



## Status of Endodontic Treatment and the Correlations to the Quality of Root Canal Filling and Coronal Restoration

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### ABSTRACT

**Introduction:** This cross-sectional study evaluated the prevalence and quality of root canal treatment in 1,977 digital radiological files.

**Materials and methods:** Data were statistically analyzed using descriptive analysis, and the chi-square test was performed with a 5% significance level.

**Results:** The mean age of the study population was 34.9 years. The endodontic treatment frequency was 6.14%, significantly higher in premolars. Adequate endodontic treatment was observed in 39.7% of analyzed cases. Molars were significantly more frequent with regard to inadequate filling quality. In 47.6% of cases, the filling's apical limit was classified as adequate, and there was a higher incidence of molars that were inadequate. Restorations were classified as adequate in 79.0% of cases, and molars were responsible for the highest frequency of inadequate restorations. The frequency of teeth with endodontic treatment that showed no periapical changes was 47.7%. There was no significant difference in the presence of periapical change according to gender. An increased presence of periapical change was observed with increasing age. The periapical lesions were observed in 45% of cases and related to inadequate filling quality. The apical limit was considered inadequate and related to periapical changes in 42% of cases. Periapical changes were present in 52% of cases, regardless of the quality of the filling and apical limit. Such changes were present in 42% of cases with adequate coronal restoration.

**Conclusion:** It can be concluded that apical periodontitis (AP) is associated with the quality of endodontic treatment. The coronal restoration affects significantly the success rate of endodontic treatment.

**Clinical significance:** The quality of the root filling and coronal restoration is closely related to periapical health.

**Keywords:** Endodontics, Panoramic, Radiography, Root canal preparation.

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### INTRODUCTION

Endodontic treatment is defined as a combination of mechanical instrumentation and chemical debridement, followed by filling with biocompatible material, to maintain or restore the health of the periapical tissue.<sup>1</sup> Successful treatment depends on the knowledge of etiology, pathophysiology, and clinical manifestations.<sup>2,3</sup> Many factors can influence prognosis, such as inadequate antisepsis, poor coronal access, inadequate instrumentation, nonobturated root canals, deficient restorations, preoperative status of the pulp tissue, microbiological culture before filling, apical limit, and presence of previous periapical lesions.<sup>4,5</sup> Anatomical variability can also interfere on the prognosis.<sup>6,7</sup>

Technological advances in methods, instruments, and materials have provided better results; however, the discrepancy in success rates may reflect a difference in the quality of the performed endodontic treatment.<sup>8</sup>

Success rates are based on the absence of clinical and radiographic signs/symptoms of inflammation and

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infection.<sup>4</sup> Epidemiological studies have documented the quality of endodontic treatment in several countries involving different populations by evaluating radiographic parameters of apical limits and filling homogeneity.<sup>8-10</sup> The absence of a coronal seal due to missing or improper restoration allows bacteria and bacterial factors in the oral cavity to penetrate the filling material and eventually reach the apical foramen, influencing treatment success.<sup>11</sup>

Although the periradicular tissue produces a variety of responses to infectious process, liable to restrict the propagation of infectious elements, the apical periodontitis (AP) should not be considered an exclusively local phenomenon.<sup>12</sup> Therefore, the spread of infection to surrounding tissue compartments is possible and can be related to serious implications.<sup>13,14</sup> Endodontic health planning for a population allows an understanding of the disease's relationships and involves a preventive approach and analysis of their distribution, prevalence, severity, and risk factors.<sup>15</sup> Epidemiological studies in different societies contribute through the observation of factors associated with the health/disease process, providing important information for the development of preventive or therapeutic strategies and for understanding their results.<sup>16</sup>

The present study aimed to evaluate the prevalence and quality of root canal treatment, the prevalence of periapical radiolucency, and the quality of coronal restoration using routine imaging exams.

