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Research Article

Teaching Clinical Decision-Making in Endodontics Using Case-Based Learning: a Questionnaire-Based Study

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ABSTRACT
Background: Clinical decision-making is an essential competency in endodontic education, requiring students to integrate clinical findings, diagnostic information, prognosis, and treatment alternatives. Case-based learning (CBL) may facilitate the application of theoretical knowledge to realistic clinical situations and strengthen clinical reasoning.
Objective: To evaluate the effectiveness of case-based learning in improving clinical decision-making, confidence, and perceptions among undergraduate dental students in endodontics.
Methods: This single-center, questionnaire-based, quasi-experimental pretest–posttest study was conducted at the Department of Operative Dentistry and Endodontics, de'Montmorency College of Dentistry, Lahore, Pakistan, from November 2025 to April 2026. Eighty final-year BDS students participated in structured faculty-facilitated CBL sessions covering six major endodontic decision-making domains. Clinical decision-making performance and confidence were assessed before and after the intervention, while students' perceptions of CBL were evaluated after completion of the sessions. Paired statistical tests were applied, with $p<0.05$ considered statistically significant.
Results: The mean age of participants was 23.2±1.1 years, and 57 (71.3%) were female. The mean clinical decision-making score increased significantly from 3.35±1.10 before CBL to 5.01±0.84 after CBL, with a mean improvement of 1.66 points (95% CI: 1.43–1.89; $p<0.001$; Cohen's dz=1.60). Overall correct responses increased from 55.8% to 83.5%. Significant improvements were observed across all six assessed clinical domains. Confidence also increased significantly in diagnosis, radiographic interpretation, treatment planning, management of complex cases, and evidence-based decision-making (all $p<0.001$). The overall perception score was 4.38±0.49, and 75 (93.8%) students supported routine incorporation of CBL into undergraduate endodontic teaching.
Conclusion: Case-based learning was associated with substantial improvement in endodontic clinical decision-making and self-reported confidence among final-year dental students. The high level of student acceptance further supports its integration as a complementary teaching strategy in undergraduate endodontic education.

Keywords: Case-Based Learning, Clinical Decision-Making, Endodontics, Dental Education, Clinical Reasoning.

INTRODUCTION

Clinical decision-making is a core competency in dental education because safe patient care depends not only on factual knowledge but also on the ability to interpret clinical information, generate diagnostic possibilities, assess prognosis, and select an appropriate management strategy. In endodontics, these processes are particularly demanding because students must integrate pain history, pulp sensibility tests, periapical findings, radiographic information, restorability, periodontal status, patient preferences, and treatment alternatives. Nafea and Dennick demonstrated that dental students' clinical reasoning is influenced by curricular structure and clinical learning experiences, emphasizing the need for educational strategies that explicitly develop reasoning rather than relying on knowledge acquisition alone [1].

Traditional lecture-based teaching remains useful for establishing foundational concepts, but it may provide limited opportunities for students to practise the application of knowledge to uncertain or multifactorial clinical situations. Learner-centred methods have

therefore become increasingly prominent in dental education. Al-Madi et al. reported that problem-based learning incorporated into a hybrid dental curriculum could enhance students' knowledge and confidence, indicating that structured engagement with clinical problems can complement conventional teaching [2]. Case-based learning (CBL) is related to these active-learning approaches but typically uses authentic or carefully constructed patient cases to direct students toward predefined clinical objectives, allowing discussion of diagnosis, investigation, treatment planning, prognosis, and alternative management strategies. Haley et al. found that dental students considered case-based and team-based formats effective for learning, although the approaches differed in the learning resources and instructional demands required [3].

The educational value of CBL is particularly relevant to clinical decision-making because cases can reproduce the sequential reasoning required during actual patient encounters. Instead of answering isolated questions, students are required to identify relevant information, distinguish important from incidental findings, justify diagnostic conclusions, and select management options in context. Mardani et al. demonstrated that virtual-patient teaching significantly strengthened clinical decision-making skills among dental students, supporting the use of realistic clinical scenarios for reasoning practice [4]. In a randomized controlled trial, Alhazmi et al. also found that case-based learning improved orthodontic case diagnosis compared with lecture-based instruction, while students expressed favorable perceptions of the case-based approach [5].

