Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Radiographic Diagnostic Competency of Final-Year Dental Students Following Clinical Endodontic Training: Comparison with Academic Staff

Fatma Selenay UÇAŞ-YILDIZ

fatmaselenay.ucas@erbakan.edu.tr

Necmettin Erbakan University

Arslan TERLEMEZ

Necmettin Erbakan University

Research Article

Keywords: radiographic interpretation, diagnostic competency, endodontic education, clinical decision-making, undergraduate dental education

Posted Date: September 7th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10573485/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Radiographic interpretation is an essential component of diagnostic competency in endodontic education because it enables assessment of treatment quality, identification of procedural complications, and informed clinical decision-making. This study aimed to evaluate the radiographic diagnostic competency of final-year dental students by comparing their assessments of endodontic treatment quality with those of academic staff.

Methods

This cross-sectional observational study included 54 final-year dental students. Fifty-four postoperative periapical radiographs of root canal treatments performed during fourth-year clinical endodontic training were randomly selected. All radiographs had been previously assessed by academic staff using a structured clinical assessment rubric. Students independently evaluated anonymized postoperative periapical radiographs using the same rubric. Differences between scores were analyzed using the Wilcoxon signed-rank test, and agreement was assessed using the intraclass correlation coefficient (ICC).

Results

The mean student score was 6.15 ± 2.06, whereas the mean academic staff score was 5.44 ± 2.46. Students assigned significantly higher scores than academic staff ($p = 0.035$). Agreement between student and academic staff assessments was fair (ICC = 0.437; $p < 0.001$). Subgroup analysis showed no statistically significant differences according to procedural complication status.

Conclusion

Final-year dental students demonstrated fair agreement with academic staff in the radiographic assessment of endodontic treatment quality. However, students tended to assign more favorable scores than academic staff, suggesting a tendency to overestimate treatment quality during radiographic assessment. These findings emphasize the importance of strengthening radiographic interpretation skills during undergraduate endodontic education to better prepare students for independent clinical decision-making.

Background

Accurate radiographic interpretation is a fundamental component of successful endodontic practice. It enables clinicians to evaluate treatment quality, identify procedural complications, assess treatment

prognosis, and make appropriate clinical decisions (1). Therefore, the ability to critically assess postoperative radiographs represents an essential diagnostic competency that should be developed during undergraduate education before independent clinical practice (2).

Undergraduate endodontic education aims not only to develop students' technical skills in performing root canal treatment but also to prepare them to independently evaluate treatment outcomes (1, 3). In Türkiye, undergraduate dental education follows a five-year curriculum. Accordingly, final-year dental students who have successfully completed both their preclinical and clinical endodontic training are expected to possess sufficient theoretical knowledge, technical skills, and diagnostic judgment to accurately interpret postoperative radiographs before graduation and entry into independent clinical practice (2).

Assessment of diagnostic competency in clinical endodontic education is commonly based on the radiographic evaluation of completed root canal treatments (4). Postoperative periapical radiographs provide essential information regarding treatment quality by allowing assessment of apical termination, canal taper, and obturation quality (5). In addition, accurate radiographic interpretation enables the detection of procedural complications such as perforation, instrument separation, and canal transportation, which may substantially affect treatment prognosis, retreatment planning, and referral decisions. However, despite the use of predefined evaluation criteria, radiographic assessment remains partly dependent on the evaluator's clinical experience and diagnostic judgment, which may result in variability between assessors (6, 7).

To improve objectivity in undergraduate assessment, structured clinical rubrics have been increasingly incorporated into dental education. These analytical assessment systems standardize scoring by providing predefined technical criteria for the systematic assessment of treatment outcomes (8). Nevertheless, standardized assessment tools cannot eliminate differences in clinical judgment, and it remains uncertain whether students who have completed their clinical endodontic training interpret postoperative radiographs in a manner comparable to experienced academic staff (9).

Although previous studies have investigated rubric-based assessment systems, examiner agreement, and methods for evaluating technical quality in dental education, limited evidence is available regarding the diagnostic competency of final-year dental students in independently interpreting the radiographic quality of clinical endodontic treatments after completing their clinical internship (10). Furthermore, it remains unclear whether the radiographic assessments of final-year dental students are comparable to those of experienced academic staff under routine educational conditions (3, 11). Therefore, the present study evaluated whether final-year dental students who had completed their clinical endodontic internship were able to independently interpret the radiographic quality of endodontic treatments at a level comparable to academic staff. This approach provides valuable evidence regarding students' readiness for independent clinical practice (12).

