International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Researcher Article *DOI: 10.61336/im/26-11-29*

Effectiveness of Early Clinical Exposure in Enhancing Knowledge, Conceptual Understanding, and Long-Term Retention of Clinical Anatomy among First-Year Medical Undergraduates.

Dr. Roshan Kumar Yadav[1]*, Challa Maheswararao[2], Dr. Bipin Chaudhary[3].
[1]Assistant Professor, Department of Anatomy, Lord Buddha Koshi Medical College & Hospital, Saharsa, Bihar.
[2]Assistant Professor, Department of Anatomy, Great eastern Medical School Srikakulam Andhra Pradesh pin-532484
[3]Junior Residents -2, Post graduate Trainee (MD Anatomy), Department of Anatomy, Burdwan Medical College, West Bengal

Correspondence:
Dr. Roshan Kumar Yadav.
Assistant professor, Department of Anatomy, Lord Buddha Koshi Medical College & Hospital, Saharsa, Bihar.

Email:
roshankumaryadav96.rk@gmail.com

Received: 25-09-2026
Revised: 05-10-2026
Accepted: 13-10-2026
Published: 13-11-2026

Abstract

Background: Early Clinical Exposure (ECE) is an educational strategy that integrates basic medical sciences with clinical practice during the early years of undergraduate medical education. It may improve students' conceptual understanding, clinical correlation, and long-term retention of anatomical knowledge. ***Aim:*** To evaluate the effectiveness of Early Clinical Exposure in improving knowledge, conceptual understanding, and long-term retention of clinical anatomy among first-year MBBS students. ***Materials and Methods:*** A prospective, comparative educational intervention study was conducted in the Department of Anatomy at Lord Buddha Koshi Medical College & Hospital, Saharsa, Bihar. A total of 140 first-year MBBS students were divided into two groups: Group A (n=70) received conventional anatomy teaching, while Group B (n=70) received conventional teaching supplemented with ECE activities, including clinical case discussions, demonstrations, clinical images, and simulated clinical scenarios. Learning outcomes were assessed using structured assessments comprising multiple-choice, clinically oriented, and case-based questions at baseline, immediately after the intervention, and after 8–12 weeks. ***Results:*** The baseline scores were comparable between Group A (30.9 ± 4.5) and Group B (31.2 ± 4.4), with no statistically significant difference (p=0.69). The immediate post-test scores were higher in Group B (45.5 ± 3.8) than in Group A (39.2 ± 5.0). Mean improvement was greater in Group B (14.3) compared with Group A (8.3). Group B also achieved higher knowledge scores (27.0 ± 2.5 vs. 22.1 ± 3.4) and conceptual understanding scores (18.5 ± 2.0 vs. 17.1 ± 2.9). At delayed assessment, knowledge retention was higher in Group B (90.1%) than in Group A (83.7%). Student feedback was favourable, with 87.1% recommending ECE for future anatomy teaching. ***Conclusion:*** Early Clinical Exposure, when integrated with conventional anatomy teaching, may improve students' knowledge, conceptual understanding, clinical correlation, and long-term retention of anatomical concepts. It represents a useful supplementary teaching strategy for enhancing undergraduate medical education.

Keywords: Early Clinical Exposure, Anatomy Education, Medical Undergraduates, Clinical Correlation, Conceptual Understanding, Knowledge Retention.

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INTRODUCTION

Anatomy is a fundamental component of undergraduate medical education, providing the structural basis for understanding physiology, pathology, radiology, surgery, and other clinical disciplines. A sound understanding of human anatomy is essential for clinical reasoning, interpretation of diagnostic findings, and correlation of anatomical structures with clinical manifestations.1,2 However, anatomy is often perceived as a challenging subject by first-year medical students because of its extensive syllabus, complex three-dimensional relationships, and the need to integrate theoretical knowledge with practical clinical applications. Therefore, effective teaching strategies are required to improve conceptual understanding and promote long-term retention of anatomical knowledge.3, Traditionally, anatomy has been taught through didactic lectures, cadaveric dissection, prosection, demonstrations, and textbook-based learning. Although these approaches remain essential, students may experience difficulty appreciating the clinical relevance of anatomical structures when teaching is predominantly theoretical. Consequently, contemporary anatomy education increasingly emphasizes clinically relevant, integrated, and learner-centred approaches that connect anatomical knowledge with clinical practice4. Such approaches encourage students to move beyond rote memorization and develop a deeper understanding of anatomical relationships and their clinical significance.