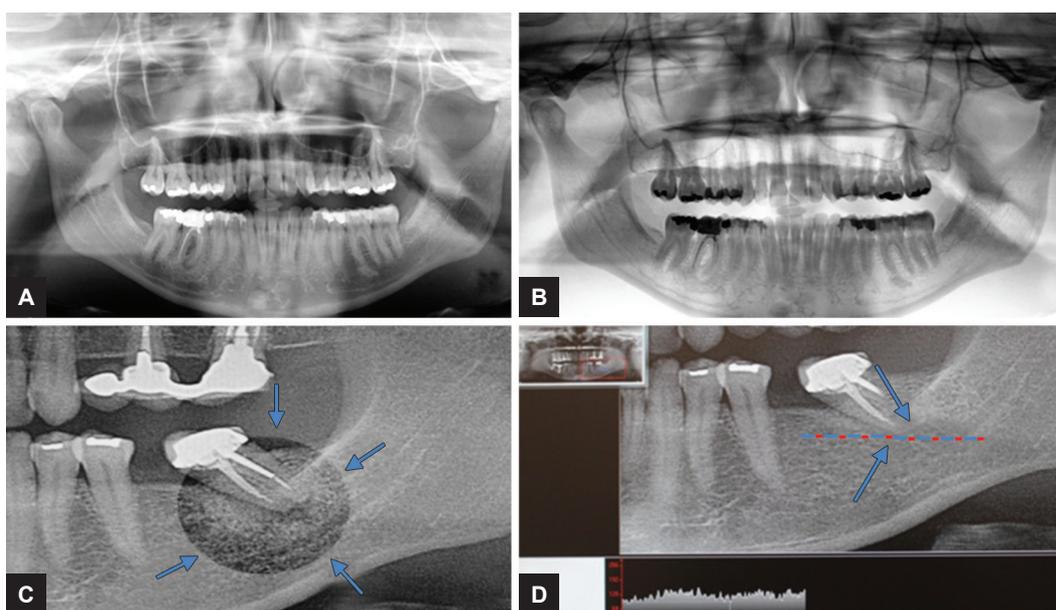
## MATERIALS AND METHODS

This cross-sectional study analyzed 1,977 digital radiological files belonging to a specialized radiology clinic.

Of these, 1,398 panoramic radiographs taken with KODAK 9000C 3D equipment (KODAK Dental System group, Carestream Dental LLC, Atlanta, GA, USA) were selected as the study sample. Radiographic evaluation was performed after approval of the research project by the Research Ethics Committee under Protocol No. 2012-060. The inclusion criteria were panoramic radiographs showing high technical standard and quality with regard to density and contrast. Radiographs of completely edentulous patients and patients with the presence of orthodontic appliances and/or the presence of implants that overlapped the roots of the endodontically treated teeth, precluding evaluation, were discarded. Files without the presence of panoramic radiographs were also discarded, totaling 579.

The study included patients, males and females, aged 15 to 65 years. Two calibrated endodontics specialist evaluators with over 10 years of experience analyzed the radiographs. Calibration was performed during the pilot study by determining the periapical index (PAI) and endodontic treatment quality. Values of 0.89 for the AP index and 0.87 for endodontic treatment quality were obtained. Evaluation was performed on a 20" Samsung liquid crystal display screen using resources from Trophy DICOM 6.2 software, Kodak Imaging System, Carestream Health (KODAK Dental System group, Carestream Dental LLC, Atlanta, GA, USA). These features included standard image (Fig. 1A), inverted image (Fig. 1B), magnification (Fig. 1C), densitometric analysis (Fig. 1D), rules for length and maximum magnification measurements, which were provided by the program itself in DICOM format.

