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Bridging Traditional Knowledge and Modern Technology: Artificial Intelligence in Anatomy Education for Ayurveda

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ABSTRACT

Background: Ayurveda education has always placed a strong emphasis on anatomy *(Sharira Rachana)*, which serves as the basis for both clinical practice and surgical proficiency. Although traditional mentorship and cadaver dissection are still the gold standards, contemporary issues such as scarce cadavers, resource limitations, and the cognitive dissonance between classical and biomedical anatomy necessitate creative pedagogical approaches. Tools powered by artificial intelligence (AI), like augmented reality (AR), virtual reality (VR), and adaptive learning platforms, present exciting opportunities to improve anatomy instruction.

Materials and Methods: This conceptual review combines ideas from contemporary literature on medical education and digital learning technologies with insights from traditional Ayurvedic texts *(Charak Saṃhitā, Suśruta Saṃhitā, and Aṣṭāṅga Hṛdaya)*. Search terms such as "AI in anatomy education," "AI and Ayurveda," "Virtual Anatomy," "Digital Anatomy Models," and "Traditional Medicine Education" were used to search electronic databases (PubMed, Scopus, Google Scholar, DOAJ, and ScienceDirect). To identify connections between traditional Ayurvedic anatomical knowledge and AI-enabled pedagogical strategies, pertinent findings were critically examined.

Results and Discussion: Although lectures and cadaver-based training are vital in Ayurvedic education, access is limited by ethical, practical, and financial challenges. Emerging tools such as VR/AR simulations, virtual dissections, and intelligent tutoring systems can improve engagement, individualize learning, and align Ayurveda's epistemology with modern anatomy models. In Nepal, where cadaver shortages and resource gaps persist, AI can make anatomy education more inclusive and culturally sensitive while retaining dissection and mentorship as core pillars.

Conclusion: AI-powered tools offer transformative opportunities to blend modern technology with traditional Ayurvedic anatomy teaching. Applied thoughtfully, they can enrich rather than replace classical methods, enhancing interactivity, personalization, and clinical relevance. Integrating AI with *Sharira Rachana* pedagogy in Ayurvedic programs could produce graduates better prepared for regional and global healthcare challenges.

Keywords: Virtual Dissection, Artificial Intelligence, Sharira Rachana, AI and Ayurveda, Virtual Anatomy Learning, Digital Anatomy Models.

INTRODUCTION

The word "anatomy" originates from the Greek word "anatome," which means "cutting up." It is commonly acknowledged that dissection is a crucial component of medical education since it gives students a practical understanding of the body and introduces them to the changes it undergoes after death. As time passed, it became increasingly evident that sound medical and surgical procedures depend on a thorough and precise knowledge of human anatomy, which can be acquired through studying and instructing in human dissection.[1]

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Understanding more complex medical sciences requires an understanding of human anatomy, which is a fundamental and significant component of medical education. Intellectual and emotional insights into medical education can be gained by studying physical anatomy. In order to establish patient primacy, understand the complexity and diversity of the body, acquire the fundamental medical terminology, and develop a touch-based perception of the cadaver or patient, cadaver-based anatomy instruction is essential for the best learning outcomes.[2]

One of the world's oldest medical systems is Ayurveda. It has been discussed in historical books and is founded on Vedic philosophy. Early Ayurvedic surgeons like *Sushruta* discussed the body's parts and surgical techniques in detail in the Sushruta Samhita and other writings. The Susruta Samhita had already provided essential knowledge about anatomy and surgery by the sixth century BCE.[3] Therefore, even though it was uncommon to dissect, Ayurveda has always been founded on an understanding of anatomy. Through clinical practice, animal sacrifice, patient observations, and limited autopsy, early writers gained knowledge of human morphology. Over time, Ayurvedic scholars organized the body into *dhātus* (tissues), *srotas* (channels), *marmas* (vital points), and other concepts to create a thorough anatomical model. Patients were diagnosed and cured using this model.

