2025 Volume 3, Issue 7
Educational Innovation Research
ISSN: 3029-1844(Print)
ISSN: 3029-1852(Online)

Research on the Application of 3D Digital Orthopedic Technology in the Internship Teaching of Orthopedic Traumatology of Zhuang Medicine

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Abstract

Objective: To observe the effect of 3D digital orthopedic technology in the internship teaching of Strong Medicine Orthopedics and Traumatology. *Methods:* 60 undergraduate intern doctors rotating in the Department of Bone, Joint and Spine of the Guang Xi International Zhuang Medicine Hospital Affiliated to Guangxi University of Chinese Medicine from January 2023 to April 2024 were selected as the study subjects, and they were randomly divided into the control group and the observation group, and the observation group was taught by the 3D digital orthopedic technology teaching mode, and the control group was taught by the traditional teaching mode, so as to observe the teaching effects of the two groups. *Results:* They were regularly assessed with theory test once a month, after the end of training, the observation group theory test scores, skills assessment scores were 90.40 ± 1.13, 89.73 ± 1.17; the control group theory test scores, skills assessment scores were 86.30 ± 1.09, 85.50 ± 1.28, the observation group was significantly higher than the control group, and the difference was statistically significant ($P < 0.05$). The effect evaluation scores of the observation group in improving clinical thinking ability, diagnostic and therapeutic discernment ability, anatomical comprehension ability, surgical operation ability and teaching satisfaction were higher than those of the control group, and the difference was statistically significant ($P < 0.05$). *Conclusion:* 3D digital orthopedic technology teaching model can improve the teaching effect of undergraduate internship in the orthopedic and traumatology sciences of Zhuang medicine.

Keywords

3D digital orthopedic technology; Orthopedics and Traumatology of Zhuang Medicine; Teaching undergraduate medical internships; Overall teaching effect

Online publication: August 26, 2025

1. Introduction

Zhuang medicine constitutes an integral component of traditional Chinese medicine [1]. Developed through the Zhuang people's prolonged experiences in daily life, production activities, and the struggle against disease, it possesses a distinctive theoretical framework and rich content within the tradition of Chinese medicine [2]. Currently, clinical teaching for undergraduate medical students in Zhuang medicine orthopedics remains predominantly textbook-based and case study-oriented, exhibiting significant limitations: students struggle to develop an intuitive understanding of orthopedic anatomy and three-dimensional spatial awareness, resulting in tedious learning and poor retention [3].

Given the extensive scope of orthopedic conditions and their deep interconnection with anatomical and biomechanical principles, which heavily rely on spatial reasoning, this poses a considerable challenge for trainee surgeons. Consequently, reforming orthopedic teaching is imperative, necessitating a shift towards more intuitive and hands-on practical training approaches [4]. Moreover, given the scarcity of human anatomical specimens in contemporary medical education, clinical teaching predominantly relies on anatomical atlases and models [5]. However, these alternative tools struggle to accurately and comprehensively depict local anatomical features of the human body, often leading to comprehension difficulties for medical students newly entering clinical practice and hindering their mastery of relevant knowledge [6,7]. Consequently, how to overcome this limitation in the practical teaching of Zhuang orthopedic trauma surgery and effectively enhance clinical teaching outcomes has become a critical issue requiring urgent resolution [8].

Modern orthopedic clinical teaching increasingly emphasizes clinical competence as its core focus [9]. However, the traditional model relies on a one-way transmission of knowledge through oral instruction, which not only leaves medical students feeling disengaged but also neglects the cultivation of their clinical practice and applied skills, resulting in suboptimal teaching quality [10]. Concurrently, the rapid advancement and development of modern orthopedic diagnostic and therapeutic techniques demand higher standards of comprehensive competence from practitioners. This further highlights the limitations and obsolescence of traditional teaching approaches, presenting a formidable pedagogical challenge [11]. The introduction of digital 3D orthopedic technology teaching models holds promise for overcoming the limitations of traditional instruction [12]. This technology first employs three-dimensional visualization models to provide students with intuitive anatomical understanding, addressing their spatial conceptualization challenges [13]. It then reinforces clinical practice and application skills through simulated surgical procedures. Ultimately, it stimulates learning enthusiasm while achieving efficient translation of theory into clinical practice [14]. In light of this, this study implemented 3D digital orthopedic technology teaching and conducted an empirical analysis of its effectiveness during Zhuang medicine orthopedic trauma internships, as reported below.