The results were compiled on a spreadsheet created especially for this purpose. Each dental element was



**Figs 1A to D:** (A) Standard image in panoramic radiograph; (B) inverted image; (C) magnification; and (D) densitometric analysis

individually evaluated, and the following categories were determined: (1) Missing tooth; (2) tooth without endodontic treatment; and (3) tooth treated endodontically. For analysis of endodontic treatments, the following qualities were observed: Fillings, coronal restoration, and presence of periapical lesions. The criteria used for radiographic analysis of filling and restoration quality were as follows<sup>10</sup>: Filling quality [(1) adequate – all canals were obturated, without voids, and the top of the root canal filling was 0 to 2 mm short of the radiographic apex; (2) inadequate – the top of the root canal filling was more than 2 mm short of the radiographic apex or was grossly overobtured with the presence of voids and inadequate density]. Coronal restoration was evaluated as follows: (1) Adequate – intact with good margin of adaptation and without recurrent signs of decay; (2) inadequate – open margins, recurrent decay, or absence of restoration. Periapical status was evaluated using the PAI cited by Orstavik et al<sup>17</sup>: (1) Normal periapical structures, (2) small changes in bone structure, (3) changes in bone structure with small mineral loss, (4) clearly visible periodontitis with radiolucent area, and (5) advanced form of periodontitis with exacerbated appearance. A PAI score of 1 was defined as a healthy periapical region, i.e., normal periodontal ligament thickness and bone density showing normal appearance. All other PAI scores (2, 3, 4, and 5) were evaluated as AP. Multirrooted teeth were graded according to the root exhibiting the most severe condition.

Data were statistically analyzed using descriptive analyses (simple and relative frequencies), and the chi-square test was performed to check the data significance level. Analyzed factors were prevalence of endodontic treatment, quality of endodontic treatment (filling quality and apical limit), prevalence of AP, and coronal restoration quality. These factors were related to dental group, gender, and age.

## RESULTS

The study included 1,398 individuals, aged between 15 and 65 years, with a mean of 34.9 years. A total of 37,928 teeth were analyzed; of these, 2,329 (6.14%) had been subjected to endodontic treatment. Table 1 shows the analysis of endodontic treatment frequency regarding dental groups. Upon analyzing the dental groups, the molars had the highest frequency of inadequate restorations (25.6%,  $p < 0.05$ ), and the incisors had the lowest frequency of inadequate restorations (16.3%,  $p < 0.05$ ). A total of 47.7% of teeth with endodontic treatment showed no periapical changes. The molar group had the highest frequency of AP (67.3%,  $p < 0.05$ ), and 5% of these teeth were at levels 3 and 4 of the PAI scoring system. The incisor group had the lowest frequency of teeth with periapical changes (36.1%,  $p < 0.05$ ). Comparing upper

**Table 1:** Analysis of endodontic status regarding dental groups (%)

Dental Group/ Endodontic Status	Incisors	Canines	Premolars	Molars
Not treated	94.99	96.36	91.76	93.49
Treated	5.01 <sup>b*</sup>	3.64 <sup>c</sup>	8.24 <sup>a</sup>	6.51 <sup>b</sup>
Total	100.0	100.0	100.0	100.0

\*Different letters represent statistically significant differences ( $p < 0.05$ )

and lower teeth, a higher percentage of lower teeth lacked endodontic treatment ( $p < 0.05$ ). Only the molar group had a higher percentage of upper teeth without endodontic treatment ( $p < 0.05$ ). The  $p$  value demonstrates a significant difference between upper and lower teeth. The lower incisors showed the lowest percentage of endodontic treatment (1.1%). Statistically significant differences ( $p < 0.05$ ) between upper and lower teeth were observed in all groups regarding the presence of periapical changes. These differences were especially apparent in the premolars and molars, where the upper teeth had a greater presence of periapical change, especially the upper (74.3%) and lower molars (61.7%). There was no statistically significant difference ( $p < 0.05$ ) in the presence or absence of periapical changes according to gender for the canine and premolar groups. Only the molar groups showed a statistically significant difference ( $p < 0.05$ ). The incisors were within the analysis limit for significance. When all dental groups were considered, there was no significant difference between genders ( $p < 0.05$ ). Regarding age group, there was an increased presence of periapical changes with increasing age.