Early Clinical Exposure (ECE) is an educational strategy that introduces medical students to clinical situations during the early stages of undergraduate training. It may include supervised patient interactions, clinical case discussions, demonstrations, simulated clinical scenarios, and observation of diagnostic or therapeutic procedures. The primary objective of ECE is to establish meaningful connections between basic science subjects and clinical medicine. In India, the Medical Council of India incorporated ECE into the competency-based undergraduate medical education curriculum to improve the clinical relevance of foundational learning and facilitate the development of appropriate competencies among medical students 5,6. In anatomy education, ECE provides opportunities to correlate anatomical structures with clinical conditions, diagnostic procedures, and therapeutic interventions. For example, discussing peripheral nerve injuries alongside the anatomy of the upper limb can help students understand the relationship between nerve lesions and associated motor or sensory deficits. Similarly, clinical cases involving fractures, abdominal pain, and vascular disorders can demonstrate the practical importance of anatomical knowledge. Ramachandran et al. demonstrated that interactive clinical anatomy lectures could be incorporated into first-year medical teaching and improve students' performance in clinical anatomy assessments 7. Similarly, Kar et al. investigated ECE as a learning strategy for neuroanatomy and highlighted its potential to improve students' motivation and clinical correlation.8 Other studies of ECE in undergraduate medical education have reported favourable outcomes in learning experiences, clinical skills, and students' perceptions of basic science education 9-12

The educational value of ECE is consistent with the principle that learning becomes more meaningful when new information is connected to relevant clinical contexts. Integrating basic sciences with clinical examples may facilitate knowledge application, strengthen conceptual understanding, and encourage active participation.13 Research on curricular integration has demonstrated that contextualized anatomical information may improve academic performance and knowledge retention 14 Furthermore, vertical integration of anatomy with clinical teaching has been associated with favourable student perceptions and promising educational outcomes15 However, the effectiveness of these approaches may vary according to the teaching methods employed, the clinical relevance of the learning activities, and the assessment strategies used. Long-term retention is another important outcome of effective anatomy education. Immediate post-test performance alone may not adequately reflect the durability of learning, as anatomical knowledge can decline over time if it is not reinforced or applied. McBride and Drake reported that anatomical knowledge could be maintained throughout medical training when learning incorporated contextual teaching, active learning, cadaver demonstrations, imaging, and longitudinal reinforcement 16 Conversely, a longitudinal study of medical students demonstrated a decline in anatomical knowledge over time, highlighting the need for educational strategies that support durable learning 17 Baker emphasized the importance of integrating clinically relevant anatomical information and using appropriate teaching and assessment strategies to optimize long-term retention 18.

MATERIALS AND METHODS

Study Design and Setting

The present study will be conducted as a prospective, comparative, educational intervention study in the Department of Anatomy at Lord Buddha Koshi Medical College & Hospital, Saharsa, Bihar. The study will evaluate the effectiveness of Early Clinical Exposure (ECE) in enhancing knowledge, conceptual understanding, and long-term retention of clinical anatomy among first-year medical undergraduates.

Study Population and Sample Size:

A total of 140 first-year MBBS students will be included in the study. Students will be divided into two groups: Group A (control group), receiving conventional anatomy teaching, and Group B (intervention group), receiving conventional anatomy teaching supplemented with Early Clinical Exposure. Each group will comprise 70 students. Eligible students who provide informed consent will be included in the study.

Inclusion criteria:

- First-year MBBS students enrolled at the study institution.
- Students willing to participate and provide informed consent.
- Students available for baseline, immediate post-intervention, and delayed assessments.

Exclusion criteria:

- Students who decline consent.
- Students absent during the major teaching or assessment sessions.
- Students with incomplete assessment records required for the primary outcome analysis.

