



Prevalence and Types of Iatrogenic Errors in Root Canal Treatments Performed by Dental Students: A Retrospective Radiographic Study

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Abstract

Introduction: Root canal therapy is an essential part of dental care that has a high success rate, as reported under controlled conditions. Nevertheless, procedural errors can be present when conducted by undergraduate students and have a detrimental impact on treatment outcomes. To better endodontic education and clinical performance, the frequency and types of iatrogenic errors should be evaluated. The study aimed to determine the prevalence and the nature of iatrogenic errors during root canal treatments that are administered by undergraduate dental students in their fifth year. **Materials and Methods:** One hundred and twenty-five endodontically treated teeth were chosen randomly. The fifth-year dental students performed all the treatments using a standardized endodontic protocol. Preoperative, intraoperative, and postoperative radiographs were assessed to find out iatrogenic errors, such as ledge, perforation, canal obstruction, separation of instruments, overfilling, underfilling, and voids. This descriptive study reports the frequency of errors without inferential statistical analysis. **Results:** Radiographic evaluation indicated that at least one of the iatrogenic errors during treatment was observed in 32.8% of the treated cases. The most common mistake was obturation voids, which were identified 11.2% of the total cases and were found mostly in the second premolars. **Conclusion:** Root canal treatments that were carried out by undergraduates had a relatively high number of iatrogenic errors, with obturation errors being the most frequent. These results lead to the necessity of more effective clinical training, better supervision, and integration of more sophisticated endodontic procedures to minimize errors in the course of the procedure and enhance the quality of the treatment.

Keywords: Root Canal Treatment; Radiographical Quality; Undergraduate Clinical Training

Introduction

Root canal treatment (RCT) is a fundamental procedure in comprehensive dental care. Studies conducted under controlled conditions have established this procedure to be successful and its success rate has been shown to be more than 90% [1-4]. However, such rates decrease significantly, to 40-65 percent, under circumstances where RCT is performed by general dentists [5]. This variance is highly explained due to insufficient training on education and lack of practitioner assurance in the performance of root canal procedures [6, 7]. Root canal preparation is one of the most vital steps in RCT specifically in the undergraduate clinical training. Unless done with accuracy, this step is likely to experience iatrogenic errors which may affect the

success of the treatment [8]. To improve undergraduate dental courses and overall treatment outcomes, it is necessary to identify and correct the reasons of such errors [9, 10]. The process of root canal treatment presupposes various interdependent procedures, and each of them can seriously affect the ultimate prognosis. Several mishaps like the formation of ledges, root perforation or separation of instruments are frequent during the canal instrumentation that could preclude the successful completion of intracanal procedures, reducing the chances of successful treatment [11]. Moreover, obturation quality is also a critical factor in success in treatment. Excessive and insufficient fills may have a negative impact. The main radiographic features of a technically adequate obturation are the location of the obturation material in relation to the apex (it should be 0.5-2 mm short), the

density, the absence of voids, and tapering of the coronal to the apical areas [12, 13]. Radiographic evaluation is very popular to test these parameters and is a crucial measure of assessing the technical quality of RCT [14, 15]. Since the quality of the obturation of root canals is strongly interconnected with the prognosis, regular radiographic testing is crucial [10, 16, 17].

Thus, the assessment of the quality of root canal treatment performed and the determination of the rate and causes of the errors made in the processes can be used to inform the development of dental education and eventually provide better patient care [18]. The current research aims to evaluate the radiographical quality of technical quality in root canal procedures done by undergraduate dental students using manual instrumentation at the College of Dentistry, during 2020- 2022, to identify frequent procedural mistakes. Although several studies have evaluated the technical quality of root canal treatments performed by undergraduate students, most have focused solely on overall success rates or isolated procedural errors without analyzing their distribution according to specific tooth types. The present study provides a more detailed, tooth-specific assessment of iatrogenic errors, identifying anatomical patterns associated with particular teeth and canal configurations. Furthermore, this work reflects current undergraduate training practices within a standardized educational setting, offering updated evidence that may support targeted curriculum modifications and technique selection aimed at reducing procedure-related errors.