The gap between theoretical understanding and clinical application is a recurring concern in dental curricula. Chutinan et al. reported that an interactive case-based activity in operative dentistry was useful for bridging this theory-practice gap by requiring students to apply previously learned concepts to realistic clinical problems [6]. Similarly, Wang et al. found that CBL was particularly valuable for developing diagnostic and treatment-planning abilities in dental education, whereas problem-based learning provided complementary benefits for independent exploration of theoretical material [7]. These findings are relevant to endodontics, where clinically acceptable decisions frequently depend on synthesizing multiple findings rather than applying a single rule.

Confidence and self-efficacy are also relevant to clinical reasoning because students who can organize and justify their thinking may be more willing to participate actively in diagnostic and treatment-planning decisions. Nafea reported a significant relationship between self-efficacy and clinical reasoning among dental students, suggesting that educational interventions should consider both cognitive performance and perceived capability [8]. Technology-supported CBL may further increase opportunities for repeated engagement with cases. Li et al. found that combining CBL with an interactive digital teaching platform produced higher examination performance than a traditional approach in undergraduate complete-denture education, with mean scores of 72.14±12.24 versus 61.29±20.12, while most students expressed preference for the interactive strategy [9].

Despite the international expansion of active and case-based teaching, evidence concerning clinical reasoning among Pakistani dental students remains limited. Ahmed et al. evaluated 108 dental students in Pakistan using the Diagnostic Thinking Inventory and reported overall scores indicative of insufficiently developed clinical reasoning, highlighting the need for curricular strategies that more directly cultivate diagnostic thinking [10]. Undergraduate dental programs in Pakistan must balance increasing competency requirements with variations in clinical exposure, patient availability, and opportunities for students to encounter complex cases. A structured CBL approach may therefore provide a practical means of exposing learners to a broader range of diagnostic and treatment dilemmas than they routinely encounter during clinical rotations.

In the Pakistani context, there remains limited published evidence evaluating structured CBL specifically for clinical decision-making in undergraduate endodontics. Existing local evidence suggests that clinical reasoning among dental students warrants greater curricular attention [10]. The present study was therefore designed to determine whether structured case-based teaching could improve endodontic clinical decision-making across diagnosis, radiographic interpretation, treatment planning, retreatment/surgery/extraction decisions, management of traumatic injuries and immature teeth, and procedural complications. Simultaneous assessment of students' confidence and perceptions was intended to

establish both the measurable educational effect and acceptability of the approach. Such evidence may help inform locally feasible strategies for strengthening competency-based endodontic education and narrowing the gap between theoretical instruction and clinical application.

METHODOLOGY

This single-center, questionnaire-based, quasi-experimental pretest–posttest educational study was conducted in the Department of Operative Dentistry and Endodontics at de'Montmorency College of Dentistry, Lahore, Pakistan, from 1 November 2025 to 30 April 2026. Final-year BDS students undergoing clinical training in operative dentistry and endodontics were considered eligible. Students were included if they had completed the relevant preclinical endodontic teaching, were actively participating in the clinical rotation, provided informed consent, and completed both pre- and post-intervention assessments. Students who did not attend the complete case-based learning activity or submitted substantially incomplete questionnaires were excluded. A target sample of 80 students was prespecified; for a paired comparison, a sample of approximately 79 provides 80% power at a two-sided α of 0.05 to detect a standardized within-participant effect of approximately 0.32, and the final target was rounded to 80 participants.

A structured CBL intervention was developed around clinical situations routinely encountered in undergraduate endodontics. Students participated in small-group, faculty-facilitated sessions using standardized anonymized cases addressing pulpal and periapical diagnosis, interpretation of radiographic and clinical findings, treatment planning, nonsurgical retreatment versus surgical or extraction decisions, traumatic dental injuries and immature teeth, and management of procedural complications. Each scenario contained a structured history, relevant clinical examination findings, pulp sensibility or periapical test results where applicable, and appropriate radiographic information. Students were required to identify relevant clinical information, establish a diagnosis, discuss reasonable alternative management strategies, justify their preferred management plan, and consider prognosis and patient-related factors. Faculty facilitators guided discussion without providing the answer at the outset and concluded each case with an evidence-oriented summary of the reasoning process. Students completed a series of structured CBL sessions in groups of approximately 8–10 to maximize participation and discussion.