Table 2 shows the analysis of filling quality regarding dental groups. Of the analyzed teeth, 39.7% had adequate endodontic treatment. There was also a greater percentage of inadequate obturation with increasing age. That is, the percentage of teeth with obturations that were considered adequate was higher in younger patients, with the exception of the molar group, which exhibited no differences in terms of age for either the presence of periapical changes or obturation quality. Correlation analysis between the presence of periapical changes and obturation quality revealed that when obturation quality was classified as adequate, periapical changes were present in 7% of cases. However, when obturation quality was considered inadequate, periapical changes

**Table 2:** Analysis of filling quality regarding dental groups (%)

Dental group/ Filling quality	Incisors	Canines	Premolars	Molars	Total
Adequate	55.6	40.4	41.6	26.8	39.7
Inadequate	44.4 <sup>c*</sup>	59.6 <sup>b</sup>	58.4 <sup>b</sup>	73.2 <sup>a</sup>	60.3

\*Different letters represent statistically significant differences ( $p < 0.05$ )

**Table 3:** Analysis of apical limit regarding dental groups (%)

Dental group/ Apical limit	Incisors	Canines	Premolars	Molars	Total
Adequate	65.2	48.5	47.8	35.2	47.6
Inadequate	34.8 <sup>c*</sup>	51.5 <sup>b</sup>	52.2 <sup>b</sup>	64.8 <sup>a</sup>	52.4

\*Different letters represent statistically significant differences ( $p < 0.05$ )

were present in 45% of endodontically treated teeth, a difference that was statistically significant ( $p < 0.05$ ). When the apical limit was considered adequate, periapical changes were present in 10% of cases. When the apical limit was considered inadequate, periapical changes were present in 42% of cases of endodontic treatment, a difference that was also statistically significant ( $p < 0.05$ ). In total, periapical changes were present in 52% of cases, regardless of obturation quality and the apical limit of the obturation.

Table 3 shows the analysis of apical limit regarding dental groups. In relation to the apical limit of obturation, 1,108 teeth were classified as adequate. In 79.0% of cases, restorations in endodontically treated teeth were classified as adequate, and inadequate in 21.0% of cases. Periapical changes were absent in 42% of cases where coronal restoration was adequate and were present in 37% of cases where coronal restoration was considered adequate. In 15% of cases, the coronal restoration was considered inadequate and associated with periapical changes. However, periapical lesions were absent in only 6% of all cases of inadequate coronal restorations, a difference that was statistically significant ( $p < 0.05$ ).

## DISCUSSION

Epidemiological studies are essential in planning health measures and evaluation of measures taken.<sup>16</sup> Knowledge of epidemiological factors associated with endodontic treatment is essential for the adoption of preventive measures and the establishment of more effective treatment protocols.<sup>15</sup> In this context, action planning involves the need for knowledge about the distribution, prevalence, and severity of a given disease.<sup>16</sup> Epidemiological studies have documented the quality of endodontic treatment in several countries involving different populations by evaluating radiographic parameters of apical limit and filling homogeneity.<sup>4,8-10</sup>

Digital panoramic radiographs enable analysis in a single field, allowing all teeth to be seen, reducing the patient's radiation dose by up to 10-fold compared with a full periapical radiographic examination; in addition, the image capture is simple and fast and works on patients who are unable to open their mouths.<sup>18</sup> At the same time, modern diagnostic imaging resources, such as cone beam computed tomography (CBCT), have demonstrated the

projection of three-dimensional (3D) images, making this form of imaging particularly suitable for endodontic use.<sup>19,20</sup> However, the use of CBCT is recent, and due to its high cost, it is not widely used in epidemiological studies. This examination will potentially become routine in dental clinics due to its high quality, specificity, and the capability to produce 3D images.<sup>21</sup>

The present study showed that among the expected total of 44,736 teeth to be evaluated, 6,808 (15.2%) teeth were absent, particularly molars (28.3%) and premolars (11.3%). Regarding the presence of periapical change, premolars and molars were predominant, with molars representing 74.3% and premolars 55.0% in the upper teeth and molars representing 61.7% and premolars 40.1% in the lower teeth. These findings may be related to the fact that premolars and molars have higher anatomical variability and types of root branching.<sup>22</sup> Root canal morphology of these teeth is complex and variable, making endodontic treatment more difficult and consequently reducing prognostic predictability.<sup>20</sup> These variations represent a source of infection and a major cause of treatment failure, even leading to early loss of dental elements.<sup>23</sup>

The data revealed a predominance of females ( $n = 856$ , 61.2%) over males ( $n = 542$ , 38.8%). This finding can be explained by women's greater concern for and awareness of self-care.<sup>24,25</sup> Overall, there was no statistically significant gender difference in the present study.

