

Motion graphic video-based training and its effect on scrub nurse performance during dynamic hip screw surgery in Iran: a pilot randomized controlled trial

Reza Feizi

Iran University of Medical Sciences

Ashkan Karimi

Shahid Beheshti University of Medical Sciences

Reza Tavakkol

Torbat Heydariyeh University of Medical Sciences

Amir Arsalan Saeedi

Gerash University of Medical Sciences

Hamed Parnikh

hamedparnikh33@gmail.com

Arak University of Medical Sciences

Research Article

Keywords: Operating room nursing, Education nursing, Femoral neck fractures, Bone screws, Pilot randomized controlled trial

Posted Date: August 18th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10113784/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Clinical education in the operating room for complex orthopedic procedures such as dynamic hip screw (DHS) fixation is challenging due to limited visibility and high technical demands. This pilot study evaluated the effect of motion graphic video-based training on the performance of operating room technology students during proximal femur fracture surgery.

Methods

This pilot randomized controlled trial was conducted at Valiasr Hospital, Arak University of Medical Sciences, Iran, from December 2024 to July 2025. A total of 30 operating room technology students in their 6th or 8th semester were randomly assigned to intervention ($n = 15$) and control ($n = 15$) groups using block randomization. Both groups received routine clinical training from the same instructor. The intervention group additionally viewed a 15-minute motion graphic video demonstrating DHS surgical steps. Students' performance as first scrub nurse was assessed before and after a 15-day training period by a blinded evaluator using a validated 43-item checklist (CVI = 1, CVR = 0.95, Cronbach's $\alpha = 0.90$). Data were analyzed using paired and independent t-tests in SPSS version 22. Effect sizes (Cohen's d) were calculated for between-group comparisons.

Results

Both groups showed significant improvement from pre-test to post-test (control: 62.00 ± 9.6 to 79.30 ± 2.45 ; intervention: 62.5 ± 6.45 to 77.8 ± 3.88 ; $P < 0.001$). No significant differences were found between groups in pre-test ($P = 0.893$) or post-test ($P = 0.685$) scores. The between-group effect size for post-test scores was Cohen's $d = 0.34$ (95% CI: 0.38 to -1.06).

Conclusion

This pilot study provides preliminary evidence that motion graphic-based training improves students' skills but was not superior to routine instruction. The observed effect size (Cohen's $d = 0.34$) suggests that a definitive trial with approximately 150 participants (75 per group) would be adequately powered to detect clinically meaningful differences. Direct clinical experience and real-time feedback appear to play a dominant role in developing psychomotor competence. The feasibility of the intervention, recruitment, and outcome measurement was successfully demonstrated, supporting progression to a larger-scale trial.

Trial registration:

Background

Clinical education in the operating room is a key component in the training of operating room technology students. The OR environment is not only a place for performing complex therapeutic interventions, but also provides a setting for practical learning, clinical decision-making, and interdisciplinary interaction [1]. Students face challenges in learning surgical procedures, such as limited direct observation of surgical steps and psychological pressure due to the stressful OR atmosphere [2]. Studies have shown that most errors in the OR occur during the early stages of learning, primarily due to learners' insufficient knowledge [3].

Proximal femur fractures, especially in the elderly, are common and costly injuries in the healthcare system, with a rising global incidence. Estimates suggest that the annual number of these fractures will exceed 4.5 million cases by 2050 [4]. Proximal femur fractures are classified anatomically into femoral neck, intertrochanteric, and subtrochanteric types, each with different clinical features, surgical methods, and prognoses [5]. Intertrochanteric fractures are typically treated with internal fixation, with the most common techniques being dynamic hip screw (DHS) or intramedullary nailing. DHS is considered a cost-effective and reliable option due to its lower cost and greater surgeon familiarity with the technique [6].

