

Original research

Obturation assessment of root canal treatments performed by undergraduate dental students



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ABSTRACT

Objectives: To assess radiographically the technical quality of root fillings placed by undergraduate students at the Faculty of Dental Medicine of the University of Porto.

Methods: The records of 318 patients were assessed, of which 225 radiographs of root canal fillings in single-rooted teeth were selected. The radiographs were examined using the VixWin Platinum v1.1 Imaging Software (Gendex, USA). The quality of root canal filling was graded as "acceptable" when both length and density were adequate. Procedural errors were registered. Chi-square tests were used for statistical analysis, considering a 0.05 significance level.

Results: Root canal fillings were considered acceptable in 53.3% of the cases. There was a greater percentage of adequate density (70.7%) than adequate length (64%). There was a statistically significant association between the quality of the filling and the type of tooth, with maxillary anterior teeth presenting higher quality ($p=0.027$). The most common reason for inadequate length was short-filling (33%). There was a statistically significant relationship between the academic year and the density of the fillings ($p=0.009$). Overall procedural errors occurred in 3.6% of the cases, with the most common being ledge formation and apical transportation.

Conclusions: The quality of root canal fillings in single-rooted teeth performed by junior dental students at the University of Porto was considered acceptable in 53.3% of cases. (Rev Port Estomatol Med Dent Cir Maxilofac. 2018;59(3):162-168)

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Avaliação da qualidade de tratamentos endodônticos realizados por estudantes de Medicina Dentária

R E S U M O

Palavras-chave:

Estudantes de Medicina Dentária
Educação
Endodontia

Objetivos: Avaliar radiograficamente a qualidade das obturações de tratamentos endodônticos realizados por estudantes do Mestrado Integrado da Faculdade de Medicina Dentária da Universidade do Porto.

Métodos: Foram avaliados os registos de 318 pacientes, dos quais foram selecionadas 225 radiografias periapicais de dentes monorradiculares. As radiografias foram examinadas utilizando o software de imagem VixWin Platinum v1.1 (Gendex, EUA). A qualidade do tratamento endodôntico foi classificada como "aceitável" quando o comprimento e a densidade estavam adequados. Os erros iatrogénicos foram registados. O teste qui-quadrado foi utilizado para análise estatística, considerando um nível de significância de 0,05.

Resultados: O tratamento endodôntico foi considerado aceitável em 53,3% dos casos. Houve uma maior percentagem de densidade adequada (70,7%) do que comprimento adequado (64%). Verificou-se uma associação estatisticamente significativa entre a qualidade da obturação e o tipo de dente, sendo os dentes anteriores superiores a apresentar maior qualidade ($p = 0,027$). A razão mais comum para o comprimento inadequado foram as obturações curtas (33%). Verificou-se uma relação estatisticamente significativa entre o ano letivo e a densidade da obturação ($p = 0,009$). Erros iatrogénicos ocorreram em 3,6% dos casos, sendo os mais comuns a formação de degraus e o transporte apical.

Conclusões: A qualidade dos tratamentos endodônticos em dentes monorradiculares realizados por estudantes de Medicina Dentária da Universidade do Porto foi considerada aceitável em 53,3% dos casos. (Rev Port Estomatol Med Dent Cir Maxilofac. 2018;59(3):162-168)

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Introduction

The European Society of Endodontology has revised the quality guidelines for endodontic treatment in a consensus report.¹ That document addresses, essentially, the appropriateness of the treatment modality and the quality of treatments rendered to populations. Although the overall quality of root canal treatment (RCT) cannot be determined strictly based on the combination of adequate length and density of its filling, these aspects have an impact on the outcome, being strongly correlated to success rates, and are accepted as an accurate indicator of RCT's quality.^{2,3}

There has been an effort to promote a mutual recognition of international qualifications to enable the free movement of dentists across the European Union. That action has highlighted the need for recommendations to aid the curriculum revisions in European dental schools on a common framework. Bench documents such as "The Profile and Competences for the Graduating European Dentist" and "Undergraduate Curriculum Guidelines" have emphasized a competence-based curriculum and assessment of the new graduate.^{4,5}

Following the Bologna recommendations, most European dental schools have a 5-year programme, with the first three years devoted to didactic teaching and the two last years to an essentially clinical approach. This structure is established in

