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Impact of Implementing a Surgical Anatomy Study Guide on Knowledge Level of Operating Room Technology Students: An Assessment of Knowledge Changes

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A B S T R A C T

Introduction: Surgical anatomy is central to safe perioperative practice, yet evidence on how it is best taught to operating room technology students remains limited. Structured study guides are promising tools for improving retention and clinically oriented learning, but their effectiveness in this specific learner population is understudied. This study therefore assessed the effect of implementing a surgical anatomy study guide on operating room technology students' knowledge level.

Material and methods: This interventional study employed a Solomon four-group design among 60 undergraduate operating room technology students selected through census sampling. Participants were randomly assigned to intervention or control groups. Intervention groups received a surgical anatomy study guide during a six-week clinical training period, whereas controls followed routine instruction. Knowledge was assessed using 20-item multiple-choice tests administered before and after the intervention.

Results: Knowledge scores were higher in the intervention groups than in the control groups, with the highest mean observed in the intervention-only group (25.50±7.044 vs 13.50±3.564, 11.82±2.183, and 21.80±6.361). Among pre-tested participants, MCQ scores were significantly higher in the intervention group than in the control group (mean difference=−9.98; t=−4.97, df=24, p<0.001), while variance homogeneity was not significantly violated (Levene's F=4.17, p=0.052).

Conclusion: Implementing a surgical anatomy study guide significantly improved the knowledge level of operating room technology students, as evidenced by markedly higher MCQ scores in the intervention groups compared with controls. These findings support integrating structured study guides into operating room technology education. Further research with larger samples and longitudinal designs is recommended.

Introduction

Surgical anatomy occupies a uniquely consequential position within the broader landscape of the anatomical sciences. Unlike the descriptive anatomy taught in traditional medical curricula, surgical anatomy is explicitly oriented toward clinical application, emphasizing the spatial relationships, tissue planes, and vascular and neural structures that surgeons must anticipate before, during, and after an operative procedure [1].

This applied orientation demands that learners not merely recognize structures but reason about them in three dimensions, under conditions of time pressure, altered anatomy, and the physiological stress of the operating theater. Consequently, the manner in which surgical anatomy is taught and learned has become a subject of sustained pedagogical inquiry, with educators increasingly questioning whether conventional lecture-based

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instruction adequately prepares students for the cognitive demands of the surgical environment [2].

Operating room technology is a comparatively young yet rapidly professionalizing allied health discipline. Practitioners in this field function as integral members of the surgical team, responsible for the preparation of sterile fields, the management of instruments, and the anticipation of the surgeon's needs throughout a procedure. This role requires a working command of surgical anatomy that differs in character from that required of physicians: it is less concerned with diagnosis and more concerned with the practical recognition of structures, the logic of surgical exposure, and the safe handling of tissues and equipment [3]. As the scope of practice for operating room technologists has expanded in many health systems, so too has the expectation that their foundational education will impart a genuinely functional, rather than merely nominative, knowledge of human anatomy [4].

Despite the centrality of anatomy to the operating room technologist's role, the evidence concerning how this subject is best delivered within undergraduate programs remains fragmented and inconclusive. Across the health professions, anatomy education has undergone a pronounced shift over the past two decades, moving away from exhaustive, fact-dense curricula toward approaches that emphasize clinically relevant, cognitively integrated learning [5]. This transformation has been driven partly by reductions in curricular time, partly by the emergence of digital and three-dimensional teaching resources, and partly by a growing recognition that retention of anatomical knowledge is optimized when content is encountered in a manner that mirrors its eventual clinical use [6]. Yet the specific implications of these trends for operating room technology education have received comparatively little empirical attention, leaving program directors with limited guidance when designing anatomy courses for this learner population.

