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shaimaa omar
Tanta University
Asmaa Aly Eldesouky
Menoufia University
Eman Badawy Konsowa
Menoufia University
Hanan mosbah El Fakharany
Elmenshawy General Hospital
mahmoud ramdan
Tanta University
Mona Mohamed Abo El-Noor
Tanta University
Marwa Mahmoud Awad
Tanta University
moaz mohamed osama
moaz_torky@dent.tanta.edu.eg

Tanta University

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Enhancing Tooth Reduction Skill in Fixed Prosthodontics Using Case-Based Learning Among Dental Students:

A Quasi-Experimental Study

Shaimaa Omar[a] , Asmaa A. Eldesouky [b], Eman B. Konsowa [b], Hanan M. ElFakharany [c], Mahmoud R. Rekih [a], Mona M. Abo El-Noor [d], Marwa M. Awad [e], Moaz M.O.* [a,f].

[a] Fixed Prosthodontics Department, Faculty of Dentistry, Tanta University, 31773, Tanta, Egypt.

[b] Histology Department, Faculty of Medicine, Menoufia University, 32511, Shebin el-kom, Menoufia, Egypt.

[C] Elmenshawy General Hospital, Tanta, Egypt.

[d] Forensic Medicine and Clinical Toxicology Department, Faculty of Medicine, Tanta University, 31527, Tanta, Egypt.

[e] Medical Physiology Department, Faculty of Medicine, Tanta University, 31527, Tanta, Egypt.

[f] Fixed Prosthodontics Department, Faculty of Applied Health Science Technology, New Mansoura University, New Mansoura, Egypt.

"Corresponding author: Moaz M. Osama"

Email : moaz_torky@dent.tanta.edu.eg

Abstract

Background: Developing proficiency in tooth preparation is a primary objective in undergraduate dental education. Traditional teacher-centered lectures are often used to impart a significant volume of information to a large number of students. In contrast, Case-Based Learning (CBL) offers an interactive, student-centered approach designed to utilize real-life clinical scenarios to promote deeper understanding and reflective thinking.

Objectives: This study aimed to evaluate the effectiveness of CBL compared to traditional lecture-demonstration methods in enhancing the foundational knowledge and practical tooth reduction skills of dental students in fixed prosthodontics

Materials and Methods: A quasi-experimental study was conducted at the Faculty of Dentistry, Tanta University, involving 60 second-year dental students. Participants were assigned to an experimental group (n=30) receiving four weekly 90-minute CBL sessions and a control group

(n=30) receiving traditional lectures and clinical demonstrations. Outcomes were measured using a 10-item multiple-choice pre-test and post-test for knowledge, and technical performance was evaluated using a validated analytic rubric to score tooth preparations on typodont models.

Results: Baseline pre-test scores showed no significant difference between the two groups (P=.753), indicating comparable initial knowledge. Following the intervention, the CBL group achieved a significantly higher mean score on the post-test (9.17 ± 1.02) compared to the control group (7.73 ± 1.96). Furthermore, the CBL group demonstrated superior practical performance with a significantly higher mean score (33.9 ± 2.68) than the control group (28.83 ± 1.84).

Conclusion: CBL significantly enhances both foundational knowledge and practical tooth reduction skills compared to traditional teaching methods. These findings support the integration of case-based interactive activities into the preclinical dental curriculum to better prepare students for clinical practice

Trial registration:

Trial registration: ClinicalTrials.gov, NCT07393724, registered on 6 February 2026 (Retrospectively registered).

Keywords: Case-Based Learning, Fixed Prosthodontics, Dental Education, Tooth Preparation, Preclinical Skills.

Introduction

The dental field, similar to other paramedical and medical fields, demands advanced clinical abilities that necessitate extensive application of the cognitive, affective, and psychomotor learning domains (1)**.** Theory, preclinical labs, and clinical training are the usual components of a dentistry school's curriculum (2)**.**

Crowns, fixed partial dentures, and other restorations are an integral aspect of fixed prosthodontics, a foundational field of dentistry that restores the health, function, and aesthetics of damaged dentition (3). In clinical practice, all general dentists should accurately prepare teeth for a fixed prosthesis. Unlike most human tissues, dental enamel and dentin are non-regenerative; as a result, meticulous planning and execution are required for the removal of biological material from teeth (4)**.** As a means of connecting classroom learning with practical experience, one of the main goals of undergraduate dentistry education is the development of competence in tooth preparation (5)**.**

Faculty are constantly searching for more effective techniques to teach because dental school courses are so extensive and in-depth (6).