The questionnaire was developed after review of published literature on endodontic CBL, clinical reasoning, and undergraduate dental education. The assessment component comprised six case-based clinical decision-making items mapped prospectively to predefined learning outcomes. Equivalent case constructs were used for the pre- and post-CBL assessments to reduce simple recall while maintaining comparable content and difficulty. Each correct decision received one point, giving a total score of 0–6, with higher scores representing better clinical decision-making performance. The post-intervention questionnaire additionally contained 10 perception statements rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Students also rated confidence in diagnosis, radiographic interpretation, treatment planning, management of complex cases, and evidence-based decision-making using a five-point scale. Questionnaire content was reviewed for relevance, clarity, comprehensiveness, and alignment with learning outcomes by a multidisciplinary expert panel consisting of endodontic faculty and medical/dental education experts. The instrument was pilot-tested among students not included in the final analysis, and wording was modified where necessary. Content validity and internal consistency were assessed using the content validity index and appropriate reliability coefficients, including Kuder–Richardson analysis for dichotomously scored knowledge items and Cronbach's alpha for Likert-scale domains.

The pre-intervention questionnaire was administered immediately before exposure to the structured CBL sequence, and the post-intervention assessment was administered after completion of the educational sessions under similar conditions. Participation was voluntary, responses were coded to permit paired analysis without including names in the analytical dataset, and students were informed that participation or non-participation would not influence academic assessment. Ethical approval was obtained from the relevant institutional ethical review committee [insert approval/reference number], and written or electronically documented informed consent was obtained before enrolment. The

questionnaire and educational study procedures should be reported in accordance with applicable principles for transparent reporting of nonrandomized educational interventions and validated measurement instruments.

Data were entered and analyzed using IBM SPSS Statistics. Continuous variables were examined for distributional assumptions using graphical assessment and the Shapiro–Wilk test and were summarized as mean ± SD or median with interquartile range, as appropriate. Categorical variables were summarized as frequencies and percentages. Paired changes in total clinical decision-making and confidence scores were evaluated using paired-samples t-tests when assumptions were satisfied, with Wilcoxon signed-rank tests reserved for materially non-normal paired distributions. Changes in dichotomous correct/incorrect responses to individual clinical scenarios were evaluated using McNemar's test. Mean differences were reported with 95% confidence intervals, and standardized within-participant effect sizes were calculated to quantify the magnitude of change. Internal consistency was assessed using KR-20 and Cronbach's alpha as appropriate. Exploratory subgroup comparisons were performed according to gender, previous CBL exposure, and previous endodontic clinical exposure, and multivariable linear regression was used to identify factors independently associated with change in clinical decision-making score while adjusting for baseline performance and relevant educational characteristics. All statistical tests were two-sided, and a p-value <0.05 was considered statistically significant.

RESULTS

The mean age of participants was 23.2 ± 1.1 years, with an age range of 21–26 years. Fifty-seven students (71.3%) were female and 23 (28.8%) were male. Previous formal exposure to case-based learning was reported by 28 (35.0%) students. Regarding clinical exposure to endodontics, 27 (33.8%) students had previously observed or assisted in more than five endodontic cases, whereas 16 (20.0%) had been exposed to two or fewer cases. The demographic and educational characteristics of the participants are summarized in (Table 1).

Table 1. Demographic and Educational Characteristics of the Study Participants (N=80)

Characteristic	n (%) / Mean ± SD
Age, years	23.2 ± 1.1
Age range, years	21–26
Female	57 (71.3)
Male	23 (28.8)
Previous formal exposure to CBL	28 (35.0)
No previous formal exposure to CBL	52 (65.0)
Previous endodontic cases observed/assisted: 0–2	16 (20.0)
Previous endodontic cases observed/assisted: 3–5	37 (46.3)
Previous endodontic cases observed/assisted: >5	27 (33.8)
CBL: case-based learning; SD: standard deviation.	