A persistent and well-documented challenge in anatomy education is the decay of knowledge over time. Longitudinal studies have repeatedly demonstrated that students retain only a fraction of the anatomical detail they are taught, with the steepest declines occurring in the months following initial instruction [7]. This phenomenon of knowledge attrition is of particular concern for operating room technology students, whose professional duties demand the rapid and accurate recall of anatomical relationships in high-stakes settings. The problem is compounded by the fact that traditional assessment practices, which frequently reward short-term memorization immediately before examinations, may overestimate the depth and durability of student learning [8]. In response, educators have increasingly advocated for instructional strategies that promote spaced repetition, active recall, and the application of knowledge to authentic clinical scenarios as means of counteracting attrition and fostering more enduring understanding [9].

Among the pedagogical tools that have been proposed to address these challenges, structured study guides have attracted considerable interest. A study guide, in its most effective form, is not merely a condensed summary of course content but a deliberately designed instructional scaffold that directs the learner's attention toward the most clinically salient material, organizes it within a coherent conceptual framework, and provides opportunities for self-assessment [10]. When well-constructed, study guides can serve to align student effort with the learning objectives of a course, reduce the cognitive load associated with navigating large volumes of information, and support the metacognitive processes that underlie self-regulated learning [11]. However, the effectiveness of study guides is not guaranteed by their mere existence; their impact depends heavily on their design quality, their integration with other instructional activities, and the extent to which students engage with them meaningfully rather than superficially [12].

Within the specific context of surgical anatomy, the potential value of a well-designed study guide is especially pronounced. Surgical anatomy courses typically confront students with an extensive and technically demanding body of material, much of which is presented in the abstract before students have had substantial clinical exposure. A study guide tailored to surgical anatomy can foreground the relationships and landmarks that matter most in practice, thereby helping students to distinguish essential from peripheral content [13]. Moreover, by presenting anatomical information in a manner organized around surgical procedures and approaches rather than purely around regional or systemic classifications, such a guide may facilitate the transfer of knowledge from the classroom to the operating room a transfer that is frequently identified as a weak point in clinically oriented education [14].

Nevertheless, the empirical evidence specifically addressing the use of study guides in surgical anatomy education for operating room technology students remains sparse. Most existing research has been conducted among medical students or within the broader allied health context, and the findings, while generally encouraging, have not been uniformly positive. Some studies report measurable gains in examination performance and long-term retention following the introduction of structured guides, whereas others find more modest or negligible effects, often attributed to variable levels of student compliance. This heterogeneity underscores the need for context-specific investigation rather than the wholesale extrapolation of findings from one learner population to another.

The distinctive professional orientation, prior preparation, and motivational profile of operating room technology students warrant dedicated study of how a surgical anatomy study guide influences their learning outcomes [15].

The present study was designed to address this gap in the literature. Given the central importance of anatomical competence to safe and effective perioperative practice, and given the ongoing debates concerning optimal instructional methods in this field, an examination of a structured surgical anatomy study guide within an undergraduate operating room technology program offers both theoretical and practical value. The aim of this study was to determine the effect of implementing a surgical anatomy study guide on the knowledge level of operating room technology students, through a quantitative assessment of changes in their anatomical knowledge.

Material and methods

Study Design

This study was an interventional, quasi-experimental investigation designed to evaluate the effect of implementing a surgical anatomy study guide on the knowledge level of undergraduate operating room technology students. A Solomon four-group design was used to minimize the influence of testing effects and to strengthen the validity of the findings. The study was conducted over a 14-week period in the Faculty of Nursing and Midwifery and affiliated educational hospitals of Tabriz University of Medical Sciences, where the intervention and outcome assessment were carried out under controlled academic conditions.

Sampling

A census sampling approach was used, and all undergraduate operating room technology students enrolled in the fifth and seventh semesters who met the eligibility criteria were invited to participate. Because the total accessible population was limited, no sampling fraction was applied, and all eligible students were considered for inclusion. After obtaining informed consent, participants were allocated randomly into four study groups according to the Solomon four-group framework: two intervention groups and two control groups. Random allocation was performed separately within each semester using a simple draw method to ensure balanced group assignment.