Inappropriate technique and failure to adhere to aseptic principles in DHS surgery can lead to complications such as infection, nonunion, or screw cut-out [7]. Proper training in surgical technique and aseptic principles to reduce postoperative complications is a priority for the healthcare system [8]. However, students in orthopedic internships have limited understanding of this procedure due to the complexity of hip anatomy, limited surgical opportunities, and the need for high precision in implant placement. Studies indicate that the use of surgical simulators, step-by-step training, and structured feedback can significantly enhance the quality of learning for hip surgical techniques such as DHS [9].

Motion graphics, as a modern visual communication tool combining graphic design, animation, and sound, play an important role in conveying complex concepts in a simple and engaging manner. The use of this combination in educational settings increases concentration, understanding of abstract concepts, and more active student interaction with content [10]. Research has shown that using motion graphic videos in education, particularly in medical sciences, improves conceptual learning and enhances information retention in students. This method, by activating multisensory learning, can be an effective alternative to traditional theoretical teaching methods [11].

Objectives

The present study aimed to determine the effect of motion graphic video-based training on the performance of operating room technology students as scrub nurses in proximal femur fracture surgery

using DHS at Arak University of Medical Sciences. The hypothesis was that using motion graphic videos as an educational tool would improve students' clinical skills.

Methods

Study design

This was a pilot randomized controlled trial designed and reported in accordance with the CONSORT guidelines for pilot and feasibility trials. Given the exploratory nature of this study and the limited number of eligible students during the study period, a sample size of 30 participants (15 per group) was considered sufficient for a pilot study to estimate effect sizes and inform future definitive trials. After meeting the inclusion criteria, participants were assigned to intervention and control groups using block randomization with a computer-generated random numbers table. Allocation was performed by a researcher not involved in outcome assessment. The primary outcome was students' performance scores based on the skills checklist before and after the intervention. The CONSORT checklist for pilot trials is provided as Additional file 1. The trial was retrospectively registered at ClinicalTrials.gov(NCT07701564); first submitted on July 1, 2026.

Setting

This study included a pre-test and post-test design with a control group. It began on December 21, 2024, and concluded on July 22, 2025, at Valiasr Teaching Hospital, Arak University of Medical Sciences.

Participants

Participants were all 6th- and 8th-semester undergraduate operating room technology students at Arak University of Medical Sciences in the 2024–2025 academic year.

Inclusion criteria were: being a 6th- or 8th-semester undergraduate operating room technology student, having completed the theoretical course (orthopedic operating room technology and care), and willingness to participate.

Exclusion criteria were: withdrawal or unwillingness to continue cooperation at any stage, prior clinical experience in orthopedics that could affect results, and absenteeism or insufficient presence during the internship.

Interventions

Students were randomly assigned to intervention and control groups. Both groups received routine training on the proximal femur fracture surgery procedure using DHS from a single instructor at the beginning of the course.

In the control group, students' practical skills as first scrub nurse were assessed twice: the first assessment on the first day of internship after performing the scrub role, and the second assessment at the end of the 15-day internship. These assessments were conducted using a researcher-made checklist by an independent evaluator blinded to group allocation.

In the intervention group, on the first day after receiving routine training similar to the control group, an initial assessment was performed by the same blinded evaluator. Then, a 15-minute motion graphic video was provided to students, which they could watch unlimited times. This video, combining film and animation, visually taught the steps of proximal femur fracture surgery using the DHS technique. Video content included introduction of surgical instruments, anatomy review, surgical table setup, patient preparation and draping, and instrument delivery to the surgeon.

After watching the video, students in the intervention group attended the OR and performed the role of first scrub nurse. At the end of the 15-day internship, their performance was reassessed by the same blinded evaluator.

To prevent contamination between groups, the control group was enrolled first. Intervention group students were asked not to discuss the educational video with other students. To ensure educational equity, the video was provided to the control group after study completion.

Outcomes

In this study, the following outcomes were investigated: demographic characteristics and the intervention and control groups' scores for performance as operating room nurse students in proximal femur fracture surgery with a checklist.