In contemporary Ayurvedic schools, including BAMS and postgraduate degrees, *Sharīra Rachana* (anatomy) remains a crucial subject. However, rather than being taught together, classical anatomy and contemporary biomedical anatomy are typically taught side by side in Ayurvedic classes. According to Joshi et al., current graduate curricula outline topics from Ayurveda and modern medical science independently, ignoring the two fields' integration.[4] As a result, when outdated ideas conflict with modern anatomical terminology, students may suffer from cognitive dissonance. According to experts, teaching strategies need to be modified. Nair et al. for instance, argue that Ayurvedic anatomy education needs to acknowledge the "limitations of ancient anatomical and physiological constructs" and modify the curriculum appropriately.[5] Actually, like contemporary medical schools, many Ayurvedic institutes now teach *Sharīra Rachana* through a mix of lectures and practical dissection. According to Deepshikha and Kutte, classical anatomy is still taught in Ayurvedic programs using a combination of lectures and practical exercises involving cadaver dissections. But they also point out that the use of digital tools to improve learning, such as QR codes, virtual reality, and sophisticated imaging, is growing. The goal of these evolving strategies is to increase student engagement and make the material more clinically relevant.[6]

The goal is still the same: to gain a thorough understanding of body anatomy in order to support safe practice. Despite being viewed differently than allopathic anatomy, anatomy is still very important in Ayurveda. For instance, understanding *marmas*, or energy points, is crucial for manual therapies and Ayurvedic surgery. Teachers see value in teaching both viewpoints and helping students "bridge epistemological differences" between the traditions.[7]

We now have new opportunities to teach anatomy in any medical system due to rapidly evolving technologies. "Advanced imaging and artificial intelligence (AI) provide a solution, offering virtual dissection simulations and personalized learning tools that replicate 3D anatomy and cater to individual student requirements," according to recent research in mainstream medical education.[8] It has been discovered that AI-driven tools such as adaptive learning algorithms and virtual reality anatomy tables help anatomy students stay engaged and comprehend the material they are studying. These advancements imply that there are a lot of intriguing possibilities, despite the fact that Ayurvedic AI research is still relatively new. AI has the potential to help Ayurvedic students visualize ancient anatomical concepts in three dimensions, adapt learning to their needs, and integrate traditional and contemporary perspectives with contemporary medical education techniques.

MATERIALS AND METHODS

This is a conceptual review. References concerning the utilization of Artificial Intelligence (AI) in anatomy education, specifically within the framework of Ayurveda and modern medical science, have been gathered, and pertinent materials have been assembled from both classical and contemporary sources. The classical Ayurvedic texts, including *Charaka Samhita, Sushruta Samhita, and Ashtanga Hridaya*, along with their commentaries, were examined to investigate the traditional principles of anatomy *(Sharira Rachana)* and their educational methodologies.

Furthermore, modern references such as anatomy textbooks, medical education materials, and digital learning resources were utilized. We did a full literature search using electronic databases like Google Scholar, PubMed, Scopus, DOAJ, and Science Direct. The search strategy utilized keywords and combinations including "Artificial Intelligence in Anatomy Education," "AI and Ayurveda," "Virtual Anatomy Learning," "Medical Education Technology," "Digital Anatomy Models," "Traditional Medicine Education," and "Integrating AI in Ayurveda."

The gathered information was rigorously analyzed, synthesized, and restructured to underscore the convergence of traditional Ayurvedic anatomical knowledge and contemporary AI-driven educational technologies. In the end, conclusions were made about how AI could make anatomy education for Ayurveda students more effective, accessible, and integrated.

RESULTS AND DISCUSSION

A key component of Ayurvedic medical education is anatomy *(Rachana Sharir)*, which is typically taught through lectures and practical exercises like dissecting cadavers, bone samples, and histology slides.[8] Clinical skills and student engagement are greatly enhanced by hands-on experiences. However, there are moral and practical issues with Ayurvedic programs that replicate cadaver dissections and interactive anatomy labs.[9] These gaps

are starting to be filled by contemporary digital tools; students now supplement their education with virtual dissection software and 3D physical models. Virtual Dissection (VD) systems, for instance, offer interactive, high-resolution models of the human body to supplement conventional techniques. By allowing for repeated practice and addressing cadaver shortages, VD can greatly improve students' spatial understanding of anatomy. By offering realistic, interactive visuals, VD has actually been demonstrated to significantly enhance the anatomy learning experience in the Bachelor of Ayurvedic Medicine and Surgery (BAMS) program.[10]

Innovations unique to Ayurveda are also beginning to emerge. The CADAVIZ system, a virtual dissection table designed for Ayurvedic education, offers the "first of its kind" interactive anatomy module from an Ayurvedic perspective. Teachers can use this 3D simulation table to give students a thorough understanding of human anatomy that is consistent with Ayurvedic principles, assisting students in drawing the link between traditional "Rachana Sharir" descriptions and realistic anatomical models.[9] As more educators realize that these technological tools allow students to study anatomical structures outside of cadavers, the use of imaging and visualization tools (like MRI scans, ultrasounds, and augmented reality) in anatomy classes is also increasing. In conclusion, modern *Rachana Sharir* education is shifting away from static lectures and towards hybrid approaches that incorporate virtual models, imaging, and simulation in order to improve student comprehension.[6]