Traditional methods of teaching hold that dental schools fail to adequately instill in their students the critical thinking and patient-centered care skills necessary to practice modern dentistry. According to surveys conducted among faculty members, the majority of graduate students struggle when it comes to applying their preclinical didactic knowledge to real-world patient care scenarios (7).

While traditional teacher-centered lectures are efficient for delivering vast amounts of information to large groups, they often result in passive learning. Through student-centered active learning, in which students engage in conversation with one another and with the teacher through questioning, sharing, and other means, students are able to learn more effectively. (8).

Collaborative learning with a focus on the students is known as case-based learning (CBL). Through the use of case scenarios that reflect real-life situations that students could face in the future, CBL encourages active learning. This makes the material more memorable by showing students how it relates to their aim of clinical practice and how it flows logically from one concept to the next (9). Adopting active learning frameworks like Case-Based Learning (CBL) has proven to optimize educational efficiency; it reduces total contact hours without compromising student outcomes on both clinical practical and standardized assessments (10).

This study aimed to evaluate the effectiveness of case-based learning as an interactive method of teaching, in enhancing tooth reduction skills in fixed prosthodontics among dental students. The null hypothesis of the study was that there is no difference in learning outcomes between undergraduate pre-clinical students educated through case-based learning and those using traditional teaching methods.

Methodology

Study Design

This study employed a quasi-experimental study design to assess the comparative effectiveness of Case-Based Learning (CBL) versus traditional lecture-demonstration methods in enhancing dental students' knowledge and practical skills in prosthodontics. The design was selected because random assignment of students to instructional groups was not feasible within the constraints of

the existing academic schedule and curriculum structure. This approach enabled the investigation of learning outcomes in an authentic educational environment while maintaining ecological validity.

Study Setting and Duration

The study was conducted at the Pre-clinical Simulation Laboratory, Fixed Prosthodontics Department, Faculty of Dentistry, Tanta University. The intervention spanned a four-week period, during which both the experimental and control groups attended weekly 90-minute sessions. Content coverage was identical for both groups, ensuring that differences in outcomes could be more confidently attributed to the instructional method.

Participants

The study included summer course second-year dental students with no prior formal training in fixed prosthodontics tooth preparation. They completed all prerequisite coursework in dental morphology and basic operative dentistry. Participants were asked to provide informed consent and commit to all study sessions.

We excluded students who had previously received formal training in CBL methodology, participants with more than 25% absence rate in regular prosthodontics classes, students who had previously failed the prosthodontics course, and individuals with physical limitations that might affect their performance in practical assessments.

A total of 60 second-year dental students who met the inclusion criteria participated in the study. Participants were assigned to two groups (n=30 per group) based on their pre-existing clinical rotation schedules, a non-random process that defined the groups as "non-equivalent." To address potential baseline disparities, demographic and academic background data, including age, gender, and prior prosthodontics exposure, were collected. Baseline equivalence between groups was statistically tested before the intervention to ensure that any post-intervention differences could be more reliably interpreted.

Ethical Considerations

Ethical approval (R-FP-7-25-3209) was obtained from the Institutional Research Ethics Committee of the Faculty of Dentistry, Tanta University. **Written informed consent** was obtained from all participants involved in the study, and participants were asked to provide informed consent and commit to all study sessions. This study was conducted in accordance with the principles of the **Declaration of Helsinki**. Participation was voluntary, and all participants were informed about the purpose of the study and their right to withdraw at any time without any academic consequences. The non-randomized allocation method was justified by the need to align with existing academic scheduling and to minimize disruption to the educational process.

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Intervention

Experimental Group (Case-Based Learning – CBL):

The experimental group participated in four weekly 90-minute CBL sessions, each facilitated by two trained instructors. Each session presented a clinical case scenario aligned with the prosthodontics curriculum. Students worked in small groups to analyze the case, discuss underlying principles, and propose clinical solutions. Sessions concluded with an instructor-facilitated debrief and formative assessment of students' clinical reasoning and problem-solving skills.

Control Group (Traditional Lecture and Demonstration):

The control group attended four weekly 90-minute sessions delivered by the same instructor, using a traditional format that combined didactic lecturing with clinical demonstrations. The learning objectives and theoretical content were identical to those covered in the CBL sessions, ensuring content equivalence between groups.