Data sources/measurement

To assess students' performance as first scrub nurse during DHS surgery, a researcher-made checklist was developed. This instrument included 43 items distributed across three clinical phases:

- **Preoperative phase (13 items):** evaluating proper gowning and gloving (closed-gloving technique), identification of basic orthopedic and DHS-specific instruments, arrangement of surgical table supplies, accurate counting of gauze/needles/instruments, awareness of table and scrub nurse positioning, skin preparation with green povidone-iodine, surgical draping, application of adhesive sterile drape, donning of the second pair of gloves (open-gloving), fixation of suction tubing and electrocautery pencil, and draping of the C-arm machine.
- **Intraoperative phase (24 items):** assessing the correct handover of surgical instruments including scalpel blades (No. 1 and No. 2), Farabeuf retractors, Metzenbaum scissors, Roux and Bent retractors, DHS angle guide, guide pin and drill for guidewire insertion, instruments for measuring Lag Screw length, Triple Reamer preparation, nail and Side Plate handover with appropriate size,

Thamp and mallet, drill with 3.2 mm bit, Depth Gauge, identification and selection of screws (Side Plate screws, Compression Screw), appropriate screwdrivers, drain (Hemovac) selection, and sutures for fascial (Vicryl round needle), subcutaneous (Vicryl cutting needle), and drain fixation (Silk cutting needle).

- **Postoperative phase (6 items):** covering drain fixation, selection of appropriate suture for skin closure (Nylon cutting needle) and skin suturing technique, proper dressing of the skin and drain site, disposal of sharp instruments in the safety box, and correct handover of instruments to the Central Sterile Supply Department (CSSD).

Each item was scored on a 3-point scale: 0 = does not perform, 1 = performs incompletely, and 2 = performs correctly. Thus, total scores ranged from 0 to 86.

For content validity, the initial version was reviewed by 10 faculty members of operating room departments from various Iranian universities of medical sciences. After applying suggested modifications, content validity was confirmed with a Content Validity Index (CVI) of 1.0 and a Content Validity Ratio (CVR) of 0.95. Reliability was confirmed with Cronbach's α of 0.90, indicating excellent internal consistency. The checklist was also pilot-tested before the main study to assess clarity and feasibility.

Study size

Due to the limited number of eligible operating room technology students during the study period and the exploratory nature of this investigation, a conventional sample size of 30 participants (15 per group) was determined for this pilot study. This sample size is consistent with recommendations for pilot randomized controlled trials in educational interventions, which typically require 10–15 participants per group to estimate effect sizes, assess feasibility, and inform sample size calculations for future larger-scale studies [12]. After data collection, a post-hoc power analysis based on the primary outcome demonstrated a statistical power of 0.80 for detecting within-group changes. However, the small sample size remains a limitation and may reduce the ability to detect small between-group differences. The results of this pilot study should be interpreted with caution and will inform the design of future definitive trials with adequate statistical power. Based on the observed effect size (Cohen's $d = 0.34$ from the between-group comparison), a power calculation ($\alpha = 0.05$, power = 0.80, two-tailed) indicates that a future definitive trial would require approximately 150 participants (75 per group) to detect a statistically significant difference between groups.

Randomization

For allocation to intervention and control groups, block randomization with a computer-generated random numbers list was used. The list was prepared by a statistical consultant, and participants were allocated in pairs randomly to minimize selection bias. Of the 30 eligible students, 15 were allocated to each group.

Blinding

The outcome assessor was blinded to group allocation. However, due to the nature of the educational intervention, participants and the instructor could not be blinded.

Statistical methods

Descriptive and inferential statistics were used for data analysis. Descriptive indices including mean, standard deviation, minimum, maximum, and frequency described participant characteristics and performance scores. Before comparative tests, normality of score distribution was assessed using the Kolmogorov–Smirnov test. Results showed that pre-test and post-test score distributions in both groups followed a normal pattern ($p > 0.05$).

Paired t-tests were used to compare performance within each group before and after intervention. Independent t-tests were used to compare mean scores between groups. Before independent t-tests, homogeneity of variances was assessed using Levene's test, which confirmed equality of variances ($p > 0.05$). Significance level for all analyses was set at 0.05. All statistical analyses were performed using SPSS version 22.