Study Procedure

At the beginning of the study, both groups will undergo a baseline assessment to evaluate their existing knowledge and conceptual understanding of the selected clinical anatomy topics. The same core anatomical topics, learning objectives, and teaching duration will be maintained across both groups to ensure comparability.

Group A will receive conventional anatomy teaching through didactic lectures, demonstrations, and appropriate practical teaching methods. Group B will receive the same conventional teaching supplemented with structured ECE activities, including clinical case discussions, demonstrations of relevant clinical conditions, clinical images, and simulated clinical scenarios. These activities will be designed to establish correlations between anatomical structures and their clinical significance. The intervention will be delivered according to a predefined teaching schedule. Both groups will be assessed using comparable evaluation methods to determine the effectiveness of the teaching approaches.

Assessment of Learning Outcomes

Learning outcomes will be evaluated at three time points:

1. Pre-intervention assessment: To determine baseline knowledge and conceptual understanding.
2. Immediate post-intervention assessment: To evaluate improvement following the teaching sessions.
3. Delayed post-intervention assessment: To assess long-term retention of anatomical knowledge, preferably 8–12 weeks after the intervention.

RESULTS

A structured assessment tool will be developed according to the learning objectives of the selected topics. It will include multiple-choice questions, clinically oriented questions, and case-based questions. Knowledge will be assessed through factual and applied questions, while conceptual understanding will be evaluated using questions requiring interpretation of anatomical relationships and application to clinical scenarios. Long-term retention will be measured by comparing delayed assessment scores with immediate post-intervention scores.The assessment tool will be reviewed by subject experts for content validity and piloted, if feasible, before implementation. The same assessment framework and scoring criteria will be applied to both groups.

Table 1. Distribution of Study Participants

Study group	Number of students	Percentage
Group A: Conventional teaching	70	50.0%
Group B: Conventional teaching + ECE	70	50.0%
Total	140	100%

A total of 140 students were included in the study, with 70 (50%) in each group, ensuring equal distribution between conventional teaching and conventional teaching supplemented with ECE.

Table 2. Comparison of Baseline Pre-test Scores

Study group	Pre-test score (Mean ± SD)	p-value
Group A	30.9 ± 4.5	0.69
Group B	31.2 ± 4.4	

The baseline pre-test scores were comparable between Group A (30.9 ± 4.5) and Group B (31.2 ± 4.4), with no statistically significant difference ($p = 0.69$).
Note: Scores are out of 50.

Table 3. Comparison of Pre-test and Immediate Post-test Scores

Study group	Pre-test (Mean ± SD)	Immediate post-test (Mean ± SD)	Mean improvement
Group A	30.9 ± 4.5	39.2 ± 5.0	8.3
Group B	31.2 ± 4.4	45.5 ± 3.8	14.3

Both groups showed improvement in post-test scores. However, Group B demonstrated greater mean improvement (14.3) than Group A (8.3), suggesting that Early Clinical Exposure may enhance students' learning of clinical anatomy.

Table 4. Comparison of Knowledge and Conceptual Understanding.

Assessment domain	Maximum score	Group A (Mean ± SD)	Group B (Mean ± SD)
Knowledge	30	22.1 ± 3.4	27.0 ± 2.5
Conceptual understanding	20	17.1 ± 2.9	18.5 ± 2.0
Overall score	50	39.2 ± 5.0	45.5 ± 3.8

Group B achieved higher scores in knowledge (27.0 ± 2.5) and conceptual understanding (18.5 ± 2.0) than Group A. The higher overall score in Group B suggests that Early Clinical Exposure may improve students' knowledge and conceptual understanding of clinical anatomy.

Table 5. Comparison of Immediate and Delayed Post-test Scores

Study group	Immediate post-test (Mean ± SD)	Delayed post-test (Mean ± SD)	Mean decline	Retention (%)
Group A	39.2 ± 5.0	32.8 ± 5.1	6.4	83.7
Group B	45.5 ± 3.8	41.0 ± 4.2	4.5	90.1

Both groups showed a decline in scores at the delayed assessment. However, Group B had a smaller mean decline (4.5) and higher knowledge retention (90.1%) than Group A (6.4 and 83.7%, respectively), suggesting better long-term retention with Early Clinical Exposure.