Therefore, this study aimed to evaluate the radiographic diagnostic competency of final-year dental students following clinical endodontic training by comparing their independent assessments of clinical

endodontic treatment quality with those of academic staff (3, 7, 13). Agreement between student and academic staff assessments was used as an indicator of students' diagnostic competency in radiographic interpretation. The null hypothesis was that no significant differences would exist between student and academic staff assessments (5, 11, 14, 15).

Materials and Methods

Study Design and Ethical Approval

This cross-sectional observational study was designed to evaluate the radiographic diagnostic competency of final-year dental students by comparing their assessments of the radiographic quality of clinical endodontic treatments with those of academic staff. The study was conducted using archived radiographic records and educational assessment data and did not involve any additional clinical intervention.

Ethical approval for the study was obtained from the Ethics Committee of the Faculty of Dentistry, Necmettin Erbakan University (Decision No: 2026/842; Application ID: 31910). Written informed consent was obtained from all participating students prior to their inclusion in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki and applicable scientific research ethics guidelines.

Participants

Fifty-four volunteer fifth-year dental students who had successfully completed their clinical endodontic internship were included in the study.

The minimum required sample size was calculated as 40 participants using G*Power software (v3.1.9.7) based on an anticipated moderate effect size (0.40), statistical power of 80%, and a significance level of $\alpha = 0.05$. To increase the robustness of the statistical analysis, a total of 54 participants were ultimately included in the study.

All participants had previously performed clinical root canal treatments during their undergraduate clinical endodontic training. Participation was voluntary, and all data were collected anonymously. Participant identities were kept confidential throughout the study.

Case Selection

Fifty-four clinical root canal treatment cases previously performed by the same student cohort during their fourth-year undergraduate clinical endodontic training were selected from the institutional clinical archives using a computer-generated randomization sequence. All cases were anonymized and presented in a numbered format prior to assessment. Because cases were allocated randomly, participants could potentially evaluate a case they had previously treated. However, all radiographs were

anonymized, presented in a blinded numbered format, and students were unaware of the case identity during assessment.

Case selection was performed according to the following inclusion criteria:

• availability of complete radiographic records, including both preoperative and postoperative periapical radiographs;

• adequate radiographic image quality for assessment;

• completed root canal obturation procedures;

• availability of archived academic staff assessment forms.

Differences in the interpretation of radiographically detectable procedural complications, as well as cases in which radiographic findings were incorrectly interpreted as complications despite their absence, were intentionally retained as part of the study design.

Radiographic Assessment Procedure

All selected cases had previously been evaluated by academic staff using a structured clinical assessment rubric as part of routine clinical education. These evaluations served as the reference standard for comparison. Participating students were blinded to the original academic staff scores throughout the evaluation process.

Each participating student was randomly assigned a single radiographic case for evaluation. Accordingly, each of the 54 selected clinical cases was independently evaluated by a single final-year student, and the student scores were subsequently compared with the original academic staff scores previously assigned to the same case.

For the present study, only anonymized postoperative periapical radiographs were presented to the participating fifth-year students for evaluation, as the assessment focused exclusively on the radiographic quality of the completed endodontic treatment. Preoperative radiographs were used solely during case selection to confirm the completeness of the clinical records but were not included in the evaluation process. Prior to evaluation, students were briefly reminded of the rubric criteria; however, no calibration session, sample case discussion, or reference scoring exercise was performed. No time limit was imposed during the evaluation process.

Assessment parameters related to behavioral performance and clinical procedures requiring direct chairside observation were excluded from the analysis because the retrospective design of the study allowed evaluation exclusively through archived radiographic records and documented treatment outcomes.

Assessment Rubric

The structured assessment rubric used in the study was routinely employed in undergraduate clinical endodontic education for the evaluation of technical treatment quality. The rubric was developed according to fundamental endodontic treatment objectives and radiographic quality criteria (Supplementary File 1).

The evaluated parameters included:

• apical termination level of the root canal filling;

• canal taper and conical form;

• quality and homogeneity of root canal obturation.

Each parameter was scored according to predefined institutional grading criteria. Radiographically detectable procedural complications such as perforation, instrument separation, or canal transportation were considered critical treatment errors. In cases where such complications were identified, the total score assigned to the case was reduced by 50%.

Statistical Analysis

All collected data were transferred to SPSS software (version 25.0; IBM Corp., Armonk, NY, USA) for statistical analysis. Descriptive statistics were calculated for both academic staff and student assessment scores and are presented as mean ± standard deviation, median, and minimum–maximum values.