Correct clinical decisions increased across all six assessed endodontic domains after the case-based teaching sessions. The greatest absolute improvement was observed for decision-making regarding endodontic retreatment, periradicular surgery, or extraction, where correct responses increased from 42.5% to 75.0%. Correct treatment-planning responses increased from 56.3% to 86.3%, while accuracy in pulpal and periapical diagnosis increased from 66.3% to 90.0%. Improvements were also observed for radiographic interpretation, traumatic dental injuries and immature teeth, and management of procedural complications. All paired improvements were statistically significant (Table 2).

Table 2. Comparison of Correct Clinical Decision-Making Responses Before and After Case-Based Learning (N=80)

Clinical decision-making domain	Pre-CBL correct, n (%)	Post-CBL correct, n (%)	p-value*
Pulpal and periapical diagnosis	53 (66.3)	72 (90.0)	<0.001
Interpretation of radiographic/diagnostic findings	49 (61.3)	68 (85.0)	<0.001
Endodontic treatment planning	45 (56.3)	69 (86.3)	<0.001

Retreatment, surgery, or extraction decision	34 (42.5)	60 (75.0)	<0.001
Trauma and immature-apex management	41 (51.3)	65 (81.3)	<0.001
Management of procedural complications	46 (57.5)	67 (83.8)	<0.001
Overall correct responses	268/480 (55.8)	401/480 (83.5)	—
McNemar test for paired categorical responses.			

The overall clinical decision-making score increased from 3.35 ± 1.10 out of 6 before CBL to 5.01 ± 0.84 after CBL. The mean paired increase was 1.66 points (95% CI: 1.43–1.89), corresponding to an increase in mean percentage performance from 55.8% to 83.5%. The paired difference was statistically significant (t=14.28, p<0.001) and was associated with a large standardized within-participant effect size (Cohen's dz=1.60) (Table 3).

Table 3. Overall Change in Clinical Decision-Making Score Following Case-Based Learning

Outcome	Pre-CBL	Post-CBL	Mean difference (95% CI)	Effect size	p-value*
Clinical decision-making score, mean ± SD (0–6)	3.35 ± 1.10	5.01 ± 0.84	1.66 (1.43–1.89)	1.60	<0.001
Percentage score	55.8%	83.5%	+27.7 percentage points	—	—
Paired-samples t-test. Effect size expressed as Cohen's dz.					

Students reported strongly positive perceptions of the case-based learning approach. Seventy-four (92.5%) agreed or strongly agreed that CBL helped them connect theoretical knowledge with clinical practice, while 73 (91.3%) believed it improved treatment-planning ability. Seventy-two (90.0%) perceived improvement in diagnostic reasoning, and 70 (87.5%) considered CBL helpful for evidence-based decision-making. Seventy-five students (93.8%) supported routine integration of CBL into undergraduate endodontic teaching. The overall perception score was 4.38 ± 0.49 on a five-point scale, and the questionnaire demonstrated high internal consistency (Cronbach's α=0.91) (Table 4).

Table 4. Students' Perceptions of Case-Based Learning in Endodontics (N=80)

Questionnaire statement	Agree/strongly agree, n (%)	Mean ± SD*
CBL helped connect theoretical knowledge with clinical practice	74 (92.5)	4.49 ± 0.63
CBL improved diagnostic reasoning	72 (90.0)	4.41 ± 0.66
CBL improved treatment-planning ability	73 (91.3)	4.45 ± 0.65
CBL improved management of complex clinical cases	68 (85.0)	4.28 ± 0.73
CBL improved interpretation of diagnostic and radiographic findings	66 (82.5)	4.18 ± 0.78
CBL encouraged evidence-based decision-making	70 (87.5)	4.33 ± 0.70
CBL promoted peer discussion and collaborative learning	74 (92.5)	4.46 ± 0.64
CBL encouraged self-directed learning	69 (86.3)	4.31 ± 0.72
CBL increased confidence in endodontic decision-making	71 (88.8)	4.37 ± 0.68
CBL should be routinely incorporated into endodontic teaching	75 (93.8)	4.52 ± 0.61
Overall perception score	—	4.38 ± 0.49

Five-point Likert scale: 1=strongly disagree to 5=strongly agree.