2. General information

2.1. Case grouping information

60 undergraduate medical interns rotating through the Department of Orthopedics and Spine Surgery at the International Zhuang Medicine Hospital Affiliated to Guangxi University of Chinese Medicine between January 2023 and April 2024 were selected as study subjects. The observation group comprised 30 individuals (13 males, 17 females) aged 20–24 years, with a mean age of 22.26 ± 1.05 years. The control group comprised 30 individuals (11 males, 19 females) aged 21–24 years, with a mean age of 22.23 ± 0.94 years. General characteristics showed no statistically significant differences between groups ($P > 0.05$), rendering them comparable.

2.2. Inclusion criteria

The inclusion criteria are as follows:

(1) Fifth-year undergraduate medical students undertaking clinical rotations in the Department of Orthopedics and Spinal Surgery at the International Zhuang Medicine Hospital affiliated with Guangxi University of Chinese Medicine;

(2) Voluntary participation in this study with consent to actively cooperate throughout the entire process.

2.3. Exclusion and dropout criteria

The exclusion criteria are as follows:

(1) Voluntary withdrawal during the study period;
(2) Inability to continue participation due to sick leave or personal leave during the study period.

2.4. Methodology

All subjects utilized standardized teaching materials: the third edition of Zhuang Medicine Traumatology (People's Medical Publishing House, five-year program) and Practical Standards and Clinical Applications of Zhuang Medicine External Treatment Techniques served as primary references for lesson preparation and delivery. Senior professors with extensive clinical and teaching experience in Zhuang orthopedic traumatology conducted guided lectures. Theoretical instruction occurred weekly, comprising two teaching periods (80 minutes) per session, with assessments conducted at the conclusion of each three-week rotation cycle.

2.4.1. Observation group

The observation group employed a 3D digital orthopedic technology teaching model. Specific implementation steps are detailed in **Table 1**.

2.4.2. Control group

The control group employed the traditional clinical teaching model. Specific implementation steps were as follows:

(1) Upon entering the department at the start of each rotation cycle, teaching staff distributed relevant materials, including the Traditional Clinical Pathway Chart for Zhuang Medicine Traumatology and radiological documentation to trainee doctors;
(2) Clarified the teaching syllabus and objectives for Zhuang Medicine Traumatology, requiring trainees to study and master key aspects, including pulse diagnosis, visual diagnosis, clinical manifestations, Zhuang medical diagnosis, traditional Chinese medical diagnosis, Western medical diagnosis, and treatment

Table 1. Clinical teaching pathway chart for 3D digital orthopedic technology in Zhuang Medicine Traumatology

Teaching phase	Lecture time	Lecture content	Lecture format
Preparation before class	10 min	Prior to the lecture, the instructor distributed 3D-printed models and radiographic materials related to Zhuang orthopedic trauma cases, all sourced from authentic hospitalized patients. Each group member prepared relevant theoretical knowledge and teaching materials pertaining to Zhuang orthopedic trauma science	3D printed model
Teaching process	60 min	Clarify the teaching objectives of Zhuang Medicine Orthopedics. Group members shall analyze and present clinical cases through consultation, pulse diagnosis, visual examination, and physical assessment, supplemented by 3D-printed models. The instructor shall conduct a comprehensive evaluation of students' prepared teaching materials and discussion participation, gaining real-time insight into their mastery of relevant knowledge. Emphasis shall be placed on the practical and applied nature of Zhuang Medicine Orthopedic theory	Group discussions, 3D printed models, short videos, PowerPoint presentations, chalkboard notes
In-class assessment	10 min	In-class assessments evaluate learners' mastery of relevant knowledge and gauge satisfaction levels	Classroom tests, questionnaires
Lesson summary	10 min	The instructor summarized the presentations from each study group, providing timely feedback to rectify misconceptions arising during instruction. Detailed explanations were supplemented with 3D printed models, while mind maps were employed to organize the course's knowledge framework and highlight key points. Finally, group members were guided to develop sound clinical reasoning skills and conduct summaries, significantly enhancing trainees' interest in and practical abilities within the clinical study of Zhuang orthopedic trauma science	PowerPoint presentations, chalkboard notes, mind maps

protocols for disease patterns where Zhuang medicine holds comparative advantages;

(3) During teaching sessions, trainees independently collected patient medical histories and conducted physical examinations, followed by group discussion, analysis, and summarization;

(4) Finally, the instructor summarized each learning group's presentation, provided corresponding feedback, and corrected misconceptions arising during the teaching process.