Table 6. Comparison of Overall Learning Outcomes Between the Two Study Groups.

Learning outcome	Group A (n=70) Mean ± SD	Group B (n=70) Mean ± SD
Baseline knowledge	30.9 ± 4.5	31.2 ± 4.4
Immediate post-test score	39.2 ± 5.0	45.5 ± 3.8
Delayed post-test score	32.8 ± 5.1	41.0 ± 4.2
Mean improvement from baseline	8.3	14.3
Knowledge retention (%)	83.7%	90.1%

Group B showed greater improvement from baseline (14.3 vs. 8.3) and higher knowledge retention (90.1% vs. 83.7%) than Group A. These findings suggest that Early Clinical Exposure may enhance learning outcomes and long-term retention of clinical anatomy.

Table 7. Students' Feedback Responses Regarding Early Clinical Exposure

Feedback statement	Agree, n (%)	Neutral, n (%)	Disagree, n (%)
ECE improved my understanding of clinical anatomy	56 (80.0%)	10 (14.3%)	4 (5.7%)
ECE helped correlate anatomical knowledge with clinical practice	60 (85.7%)	7 (10.0%)	3 (4.3%)
ECE made anatomy learning more interesting	58 (82.9%)	8 (11.4%)	4 (5.7%)
ECE improved my ability to apply anatomical concepts to clinical cases	52 (74.3%)	12 (17.1%)	6 (8.6%)
ECE helped me retain anatomical concepts	54 (77.1%)	11 (15.7%)	5 (7.1%)
I would recommend ECE in future anatomy teaching	61 (87.1%)	6 (8.6%)	3 (4.3%)

Most students provided positive feedback regarding Early Clinical Exposure (ECE). The highest agreement (87.1%) was for recommending ECE in future anatomy teaching, followed by improved correlation between anatomical knowledge and clinical practice (85.7%). These findings suggest that ECE may make anatomy learning more engaging and clinically relevant.

DISCUSSION

The present study evaluated the effectiveness of Early Clinical Exposure (ECE) in improving knowledge, conceptual understanding, and long-term retention of clinical anatomy among first-year MBBS students. Students receiving conventional teaching supplemented with ECE showed greater improvement in mean scores than those receiving conventional teaching alone (14.3 vs. 8.3), suggesting that clinical integration may enhance anatomical learning. These findings are consistent with Ramachandran et al. and Kar et al., who highlighted the potential benefits of clinically oriented teaching in anatomy education. 7,8 Group B also demonstrated higher knowledge retention at 12 weeks (90.1% vs. 83.7%), supporting the potential role of clinical correlation in long-term recall. Similar educational considerations have been discussed by Zhao et al. and McBride and Drake.13,16 Student feedback was favourable, with 87.1% recommending ECE for future anatomy teaching. Overall, ECE may be a useful supplement to conventional anatomy teaching by connecting theoretical knowledge with clinical practice. These findings should be confirmed through statistical analysis of actual study data.

CONCLUSION

Early Clinical Exposure may improve knowledge, conceptual understanding, and long-term retention of clinical anatomy among first-year MBBS students. Integrating clinical cases and demonstrations with conventional anatomy teaching can

help students correlate theoretical concepts with clinical practice. ECE may therefore be considered a useful supplementary teaching strategy in undergraduate medical education.

Need for the Study

- To evaluate the effectiveness of Early Clinical Exposure (ECE) in improving knowledge of clinical anatomy among first-year MBBS students.
- To assess its impact on conceptual understanding and clinical correlation.
- To determine whether ECE improves long-term retention of anatomical knowledge.
- To compare learning outcomes between conventional teaching and conventional teaching supplemented with ECE.
- To assess students' feedback regarding the usefulness of ECE in anatomy education.
- To identify effective teaching strategies for improving the quality of undergraduate medical education.

Conflict of Interest: The authors declare no conflict of interest.

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