Inclusion and Exclusion Criteria

Students were eligible for inclusion if they were willing to participate in the study, were officially enrolled in the fifth or seventh semester of the continuous undergraduate operating room technology program, and were registered for the relevant internship courses during the study period. Students were excluded if they failed to complete the post-test or withdrew before finishing all stages of the study, or if they did not adequately study the provided surgical anatomy study guide in the intervention groups. In addition, any self-reported communication between control-group students and intervention-group students regarding the content of the study guide was considered a protocol violation and led to exclusion, because such interaction could contaminate the comparison between groups and compromise the internal validity of the study.

Procedure

The knowledge outcome was assessed using a researcher-developed multiple-choice questionnaire based on the educational objectives of the operating room internship courses for the fifth and seventh semesters. The tool consisted of 20 four-option items, each with one correct answer, and was designed to measure the students' understanding of surgical anatomy content relevant to their internship training. The questionnaire was prepared in alignment with the course objectives and reviewed by subject-matter experts in operating room technology, anatomy, and medical education to ensure content relevance and educational appropriateness. The same instrument was used for both the pre-test and post-test in the study, and scoring was based on the number of correct responses, with higher scores indicating greater knowledge. The intervention consisted of providing the surgical anatomy study guide to the assigned intervention groups during the middle phase of the study. Before the intervention, pre-tests were administered to the relevant groups according to the Solomon design. During the intervention phase, participants in the intervention groups received the study guide and were instructed to use it independently as a supplementary learning resource during their clinical training period. Control groups continued their routine educational experience without access to the guide. To reduce information exchange between groups, the clinical schedules were organized so that intervention and control participants did not attend the same practical sessions. At the end of the study period, post-tests were administered to all groups under identical conditions. Thus, the primary variable under investigation was the change in knowledge score before and after implementation of the surgical anatomy study guide (figure 1).

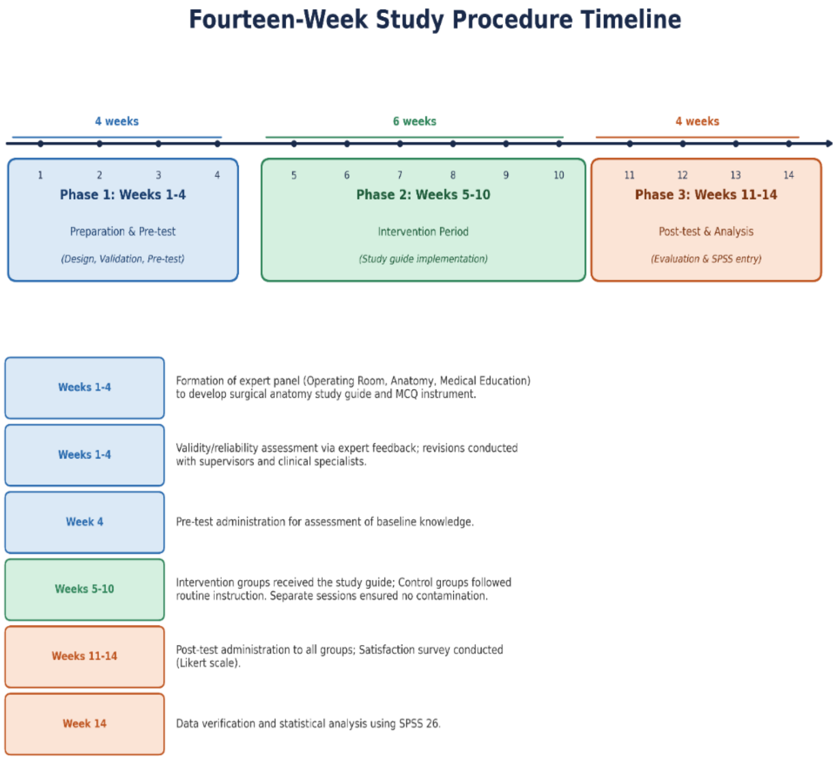

Figure 1. Fourteen-Week Study Procedure Flowchart for the Implementation and Evaluation of the Surgical Anatomy Study Guide7