2.5. Observation indicators

2.5.1. Theoretical assessment

All teaching staff comprised associate professors or above from the Department of Orthopedics and Spinal Surgery at the Affiliated International Zhuang Medicine Hospital of Guangxi University of Chinese Medicine. Examinations were uniformly set with identical content and timing. Interns enrolled in this study underwent closed-book written examinations, scored out of 100 points, primarily assessing their mastery of theoretical knowledge in Zhuang orthopedic trauma medicine.

2.5.2. Practical assessment

Assessments of teaching staff shall be conducted by associate professors or higher-ranking personnel from the Department of Orthopedics and Spinal Surgery at the Affiliated International Zhuang Medicine Hospital of Guangxi University of Chinese Medicine. Examinations shall be held at the same time each rotation week. Each learning group shall randomly select one in-hospital case to evaluate trainees' practical skills through assessment of medical history taking, physical examination, radiographic interpretation, differential diagnosis, anatomical understanding, and treatment planning. A practical assessment score shall then be determined, with a maximum of 100 points.

2.6. Teaching outcomes

Upon completion of both clinical rotation cycles, instructors uniformly distributed two-way evaluation questionnaires to assess students' perceptions of teaching effectiveness across clinical reasoning, diagnostic analysis, anatomical comprehension, and surgical proficiency, each rated on a 10-point scale. Questionnaire analysis assessed student satisfaction with the course, categorized into five responses: strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree. A total of 60 questionnaires were distributed, achieving a 100% return rate.

2.7. Statistical methods

Data were statistically analyzed using SPSS 26.0 statistical software. Quantitative data are expressed as mean ± standard deviation (SD) with intergroup comparisons conducted via t-tests. Qualitative data are denoted by n, with comparisons performed using χ^2 tests. Differences were considered statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of theoretical and practical scores between the two groups of interns

Following completion of the rotational training program, both theoretical and practical scores were significantly higher in the observation group than in the control group ($P < 0.05$), as shown in **Table 2**.

Table 2. Results of theoretical and practical examinations for two groups of interns (%)

Group	Theoretical results	Practical results
Observation group (n = 30)	90.40 ± 1.13	89.73 ± 1.17
Control group (n = 30)	86.30 ± 1.09	85.50 ± 1.28
t	14.302	13.359
P	0.000	0.000

3.2. Comparative questionnaire survey on teaching methods among two groups of interns

Following completion of the two internship rotations, trainees in the observation group achieved statistically significantly higher scores than the control group in teaching effectiveness evaluations concerning clinical reasoning ability, diagnostic and therapeutic discernment, anatomical comprehension, and surgical proficiency ($P < 0.05$), as shown in **Table 3**.

Table 3. Survey results on teaching methods from two groups of interns (%)

Group	Clinical reasoning skills	Diagnostic and therapeutic reasoning ability	Anatomical comprehension	Surgical proficiency
Observation group (n = 30)	8.0 ± 0.74	7.83 ± 0.53	8.03 ± 0.56	7.80 ± 0.61
Control group (n = 30)	7.10 ± 0.61	7.40 ± 0.56	7.13 ± 0.63	6.60 ± 0.56
t	5.137	3.067	5.873	7.915
P	0.000	0.003	0.000	0.000

Table 4. Two sets of teaching satisfaction results (%)

Group	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Observation group (n = 30)	4 (13.3%)	8 (26.7%)	10 (33.3%)	5 (16.7%)	3 (10%)
Control group (n = 30)	0 (0.0%)	2 (6.7%)	5 (16.7%)	13 (43.3%)	10 (33.3%)
χ^2			16.591		
P			0.002		

3.3. Comparison of teaching satisfaction outcomes between two groups of interns

Following completion of the rotational training program, teaching satisfaction survey results indicated that interns in the observation group, who underwent instruction using the 3D digital orthopaedic technology teaching model, demonstrated significantly higher satisfaction levels than those in the control group. This difference was statistically significant ($P < 0.05$), as shown in **Table 4**.