Portugal, where dental students conclude their studies with a dental master's degree. However, the underlining recommendations of the Bologna declaration, which promote active learning, have not been totally achieved due to an inadequate student-staff ratio and lack of vocational training to enable a smoother transition from the dental school to the autonomous general practice.⁶

This fact is supported by epidemiologic studies that report a high prevalence of apical periodontitis in populations and low standards of RCTs that have not improved in the last decade.^{5,7} Nickel-titanium rotary instrumentation systems have enabled improving the technical quality of endodontic treatments, with a more predictable performance.⁸ Nevertheless, stainless-steel hand instrumentation continues to be taught as the only approach in most dental schools.^{3,9}

New imaging modality tools, such as cone-beam computed tomography (CBCT), have overcome the bi-dimensional nature limitations of the conventional radiology. The recent developments in the resolution of CBCT devices and user-friendly software interfaces are promising, as they allow a more detailed study of the canal complexity in vivo.^{10,11} Still, this improved technology is not generally provided in current endodontic teaching.

New graduates are challenged by an elderly population aware of the importance of preserving their teeth. Despite the

high success rates achieved in specialist environments, most of the RCTs continue to be performed by general dental practitioners, resulting in the reported inadequate technical quality and high correlation with apical periodontitis.¹²⁻¹⁴ Improving the quality of the treatments performed by dental students and their competences will certainly contribute to providing a better standard of care to populations. Students are expected “to be competent at” procedures with a moderate grade of difficulty, but also “to have knowledge of” and “to be familiar with” a wide range of treatments, thus being encouraged to undertake continuous learning following graduation.⁵ The quality of the education received by undergraduate dental students might be linked to the quality of the treatment they provide to populations once graduated.

The aim of this investigation was to assess radiographically the technical quality of root fillings placed by undergraduate students at the Faculty of Dental Medicine of the University of Porto (FMDUP).

Material and methods

Records of all the 318 patients who underwent endodontic treatments (permanent teeth) by 4th-year undergraduate students at FMDUP from 2012 to 2017 were selected and evaluated.

The exclusion criteria were: records that did not include preoperative, working-length, master cone control and postoperative periapical radiographs; radiographs of poor quality; incomplete endodontic treatments and radiographs not including the entire length of the root. Apical root resorptions, calcifications, retreatments and teeth with incomplete root formation were also excluded. Based on these criteria, 93 records were excluded. The final sample consisted of 225 records of filled single-rooted teeth.

An aseptic technique with rubber dam isolation was applied in all cases. Working lengths (WL) were determined through periapical radiographs. All teeth had one preoperative radiograph, enabling the visualization of the coronal and apical morphologies, aiming to estimate the length of the tooth. The periapical film was placed parallel to the tooth, with the central beam directed at a right angle to the film. A 2nd periapical film was done, with a file inserted with the estimated length subtracted by 2 mm, providing that its tip stayed less than 3 mm from the radiographic apex. In that situation, Ingle’s rule could be applied to determine the WL. If the tip stayed further than 3 mm, the file was inserted deeper and another x-ray was taken. The WL was then determined. All teeth were instrumented with a manual technique using stainless-steel K-files in a step-back technique and irrigation with 2.5% sodium hypochlorite solution (syringe and needle). There were no single visit treatments. Calcium hydroxide was used as dressing between sessions. In the obturation session, after finishing the root canal preparation, a master cone with similar size of the last instrument with all the WL was selected and assessed through a radiographic control (parallel technique). The tooth was ready to fill when the master cone was between 1 to 2 mm from the radiographic apex. In cases when this didn’t occur, students were encouraged to improve it, re-instrumenting the root canal or selecting another master

cone. All root canals were filled with gutta-percha and a zinc-oxide eugenol-based sealer using the cold lateral compaction technique and were restored with temporary filling materials. All the treatment steps were conducted under the supervision of teaching staff of the department with an average staff-to-student ratio of 1/20 binomial.

The technical quality of the RCT was evaluated based on the immediate postoperative radiograph of each case, as assessed by two operators (one with a vast experience of teaching and a PhD student). Both operators examined all cases, independently, after previous calibration, with 20 assorted filled teeth, repeated with an interval of a month. The intra-observer agreement was of 0,90 (Cohen’s Kappa) for the teacher and 0,80 for the PhD student. If there was a disagreement, the two operators discussed the case to reach a consensus. All radiographs were examined using the VixWin Platinum v1.1 Imaging Software (Gendex, USA). The quality of the endodontic treatment was determined by the length of the root filling in relation to the radiographic apex and the density of the obturation according to the presence of voids (Table 1). The quality of the root canal filling was considered “acceptable” when both length and density were adequate; “unacceptable” when both, length and density, or one of these variables were inadequate. Iatrogenic errors including ledges, perforations and fractured instruments were also recorded.