A 20-item Multiple-Choice Question (MCQ) test was used to assess the knowledge dimension of the participants. Each item consisted of a stem presenting a clinical or anatomical scenario relevant to surgical anatomy, followed by four response options, of which only one was correct while the remaining three served as distractors. The items were designed in accordance with established MCQ-writing principles, including the use of clearly focused stems, plausible and homogeneous distractors, and avoidance of negative phrasing and cueing language. The content of the test was aligned with the educational objectives of the operating room internship courses, so that the items reflected the knowledge expected to be acquired through the surgical anatomy study guide. The same instrument was administered in both the pre-test and post-test phases under standardized conditions, and each correct answer was scored as one point, yielding a total possible score of twenty. Higher scores were interpreted as indicating a higher level of knowledge, and the difference between pre-test and post-test scores was used as the primary outcome measure of knowledge change.

Statistical Analysis

Data analysis was performed using SPSS version 26. Descriptive statistics were used to summarize participants' characteristics and knowledge scores, including frequency, percentage, mean, and standard deviation. The normality of the knowledge score distribution was assessed using the Kolmogorov Smirnov test, and because the data were normally distributed, parametric tests were applied for inferential analysis. Group comparability at baseline was examined using one-way analysis of variance (ANOVA). To compare pre-test and post-test knowledge scores between intervention and control groups, independent-samples t-tests were used. Equality of variances was evaluated with Levene's test before applying the t-tests. A two-sided p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

This study was approved by the Ethics Committee of Alborz University of Medical Sciences under the ethical code IR.ABZUMS.REC.1403.199. All participants were informed about the aim, procedures, voluntary nature, and academic purpose of the study before enrollment, and informed consent was obtained from each participant. Confidentiality of the collected data was strictly maintained, and students were assured that their decision to participate or decline would not affect their academic evaluation or internship status. The study was conducted in accordance with ethical principles for research involving human participants.

Results

Among the 47 operating room technology students enrolled in the study, the gastrointestinal arena was the more prevalent setting in the control (54.5%), intervention (55.6%), and intervention-with-pre-test (73.3%) groups, whereas the technique-focused format predominated in the control-with-pre-test cohort (58.3%). Female students constituted the majority of the sample overall (63.8%), with the intervention group being the only cohort in which males outnumbered females (55.6%). (table 1).

Table 1. Frequency and percentage distribution of participants' demographic and educational characteristics across study groups

Group	Variable	Technique	Gastrointestinal Arena	Male	Female	Single	Married	Total
Control	Frequency	5	6	4	7	11	0	11
	Percentage	45.50%	54.50%	36.40%	63.60%	100.00%	0.00%	100.00%
Control with pre-test	Frequency	7	5	3	9	11	1	12
	Percentage	58.30%	41.70%	25.00%	75.00%	91.70%	8.30%	100.00%
Intervention	Frequency	4	5	5	4	9	0	9
	Percentage	44.40%	55.60%	55.60%	44.40%	100.00%	0.00%	100.00%
Intervention with pre-test	Frequency	4	11	5	10	13	2	15
	Percentage	26.70%	73.30%	33.30%	66.70%	86.70%	13.30%	100.00%

Descriptive analysis of the knowledge assessment scores revealed marked differences across the four study groups. Participants in the control group achieved a mean MCQ score of 13.5 (SD=3.564), while those in the control group that also completed a pre-test scored slightly lower, with a mean of 11.82 (SD=2.183). In contrast, participants assigned to the intervention condition attained a substantially higher mean score of 25.5 (SD=7.044), and the intervention group that received a pre-test recorded a mean score of 21.8 (SD=6.361). Notably, both intervention cohorts outperformed the control cohorts by a considerable margin, with the intervention-only group demonstrating the highest mean score. The greater variability observed within the intervention groups (as reflected in their larger standard deviations) suggests a wider dispersion of individual knowledge gains relative to the more homogeneous control groups (figure 2).