In order to enhance learning, AI-driven educational technologies are being quickly incorporated into contemporary medical curricula. According to a thorough review, gamified tests, 3D interactive models, virtual reality (VR) and augmented reality (AR) simulations, and intelligent tutoring programs that adapt to the needs of each individual student are examples of AI applications in anatomy education.[8]

Immersion can be produced by these AI tools. For example, VR-based 3D anatomy modules let students "enter" and work with anatomical structures in three dimensions, which has been demonstrated to increase learning satisfaction and engagement. In one study, compared to traditional classes, medical students who used 3D anatomy models as part of a blended learning framework reported higher satisfaction and marginally better quiz scores. [11]

AI makes adaptive learning possible in addition to visualization. Intelligent tutoring systems are able to dynamically customize feedback and content based on each student's performance data. Machine learning, for instance, is used by the Area[9] Rhapsode platform to gather mastery-level data for every learning objective and customize anatomy quizzes. First-year medical students who utilized this AI-powered adaptive learning for liver anatomy in a flipped classroom pilot demonstrated significantly better mastery by the end, almost all students had attained conscious competence, and conscious incompetence decreased from approximately 18% to 2%. Students who participated in the study reported "better learning quality, positive repurposing of study time, enhanced metacognitive awareness."[12]

These findings imply that learning anatomy can be greatly reinforced by AI-driven evaluation and feedback. Overall, by tailoring instruction to each student's progress, AI in medical education has been shown to improve engagement and knowledge retention. Chatbots and automated tests provide immediate feedback and self-directed assistance, while virtual simulations and augmented reality (AR) provide secure, interactive settings for practical experience.[13]

Teaching anatomy is changing quickly all over the world due to modern digital tools.
1. Immersive VR/AR: Unlike flat textbook images, virtual and augmented reality systems give students interactive, three-dimensional views of the body. For example, according to Niu et al., using VR in conjunction with 3D anatomy models greatly increased students' pre-class learning scores and engagement.[11] While AR by itself did not significantly alter test scores, a recent meta-analysis demonstrates that VR instruction produces significant gains in anatomy knowledge (SMD≈0.58) over traditional methods.[14]

2. Tools for 3D visualization: Learning is further enhanced by 3D-printed models and virtual dissection tables. These enable the practical investigation of small or uncommon structures and the simulation of cadaver dissections.15According to Abdellatif et al., the ability to produce intricate anatomical models for surgical simulations or teaching anomalies is made possible by declining 3D printing costs. Continuous use of 3D models increased student interest and satisfaction in a blended learning trial, despite mixed long-term exam results.[11]

3. Artificial Intelligence: AI-powered tools can automate feedback, analyze massive imaging data, and customize anatomy instruction (e.g., chatbots or adaptive tests). AI reduces the need for in-person instruction while providing deeper learning, remote access, rapid feedback, and innovative assessments, according to Abdellatif et al. All things considered, these technologies make learning anatomy more interesting, flexible, and accessible, thereby addressing issues like a lack of cadavers or varying learning speeds.[15]

In order to apply these AI techniques to Ayurveda, technology must be modified while also honoring Ayurvedic teaching methods. AI's prowess in pattern recognition and data analysis can aid in bridging the gap between biomedical anatomy and Ayurvedic concepts (such as doshas and prakriti). An AI system might, for example, provide interactive modules that highlight the similarities between human anatomy and Ayurvedic theory or examine Ayurvedic case data to recommend individualized study plans. According to a recent review, artificial intelligence (AI) holds promise for improving Ayurvedic education by facilitating more individualized learning and improved diagnostic training within the Ayurvedic framework.[16] AyurCeL is an example of an e-learning platform that combines traditional case repositories and preprints with contemporary web technology to preserve Ayurveda's rich history while enhancing accessibility and clinical

relevance. Real-world applications are starting to emerge. A virtual patient simulator designed especially for Ayurvedic education is the AyurSIM platform.[17]

In essence, AyurSIM uses AI-simulated patients to apply problem-based learning by presenting realistic clinical scenarios in a digital format. By providing interactive, contextualized case studies that reflect actual clinical reasoning, this platform "effectively bridges traditional Ayurvedic education with modern methodologies."[18] These tools fill the gap caused by a lack of live clinical exposure by enabling Ayurvedic students to repeatedly practice diagnostic and treatment planning skills in a secure setting. Using AI in anatomy classes might entail developing intelligent tutors or VR content with an Ayurvedic theme. For instance, CADAVIZ helps students make the connection between Ayurveda and biomedicine by offering 3D anatomical images that are framed using Ayurvedic terminology (*Shava-vichhedana*, etc.).[9] Similar to this, an AI-powered adaptive quiz system might present questions pertaining to Ayurvedic principles and Rachana Sharir concepts, varying in difficulty according to student performance. Teachers can make Rachana Sharir more interesting and culturally relevant by fusing Ayurveda's holistic perspective of the body with AI's analytical capabilities.