Materials and Methods

One hundred and twenty-five endodontically treated teeth were selected at random to use in this study. The treatments were administered by undergraduate dental students in the 5th year, at the University of Basrah, College of Dentistry, Iraq, in the academic year 2021 to 2022. All endodontic procedures were performed under the direct supervision of Dr. Zahraa M. Al-Hawwaz. Ethical approval was received from the ethical and research committee by Institutional Review Board IRB at College of Dentistry, University of Basrah. Informed consent was obtained from all caregivers of participated.

Inclusion Criteria

Only those cases that have full radiographic records, such as preoperative (initial), intraoperative (working length and master cone check), and postoperative (final), were considered. Every radiograph was supposed to have a satisfactory image quality and processing. Also, anterior teeth (incisors and canines) and premolars were used as inclusion criteria.

Clinical Procedures

As part of the first appointment, a clinical and radiographic evaluation was conducted. A professional case challenge interview was carried out before treatment. Postgraduate clinics referred cases that were considered to be very complex. Treatments that had the eligibility criterion of undergraduate management were done as per a standardized procedure of the Endodontic Department in the College of Dentistry. After the rubber dam, caries removal, and access cavity preparation procedures were carried out to achieve straight-line access to the canals. Endo-Z burs were used to derooft the pulp chamber, where flared access to the canal orifices and correct funneling of the chamber walls were achieved. Periapical radiographs were used to determine the working lengths. The step-back technique using stainless steel K-files was used to perform canal instrumentation (Dentsply Maillefer, Switzerland). The instrumentation process was conducted by continuous irrigation with 5.25 percent sodium hypochlorite. The Obturation was done with cold lateral compaction utilizing gutta-percha (Meta Biomed, Korea) and either Zinc Oxide Eugenol sealer or Dia-ProSeal, which is a two-component epoxy resin root canal sealer. Temporary restorations of teeth were done, and radiographs were taken at the end of treatment. All radiographic evaluations were performed using a standardized digital periapical radiography system routinely employed in the undergraduate clinics of the College of Dentistry. Preoperative, intraoperative, and postoperative periapical radiographs were obtained using the paralleling technique to reduce image distortion and ensure consistency.

Data Collection and Analysis

There was an analysis of radiographic data in terms of errors in the procedure. Errors classified as Iatrogenic based on intraoperative or immediate postoperative digital radiograph and backed by all relevant case notes. Canal obstruction was defined as the inability to negotiate the canal to the established working length due to blockage by dentinal debris, pulp remnants, or compacted filling material, without deviation from the original canal anatomy. In contrast, ledge formation was diagnosed when instrument deviation from the natural canal curvature created an artificial irregularity that prevented further advancement to the working length, as confirmed by radiographic and clinical assessment. Broken instruments were confirmed radiographically by the presence of a radiopaque fragment within the root canal space that was clearly separated from the main instrument, visible on intraoperative or postoperative periapical radiographs. Confirmation was supported by clinical notes indicating file separation during instrumentation and the inability to retrieve the fragment during the procedure. The presence of errors was defined using the following criteria:

1. Apical Perforation: Diagnosed in case the canal filling protruded above the apical foramen or moved off course towards a different terminal of the apical terminus.
2. Ledge Formation: Diagnosed when the root filling had reached a minimum of 1 mm less than the initial working length or had gone out of the natural canal curve.
3. Voids in Obturated Canals: Identified by gaps within the canal filling or between the filling material and canal walls.
4. Underfilling: Defined as canal obturation terminating more than 2 mm short of the radiographic apex.
5. Overfilling: This was a result of the extrusion of the filling material beyond the apex, as it closed the total canal space.

Radiographic Assessment

Two calibrated examiners who had clinical experience in endodontics independently carried out radiographic assessment. Before data collection, we had calibration sessions performed by use of a sample of radiographs to normalize the diagnostic criteria of identification of iatrogenic errors. In instances of disagreement, joint reevaluation was determined to reduce inter-examiner variability and thus, consensus was achieved.

Limitation

This was a retrospective descriptive study; the sample size was based on the availability of cases and not a priori power analysis. Generalizability may be limited by the lack of a specialist control group, the lack of stratification of the molar teeth, and the lack of complexity stratification of the cases. The results of the error frequencies were described, but no inferential statistics were provided, and the evaluation was based on the two-dimensional periapical radiograph, which can underestimate some of the

errors. It is suggested that future prospective research that involves control groups, complexity scoring, inferential analysis, and three-dimensional imaging should be factored.