Table 1. Criteria for assessing the radiographic quality of root canal filling.

Criteria	Definition
Length	Adequate: Filling material ending 0–2 mm short of the radiographic apex.
	Short-filling: Root filling ending >2 mm short of the radiographic apex.
	Over-filled: materials flush with the apex or extruded beyond the apex.
Density	Adequate: No visible voids within or between the material and the root canal walls.
	Inadequate: Visible voids within or between the material and the root canal walls.

Statistical analysis of the data was carried out using the IBM SPSS Statistics 25.0 software (SPSS Inc, Chicago, IL) and the chi-square test. Differences were considered significant at a value of $p < 0.05$.

Results

The sample consisted of individuals with ages between 14 and 93 years, with a mean of 55.36 (\pm 18.07) years. The distribution by sex was 65.3% women and 34.7% men. 42.7% were maxillary anterior teeth, 20.4% were mandibular anterior teeth, 8% were maxillary premolars and 28.9% were mandibular premolars. The frequency of RCT per academic year is

Year	N	%
2012/2013	61	27.1
2013/2014	70	31.1
2014/2015	43	19.1
2015/2016	26	11.6
2016/2017	25	11.1
Total	225	100

shown in Table 2. The distribution of RCT per tooth is represented in Figure 1. The tooth 35 was the most frequently treated.

Concerning the quality of root fillings, in terms of length and density, most fillings had an adequate density (70.7%) and slightly fewer had an adequate length (64%). Acceptable quality (adequate length and density) was found in 53.3% of root canal fillings (Figures 2 and 3). There was a statistically significant association between quality (acceptable and unacceptable) and tooth type, as the acceptable quality was associated with maxillary anterior teeth ($\chi^2=9.156$, $gl=3$, $p=0.027<0.05$). The most common reason for inadequate length was short-filling (33.3%) (Figure 2). In the analysis by academic year, there was no statistically significant association between the academic year and quality (acceptable/unacceptable) ($\chi^2=8.201$, $gl=4$, $p=0.084>0.05$). nor between the academic year and the length ($\chi^2=9.601$, $gl=8$, $p=0.294>0.05$). However, there was a statistically significant association between the academic year and density ($\chi^2=13.573$, $gl=4$, $p=0.009<0,05$). Regarding the frequency of treatments in maxillary anterior teeth, there was a nonuniform distribution over the years, since it decreased over the years studied.

Iatrogenic errors were detected in 3.6% (1.7% – 6.6%) of the cases, with the most common being ledge formation and apical transportation.

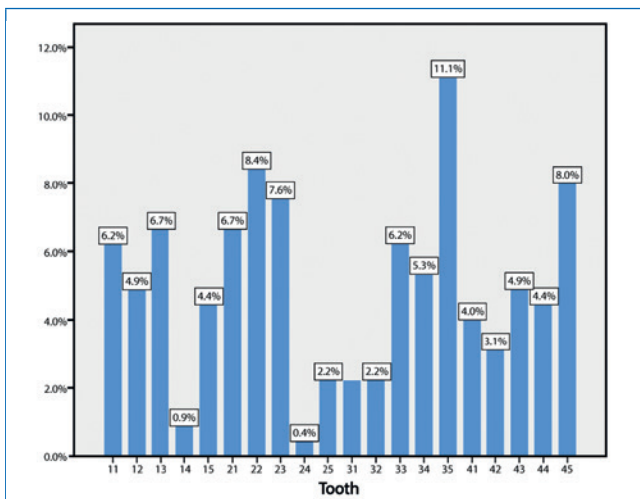


Figure 1. Distribution (%) of root canal filling per tooth type.