In addition to null hypothesis significance testing, **effect sizes (Cohen's d)** were calculated for between-group comparisons to provide a meaningful measure of the magnitude of the intervention effect, which is particularly important for this pilot study. Cohen's d was interpreted as: 0.2 = small, 0.5 = medium, and 0.8 = large effect. The 95% confidence intervals for Cohen's d were also reported to indicate the precision of the estimates.

Results

Participant flow

A total of 30 students participated in this pilot study. Of these, 24 (80%) were female and 6 (20%) male. Semester distribution was equal between 6th and 8th semesters (15 students each, 50%). Mean age was 22.5 years (range 21–31). Chi-square tests showed no significant differences between groups in gender, marital status, or semester. Independent t-tests showed no significant differences in mean age or grade point average between groups. Thus, groups were homogeneous in baseline characteristics (Table 1).

Table 1
Demographic characteristics of the research samples in the control and intervention groups

Characteristic	Total	Group		P-value
		Intervention(n = 15)	Control(n = 15)	
Gender				0.674
Female	24(80%)	12(80%)	12(80%)	
Male	6(20%)	3(20%)	3(20%)	
Total	30	15	15	
Semester				1.00
6	15	8(53.3%)	7(46.7%)	
8	15	7(46.7%)	8(53.3%)	
Total		15	15	
Age(year)		22.3 ± 2.81	22.7 ± 2.45	0.802
Grade point average		16.93 ± 1.18	17.03 ± 1.07	0.798

*Values are presented as number (%) or mean±standard deviation.

Main results

Intra-group comparison:

The Kolmogorov–Smirnov test confirmed normal distribution of pre-test and post-test scores in both groups ($p > 0.05$).

Intervention group: Mean performance scores increased from 62.5 ± 6.45 at pre-test to 77.8 ± 3.88 at post-test. Paired t-test showed this increase was statistically significant ($t = -7.347$, $p < 0.001$).

Control group: Mean performance scores increased from 62.00 ± 9.6 at pre-test to 79.30 ± 2.45 at post-test. This change was also statistically significant ($t = -6.108$, $p < 0.001$).

These results indicate that both groups showed significant improvement during the internship (Table 2).

Table 2. Intra-group comparison of pre- and post-test performance scores of operating room nurse students in DHS surgery between the control and intervention groups

Group	Mean $\pm$ SD ^a	t-value	P-value [*]
Control		-6.108	0.001
Pre-test	9.6 $\pm$ 62.0		
Post-test	2.45 $\pm$ 79.30		
Intervention			
Pre-test	6.45 $\pm$ 62.5	7.347-	0.001
Post-test	3.88 $\pm$ 77.8		

^aSD, standard deviation.

^{*}Statistical significance was set at P-value < 0.0

Interroup comparison:

Pre-test: Independent t-test showed no significant difference in pre-test scores between groups (p = 0.852).

Post-test: Independent t-test for post-test scores also showed no significant difference between groups (p = 0.357).

Levene's test confirmed homogeneity of variances for both phases (p > 0.05). These findings indicate that although both groups improved, motion graphic-based training did not show statistically significant superiority over routine training (Table 3).

Table 3

Intergroup comparison of pre and post-test performance scores of operating room nurse students in DHS surgery between the control and intervention groups

Phase	Intervention (Mean $\pm$ SD ^a)	Control (Mean $\pm$ SD)	t-value(^b df=28)	P-value [*]	Cohen's d (95% ^c CI)
Pre-test	62.33 $\pm$ 6.52	61.80 $\pm$ 8.95	-0.188	0.852	-0.07 (- 0.78 to 0.65)
Post-test	78.13 $\pm$ 3.60	79.47 $\pm$ 3.60	0.934	0.357	0.34 (- 0.38 to 1.06)

^aSD, standard deviation; ^cCI, confidence interval, ^bdf; degrees of freedom.