Results

Distribution of Iatrogenic Errors in Root Canal Treatments Performed by Undergraduate Dental Students

Table 1 demonstrates the frequency of the procedural errors in root canal treatments done by the 5th-year dental students. Errors were noted in at least 32.8 percent of the cases studied, and in 67.2 percent of the cases, no radiographic mistakes were observed. The most frequent error was that of voids (11.2%), followed by lack of fillings (9.6%), and finally, overfilling (6.4%). The error distribution was found to vary depending on the type of tooth, with the greatest error rates being in the maxillary central incisor and the maxillary first premolar, and the least errors in the mandibular anterior teeth. These findings are an indication that the type of tooth and anatomical complexity can affect the prevalence of procedural error during clinical training of dental students.

All mistakes: This is the number of teeth where at least one iatrogenic error was identified, but it is not required to be classified according to the type of error it is. In this column, every tooth was counted once, regardless of the number of errors. Conversely, the individual error type of the Total No. column reflects the actual count of the particular error, and this number can be higher than the count of teeth afflicted since there can be more than a single error in a given tooth. None means teeth in which the iatrogenic errors cannot be detected radiographically.

Table 1. Radiographic Assessment of Error Types According to Tooth Type

Error type	Over filling	Under filling	Over instrumentation	Void	Ledge	Broken instrument	Perforation	All mistakes	None	Total
Upper central	4	3	2	2				11	13	24
Upper lateral	1	1		2	1		1	6	8	14
Upper canine		1	1	1				3	19	21
Upper 1 st bicuspid	1	4		4				10	14	24
Upper 2 nd bicuspid				2			1	3	4	7
Lower central		1						1	6	7
Lower lateral								0	4	4
Lower canine								0	3	3
Lower 1 st bicuspid		1		2				3	6	9
Lower 2 nd bicuspid	2	1		1		1		5	7	12
Total No.	8	12	3	14	1	1	2	41	84	125
Total percentage	6.4%	9.6%	2.4%	11.2%	0.8%	0.8%	1.6%	32.8%	67.2%	100%

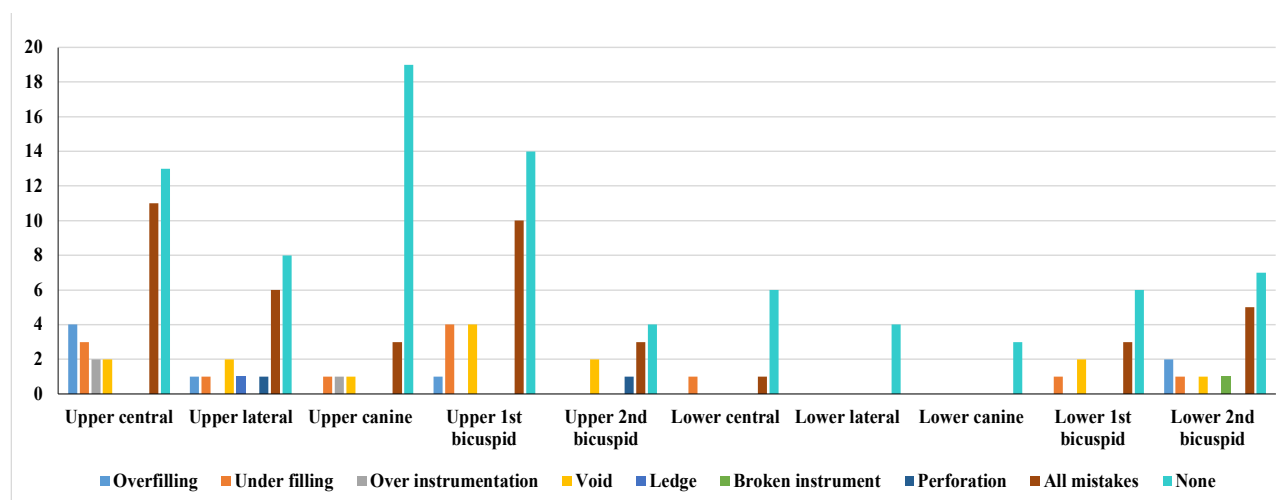


Figure 1. The flowchart also shows the process of radiographic evaluation and classification of iatrogenic errors in root canal treatments done by undergraduate dental students. The visualization summarizes the process of selecting cases, radiographic assessment (preoperative, intraoperative, and postoperative), and the classification of procedural errors that are found during the analysis

Discussion

University dental schools are a pillar of undergraduate dental training as they offer students the much-needed practical clinical training needed to practice general dentistry. In this regard, it is of paramount importance to assess the quality of the dental education, especially in endodontic and the quality of treatments provided by the students [17]. The current research was done to evaluate the technical quality of the root canal treatment (RCT) provided by the fifth-year dental students and to define which types and rates of iatrogenic error were made during the clinical training. Radiographic assessment of the procedures was done to identify errors that may have occurred during the procedures, such as ledge formation, voids, separation of instruments, overfilling, and underfilling, as shown in Table 1 and Figure 1.