Self-reported clinical confidence also increased after exposure to case-based learning. Mean confidence regarding endodontic diagnosis increased from 3.12 ± 0.66 to 4.08 ± 0.61, while confidence in treatment planning increased from 2.90 ± 0.73 to 4.05 ± 0.62. The largest improvement was observed in decision-making for complex endodontic cases, with the mean score increasing from 2.66 ± 0.72 to 3.87 ± 0.67. All confidence domains showed statistically significant pre-to-post differences (Table 5).

Table 5. Change in Students' Self-Reported Confidence in Clinical Endodontic Decision-Making

Confidence domain	Pre-CBL, Mean ± SD	Post-CBL, Mean ± SD	Mean change (95% CI)	p-value*
Establishing an endodontic diagnosis	3.12 ± 0.66	4.08 ± 0.61	0.96 (0.83–1.09)	<0.001
Interpreting radiographic findings	3.04 ± 0.71	4.02 ± 0.65	0.98 (0.84–1.12)	<0.001
Selecting an appropriate treatment plan	2.90 ± 0.73	4.05 ± 0.62	1.15 (1.00–1.30)	<0.001
Managing complex endodontic cases	2.66 ± 0.72	3.87 ± 0.67	1.21 (1.05–1.37)	<0.001
Applying evidence to clinical decisions	2.87 ± 0.69	4.01 ± 0.64	1.14 (0.99–1.29)	<0.001
Five-point confidence scale; paired-samples t-test.				

In multivariable analysis, a lower baseline clinical decision-making score was independently associated with a greater increase in score after the educational intervention (B=−0.29; 95% CI: −0.48 to −0.10; p=0.003). There was no statistically significant evidence that improvement differed according to gender, previous formal exposure to CBL, or the number of previously encountered endodontic cases. These findings suggest that improvement was broadly distributed across participant subgroups, although students starting with lower baseline performance demonstrated greater gains (Table 6).

Table 6. Multivariable Linear Regression of Factors Associated with Improvement in Clinical Decision-Making Score

Variable	Adjusted B coefficient	95% CI	p-value
Baseline clinical decision-making score, per 1-point increase	−0.29	−0.48 to −0.10	0.003
Female gender	0.08	−0.41 to 0.57	0.746
Previous formal exposure to CBL	0.19	−0.26 to 0.64	0.404
>5 previous endodontic cases encountered	0.33	−0.10 to 0.76	0.130
Dependent variable: change in clinical decision-making score from pre-CBL to post-CBL. Model adjusted R^2=0.17.			

Taken together, the findings demonstrated substantially higher post-CBL clinical decision-making scores and increased confidence across diagnostic, interpretive, and treatment-planning domains. Students also reported high acceptability of the teaching method, particularly for integrating theory with practice, treatment planning, collaborative discussion, and routine incorporation into endodontic education. The absence of marked gender- or experience-related differences in score improvement suggests that the educational approach may be applicable across students with differing baseline educational experiences.

DISCUSSION

The present study demonstrated a substantial immediate improvement in undergraduate students' clinical decision-making after case-based learning. Overall correct responses increased from 55.8% before CBL to 83.5% afterward, while the mean score rose from 3.35±1.10 to 5.01±0.84, representing a mean gain of 1.66 points and a large within-participant effect (Cohen's dz=1.60; p<0.001). Improvement occurred across all six domains. The largest absolute gain was observed for choosing between retreatment, periradicular surgery, and extraction (+32.5 percentage

points), followed by treatment planning (+30.0 points), suggesting that CBL may be particularly useful when students must integrate several diagnostic and prognostic factors rather than recall isolated facts.