Statistical significance was set at P-value < 0.05^{*}

Effect size analysis:

The between-group effect size (Cohen's d) for the post-test scores was 0.34 (95% CI: -0.38 to 1.06), indicating a small-to-moderate effect in favor of the control group, although this was not statistically

significant ($P = 0.357$). The wide confidence interval reflects the uncertainty associated with the small sample size and suggests that the true effect could range from a moderate effect favoring the control group to a small effect favoring the intervention group. This effect size estimate will inform the sample size calculation for a future definitive trial.

Discussion

Key results

This pilot study aimed to investigate the effect of motion graphic video-based training on the performance of operating room technology students in proximal femur fracture surgery. Results showed that both intervention and control groups significantly improved their performance after the orthopedic internship, but the degree of improvement did not differ significantly between groups. As a pilot study with a limited sample size, the findings of this investigation should be interpreted with caution. The primary objective was to estimate the potential effect size and feasibility of motion graphic-based training in this context, rather than to definitively establish superiority over routine training. Nevertheless, the results provide valuable preliminary data that can inform the design of future adequately powered randomized controlled trials.

The lack of statistically significant difference should not be interpreted as ineffectiveness of motion graphic training; rather, it may reflect the dominant role of real clinical exposure, repeated practical exercise, and direct instructor feedback in shaping students' psychomotor skills.

Interpretation

The absence of a significant difference between groups can be explained by the nature of the skills assessed. DHS surgery involves a set of practical skills, motor coordination, real-time decision-making, and mastery of multiple instruments—skills typically enhanced through active OR presence and direct interaction with instructors. Therefore, watching an educational video alone cannot replace real clinical experience. The improvement in the control group also indicates that repeated exposure to the surgical environment, receiving feedback from instructors, and increased familiarity with procedures play important roles in enhancing clinical skills. This highlights the importance of practical experience and learning through observation and participation.

Feasibility assessment

This pilot study successfully demonstrated feasibility across several key domains. First, **recruitment** was feasible, with 30 eligible students enrolled within the study period, representing 100% of the available cohort. Second, **intervention delivery** was successfully implemented, with all students in the intervention group watching the 15-minute motion graphic video and having unlimited access to it. Third, **outcome measurement** was feasible, as the 43-item checklist demonstrated excellent psychometric properties ($CVI = 1$, $CVR = 0.95$, Cronbach's $\alpha = 0.90$) and was completed for all participants at both time points.

Fourth, no major **barriers to implementation** were identified, and contamination between groups was successfully prevented through sequential enrollment.

Comparison with previous studies

Our findings are not consistent with some previous studies reporting positive effects of multimedia education. For instance, Fatahi et al. showed that using motion graphics in cataract surgery training significantly improved student performance and was superior to routine training [13]. Motamedzadeh et al. [14] also reported that multimedia content can enhance learning and retention in operating room students. International studies confirm this trend; for example, Klefodimos emphasized the role of animated videos in increasing attention and improving information retention [11].

In contrast, some studies have reported findings similar to ours. For example, De Boey et al. in hip surgery education reported that although educational videos are useful for understanding surgical steps, they are insufficient for acquiring practical skills, and students still need real practice [9]. Similarly, Rao et al. emphasized that learning surgical skills depends primarily on practical interaction, teamwork, and direct feedback [15]. Sonoda et al. also showed that operating room nurses' performance is more influenced by real workplace experience than by theoretical or multimedia training [16].

The discrepancy between our results and studies reporting positive effects likely relates to the nature of the skills assessed. Orthopedic skills, especially in DHS surgery, require motor coordination, speed, and familiarity with multiple instruments—skills that cannot be replaced by video observation alone. Additionally, the limited sample size and relative similarity between routine training content and video content may have reduced the intervention effect in this pilot study.

Implications for future definitive trial

Based on the findings of this pilot study, proceeding to a full-scale randomized controlled trial is warranted. The observed effect size for the between-group difference in post-test scores was **Cohen's $d = 0.34$** , which is considered a small-to-moderate effect. Using this effect size, a power calculation ($\alpha = 0.05$, power = 0.80, two-tailed) indicates that a future definitive trial would require approximately **150 participants (75 per group)** to detect a statistically significant difference between groups.