In order to provide an analytical reading of the results, the discussion will be structured chronologically to discuss the topics of diagnostic methodology, errors associated with the steps of the procedure, anatomical aspects of the tooth, and educational factors. Even though the periapical radiography represents a limited method of displaying the anatomical structures in 3D, it is still the most popular diagnostic tool used in undergraduate clinical work and educational audits [20]. The use of this modality makes it consistent with similar research, even though it might underestimate some of the buccolingual errors [19]. The findings showed that complications that were associated with obturation were the most common. The most common mistake was underfilling, specifically in lower lateral incisors, and the most frequent damage was the presence of voids in maxillary teeth and overfilling in maxillary central incisors. The step-back technique

was used in all the treatments with stainless steel hand K-files and cold lateral compaction to obturate. Cold lateral compaction remains the most common type of obturation taught because of its simplicity and affordability [20], but has a reputation for giving an uneven fill of gutta-percha and being linked to both voids and minimal filling of canals, particularly those with a minimal flared canal [10]. Warm vertical compaction, on the other hand, offers a high degree of adaptation and homogeneity but with a higher risk of overextension and is also more technically challenging to undergraduate operators [21]. The causes of voids can be the lack of compaction pressure, overuse of sealer, improper choice of spreader cone or accessory cone, and insufficient experience of the operator [22]. The most frequent procedural mistake in the present research is underfilling, which could be caused by canal blockage due to a lack of irrigation, ineffective canal patency maintenance, and wrong measurements of the working length. It is worth noting that a high number of students were solely using radiography to estimate working length without electronic apex locators, although apex locators can record up to 97% accuracy in determining working length. To some degree, this dependence on traditional radiographic tools can be seen as the reason behind a high rate of length-related mistakes [23]. The step-back method of working with stainless steel hand files implies apical-coronal instrumentation, which is connected to the effect of transportation along the canal, ledge formation, and poor cleaning efficiency. Conversely, nickel-titanium (NiTi) rotary instruments, due to their greater flexibility and canal curvature retention, have a lower occurrence of errors in procedures and high-success rates as compared to stainless steel hand instruments [24]. The comparatively low rate of ledge formation in the current

study contrasts with findings in the literature that reported a significantly high rate of error. This contradiction can also be caused by the differences in the selection of cases, the experience of the operator, the exclusion of molar teeth, and the degree of clinical supervision, which should be carefully compared across studies [25, 26]. The absence of an apical stop during instrumentation, which allows for overfilling, is a well-known shortcoming of non-flexible stainless-steel files. The occurrence in this case was relatively low (2.4%), and it was only discovered in the upper lateral incisor. This is due to root curvature, which is a known risk factor in the formation of ledges. In contrast to our findings, ledge development was the most common procedural mistake [27]. The considerable flexibility of NiTi files reduces such errors, but stainless-steel files utilized in our students' technique do not. Such dangers can be avoided by using step-down or passive step-back procedures, in which larger files are processed first in the coronary, followed by smaller apical files. Interestingly, overfilling was more common in maxillary teeth, despite the past when overfilling was considered to be better on maxillary teeth than in mandibular teeth.

