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Research Article

Application of Human Skeleton Model Teaching in Accelerating the Learning of Orthopedic Surgical Handwashing Coordination for Rotating Nurses

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Abstract

Objective: To explore the application effect of human skeleton model teaching in accelerating the learning of orthopedic surgical handwashing coordination for rotating nurses. **Methods:** Seventy rotating nurses were divided into a control group and an intervention group with 35 nurses in each group based on their rotation schedule. The control group received conventional teaching methods, while the experimental group underwent teaching based on the human skeleton model. The number of surgeries required for the first independent handwashing coordination and the assembly time of external instruments were compared between the two groups. **Results**: The intervention group showed significantly fewer teaching surgeries required for the first independent handwashing coordination and reduced assembly time for external instruments compared to the control group ($P < 0.001$). **Conclusion:** Teaching based on the human skeleton model effectively shortens the learning curve of orthopedic surgical handwashing coordination for rotating nurses and improves their operational proficiency.

Keywords: Human skeletal model; Orthopedic nurse; Operating room; Orthopedic surgery; Scrub assistance

Introduction

Operating room nursing involves interdisciplinary and specialized characteristics, heavy workloads, high intensity, frequent emergency rescues, and requires knowledge of medical anatomy, surgical coordination, and other specialized skills and knowledge [1]. Orthopedic surgery, as a technically demanding and complex surgical specialty in the field of surgery, relies heavily on the close coordination of surgical team members for its successful implementation. Among them, the scrub nurse plays a crucial role in instrument preparation, transmission, and maintenance of sterile areas during the surgical procedure, and their professional ability directly affects surgical efficiency and patient safety [1]. However, the unique complexity of orthopedic surgery, such as the numerous surgical steps, complex types of specialized instruments, and strong three-dimensional anatomical structures, poses significant challenges for rotating nurses to master scrubbing and coordination skills in a short period of time.

In recent years, with the development of medical technology and the innovation of surgical methods, orthopedic surgical instruments have been continuously updated and iterated, and the use of external instruments has become increasingly common [2]. Taking knee replacement surgery as an example, a single surgery may involve more than 100 specialized instruments, and most of the instruments need to be assembled instantly during the operation. This professionalism requirement makes the traditional "mentor-apprentice" teaching model face bottlenecks in training efficiency [3]. Conventional training methods mainly rely on theoretical lectures, surgical observations, and gradual practice, but there

are obvious limitations: Firstly, the two-dimensional teaching method is difficult to accurately convey the three-dimensional anatomical structure [4]. Orthopedic surgery involves complex spatial relationships, and it is impossible to establish accurate three-dimensional cognition for nurses only through atlases or oral descriptions, leading to misjudgements of instrument delivery position and timing in actual operation. Secondly, the problem of insufficient cognition of specialized instruments is prominent. The specialized instrument systems of different manufacturers and different surgical methods are significantly different, and novice nurses often need a long time to familiarize themselves with the names, uses, and assembly methods of various instruments.

In response to these training difficulties, the field of medical education has begun to explore more effective teaching methods. Among them, the application of high-simulation human bone models shows unique advantages. These models can restore the real bone structure at a 1:1 ratio, allowing repeated operational practice and helping learners establish accurate spatial cognition. In orthopedic specialty training, model teaching can provide the following support: dynamically display joint trajectories and bony landmarks; simulate real surgical steps for operational drills; cooperate with specialized instruments for assembly training, etc. Based on this, this study takes knee replacement surgery, which is representative in orthopedic surgery and has a relatively complex coordination process, as an example to explore the application effect of human bone model teaching in accelerating the learning of orthopedic surgery scrubbing and coordination for rotating nurses, providing empirical evidence for optimizing the training program of operating room nurses.

Participants and Methods

Participants

The study population consisted of 70 operating room nurses who rotated through the orthopedic sub-specialty in the operating room of the First Affiliated Hospital of Zhongshan University from December 2023 to March 2025. Inclusion criteria were: bachelor's degree, a three-month rotation in the orthopedic sub-specialty of the operating room, and informed consent. Exclusion criteria included those unable to complete the full rotation due to personal or sick leave.

The 35 nurses who rotated from December 2023 to August 2024 were assigned to the control group, while the 35 nurses who rotated from September 2024 to March 2025 were designated as the intervention group. There were no statistically significant differences in gender or age between the two groups (P>0.05), making them comparable. Detailed information is provided in Table 1.