Several modifications are recommended for the future trial:

- **Enhanced intervention:** Consider using interactive motion graphics with embedded questions or combining the video with hands-on simulation sessions to potentially increase the intervention effect.
- **Longer follow-up:** Add a follow-up assessment at 1–3 months post-intervention to evaluate skill retention.
- **Multi-center design:** Involving multiple training centers would enhance generalizability.
- **Blinding:** Consider blinding of participants and instructors where feasible.

Limitations

Several limitations should be acknowledged. First, the relatively small sample size (30 participants) is a major limitation of this pilot study, which may have limited statistical power to detect small but clinically meaningful differences between groups. The sample size was determined based on the feasibility and availability of eligible students during the study period, and the results should be considered preliminary. Second, the census sampling method may limit generalizability to other settings or populations. Third, the short duration of the intervention (15 days) may not have been sufficient to fully capture the potential benefits of motion graphic training, particularly for long-term skill retention. Fourth, the single-center design limits external validity. Future multi-center studies with larger sample sizes and longer follow-up periods are recommended to confirm these preliminary findings.

Generalizability

Despite limitations, these findings can be useful for educational planning in operating room technology programs. In settings with limited surgical observation opportunities or large student numbers, motion graphic videos can serve as a valuable supplementary tool. However, when students have the opportunity for active OR participation and direct feedback from instructors, this method alone cannot replace practical training.

Conclusion

This pilot randomized controlled trial provides preliminary evidence that motion graphic video-based training improves the performance of operating room technology students as scrub nurses during DHS surgery. However, it did not demonstrate statistically significant superiority over routine instructor-led training.

Feasibility assessment

The study successfully demonstrated feasibility in terms of participant recruitment (30 students enrolled within the study period), intervention delivery (15-minute motion graphic video with unlimited access), and outcome measurement (validated 43-item checklist with excellent psychometric properties). No major barriers to implementation were identified.

Progression decision

Based on these findings, proceeding to a definitive full-scale randomized controlled trial is warranted. However, several modifications are recommended for the future trial

- **Sample size:** The observed effect size (Cohen's $d = 0.46$ for between-group difference) indicates that a future study would require approximately **150 participants (75 per group)** to achieve 80% power with $\alpha = 0.05$ for detecting a clinically meaningful difference. This calculation should inform the sample size for the definitive trial.

- **Intervention enhancement:** To potentially increase the intervention effect, future studies could consider using **interactive motion graphics** with embedded questions, or combining the video with **hands-on simulation sessions**.
- **Longer follow-up:** A follow-up assessment at 1–3 months post-intervention should be added to evaluate **skill retention**.
- **Multi-center design:** Involving multiple training centers would enhance generalizability.

Final statement

The findings of this pilot study suggest that motion graphic videos can serve as a valuable supplementary educational tool in settings with limited OR observation opportunities. However, they cannot replace direct clinical experience and real-time feedback. The results of this pilot will inform the design of a future definitive trial with adequate statistical power to confirm or refute these preliminary findings.

Abbreviations

DHS

Dynamic Hip Screw

OR

Operating Room

CVI

Content Validity Index

CVR

Content Validity Ratio

CSSD

Central Sterile Supply Department

CONSORT

Consolidated Standards of Reporting Trials

GPA

Grade Point Average

SD

Standard Deviation

CI

Confidence Interval

SPSS

Statistical Package for the Social Sciences

Declarations

Ethics approval and consent to participate

This study was conducted after receiving approval from the Ethics Committee of Arak University of Medical Sciences (code: IR.ARAKMU.REC.1403.219). Written informed consent was obtained from all participants, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

No potential conflict of interest relevant to this article was reported.

Funding

None.

Author Contribution

Conceptualization: Hamed Parnikh

Data curation: Reza Feizi

Methodology/formal analysis/validation: Reza Tavakkol, Ashkan Karimi Project administration: Hamed Parnikh

Funding acquisition: Reza Feizi

Writing – original draft: Ashkan Karimi

Writing – review & editing: Amir Arsalan Saeedi

All authors read and approved the final manuscript.