There are various benefits to teaching anatomy with AI:

1. Personalized Learning and Engagement: AI systems provide customized tests, comments, or next steps based on each learner's development. Students remain interested because of this personalization. Indeed, research indicates that the use of AI in anatomy frequently "enhances engagement and personalizes learning," resulting in improved comprehension.[8,19]
2. Flexibility and Accessibility: Resources on digital anatomy are accessible from anywhere at any time. Outside of the classroom, students can investigate 3D models in virtual reality or on mobile devices. This makes it possible to study continuously by overcoming schedule and geographic constraints. AI-powered apps allow students to access more flexible and accessible learning material beyond physical classrooms, according to one review.[19]
3. Decreased Dependency on Cadavers: AI-powered models lessen the need for cadavers. The drawbacks of traditional cadaver labs include a shortage of supplies, exorbitant expenses, formaldehyde safety risks, and moral dilemmas.[20] Students can repeatedly study anatomy without these issues by the use of virtual dissection tables and apps. Safer and more economical hands-on practice is the end result.

Cultural Alignment for Ayurveda: Ayurvedic knowledge can be embedded using AI tools. As mentioned, websites such as CADAVIZ match *marma* points and Ayurveda's five-element theory with anatomy views.[20] Students studying Ayurveda find it easier to relate contemporary anatomy to their traditional curriculum because of this cultural relevance. Sanskrit terms and text references can be directly incorporated into models using digital tools, maintaining Ayurvedic epistemology while utilizing cutting-edge visuals.

4. Innovative Pedagogy: AI-powered innovative pedagogy makes learning engaging and enjoyable. Students are motivated by interactive case simulations or gamified anatomy games. Future plans, for instance, call for "AI-powered anatomy detective games" in which students use real-time cues to solve virtual clinical puzzles.[19] Deeper learning and motivation can be greatly increased through gamification.
5. Improved Learning Outcomes: Teachers can create a dynamic environment by combining AI's strengths. "The benefits of AI use in anatomy teaching may boost students' objective outcomes and learning experiences," according to researchers.[19] According to preliminary data, well-designed AI-supported training improves test scores and helps students retain intricate anatomical information.

Challenges of AI Integration

There are obstacles to integrating AI in anatomy education, despite its potential:

1. Cost and Infrastructure: VR/AR setups and sophisticated AI tools can be costly. According to one review, "the cost of buying or developing AI tools and of maintaining them" is a significant obstacle, especially in environments with limited resources.[19] The cost and maintenance of these technologies may be prohibitive for many Ayurvedic colleges.
2. Expertise and Training: A lot of anatomy teachers are not well-versed in AI technologies. Teachers must be knowledgeable about and adept at using these tools in order to successfully integrate AI. Faculty development is obviously needed; educating teachers about AI applications and curriculum design is crucial. In the absence of this, advanced instruments might be underutilized.[19]
3. Digital Divide: Uneven access to dependable devices and internet. AI-enhanced learning may not be available to students in underfunded or remote areas. To guarantee that all Ayurvedic students gain, this injustice needs to be addressed.
4. Data Security and Privacy: In order to customize learning, AI systems frequently gather student' data (such as performance and biometric information). Privacy issues are brought up by this. Teachers need to protect this information and use it sensibly.[19]
5. Over-reliance and Dilution of Skills: Students run the risk of becoming overly reliant on technology. Overuse of AI tools may jeopardize more conventional abilities like tactile learning or dissection. Experts warn that relying too much on AI should not replace critical thinking or human interaction. Striking the correct balance is difficult.[8]
6. Bias and Fairness: AI systems may reinforce biases if the data

they use to learn is not diverse. A model trained on images of one demographic may incorrectly identify structures in another when it comes to anatomy. Students may be misled by such biases. Therefore, it is essential to actively check for biases and develop AI using a variety of anatomical datasets.[19]

7. Technical Restrictions: A lot of AI applications in anatomy are still in their infancy. The subtleties of intricate 3D relationships and Ayurvedic diagnostic reasoning might not be fully captured by current tools. Before AI can take the place of fundamental teaching techniques, it must undergo continuous development and thorough evaluation.