Study Procedures

All participants completed a pre-test of 10-item multiple-choice questions (MCQs) assessing foundational understanding of tooth preparation for full-coverage restorations. The questionnaire was developed by the authors specifically for this study based on the learning objectives and relevant literature. The test was reviewed and validated by three prosthodontic experts to ensure content validity.

Participants were assigned to either the CBL or control group according to their rotation schedules. Although non-random, the allocation aimed to balance group size and minimize scheduling-related confounding. Both groups completed their respective four-session instructional programs. The same 10-item (MCQs) knowledge test was re-administered to both groups to measure knowledge gains.

Each participant performed a tooth preparation on a typodont model. Performance was evaluated using a validated analytic rubric adapted from (11), used for all teeth (anterior and posterior). Two independent, blinded assessors calibrated before the study scored all preparations to ensure inter-rater reliability.

Instruments and Data Collection

A 10-item multiple-choice test assessed knowledge of tooth preparation. Items were aligned with course learning outcomes and validated by content experts. The practical rubric was an analytic rubric that assesses technical performance across multiple domains, including marginal integrity, occlusal reduction, and axial wall form. The rubric was pilot-tested and reviewed by three prosthodontic educators.

Validity and Reliability

To enhance internal validity, several strategies were implemented: the same instructor taught both groups using standardized materials; assessors were blinded to group assignment; and baseline characteristics were compared statistically. The reliability of the knowledge test was assessed using Cronbach's alpha, and inter-rater reliability for the practical scores was calculated using intraclass correlation coefficients (ICC).

Data Analysis:

The collected data were statistically analyzed and tabulated using Statistical Package for the Social Sciences (SPSS®) version 22 software. Data presented as mean ± standard deviation (SD) of each parameter. A P-value of < 0.05 was statistically significant.

Results:

The demographic variables of the study participants are presented in Table 1. The study targeted

preclinical level 1 dental students who were registered for the Fixed Prosthodontics course. All the study participants were at the same level of study.

Table 1: demographic data of the study participants

Variable	Category	n (%)
Total participants		60 (100%)
Age (years)	Mean ± SD	20.8 ± 0.7
Gender	Male	17 (28.4%)
	Female	43 (71.6%)
Academic level	Level 3	60 (100%)
Course	Preclinical Fixed Prosthodontics 1	60 (100%)

Table 2 compares the foundational **knowledge** scores by performing 10 items multiple choice questions between the Case-Based Learning (CBL) group and the Control group, both at baseline (PRE-test) and after the four-week intervention (POST-test).

The PRE-test showed that the CBL group had a mean score of 3.67 ± 0.76, and the Control group had 3.73 ± 0.87. The minimum and maximum scores ranged from 2 to 5 in both groups. A two-tailed t-test for independent samples (assuming equal variances) was performed. The difference in the dependent variable PRE-test between the Control and CBL groups was **not statistically significant** ($P = .753$). This indicates the groups started with comparable scores.

Conversely, the POST-test for the CBL group achieved a significantly higher mean score compared to the Control group ($P < .001$). The Control group's mean was 7.73 ± 1.96 with scores ranging from 5 to 10. The CBL group's mean was 9.17 ± 1.02 with scores ranging from 7 to 10. Moreover, the bar chart shows a noticeable difference in the POST-test means, with the CBL group having a higher score compared to the Control group **Fig 1**

Table 2 Comparison of foundational knowledge scores between CBL group and the control group at baseline and after intervention.

		Frequency	Minimum	Maximum	Mean ± Std.	T	p
PRE-test	Control	30	2	5	3.73 ± 0.87	0.32	.753
	CBL	30	2	5	3.67 ± 0.76		
POST-test	Control	30	5	10	7.73 ± 1.96	-3.55	.001
	CBL	30	7	10	9.17 ± 1.02		