Acknowledgments

None.

Data Availability

The datasets generated and/or analysed during the current study are not publicly available due to privacy and ethical considerations but are available from the corresponding author on reasonable request.

References

1. Carifa L, Janiszewski Goodin H. Using games to provide interactive perioperative education. *AORN J*. 2011;94(4):370–6. 10.1016/j.aorn.2011.01.018.
2. Roshanzadeh M, Shirvani M, Tajabadi A, Khalilzadeh MH, Mohammadi S. The clinical learning challenge of surgery technologist students: a qualitative content analysis. *Payavard Salamat*. 2022;16(2):102–12.
3. Krishnan S, Kumar N, Diaz E, Thornton I, Ghoddoussi F, Ellis TA 2. Anesthesiology handoff simulation case: a handoff from intensive care unit to operating room for anesthesiology learners. *MedEdPORTAL*. 2020;16:10887. 10.15766/mep_2374-8265.10887.
4. Bedi A, Toan Le T. Subtrochanteric femur fractures. *Orthop Clin North Am*. 2004;35(4):473–83. 10.1016/j.ocl.2004.05.006.
5. Kani KK, Porrino JA, Mulcahy H, Chew FS. Fragility fractures of the proximal femur: review and update for radiologists. *Skeletal Radiol*. 2019;48(1):29–45. 10.1007/s00256-018-3065-4.
6. Azar FM, Canale ST, Beaty JH. *Campbell's Operative Orthopaedics*. 13th ed. Philadelphia: Elsevier; 2016.
7. Kim WY, Han CH, Park JI, Kim JY. Failure of intertrochanteric fracture fixation with a dynamic hip screw in relation to pre-operative fracture stability and osteoporosis. *Int Orthop*. 2001;25(6):360–2. 10.1007/s002640100292.
8. World Health Organization. *WHO Guidelines for Safe Surgery 2009: Safe Surgery Saves Lives*. Geneva: WHO; 2009.
9. De Boey S, Maes M, Mertens P. Teaching hip surgery to orthopaedic residents: what's new? *Hip Int*. 2020;30(1suppl):42–7. 10.1177/1120700020966815.
10. Mustafa B. Impact effect of using computer graphics animation in education. 2023;5:1–12.
11. Kleftodimos A. Computer-animated videos in education: a comprehensive review and teacher experiences from animation creation. *Digital*. 2024;4(3):613–47. 10.3390/digital4030031.
12. Lancaster GA, Dodd S, Williamson PR. Design and analysis of pilot studies: recommendations for good practice. *J Eval Clin Pract*. 2004;10(2):307–12. 10.1111/j.2002.384.doc.x.
13. Fatahi B, Fatahi S, Nosrati S, Bagheri M. Effect of motion-graphic video-based training on the performance of operating room nurse students in cataract surgery in Iran: a randomized controlled study. *J Educ Eval Health Prof*. 2023;20:23. 10.3352/jeehp.2023.20.23.
14. Motamedzadeh M, Mahmoudi H, Ebadi A, Rahmani R. Impact of multimedia educational content on learning and retention of operating room students. *J Med Educ Dev*. 2019;12(3):215–26.
15. Rao R, Dumon KR, Neylan CJ, Morris JB, Riddle EW, Sensenig R, et al. Can simulated team tasks be used to improve nontechnical skills in the operating room? *J Surg Educ*. 2016;73(6):e42–7.

10.1016/j.jsurg.2016.06.015.

16. Sonoda Y, Onozuka D, Hagihara A. Factors related to teamwork performance and stress of operating room nurses. J Nurs Manag. 2018;26(1):66–73. 10.1111/jonm.12522.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [CONSORT2010FlowDiagramMSWord.doc](#)
- [CONSORTextensionPilotandFeasibilityTrialsChecklist.doc](#)
- [Checklist.docx](#)