The normality of score distributions was evaluated using both the Kolmogorov–Smirnov and Shapiro–Wilk tests. Since the data were not normally distributed, differences between paired student and academic staff scores were analyzed using the Wilcoxon signed-rank test. Agreement between student and academic staff scores was assessed using a two-way mixed-effects, absolute-agreement intraclass correlation coefficient (ICC).

In addition, subgroup analysis was performed according to the presence or absence of radiographically detectable procedural complications to determine whether procedural complications influenced score discrepancies between student and academic staff evaluations. Statistical significance was set at $\alpha = 0.05$.

Results

A total of 54 paired evaluations were included in the statistical analysis. Normality analysis using the Kolmogorov–Smirnov and Shapiro–Wilk tests demonstrated that neither the student nor the academic staff score distributions followed a normal distribution (all $p < 0.001$) (Table 1). Therefore, non-parametric statistical methods were used for all subsequent analyses.

Table 1
Normality analysis of student and academic staff evaluation scores.

Group	Kolmogorov–Smirnov statistic	p	Shapiro–Wilk statistic	p
Student	0.260	< 0.001	0.811	< 0.001
Academic Staff	0.219	< 0.001	0.866	< 0.001

Descriptive statistics for the student and academic staff evaluation scores are presented in Table 2. Final-year dental students assigned a higher mean score (6.15 ± 2.06) than the academic staff (5.44 ± 2.46). The median score was 6.00 for both groups, with score ranges of 2–8 for students and 0–8 for the academic staff.

Table 2
Descriptive statistics of student and academic staff evaluation scores.

Group	Mean ± SD	Median	Min-Max
Student	6.15 ± 2.06	6	2–8
Academic Staff	5.44 ± 2.46	6	0–8

Comparison of paired scores using the Wilcoxon signed-rank test revealed a statistically significant difference between student and academic staff evaluations (Z = − 2.105, p = 0.035). Final-year dental students assigned significantly higher scores than the academic staff (Table 3).

Table 3
Comparison of student and academic staff scores and agreement analysis.

Parameter	Value
Wilcoxon Z	-2.105
p	0.035
ICC	0.437
95% CI	0.194–0.630
ICC p	< 0.001

Intraclass correlation coefficient (ICC) analysis demonstrated a fair level of agreement between student and academic staff evaluations (ICC = 0.437; 95% CI: 0.194–0.630; p < 0.001).

Subgroup analysis according to procedural complication status showed no statistically significant differences between student and academic staff scores in either cases without procedural complications (p = 0.070) or cases with procedural complications (p = 0.233) (Table 4).

Table 4
Subgroup analysis of student and academic staff scores according to procedural complication status.

Group	Student Mean ± SD	Academic Mean ± SD	p
No complication	6.49 ± 1.80	6.00 ± 1.89	0.070
Complication	3.86 ± 2.34	1.71 ± 2.75	0.233

Comparison of the score discrepancies between the two procedural complication subgroups showed no statistically significant difference (p = 0.148).

Discussion

The present study evaluated the radiographic diagnostic competency of final-year dental students in interpreting postoperative endodontic radiographs and compared their evaluations with those of academic staff (16). The findings demonstrated a fair level of agreement between student and academic staff assessments (17). However, a statistically significant difference between the two groups was observed, with students tending to assign higher scores than academic staff (18). These findings suggest that although students approaching graduation demonstrate a fair level of agreement with academic staff, their radiographic evaluations still differ from those of experienced academic staff (2).

Previous studies evaluating structured assessment systems in dental education have suggested that rubric-based evaluation may improve scoring consistency and contribute to greater objectivity during clinical assessment (8, 11). The findings of the present study are generally consistent with these observations. However, the level of agreement observed in the present study remained only fair, suggesting that although final-year students develop basic radiographic assessment skills, their evaluation patterns may still differ from those of experienced academic evaluators (19).

One of the most important findings of the present study was that final-year dental students assigned significantly higher scores than academic staff. This difference may reflect variations in evaluation thresholds between inexperienced and experienced evaluators. Academic staff members may apply stricter quality criteria based on their accumulated clinical experience and greater familiarity with subtle technical deficiencies that may influence long-term treatment prognosis. In contrast, students may focus primarily on more obvious radiographic features while overlooking minor deficiencies that experienced evaluators consider clinically relevant when assessing treatment quality (20).