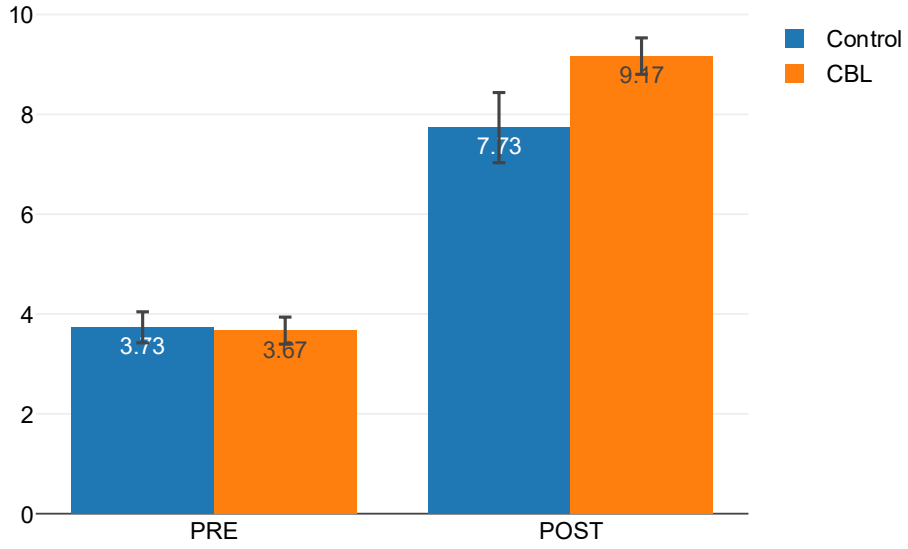


Figure 1, means of pretest and post test between CBL and control group

Practical Performance Scores:

The mean score for the Control group was 28.83 ± 1.84 with a minimum score of 25 and a maximum of 33 as shown in table 3. The CBL group had a noticeably higher mean score of 33.9 ± 2.68, with scores ranging from 27 to 37. The difference between the two groups was assessed

using t-test. The results indicate a **highly statistically significant difference** in the mean scores between 2 groups (P < .001).

Table 3 Comparison of practical performance scores between CBL group and the control group

	Frequency	Minimum	Maximum	Mean ± Std.	t	p
Control	30	25	33	28.83 ± 1.84	-8.53	<.001
CBL	30	27	37	33.9 ± 2.68		

The bar chart visually emphasizes this difference, showing the CBL group's mean was higher than the Control group's mean **Fig 2**. This strong evidence suggests that the CBL group performed significantly better than the Control group on this measure.

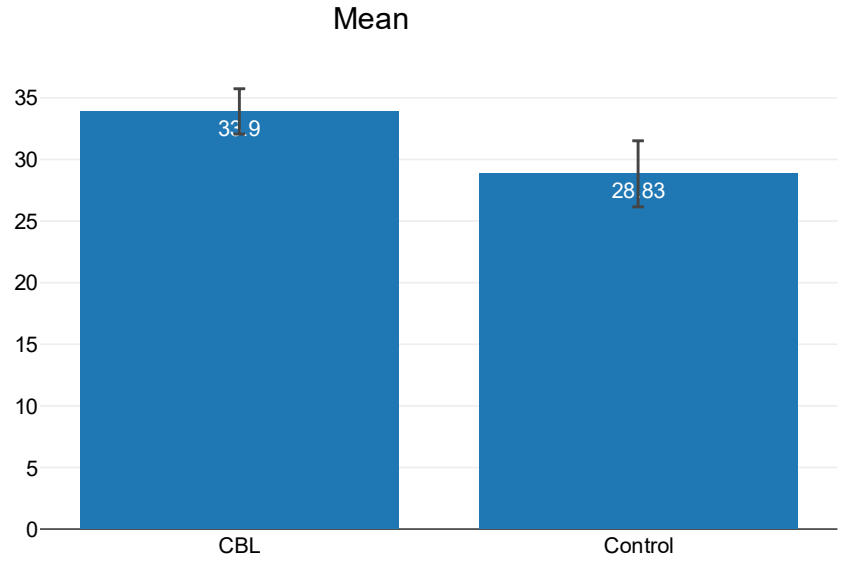


Figure 2, means of practical performance between CBL and control group

Discussion

Adopting innovative teaching methods is essential to preparing medical students for the high-level problem-solving and ethical challenges they will face in modern clinical practice (12)**.** The null hypothesis of the present study was rejected since there was a difference in learning outcomes

between undergraduate pre-clinical students educated through case-based learning and those using traditional teaching methods.

When comparing the Control and CBL (Case-Based Learning) groups' pre-test scores, we found no statistically significant difference (P =.753).

This finding strengthens the study's internal validity by confirming baseline equivalence. It demonstrates that the experimental and control groups possessed nearly identical levels of knowledge or proficiency regarding the primary outcome measures prior to the commencement of the intervention.

Conversely, the post-test for the CBL group achieved a significantly higher mean score compared to the Control group (P < .001). The results are in agreement with, Samuelson et al. (13) who conclude a student preference for CBL over traditional didactic lectures, and the findings suggest small, measurable educational benefits associated with CBL. These results justify the integration and continued evaluation of CBL within the preclinical dental curriculum, with the expectation that these advantages will manifest more fully during clinical rotations.