Group	Number of participants	Gender		Age
		Male	Female	
Control Group	35	2	33	26.94±2.80
Intervention Group	35	4	31	27.66±2.96
χ^2/t-value		0.182		1.038
P-value		0.669		0.303

Table 1: Comparison of general information between two groups of rotating nurses.

Teaching Method

Both groups of rotating operating room nurses spent three months in the orthopedic sub-specialty rotation. Taking knee replacement surgery as an example, based on the characteristics and complexity of orthopedic surgeries, the teaching objectives for orthopedics were set as follows: to familiarize with orthopedic operating room rules and regulations, understand the physiological and anatomical knowledge related to the knee joint, familiarize with the coordination process of knee replacement surgery, master the method of passing conventional surgical instruments, and grasp the assembly method and purpose of external instruments for knee replacement. The mentors for both groups of rotating nurses were the same, and the orthopedic teaching and training team leader was responsible for quality control.

Control Group: Adopting Conventional Teaching Methods

The control group utilized a one-on-one clinical teaching model. The clinical instructors individually introduced the rotating nurses to the department, providing an oral overview of the orthopedic sub-specialty operating rooms, surgical items, and equipment placement. The rotating nurses were guided through the operating room, where they scrubbed in and assisted the clinical instructor during total knee replacement surgeries. During the procedures, the instructor interspersed explanations and demonstrations of orthopedic surgical cooperation based on the actual surgical progress.

Intervention Group: Employing Human Skeleton Model-Based Teaching

Designing the Teaching Plan

In addition to the rotating nurses scrubbing in and assisting the clinical instructor, the teaching plan aimed to fully utilize the clinical resources of the operating room. It incorporated various teaching methods to create a visual clinical orthopedic surgery scenario for immersive training. This integrated classroom instruction with human skeleton models, colored atlases of surgical instruments, PBL group discussions, cooperative group exercises, and interactive video applications.

Implementing the Teaching Plan

Orthopedic Environmental Navigation

The orthopedic training leader first conducted a centralized theoretical lecture using multimedia, introducing the rotating nurses to the overall situation of operating room orthopedic regulations, surgical characteristics, and the environment. This was followed by a guided tour of the actual orthopedic operating rooms, where the leader explained the distribution of surgical rooms, functional zoning, commonly used equipment, and the placement and purposes of surgical items.

Teaching with Colored Atlas of Surgical Instruments

In the early stages of teaching, a colored atlas of orthopedic instruments was created based on different manufacturers and series, visually presenting the shape, structure, name, and quantity of the instruments. Using this atlas, the orthopedic training leader explained the name, specifications, and performance of each surgical instrument in detail, encouraging the rotating nurses to repeatedly flip through the atlas to familiarize themselves with various commonly used orthopedic surgical instruments.

Human Skeleton Model Teaching

A professor from the joint surgery department utilized a human skeleton model to provide visual teaching on knee-related anatomical and physiological knowledge to the rotating nurses. This involved dynamically and intuitively demonstrating knee flexion, extension, varus, and valgus movements, along with vivid explanations of the muscular and ligamentous forces around the knee. This helped the nurses deeply understand the anatomical structure and kinematic characteristics of the knee joint, as well as the indications for knee replacement surgery, laying a foundation for the next step of surgical scenario training.

Clinical Orthopedic Surgery Cooperation Scenario Training

The orthopedic training leader and the joint surgery professor integrated classroom teaching with clinical practice, constructing a realistic clinical cooperation scenario for total knee replacement surgery. Based on the actual needs of clinical knee replacement surgery, the orthopedic training leader prepared relevant items such as joint replacement instruments, external instruments, prosthetic trial molds, and bone power systems. In the operating room, the joint surgery professor performed key surgical steps such as femoral and tibial osteotomy, installation, and reduction of trial molds on a 1:1 scale human skeleton model using an electric saw. This simulated the clinical teaching and practice environment in a time-efficient manner. The orthopedic training leader explained the key points of nursing cooperation according to the corresponding surgical steps, demonstrating the correct assembly, transfer, use, and disassembly methods of conventional surgical tables, external instruments, and tools for knee replacement. This deepened the rotating nurses' understanding of the basic process of knee replacement surgery cooperation and orthopedic external instruments and tools.