An independent-samples t-test was conducted to compare the mean multiple-choice question (MCQ) scores of operating room technology students in the control-with-pre-test and intervention-with-pre-test groups. Levene's test indicated that the assumption of homogeneity of variances was satisfied, as the variance in MCQ scores did not differ significantly between the two groups ($F=4.17$, $p=0.052$). The subsequent t-test, however, revealed a statistically significant difference in mean MCQ scores between the two groups ($t=-4.97$, $df=24.00$, $p<0.001$), with a mean difference of -9.98. Accordingly, the null hypothesis of equal means was rejected, indicating that the observed difference in knowledge scores between the two cohorts was statistically significant and did not occur by chance. These findings provide support for the study's first research hypothesis, demonstrating a meaningful distinction in knowledge outcomes between the compared groups (figure 2).

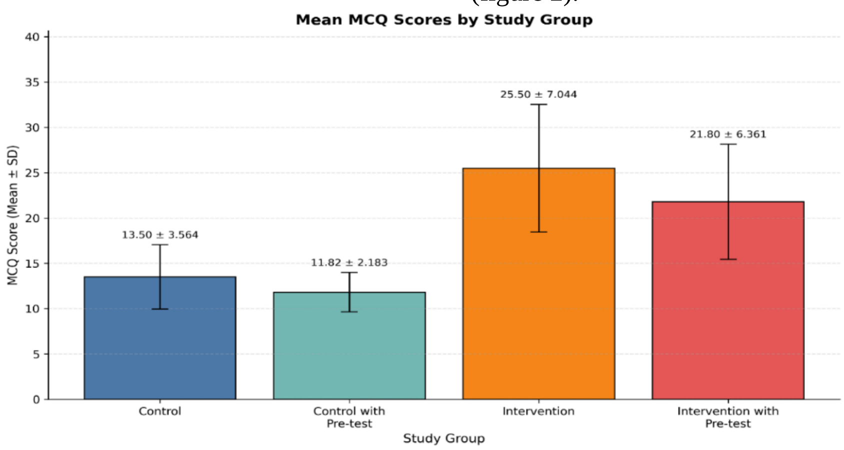

Figure 2. Comparison of Mean MCQ Knowledge Scores Among the Four Study Groups

Discussion

This study demonstrated clear differences in MCQ knowledge scores across the four Solomon four-group cohorts. The intervention-only group achieved the highest mean score (25.50 ± 7.044), followed by the intervention-with-pre-test group (21.80 ± 6.361), whereas the control and control-with-pre-test groups obtained substantially lower scores (13.50 ± 3.564 and 11.82 ± 2.183, respectively). Moreover, comparison of the two pre-tested groups showed a statistically significant advantage for students exposed to the surgical anatomy study guide (mean difference=−9.98; t=−4.97; df =24; p<0.001). These findings indicate that implementation of the study guide was associated with improved knowledge outcomes among operating room technology students, although the greater standard deviations in the intervention groups suggest individual differences in students' responses to the educational strategy [16,17].

The observed superiority of the intervention groups may be explained by the structured and focused nature of the surgical anatomy study guide. Anatomy is a complex discipline that requires students to integrate spatial relationships, terminology, morphological details, and clinical applications rather than memorize isolated facts. A well-organized guide can reduce the cognitive burden associated with identifying relevant learning material by directing students toward essential concepts and presenting them in a logical sequence. This type of structure may enable learners to allocate more cognitive resources to understanding and integrating anatomical information. In contrast, students in the control groups may have relied on less organized or more extensive sources, potentially resulting in inefficient study patterns and weaker consolidation of essential knowledge [18,19].

Another possible explanation is that the guide may have promoted more purposeful and self-regulated learning. When students are provided with clearly defined objectives, prioritized content, and an organized framework for review, they may be better able to plan their study time, monitor their understanding, and identify areas requiring further attention. These processes are particularly important in surgical anatomy, where superficial familiarity with terminology may not be sufficient for answering applied knowledge questions. The higher scores observed among the intervention cohorts may therefore reflect not only greater exposure to anatomical information but also improved learning efficiency. The guide might have helped students transform a broad subject into manageable units, thereby facilitating repeated review and more effective preparation for the MCQ assessment [20,21].