Although subgroup analysis did not demonstrate statistically significant differences according to procedural complication status, the educational importance of accurate radiographic interpretation extends beyond the findings of the present study. Accurate radiographic interpretation directly influences diagnostic accuracy and plays a fundamental role in identifying treatment-related procedural complications. In daily clinical practice, failure to recognize such complications may lead to delayed recognition of treatment failure, inaccurate prognosis assessment, and inappropriate treatment planning

(19). Furthermore, accurate detection of procedural errors is essential for determining the indication for nonsurgical endodontic retreatment and deciding whether referral to an endodontic specialist is required (21). Therefore, strengthening students' radiographic interpretation skills during undergraduate education may contribute not only to improved academic performance but also to safer clinical decision-making and more appropriate referral to endodontic specialists after graduation (15).

From an educational perspective, these findings suggest that undergraduate endodontic education successfully develops students' general radiographic evaluation skills; however, additional emphasis may be necessary to strengthen students' radiographic interpretation and diagnostic decision-making skills (5). Greater exposure to failed treatment cases, complication-based case discussions, and structured radiographic interpretation exercises may help improve students' diagnostic confidence before graduation (6). Particular emphasis should be placed on exposing students to failed endodontic cases and radiographic findings that require referral-based clinical decision-making.

Several limitations of the present study should be acknowledged. First, each participant evaluated only a single clinical case, which did not allow assessment of intra-individual scoring consistency across multiple treatment scenarios. Second, although all radiographs were anonymized, students could potentially have evaluated cases they had previously treated during undergraduate clinical training. Third, the study was conducted at a single institution, which may limit the generalizability of the findings to other undergraduate dental education settings. Fourth, students did not undergo a calibration session before evaluation, which may have contributed to inter-individual variability in scoring. Finally, the evaluation was based exclusively on postoperative radiographs and therefore did not incorporate additional clinical factors that may influence comprehensive treatment assessment.

Conclusions

Within the limitations of this study, final-year dental students who successfully completed their clinical endodontic internship demonstrated a fair level of agreement with academic staff in the radiographic evaluation of root canal treatment quality. Although students were generally able to assess overall treatment quality in a manner comparable to that of academic staff, they tended to assign significantly higher scores, suggesting that differences in radiographic interpretation remain.

Although no statistically significant differences were observed according to procedural complication status, accurate radiographic interpretation remains essential for appropriate diagnosis and clinical decision-making. The tendency of students to assign higher scores than academic staff suggests that radiographic evaluation skills continue to develop with increasing clinical experience.

These findings emphasize that accurate radiographic interpretation is an essential diagnostic skill for clinical decision-making before independent dental practice.

Abbreviations

ICC: Intraclass Correlation Coefficient

SD: Standard Deviation

CI: Confidence Interval

SPSS: Statistical Package for the Social Sciences

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Faculty of Dentistry, Necmettin Erbakan University (Decision No. 2026/842; Application ID: 31910). Written informed consent was obtained from all participating students prior to their inclusion in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets utilized and/or analysed during this study is available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This research received no external funding.

Authors' contributions

Conceptualization, F.S.U.Y. and A.T.; methodology, F.S.U.Y. and A.T.; formal analysis, F.S.U.Y.; investigation, F.S.U.Y.; data curation, F.S.U.Y.; writing—original draft preparation, F.S.U.Y.; writing—review and editing, F.S.U.Y. and A.T.; visualization, F.S.U.Y.; supervision, A.T.; All authors have read and agreed to the published version of the manuscript.

Acknowledgements

Not applicable.

Clinical trial number

Not applicable. This cross-sectional observational study was not a clinical trial and was therefore not registered in a clinical trial registry.

Generative Artificial Intelligence

During the preparation of this manuscript, the authors used ChatGPT (OpenAI, GPT-5) to improve grammar, language clarity, and readability. The AI tool was not used to generate scientific ideas, design the study, analyze data, interpret the findings, or formulate the conclusions. All AI-assisted edits were carefully reviewed and verified by the authors, who take full responsibility for the content of this manuscript.