Cooperative Group Practice

The rotating nurses were organized into pairs to repeatedly practice the correct assembly, transfer, use, and disassembly of external instruments and tools for knee replacement through mutual observation and error-checking. The orthopedic training leader presided over and controlled the scene, providing targeted feedback to those who were less skilled in the operations, offering further guidance, demonstrations, and practice opportunities.

Evaluation Methods

1 Number of supervised surgeries required for the first independent scrubbing and surgical assistance: Record the number of supervised surgeries needed for rotating nurses to independently complete scrubbing and assistance in knee replacement surgeries for the first time. The cumulative number of supervised surgeries will be recorded after the rotating nurse self-evaluates, the supervising teacher assesses, and the primary surgeon confirms that the standards have been met.

2 Assembly time for orthopedic external instruments during the first independent scrubbing and surgical assistance: The supervising teacher will use a unified timer to record the time taken by the rotating nurse to assemble orthopedic external instruments during their first independent scrubbing and surgical assistance. The timing starts when the rotating nurse first touches the instrument and verbally reports "starting assembly" and ends when they complete the functional verification of the last instrument and verbally report "assembly complete." If delays occur during the assembly process due to non-operator errors (such as missing instruments or equipment failures), the data

will be discarded and reassessed. If the operator makes obvious mistakes due to nervousness (such as dropping instruments), the data will be recorded but not excluded to reflect the true level of independent operation for the first time.

Statistical Methods

SPSS 25.0 was used for data analysis. Quantitative data were expressed as mean ± standard deviation, qualitative data were described by frequency, and comparisons between groups were performed using the t-test and chi-square test. The significance level was set at $\alpha = 0.05$.

Results

 When comparing the required number of teaching cases for handwashing coordination during the first independent surgery between the two groups of rotating nurses, see Table 2. The intervention group required significantly fewer teaching cases for handwashing coordination than the control group ($P < 0.001$).

Group	Number of participants	Number of Teaching Cases for Handwashing Coordination
Control Group	35	8.06±1.28
Intervention Group	36	5.89±1.35
$\chi^{2/}$ t-value		6.912
P-value		＜0.001

Table 2: Comparison of the required number of teaching cases for the first independent handwashing coordination during surgery between the two groups of rotating nurses (cases, ±s).

 When the two groups of rotating nurses performed their first independent handwashing and assisted with surgery, the comparison of orthopedic external instrument assembly time is shown in Table 3. The orthopedic external instrument assembly time for the intervention group was significantly shorter than that of the control group ($P < 0.001$).

Group	Number of participants	Orthopedic outpatient instrument assembly time
Control Group	35	11.34±3.55
Intervention Group	35	5.60±1.38
T-value		8.929
P-value		＜0.001

Table 3: shows the comparison of orthopedic external instrument assembly time between the two groups of rotating nurses during their first independent handwashing and surgical assistance (minutes ± standard deviation).

Discussion

Teaching Based on Human Skeleton Models Effectively Shortens the Learning Curve for Rotating Nurses in Orthopedic Surgical Scrubbing Coordination

The results of this study indicate that a teaching method based on human skeleton models can significantly shorten the learning curve for rotating nurses in orthopedic surgical scrubbing coordination. The intervention group nurses demonstrated significant improvements in the number of teaching cases required for independent surgical coordination and the time taken for instrument assembly compared to the control group ($P<0.001$), confirming the effectiveness of this teaching approach. The reasons for this can be analysed from several perspectives: Firstly, the human skeleton model provides a highly realistic three-dimensional anatomical structure, addressing the difficulty of conveying spatial relationships in traditional two-dimensional teaching [4]. By directly manipulating the model, nurses can intuitively understand bony landmarks, movement trajectories, and key surgical steps of the knee joint, significantly enhancing learning efficiency through this “learning by doing” approach [6]. Secondly, model training allows for repeated practice, overcoming the limited opportunities for hands-on experience in real surgical environments. Nurses can gradually master core skills such as instrument assembly and transfer without time pressure, effectively reducing anxiety for beginners. Furthermore, situational simulation training integrates theoretical knowledge with practical operations, cultivating nurses’ clinical thinking and adaptability through simulated real-world surgical scenarios. Unlike previous studies, this method focuses not only on developing operational skills but also on establishing clinical thinking, enabling rotating nurses to understand the clinical significance of each operational step rather than engaging

in mechanical imitation [7]. This teaching philosophy of "knowing not only how but also why" may be a key factor in shortening the learning curve.