The findings are also consistent with the educational value of active retrieval and repeated engagement with course content. A study guide that encourages students to recall anatomical structures, compare related concepts, and connect anatomy with operative procedures can support stronger memory formation than passive reading alone. Retrieval-based learning strengthens access to previously studied information and may improve performance when students encounter similar concepts in an examination. In addition, repeated exposure to clinically relevant anatomical relationships can enhance the meaningfulness of learning and promote longer-lasting retention. Thus, the higher performance of the intervention groups may have resulted from the interaction between structured content organization and cognitively active study behaviors [22,23].

The comparison between the two pre-tested groups provides particularly important evidence for interpreting the intervention effect. Because both groups completed a pre-test, they were exposed to a similar initial assessment experience; however, the intervention-with-pre-test group achieved a considerably higher MCQ score than the control-with-pre-test group. This pattern reduces the likelihood that the difference was attributable solely to test familiarity or pre-test sensitization. Although a pre-test may focus students' attention on the subject matter or alert them to the type of knowledge that will be assessed, the substantially higher performance of the intervention group suggests that the study guide contributed meaningfully beyond the possible influence of the pre-test itself. The Solomon design consequently strengthens the interpretation that the educational intervention, rather than assessment exposure alone, was associated with the observed difference [24,25].

The statistical findings further support this interpretation. Levene's test did not identify a statistically significant difference in score variances between the two pre-tested groups (F=4.17, p=0.052), allowing the equal-variance assumption to be retained for the independent-samples t-test. The subsequent analysis demonstrated a statistically significant difference in mean MCQ scores (t=−4.97, df=24, p<0.001), with a mean difference of −9.98. This difference is not only statistically significant but also educationally meaningful, given the considerable separation between the group means. Nevertheless, the results should be interpreted as evidence of an association between implementation of the study guide and higher knowledge scores, rather than as definitive proof of causality, particularly because the available analysis is based primarily on group-level descriptive statistics and a single between-group comparison [26,27].

The higher standard deviations observed in the intervention groups also warrant consideration. Although the intervention-only group achieved the highest mean, its score distribution was more heterogeneous than that of the control groups. This variability may reflect differences in students' baseline knowledge, study habits, motivation, attendance, access to supplementary learning resources, or ability to apply the guide independently. Educational interventions do not necessarily produce uniform benefits because students engage with learning materials in different ways. Some students may use the guide systematically and repeatedly, whereas others may consult it only shortly before the assessment. In addition, students with stronger prior anatomical knowledge may benefit more rapidly from an organized guide because they can integrate new information with existing cognitive schemas. Future studies should therefore examine potential moderators of intervention effectiveness and report effect sizes and confidence intervals alongside p-values [28,29].

The findings have several implications for education in operating room technology programs. Surgical anatomy is directly relevant to the recognition of anatomical landmarks, understanding of surgical approaches, anticipation of procedural requirements, and effective communication within the operating room. Strengthening students' anatomical knowledge before or during clinical education may improve their readiness to participate in operative procedures and may support safer, more coordinated practice. A study guide is also a relatively accessible educational resource that can be incorporated into existing curricula without requiring extensive technological infrastructure. Its effectiveness may be enhanced when combined with instructor feedback, case-based discussion, visual materials, laboratory demonstrations, and formative assessments. However, implementation should be accompanied by appropriate evaluation to determine whether gains in written knowledge are translated into improved practical performance and clinical decision-making [30].

Conclusion

Overall, the results suggest that implementing a structured surgical anatomy study guide was associated with substantially better MCQ performance among operating room technology students. The magnitude and statistical significance of the difference between the pre-tested intervention and control groups support the study's first research hypothesis and indicate that the guide may have provided an effective framework for organizing and consolidating anatomical knowledge. At the same time, the variability within the intervention cohorts highlights the importance of considering individual learning differences and ensuring consistent student engagement. Future research should use larger samples, assess baseline equivalence, include follow-up examinations, and evaluate both theoretical knowledge and practical competence to determine the durability and clinical relevance of the intervention.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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