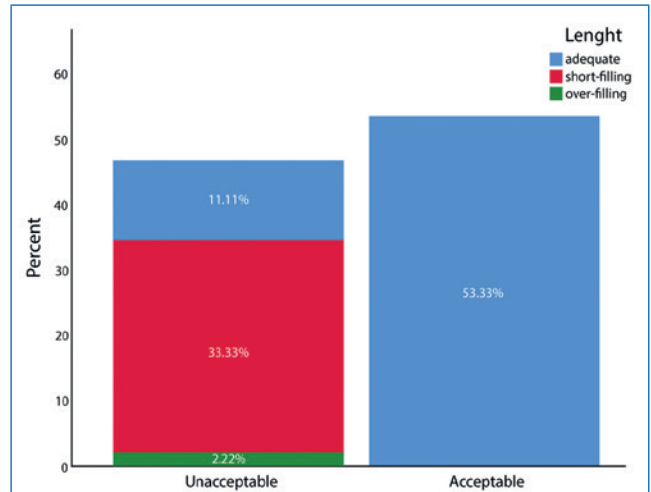


Figure 2. Quality of root canal filling in terms of length.

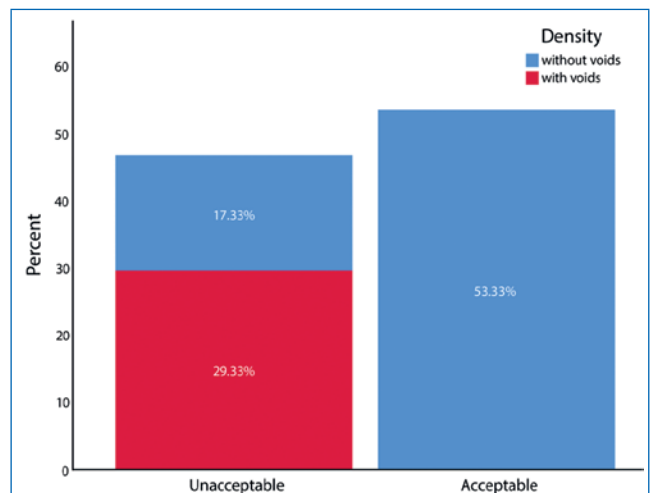


Figure 3. Quality of root canal filling in terms of density.

Discussion

The aim of this investigation was to assess radiographically the technical quality of root fillings placed by undergraduate students at FMDUP. Procedural errors were also reported.

Of the 225 root fillings in single-rooted teeth selected, 53.3% showed acceptable technical quality, with both length and density being adequate. This finding may be considered a quite good mark, as these treatments were performed with manual stainless-steel instrumentation by 4th-year dental students in their 1st clinical semester of Endodontics. Moreover, it is in agreement with other percentages reported.³ Other studies presented better performances (66%), but they only considered RCTs with rotary instrumentation.¹⁵ At Queen's University in Belfast, the pre-clinical teaching begins one semester earlier (1st semester of the 3rd year) than at FMDUP, with the clinical training starting in the 2nd semester of the 3rd year;

this enables a greater clinical exposure until graduation. At FMDUP, preclinical teaching lasts for one year, where it is mandatory that students perform six RCTs in extracted teeth, including molars. The three semesters left are held in the clinic, but only manual instrumentation is taught.

Other studies reported lower percentages of acceptable fillings, regardless of being done by 4th or 5th-year dental students.^{16,17} Nevertheless, it is recognized that student's performance is generally of low standard and that it is very important to discuss endodontic education and training.³

The recommendations for undergraduate clinical teaching in Endodontics emphasize that "the quality and consistency of student performance are more important than simply the quantity of clinical exposure." Therefore, dental schools should establish the time and resources required for their curricula to provide levels of competence that support students' assessment.⁵ A previous document on curriculum guidelines focused on the adequacy of students training to improve clinical outcome, materialized in 20 RCTs. Furthermore, students believe that an increased use of extracted natural teeth would benefit their competence in the clinical practice.^{6,18} Undoubtedly, the relationship between practice and learning is widely accepted in dental education.¹⁹ However, it is questioned if a mandatory number of procedures will give the same level of achievement in each individual student or if the number of procedures suggested should vary according to a fixed level of competence to be achieved.²⁰

The present study evaluated root canal fillings performed by 4th-grade students during five academic years (from 2012/13 to 2016/17). The percentage of students that performed one RCT in the first clinical semester decreased from 81.3% in 2012/13 to 37.9% in 2016/17. Recent graduates are experiencing an average of 12 RCTs, half of which in the preclinical environment.