Teaching Based on Human Skeleton Models Effectively Improves Proficiency in Orthopedic External Instrument Operation

This study confirms that a teaching method based on human skeleton models can significantly improve rotating nurses' proficiency in orthopedic external instrument operation. The intervention group nurses performed significantly better in terms of instrument assembly time and operational accuracy compared to the traditional teaching group ($P<0.001$), highlighting the unique value of model-based teaching in specialized instrument training. A deeper analysis of its mechanism of action reveals three main dimensions: Firstly, the human skeleton model provides a precise anatomical reference frame for instrument operation. Orthopedic external instruments such as the "four-in-one" femoral osteotomy plate and tibial plateau osteotomy device have specific anatomical adaptation requirements. Through repeated practice on a 1:1 scale model, nurses can establish a spatial correspondence between the instrument and the anatomical structure, fundamentally understanding the design principles and usage specifications of the instrument. Secondly, model-based teaching enables three-dimensional integrated training of "instrument-anatomy-surgical steps". Unlike traditional teaching, which 孤立ly focuses on memorizing instrument names, rotating nurses can fully simulate the entire process from instrument assembly to intraoperative application on the model. This contextualized learning approach significantly enhances the depth and breadth of instrument cognition [8]. It is particularly noteworthy that the progressive training mode employed in this study effectively addresses the learning challenges of complex instrument systems. Training begins with single-instrument cognition, gradually transitions to modular combinations, and finally completes the operation of the entire instrument system. This layered and progressive design aligns with the cognitive laws of skill mastery [9].

Summary

In this study, teaching based on human skeleton models was implemented in the orthopedic surgical coordination instruction for rotating operating room nurses. This approach effectively shortened the learning curve for rotating nurses in orthopedic surgical scrubbing coordination and improved their proficiency in orthopedic external instrument operation. During the application process, it was found that this teaching method has high requirements for teaching hardware resources and the overall quality of instructors. In the future, it can be further optimized by combining virtual reality **(VR)** technology to enhance operating room nursing education and training mechanisms, promoting the professional development of clinical nursing and nursing talent cultivation

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References

1. Wenjing Y, Heyu W, Qi Z, et al. (2023) Training Practice of Rotating Nurses in Orthopedic Sub-specialty of Operating Room Based on Enabling Evaluation. Journal of Nursing Science. 38: 59-62.
2. Pagan CA, Karasavvidis T, Cohen-Rosenblum AR, Hannon CP, Lombardi AV, et al. (2024) Technology in Total Knee Arthroplasty in 2023. J Arthroplasty 39 :S54-S59.
3. Yingying Z, Ying S, Li (2019) A Qualitative Study on the Real Experience of Rotating Intern Nurses in the Operating Room during Surgical Cooperation. Guangxi Medical Journal. 41: 662-664.
4. Yan M, Huang J, Ding M, Wang J, Ni J, et al. (2023) Three-Dimensional Printing Model Enhances Correct Identification and Understanding of Pelvic Fracture in Medical Students. J Surg Educ 80: 331-337.
5. Feng X, Tan J, Song Q, et al. (2015) Application of Urological Endoscopic Instrument Plastic Atlas in Instrument Handover. Journal of Nursing Science. 30: 9-10.
6. Chen Rui, Li Jing, Chen Fo, et al. (2022) The Influence of Flipped Classroom Based on CDIO Concept on the Teaching Effect of Rotating Nurses in Operating Room. Journal of Nursing Science. 37:70-73.
7. Singh A, Ferry D, Balasubramanian S (2019) Efficacy of Clinical Simulation-Based Training in Biomedical Engineering Education. J Biomech Eng 141:121011- 121011-7.
8. Choi J, Thompson CE, Choi J, Waddill CB, Choi S (2022) Effectiveness of Immersive Virtual Reality in Nursing Education: Systematic Review. Nurse Educ 47: E57-E61.
9. Xia Z, Shiqin P (2021) Application Effect of TBL Collaboration Mode Based on Learning Pyramid Theory in Teaching Rounds of Standardized Training Nurses in ICU. Nursing Research, 35: 4294-4297.