The results of this finding should be taken with caution because the current data cannot be used to make firm causal conclusions. This observation may be caused by factors like root curvature, canal morphology, and lack of a well-defined apical stop, which is especially absent when non-flexible stainless steel files are used. Ledge curvature is an established risk factor for ledges and complications. The minimal overall prevalence of over-instrumentation and ledge of this study can be, in part, explained by a structured case selection and supervision procedures. A low percentage of instances were found to be overfilling and were only on the upper canine and this could be because of poor control in reference points during obturation. They found that upper lateral incisors and second premolars were perforated, most probably due to a bur misalignment in the preparation of the access cavity. Fracture of instruments was also uncommon and can be attributed to lack of preparation of access, too much force on non-flexible instruments, omission of file size, or fatigue of instruments [27, 28]. In addition to technical aspects, the educational system and control are decisive factors in clinical outcomes. In the current research, students had to prepare detailed treatment plans for all cases and discuss and update them with faculty members, and the feedback about the treatment was provided after the treatment completion [29, 30]. It is expected that this systematic monitoring is one of the reasons why the incidence of serious iatrogenic errors was relatively low. The faculty-to-student ratios are also found to affect the quality of treatment; in the earlier studies by Vukadinov et al., better results

were found with a ratio of 1:8. The use of a larger ratio in the present study could have contributed to the error rates, which resulted in the necessity of proper supervision during the undergraduate clinical training [19]. On balance, the results show that the undergraduate-performed RCTs associated with iatrogenic errors are mainly related to obturation quality and working length determination and depend on the technique of instrumentation, tooth anatomy, and educational aspects. Although this is a descriptive research study, it is quite informative with regard to the procedural issues in undergraduate endodontics training. It should be noted that future research using modern instrumentation tools, enhanced imaging modalities, and analytical statistical measures would help to improve teaching methods and minimize mistakes during the procedure.

Conclusion

Procedural errors in undergraduate-performed root canal treatment were mostly associated with obturation quality and working length control, particularly voids, underfilling, and overfilling. To overcome these limitations, nickel-titanium rotary instrumentation should be introduced to undergraduate endodontic programs, and the use of electronic apex locators for working length determination should be made compulsory. Before clinical cases are assigned, structured simulation training using extracted teeth and endodontics training should be increased. Also, decreasing student-to-faculty ratios and implementing step-specific competency assessments before clinical advancement could substantially minimize procedural errors. Continuous radiographic audit and feedback cycles are recommended to objectively track student performance and evaluate the long-term effectiveness of these targeted educational interventions.

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Conflict of interest

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Authors' contributions

Conceptualizations: ZMA/AMA; Methodology: ZMA/ZAM; Formal Analysis and Investigations: ZMA/ZAM/AMA; Writing Original Draft Preparation, Writing-Review and Editing: ZAM/AMA; Supervision: ZAM. All authors read and approved the final manuscript.

