5.9% felt that traditional methods could be completely replaced by virtual dissection.

DISCUSSION

Anatomy education has traditionally relied on cadaveric dissection, which is considered as the gold standard for learning the human structure. However, with evolving technology and logistical challenges such as cadaver shortages, institutions have begun exploring 3D virtual dissection as an alternative or supplement. Students who engaged with 3D dissection tools reported improved spatial understanding and clarity of complex anatomical structures. This is consistent with Nicholson et al. (2016), who found that 3D visualizations enhanced laboratory performance when used alongside traditional lectures and cadaveric resources[14]. Darras et al. (2019) noted that 78.7% of students felt virtual dissection improved their understanding of cadaveric anatomy and its clinical relevance[15]. In a study involving a 3D atlas, 97% of students reported improved orientation and enthusiasm when it was used alongside cadaveric learning[16]. In contrast to these, findings from Anand et al. (2020), who reported no significant difference in knowledge acquisition between students using virtual tools and those using traditional cadavers, emphasizing that both methods can be equally effective when integrated thoughtfully into the curriculum[17].Additionally, A study exploring medical students' perceptions in Saudi Arabia and Egypt found that while virtual dissection applications were appreciated for their accessibility and clarity, students still valued traditional cadaveric dissection for its hands-on experience[18].Similarly, a study investigated the impact of cadaveric versus digital dissection on student retention of anatomical knowledge. Results indicated that while both methods were effective in promoting initial understanding, cadaveric dissection showed a statistically significant advantage in longterm retention of anatomical knowledge[19].

Numerous studies also highlight the benefits of using both methods for learning human anatomy. An open-labeled crossover randomized controlled trial with 154 first-year medical students compared academic performance and satisfaction between virtual and donor dissections. Results indicated that while both methods were effective, students expressed higher satisfaction with the combined use of virtual and traditional dissection techniques[20]. A study involving Ghanaian medical students revealed that while the Anatomage virtual dissection table enhanced visualization and understanding of anatomical structures, students still valued traditional cadaveric dissection for its tactile experience and real-life variability. The combination of both methods was deemed most effective for comprehensive learning[21]. A cross-sectional study involving first-year MBBS students evaluated attitudes toward traditional cadaveric dissection and 3D virtual dissection. The study found that while students appreciated the tactile experience of cadaveric dissection, many also recognized the value of 3D virtual tools in enhancing spatial understanding[22] .

CONCLUSION

The study concludes that traditional cadaveric dissection holds an important place in medical education; especially for understanding real anatomical variations, building 3D visualization and improving long term retention. However, there is a growing appreciation for virtual dissection tools.

Majority of the participants favoured a combination of both methods as they believed that a blend of the two methods facilitates the development of strong critical thinking skills and more flexibility for larger class sizes. The combination is also the preferred method for exam preparation.

Even though virtual dissection was considered more advantageous for its easy repetitive use and visualisation of complex structures; very few people believed that it could produce competent healthcare professionals.

Overall, the findings suggest that the best way forward is a hybrid model that blends both traditional cadaveric dissection and virtual dissection tools. Balancing both approaches could help students benefit from both hands-on experience and technological innovation, building a deeper understanding of human anatomy.

APPENDIX 1

This is a survey. There are no right or wrong answers. Please answer honestly. By submitting this form, you acknowledge and consent to participating in the survey as described, understanding that your responses may be used for research or analysis.

Questionnaire:

1. Age Group

   Under 18

   18–24

   25–30

   31–40

40+

2. Are you a medical student or professional?

   Medical student

   Dental student

   Nursing student

   Medical professional

   Other:

3. If a student, which year of study? *

   First Year

   Second Year

   Third Year

   Fourth Year

   Internship

   Residency

   Not applicable

4. Have you ever performed traditional cadaveric dissection? * Yes No I've been in the dissection hall and observed but never performed dissection.

5. Have you used virtual dissection tools (e.g., Anatomage Table, 3D Anatomy apps)?* Yes No

6. Which method do you prefer for learning anatomy? (select all applicable) * Traditional cadaveric dissection only

   Virtual dissection only Combination of both

   I've never done traditional cadaveric dissection

   I've never done virtual dissection

7. What do you find most beneficial about traditional cadaveric dissection? (select all that apply *

   Better understanding of 3D anatomy Improves retention and recall

   Exposure to real anatomical variations Prepares for clinical practice Enhances teamwork and collaboration Develops respect for the human body Other:

8. What do you find most beneficial about virtual dissection? (select all that apply)*

   No ethical concerns with cadaver use

   More accessible and cost-effective

   Can be repeated multiple times

   Useful for visualization of complex structures Easy access and repeatability

   Interactive learning with labels and annotations Ability to study at your own pace No exposure to chemicals like formalin Other

9. Do you think virtual dissection can fully replace traditional dissection in medical education? * Yes, completely

   No, traditional dissection is irreplaceable A hybrid approach (both methods together) is best Other:

10. Would you be interested in more virtual dissection tools in medical education?* Yes / No

    Yes, but only after reviewing through cadavers first

11. How comfortable are you with handling cadaveric specimens (1- very less comfortable 5- very much comfortable) *

12. Which method allows better repetition and review of anatomical structures?*

    Traditional cadaveric dissection

    Virtual dissection

    Combination of both

    Neither, I prefer diagrams and textbooks

13. What do you feel helps retain anatomical knowledge longer? (select all that apply)* Traditional cadaveric dissection Virtual dissection I've never tried cadaveric dissection I've never tried virtual dissection Other:

14. Which method do you feel provides better understanding of anatomical variation among individuals? *

    Traditional cadaveric dissection

    Virtual dissection

    Combination of both

15. How much did the interactive features (zoom, undo rotate, cross sections) in virtual dissection enhance your learning experience

    1- very less

    5- very much

16. Which method do you think is more scalable for larger class sizes. *

    Traditional cadaveric dissection

    Virtual dissection

17. Which method do you believe stimulated your critical thinking skills more effectively? * Traditional cadaveric dissection

    Virtual dissection

    Combination of both

18. Which method do you feel is better for exam preparation? *

    Traditional cadaveric dissection

    Virtual Dissection

    Combination of both

    Neither

19. Which method do you feel allows a steeper learning curve *

    Traditional cadaveric dissection

    Virtual dissection

20. Should virtual dissection be mandatory alongside traditional methods in anatomy education?*

    Yes

    No

21. Virtual dissection alone can produce competent healthcare professionals (1- strongly disagree, 5- strongly agree)*

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