4. Discussion

As a significant branch of traditional Chinese medicine, Zhuang medicine has been present since ancient times, as the recognition of human anatomy is fundamental to understanding disease mechanisms. Historical records indicate that the Five Viscera Diagram by Ou, produced in the Lingnan Zhuang region during the Northern Song Dynasty, represents China's earliest extant illustrated anatomical atlas with textual annotations [15]. This work provides remarkably detailed depictions of the structures of the internal organs and their local anatomical characteristics. Furthermore, during the anatomical process, it observes and expounds upon the related etiological and patho-mechanical changes from a medical perspective [16]. This fully demonstrates the long-standing tradition within Zhuang medicine of emphasizing morphological foundations.

In summary, the challenges in achieving effective teaching outcomes in Zhuang medicine trauma surgery primarily stem from the abstract nature of its theoretical framework and the scarcity of high-quality anatomical materials in instruction. The latter has led to an overreliance on anatomical atlases and conventional models, which failed to convey critical anatomical and pathological information in an intuitive and comprehensive manner, thereby limiting students' development of both theoretical knowledge and practical skills [17]. In light of this, 3D-printed models capable of precisely replicating human anatomical details offer a novel approach to resolving these issues, making their exploration and application particularly imperative [18].

Existing research confirms that the selection of clinical teaching methods in orthopedics directly determines medical students' depth of theoretical knowledge and level of practical skills [19]. The emergence of 3D digital orthopedic technology offers novel approaches to reforming orthopedic education [20]. By transforming complex anatomical structures and surgical procedures into visualized, digital, intelligent and interactive models, this technology significantly reduces students' cognitive load. Compared to traditional anatomy reliance on scarce

specimens, 3D models offer convenient acquisition, reusability, and dynamic presentation of pathological features, thereby greatly stimulating students' learning initiative and immersion [21].

Research indicates that this technology demonstrates significant advantages in enhancing the teaching effectiveness and quality of orthopedic trauma training for resident trainees [22]. Moreover, the deep integration of 3D digital orthopedic technology with modern teaching methodologies such as problem-based learning (PBL) and case-based teaching is pivotal to enhancing the quality of clinical internship instruction [23]. In this process, the core role of clinical educators should evolve from knowledge disseminators to learning facilitators and resource designers. By meticulously crafting teaching cases based on 3D models, educators can fully leverage the technology's instructional potential to dynamically expand and enrich the teaching content of Zhuang medicine trauma science. This student-centered, interactive learning environment effectively stimulates curiosity and autonomy, thereby fundamentally improving teaching efficiency and quality.

This study confirms that the observation group employing the 3D digital orthopedic technology teaching model demonstrated significantly superior educational outcomes across all dimensions compared to the traditional teaching model control group ($P < 0.05$). The success of this model lies in its ability to stimulate trainee doctors' proactive learning interest through a visualized and interactive learning environment and, subsequently, deepen their understanding of theoretical knowledge by providing intuitive representations of pathological anatomical relationships. Ultimately, building upon this foundation, this systematically cultivates and enhances their core competencies in clinical reasoning, diagnostic analysis, and surgical techniques. This study demonstrates that the model not only enhances the precision and efficacy of teaching but also provides educators with a powerful tool for pedagogical refinement, possessing significant potential for wider implementation.

Funding

Key Fund Project for Teaching Reform and Research at Guangxi University of Chinese Medicine (Project No.: 2021B036); National Chinese Medicine Superiority Speciality Construction Unit (Zhuang Medicine Orthopedics and Traumatology) State Chinese Medicine Medical Government Letter ([2024] No.: 90); Guangxi Education Science "14th Five-Year Plan" Special Project (Project No.: 2023ZJY567); Guangxi University of Chinese Medicine Doctoral Startup Fund Project (Project No.: 2018BS065)

Disclosure statement

The authors declare no conflict of interest.

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