References

1. Al Moaleem MM, Adawi HA, Alahmari NM, Sayed ME, Albar NH, Okshah A, et al. Using an analytic rubric system for the evaluation of anterior ceramic crown preparation performed by preclinical dental students. PLoS ONE. 2025;20(4):e0318752.
2. Alghilan MA, Munaga S, Aldakhil A. A Comparison of Dental Students' Self-Assessment and Instructors' Assessment in Competency Examinations in a Preclinical Operative Dentistry Course. Advances in medical education and practice. 2025;16:177 – 88.
3. Ardila CM, Pineda-Vélez E, Vivares-Builes AM. Artificial Intelligence in Endodontic Education: A Systematic Review with Frequentist and Bayesian Meta-Analysis of Student-Based Evidence. Dentistry J. 2025;13(11).
4. Ba-Hattab R, Taha NA, Shaweesh MM, Palma PJ, Abdulrab SJSR. Global trends in preclinical and clinical undergraduate endodontic education: A worldwide survey. 2025;15(1):10078.
5. Escribano N, Belliard V, Baracco B, Da Silva D, Ceballos L, Fuentes MV. Rubric vs. numeric rating scale: agreement among evaluators on endodontic treatments performed by dental students. BMC Med Educ. 2023;23(1):197.
6. Venskutonis T, Plotino G, Tocci L, Gambarini G, Maminskas J, Juodzbalys G. Periapical and endodontic status scale based on periapical bone lesions and endodontic treatment quality evaluation using cone-beam computed tomography. J Endod. 2015;41(2):190–6.
7. Algahtani FN, Barakat RM, Alqarni LM, Alqabbani AF, Alkadi MF, Almohareb RA. Undergraduate Endodontic Training and Its Relation to Contemporary Practice: Multicenter Cross-Sectional Study in Saudi Arabia. Int J Clin Pract. 2023;2023:7484570.
8. Jabali A, Alroomy R, Mashyakhy M, Bajawi H, Al Malwi AA, Karobari MI. Rubric system for the evaluation of root canal treatment of single canal tooth performed by preclinical dental students: a cross-sectional study. Saudi Dent J. 2025;37(1):6.
9. Dakkaki J, Drouri S, Dhoum S, Mayou R, Jabri MJERI. Evaluation Grids Endodontics Preclinical Practical Activities. 2021;2021(1):8829119.

10. Bitter K, Gruner D, Wolf O, Schwendicke F. Artificial Versus Natural Teeth for Preclinical Endodontic Training: A Randomized Controlled Trial. J Endod. 2016;42(8):1212–7.
11. Tsai ST, Ho YC, Tsai CL, Yang SF, Lai YL, Lee SY. Evaluation of students' self-assessment performance in preclinical endodontic training by means of rubrics and a 3D printed model. J Formos Med Association = Taiwan yi zhi. 2022;121(11):2203–10.
12. Hashem D, Farag A, Algarni AA, Mubarak RZ, Alwasifi Y, Saleh SA. Student Peer Assessment in Clinical Operative Dentistry: A Retrospective Study. Int J Dent. 2025;2025:9268602.
13. Gondivkar SM, Panchbhai A, Gadbail AR, Gaikwad R. Development of a Comprehensive Rubric for Assessing Dental Radiography Skills in Undergraduate Dental Students: Study Protocol. J Contemp Dent Pract. 2025;26(7):658–62.
14. Peters O, Scott R, Arias A, Lim E, Paque F, Almassi S, et al. Evaluation of Dental Students' Skills Acquisition in Endodontics Using a 3D Printed Tooth Model. Eur endodontic J. 2021;6(3):290–4.
15. Segura Egea JJ, León López M, Cabanillas Balsera D, Sauco Márquez JJ, Martin Gonzalez J, Alonso Ezpeleta OL. Undergraduate Endodontic Teaching in Dental Schools Around the World: A Narrative Review. Eur endodontic J. 2025;10(4):257–69.
16. Agwan MAS, Sheikh A, Shaikh SJPBOCI. Qualitative analysis of root canal treatments performed by undergraduate students: a retrospective study. 2021;21:e0260.
17. Jabali A, Al Malwi AA, Alroomy R, Almnea RA, Alshahrani AS, Alelyani AA et al. Evaluation and Gender Base Comparison of Single-Root Canal Treatment Performance by Clinical-Phase Dental Students Using an Analytic. Rubric Syst. 2026;20(1).
18. Öncü A, Cömert H, Alaçam TJTEJ. The technical quality of root canal filling performed by undergraduate students in pre-clinical education: Instructor versus ChatGPT-4o assessment. 2026;11(1).
19. Nakhapaksirat D, Srimawong P, Kitcharoen N, Nobnom S, Pitakanonda Ballapapinan T. Identification and evaluation of radiographic interpretation errors among undergraduate dental students. Med Educ Online. 2025;30(1):2521353.
20. Longridge NN, Dutta A, Fox K. Endodontic education - present status and future directions. Br Dent J. 2025;238(7):567–72.
21. Elsayed MA, Saleh DR, Alnahdi AM, Padmanabhan VJTJCDP. Endodontic procedural errors and associated factors among undergraduate dental students: a cross-sectional study. 2024;24(12):998–1007.

Supplementary Files

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

- SupplementaryMaterials.docx