References

- Barrieshi-Nusair KM, Al-Omari MA, Al-Hiyasat AS. Radiographic technical quality of root canal treatment performed by dental students at the Dental Teaching Center in Jordan. *J Dent*. 2004;32(4):301-7.
- Er O, Sagsen B, Maden M, Cinar S, Kahraman Y. Radiographic technical quality of root fillings performed by dental students in Turkey. *Int Endod J*. 2006;39(11):867-72.
- Friedman S, Mor C. The success of endodontic therapy--healing and functionality. *J Calif Dent Assoc*. 2004;32(6):493-503.
- Imura N, Pinheiro ET, Gomes BP, Zaia AA, Ferraz CC, Souza-Filho FJ. The outcome of endodontic treatment: a retrospective study of 2000 cases performed by a specialist. *J Endod*. 2007;33(11):1278-82.
- Sunay H, Tanalp J, Dikbas I, Bayirli G. Cross-sectional evaluation of the periapical status and quality of root canal treatment in a selected population of urban Turkish adults. *Int Endod J*. 2007;40(2):139-45.
- Jenkins SM, Hayes SJ, Dummer PM. A study of endodontic treatment carried out in dental practice within the UK. *Int Endod J*. 2001;34(1):16-22.
- Stewardson DA. Endodontics and new graduates: Part I, Practice vs training. *Eur J Prosthodont Restor Dent*. 2002;10(3):131-7.
- Zambon da Silva P, Carlos Ribeiro F, Machado Barroso Xavier J, Pratte-Santos R, Demuner C. Radiographic Evaluation of Root Canal Treatment Performed by Undergraduate Students, Part I; Iatrogenic Errors. *Iran Endod J*. 2018;13(1):30-6.
- De Moor R, Hülsmann M, Kirkevang LL, Tanalp J, Whitworth J. Undergraduate curriculum guidelines for endodontology. *Int Endod J*. 2013;46(12):1105-14.
- Khabbaz MG, Protogerou E, Douka E. Radiographic quality of root fillings performed by undergraduate students. *Int Endod J*. 2010;43(6):499-508.
- Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature -- Part 2. Influence of clinical factors. *Int Endod J*. 2008;41(1):6-31.
- Sharma A, Rawat P, Srivastava PA, Sharma A. Evaluating the Long-Term Success of Removable and Fixed Prosthodontic Treatment in Completely Edentulous Patients: Comparative Clinical-Radiographic Study. *Eur J Prosthodont Restor Dent*. 2025;33(3):238-46.
- Abu-Tahun I, Al-Rabab'ah MA, Hammad M, Khraisat A. Technical quality of root canal treatment of posterior teeth after rotary or hand preparation by fifth year undergraduate students, The University of Jordan. *Aust Endod J*. 2014;40(3):123-30.
- Hansrani V. Assessing root canal fillings on a radiograph--an overview. *Br Dent J*. 2015;219(10):481-3.
- Tsuneishi M, Yamamoto T, Yamanaka R, Tamaki N, Sakamoto T, Tsuji K, et al. Radiographic evaluation of periapical status and prevalence of endodontic treatment in an adult Japanese population. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2005;100(5):631-5.
- Moussa-Badran S, Roy B, Bessart du Parc AS, Bruyant M, Lefevre B, Maurin JC. Technical quality of root fillings performed by dental students at the dental teaching centre in Reims, France. *Int Endod J*. 2008;41(8):679-84.
- Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J*. 2006;39(12):921-30.
- Abu-Tahun I, El-Ma'aitha A, Khraisat A. Satisfaction of undergraduate students at University of Jordan after root canal treatment of posterior teeth using rotary or hand preparation. *Aust Endod J*. 2016;42(2):66-72.
- Vukadinov T, Blažić L, Kantardžić I, Lainović T. Technical quality of root fillings performed by undergraduate students: a radiographic study. *ScientificWorldJournal*. 2014;2014:751274.
- Peters CI, Sonntag D, Peters OA. Homogeneity of root canal fillings performed by undergraduate students with warm vertical and cold lateral techniques. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2010;110(3):e41-9.
- Lea CS, Apicella MJ, Mines P, Yancich PP, Parker MH. Comparison of the obturation density of cold lateral compaction versus warm vertical compaction using the continuous wave of condensation technique. *J Endod*. 2005;31(1):37-9.
- Mozayani MA, Asnaashari M, Modaresi SJ. Clinical and Radiographic Evaluation of Procedural Accidents and Errors during Root Canal Therapy. *Iran Endod J*. 2006;1(3):97-100.
- Pascon EA, Marrelli M, Congi O, Ciancio R, Miceli F, Versiani MA. An ex vivo comparison of working length determination by 3 electronic apex locators. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2009;108(3):e147-51.
- Taşdemir T, Aydemir H, Inan U, Unal O. Canal preparation with Hero 642 rotary Ni-Ti instruments compared with stainless steel hand K-file assessed using computed tomography. *Int Endod J*. 2005;38(6):402-8.
- Färber CM, Lemos M, Said Yekta-Michael S. Effect of an endodontic e-learning application on students' performance during their first root canal treatment on real patients: a pilot study. *BMC Med Educ*. 2022;22(1):394.
- Dadresanfar B, Mohammadzadeh Akhlaghi N, Vatanpour M, Atef Yekta H, Baradaran Mohajeri L. Technical quality of root canal treatment performed by undergraduate dental students. *Iran Endod J*. 2008;3(3):73-8.
- Abdulrab S, Alajam W, Al-Sabri F, Doumani M, Maleh K, Alshehri F, et al. Endodontic Procedural Errors by Students in Two Saudi Dental Schools. *Eur Endod J*. 2018;3(3):186-91.
- Yavari H, Samiei M, Shahi S, Bornha Z, Abdollahi AA, Ghiasvand N, et al. Radiographic evaluation of root canal fillings accomplished by undergraduate dental students. *Iran Endod J*. 2015;10(2):127-30.
- Alhekeir DF A-SR, Mokhlis H, Al-Nazhan S. Endodontic mishaps among undergraduate dental students attending King Saud University and Riyadh Colleges of Dentistry and Pharmacy. *Saudi Endod J*. 2013;3(1):25-30.
- Kvinnslund I, Oswald RJ, Halse A, Grønningsaeter AG. A clinical and roentgenological study of 55 cases of root perforation. *Int Endod J*. 1989;22(2):75-84.

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