The teeth that junior students most frequently treat are reported to be maxillary premolars, followed by anterior teeth.¹⁸ In the five years assessed at FMDUP, maxillary anterior teeth were the most treated. It is expected that students start with "easy" single-rooted teeth, associated with a better prognosis.²¹ In that sense, in this first clinical semester, dental students at FMDUP are not allowed to treat multi-rooted teeth. Nevertheless, the assumption of certain teeth as "easy" has been questioned with recent micro-CT studies enabling a more accurate diagnosis of canal complexities *in vivo*.^{11,22}

Comparing the prevalence of adequate fillings in terms of length and density, there was a slightly higher prevalence of adequate density (70.7%) than adequate length (64%). Other investigators refer a prevalence of adequate length.^{3,17} Similar to other reports, in the present study, there was a statistically significant higher frequency of acceptable RCTs in anterior maxillary teeth. The frequency of unacceptable fillings generally increases in posterior teeth due to their challenging anatomy.³ Other study¹⁵ did not find an association between the tooth type and the quality of root filling provided. However, it must be taken into account that, although that study included molar teeth, the use of the rotary instrumentation technique may have helped overcoming the difficulties posed by anatomic complexities, namely in molar teeth. In contrast, when manual instrumentation was used, molar teeth presented poor results.³

Corroborating other reports,¹⁵ there was a low frequency of overfilling (2.2%). Nevertheless, it is known that most of the times, even when filling materials appear to be flush with the apex in the x-ray, there may, in fact, be extrusion to the peri-apical tissues. This occurrence might be linked with a poor prognosis. Contrary to other reports with manual instrumentation,¹⁶ there was a small frequency of procedural errors (3.6% of the whole sample), with the most common being ledge formation and apical transportation.³ Ledge formation has been more likely to occur in junior students.¹⁶

The students' perception can be a valuable tool for continuous improvement in teaching methodologies.²³ On the other hand, the regular assessment of their performance is crucial to be aware of the standard of treatment that will be delivered to populations, once graduated.²⁴ In the present report, throughout the five years assessed, not all students were able to perform an RCT. Furthermore, at graduation, the average of RCTs performed in patients per student does not exceed 6, including one or two molar teeth maximum. These numbers are surely not enough to achieve "a set of specific competences essential to begin independent, unsupervised dental practice"²⁵ accounting for the high levels of stress and lack of confidence dental students generally present. Clinical experience is perceived by students as the most important aspect of their dental education.²⁶ Nevertheless, few studies address the number of RCT per student.³ The introduction of vocational training and earlier contact with patient care is often a request of the students. It is also a recommendation for the improved curricular structure, aiming to train students not only in instrumentation techniques but also to provide holistic patient care and to be aware of the foundational nature of endodontic procedures for the safe practice of clinical dentistry and, in particular, of Endodontics.^{5,27}

Although the frequency of acceptable fillings performed by students has been reported to stay between 10.9% and 85.1%,³ it cannot be assumed that a value of 50% would be a gold standard.

A plan to improve the quality of RCT in FMDUP has been discussed. One of the measures implemented was increasing the comprehension of the clinical context with an online, extra-curricular approach, focused on diagnosis and treatment plan. Those are frequently reported as difficult procedures by senior and junior students, although with higher expression in the former.¹⁸ Considering that all didactic teaching is completed before students begin RCTs in patients, one can expect that an increased clinical exposure, even if online, might increase self-confidence levels, thus helping to achieve competence. Another measure proposed was to introduce rotary instrumentation in undergraduate teaching, in order to achieve a more predictable technical quality of RCT, thus improving the quality of the outcomes. It has been highlighted that the use of hand files does not comply with European guidelines and results in students performing root fillings of poor technical quality.^{9,28} Several studies reported an overall good result with nickel-titanium rotary systems both for experienced and inexperienced operators,^{29,30} although some disadvantages have also been reported in specific root canal anatomies or specific instrumentation systems.^{31,32} Even though the frequency of instrumentation errors was not high in the present

study, the relatively low quality of the fillings and the low number of RCTs performed per student, led us to search for alternative teaching methods. Furthermore, these guiding actions are expected to improve standards of education in accordance with the guidelines of the European Society of Endodontology and raise student's confidence and the necessary competence to promote effective oral care.

Conclusion

The technical quality of RCTs performed by junior dental students at the FMDUP, although considered acceptable in 53.3% of the cases and similar to the average reported in the literature, should be improved.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Conflict of interest

The authors have no conflicts of interest to declare.

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