Ethical Considerations

Additionally, integrating AI into anatomy instruction presents moral dilemmas:

1. Informed Data Use: AI frequently uses patient and student data. Transparency regarding data handling and informed consent is essential for the ethical application of AI. At every stage, privacy needs to be protected.[19]
2. Equitable Access: AI tools should, morally speaking, help all students rather than create gaps. AI-enhanced learning must be equally accessible to underserved populations in Ayurvedic programs.
3. Bias Mitigation: It is the ethical responsibility of AI developers to reduce algorithmic biases. This entails validating the results of models trained on various anatomical sources in anatomy education.[19]
4. Preserving Human Judgment: Teachers must continue to bear the final say. AI should supplement teachers' knowledge, not replace it. Scholars point out that maintaining human mentoring and critical thinking is essential. Students should be taught to challenge and validate AI results.[8]
5. Cultural Sensitivity: Using AI ethically in Ayurveda specifically entails honoring traditional knowledge. The philosophy of Ayurveda should not be distorted by AI tools. Integrative methods need to respect Sanskrit textual ideas. For instance, in order to guarantee accuracy, scholars should be involved in the digitization of classical anatomy.[21]
6. Educational Integrity: The accuracy of AI-generated text or images should be verified. In education, spreading false information is unethical. AI curricula must be properly supervised and subjected to peer review.
7. Comprehensive policies and curriculum guidelines are needed to address these factors. Digital and ethical competency are already emphasized in medical education frameworks.[22] Ayurvedic programs ought to follow comparable guidelines.

Future Directions

In the future, Ayurvedic education can benefit from new developments in AI. Customized AI content is one important avenue. Similar to the potential of general chatbots, specialized tutoring could be provided by AI trained on Ayurvedic texts. In order to generate more accurate and cited responses than generic models, researchers advise instructors to create "custom GPTs" that are centered on anatomy.[23] Improved AR integration is another path. For instance, using a smartphone's camera, mobile apps could superimpose digital anatomical information onto a model or cadaver. Recognizing that technology should accommodate India's linguistic diversity, respondents to an Ayurvedic education survey specifically recommended incorporating AR/VR features and multilingual support into future learning platforms.[18]

Institutions of higher learning might start incorporating AI skills into the curriculum. According to surveys, faculty and students are excited about AI, suggesting that they are prepared to formally integrate it. In actuality, interdisciplinary teams, which consist of professors of anatomy and experts in artificial intelligence, may collaborate to create modules. Research should go on because, according to one review, in order to "maximize AI's potential" in anatomy instruction, educators and technologists must continue to collaborate.[24] Any college could eventually access interactive Ayurvedic anatomy models stored in shared cloud-based repositories. Teachers can guarantee that AI tools adapt to the unique requirements of Ayurvedic training by carefully innovating going forward.[25,26,27]

CONCLUSION

In conclusion, AI-powered techniques present effective new approaches to Ayurvedic anatomy instruction. Learning *Sharir Rachana* can become more interactive and individualized than ever before with the help of VR/AR simulations, intelligent tutoring, and adaptive feedback. These resources can greatly raise student engagement and performance. The tried-and-true techniques (such as cadaver dissection and mentorship) that have long been essential to medical education should be enhanced by AI, not replaced. As medicine advances, AI can effectively bridge the gap between traditional knowledge and contemporary science by assisting Ayurvedic students in developing a deeper, more intuitive understanding of anatomy. A promising way to improve anatomy instruction is provided by the fusion of AI and Ayurvedic education.

In the context of Nepal, using AI-powered tools in Ayurvedic anatomy education could be a game-changer for long-standing problems like not having enough cadavers, not having enough resources, and not having equal access to modern educational technologies. Traditional dissection and teacher-led instruction are still the most important parts of *Sharira Rachana* learning. However, adaptive simulations, virtual dissection platforms, and intelligent tutoring systems can make anatomy more accessible, interesting, and personalized for students at different schools. Pilot programs like CADAVIZ have already been started in modern medical schools of Nepal, where they are helping students see and

understand complicated anatomical ideas better. This means that similar AI-based platforms could improve Ayurvedic curricula in Nepal. However, to make it work, we need a careful investment in digital infrastructure, training of teachers, and adaptation of AI models to reflect Ayurvedic views in a way that is sensitive to different cultures. AI-driven innovations can connect traditional knowledge with modern teaching methods if they are used wisely. This will give Nepal's Ayurveda graduates a better understanding of anatomy and prepare them to meet both national and global healthcare needs with confidence.

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