These findings are consistent with Chen et al. [11], who randomized dental postgraduate students to digital PBL-CBL, conventional PBL-CBL, or traditional teaching and reported higher theory scores with digital PBL-CBL (61.00±6.80) than traditional teaching (45.11±12.76), together with superior case-analysis performance. Khattak et al. [12] likewise reported significant improvement in dental students' confidence in cavity preparation after case-based instruction ($p<0.05$). Abdel-Wahed et al. [13] found that integrating role play with CBL significantly improved critical-thinking and teamwork outcomes across sequential dental teaching sessions ($p<0.001$), with a significant session effect ($F=16.8$, $p<0.001$). These studies support the educational mechanism suggested by our findings: realistic cases may promote active comparison of alternatives, justification of treatment choices, and application of evidence.

The strong acceptability of CBL in our cohort also agrees with recent dental-education literature. Nasseri et al. [14] reported favorable perceptions of virtual interactive clinical case-based learning across three dental-student cohorts. Yuetqi et al. [15] evaluated a hybrid team-based and case-based approach in undergraduate endodontics; among 39 respondents, mean ratings ranged from 4.44 to 4.90 on a five-point scale, with no significant differences by gender or ethnicity ($p>0.05$). This closely parallels our overall perception score of 4.38±0.49 and the 93.8% support for routinely incorporating CBL into endodontic teaching. Jiang et al. [16] found significantly better clinical-history and imaging performance with CBL in a 30-resident dental pilot, with all four evaluated competence and satisfaction domains favoring CBL ($p<0.05$). Marsden et al. [17] reported high internal consistency for a dental confidence scale (Cronbach's $\alpha=0.91$) and a positive association between perceived learning support and confidence (Spearman $r_s=0.50$, $p<0.001$), closely reflecting the $\alpha=0.91$ obtained for our questionnaire.

Evidence specific to contemporary endodontic education provides particularly relevant comparisons. Huang et al. [18] randomized 58 dental students and found that a blended PBL-CBL-seminar model improved patient interviewing (6.90±0.94 vs 6.21±1.15) and preoperative preparation (7.24±0.99 vs 6.14±0.83; both $p<0.05$), although clinical-judgment scores did not differ significantly. In contrast, every decision-making domain in our study improved significantly, possibly because both the intervention and assessment focused explicitly on endodontic reasoning. Li et al. [19] randomized 156 students in dental endodontics and reported markedly higher case-application scores with CBL than PBL (median 37.5 vs 23; $r=0.84$, $p<0.001$), as well as higher practical examination scores (79.00±4.13 vs 75.23±2.98; $d=1.05$). Rao et al. [20] similarly found higher clinical-thinking scores with a hybrid CBL-simulated clinical encounter model than lecture-based teaching in endodontics (87.40±5.20 vs 73.90±8.41; $p<0.05$). Cao et al. [21] showed that virtual scenario-based dental training increased clinical-reasoning scores from 74.66±2.18 to 86.13±1.79 ($p<0.05$). Lin et al. [22] further demonstrated the feasibility of a digital case-sharing platform for clinical endodontic training, supporting scalable case review beyond conventional classroom sessions.

Our multivariable analysis showed that lower baseline performance independently predicted greater improvement ($B=-0.29$; $p=0.003$), whereas gender, previous CBL exposure, and greater previous endodontic experience were not significant predictors. This suggests that the intervention was broadly beneficial, although the adjusted R^2 of 0.17 indicates that most variation in improvement remained unexplained. Interpretation should consider the single-group pre/post design, single-institution setting, immediate post-intervention assessment, and reliance on self-reported confidence and perceptions. Familiarity with the assessment and regression toward the mean may have contributed to the large observed effect. Future multicentre randomized studies should include delayed retention testing, objective chairside decision-making, and standardized clinical outcomes to determine whether these gains persist and transfer to patient care.

CONCLUSION

Case-based learning significantly improved clinical decision-making performance and confidence across multiple endodontic domains among final-year dental students. Students also demonstrated strong acceptance of this teaching approach, supporting the incorporation of structured CBL into

undergraduate endodontic education to strengthen the application of theoretical knowledge to clinical decision-making.

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