Another study investigated the efficacy of combining case-based learning (CBL) with conventional lecture methods as a means of improving medical residents' understanding and attitudes toward research misconduct. There were 298 matched participants in the trial, which took place at two tertiary institutions in south-western China. While both approaches improved student learning, CBL was more successful than standard lectures in increasing students' understanding of research misconduct, its repercussions, and their rejection of such practices(14).

In contrast to the present findings, Arab and Saeedi (15) observed that both Case-Based Learning (CBL) and traditional lecturing yielded significant improvements in post-test scores among nursing students during a 2023 pharmacology internship. Their results suggest that both pedagogical approaches were equally effective in enhancing medication knowledge, with no significant difference between the two groups

Our results suggest the efficacy of case-based activities. A substantial increase in students' practical performance has been observed. This agrees with those who testified that CBL aided interns in identifying problems, creating treatment plans, and making diagnoses(16) . Without instructors, neither PBL nor CBL would have been possible, according to both students and educators. The

perspectives of both students and teachers were identical. This choice may be a result of CBL's use of an interactive, guided, and organized approach to delivering knowledge. Students may feel overwhelmed by the amount of work involved in preparing for CBL if they are not already well-versed in the subject matter (17)**.**

Also, (5) demonstrated in their preliminary research that using CBL in the classroom may greatly boost the self-assurance of undergraduates when it comes to cavity preparation. Students could be better prepared for the clinical setting if this method helps close the gap between theory and practice. Another study utilized the Structure of Observed Learning Outcome (SOLO) taxonomy to compare the effects of case-based learning (CBL) and lecture-based learning (LBL) on clinical decision making by fourth-year dental students. The results indicated that an integrated case-based curriculum could be beneficial in fostering students' deep learning and could lead to better integration of clinical cases that students are likely to encounter in independent practice (18).

Changes in patient care outcomes are only one example of how far-reaching the effects of CBL may be. Using this application, you may enhance your clinical performance, attitude, or teamwork by linking clinical situations in health care-related domains to a corpus of knowledge in that field. The importance of patient-centered education cannot be overstated, as learners and students pursuing careers in health care will inevitably come face-to-face with patients. In order to prove that CBL really does lead to deeper learning, assessment methods covered all the bases on Kirkpatrick's hierarchy of learning, a popular paradigm for gauging the efficacy of training (19)**.**

Study Limitations

The use of a quasi-experimental design with non-randomized group allocation introduces the risk of selection bias. Although baseline comparisons and statistical controls were applied, unmeasured confounding factors may remain. Additionally, the single-institution setting may limit the generalizability of the findings. Nevertheless, the use of blinded assessment, validated instruments, and matched instructional content strengthens the internal validity of the study within its practical context.

Recommendation

Longitudinal Follow-up is recommended to determine if the observed effects are sustained over time and provide deeper insight into the intervention's long-term efficacy. Future studies should

include multiple institutions to improve generalizability. Randomized control trials are recommended if feasible within the practical constraint to overcome the selection bias and unmeasured confounding factors. Future research could investigate long-term retention and the impact of CBL on clinical decision-making skills.

Conclusion

The study concluded that CBL significantly enhances students' knowledge compared to traditional methods among second-year dental students, Tanta university, reinforcing its utility as an effective teaching strategy. Interactive exercises based on real-life cases might be a great addition to the pre-clinical operative dentistry program

Declarations

Abbreviations

CBL case-based learning
ICC intraclass correlation coefficients

Ethics approval and consent to participate

Ethical approval (R-FP-7-25-3209) was obtained from the Institutional Research Ethics Committee of the Faculty of Dentistry, Tanta University. Written informed consent was obtained from all participants involved in the study, and participants were asked to provide informed consent and commit to all study sessions. This study was conducted in accordance with the principles of the Declaration of Helsinki. Participation was voluntary, and all participants were informed about the purpose of the study and their right to withdraw at any time without any academic consequences. The non-randomized allocation method was justified by the need to align with existing academic scheduling and to minimize disruption to the educational process.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Author contributions

S.O., M.A and M.O were responsible for the initial study of conception and design. Data collection and analysis were jointly handled by M.A, H.M, M.R and E.B. The first manuscript draft was collaboratively written by S.O., A.A. and M.O. All authors have reviewed and approved the final version of the manuscript.

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