Odesjö et al<sup>26</sup> reported that of 17,430 teeth examined, 1,492 (8.6%) underwent endodontic treatment. De Moor et al<sup>8</sup> reported 6.8% of 4,217 examined teeth. Kirkevang et al<sup>27</sup> found 773 (4.8%) of a total of 15,284. Chen et al<sup>28</sup> found 4.8% of examined teeth, and Matijevic<sup>9</sup> reported an endodontic treatment prevalence of 8.5%. These results corroborate the present study, where the occurrence of endodontic treatment was 6.1%. However, results slightly below this average were reported for teeth with endodontic treatment.<sup>29-31</sup> Several studies, including Boucher et al<sup>32</sup> and Tsuneishi et al,<sup>33</sup> had found that 23 and 21% of teeth had endodontic treatment respectively, and Hollanda et al,<sup>34</sup> who reported a 21.4% prevalence of endodontically treated teeth in an adult Brazilian population, have reported higher occurrences. The discrepancies observed among the results of different studies may be explained based on the different populations and study concepts.

In the present study, of the 2,329 teeth with endodontic treatment, premolar teeth were treated most frequently (8.24%), followed by molars (6.51%) and incisors (5.01%). Canines had the lowest frequency of endodontic treatment (3.64%). However, when comparing upper and lower teeth, the lower incisors and lower canines had the lowest prevalence rates of endodontic treatment (1.1 and 1.3% respectively) and the upper premolars and upper

incisors had the highest prevalence rates (8.8 and 8.3% respectively). Corroborating this study, Jiménez-Pinzón et al<sup>35</sup> estimated the prevalence rates of AP and endodontic treatment in an adult Spanish population. Premolars and molars had higher incidences of endodontic treatment, 2.8 and 2.7% respectively. However, Kirkevang et al<sup>27</sup> investigated the prevalence rates of endodontically treated teeth and AP in a Danish population and found that molars were treated significantly more often (8.1%) compared with premolars (5.4%) and anterior teeth (2.5%).

Matijevic et al<sup>9</sup> observed that in the maxilla, the teeth often treated endodontically were the second premolars, while in the mandible, the most commonly treated were the first molars. In the present study, it can be confirmed that the upper premolars had the greatest frequency of endodontic treatment, followed by the upper incisors and lower molars. The posterior teeth had a higher incidence of endodontic treatment. This finding may be related to the fact that these teeth do not represent the esthetic portion of the dental elements and are therefore, not cared properly. The lack of proper care suggests that the posterior teeth suffer greater effects of microorganisms in the oral environment, leading to coronal destruction (caries) and subsequent endodontic treatment.

The presence of periapical radiolucency has been used as a criterion to determine failure of endodontic treatment.<sup>35</sup> Although radiography provides a static picture of a dynamic process at the time of radiographic evaluation, AP of endodontically treated teeth may appear either during the development or treatment process.<sup>36</sup> Therefore, sectional investigations can provide reliable information on the prevalence of AP in a given population.<sup>37</sup> In the present study, it was observed that AP was present in 52.4% of endodontically treated teeth. A total of 60.3% of obturations were considered to be of inadequate quality, and 52.4% of the apical limits of obturation were considered inadequate. The relationship between the quality of endodontic treatment (quality of obturation and apical limit) and its association with AP has been demonstrated in other epidemiological studies.<sup>16,30,32,34,38,39</sup>

Apical periodontitis is a sequel of endodontic infection and manifests as the host defense response to microbial challenge emanating from the root canal system.<sup>12</sup> Most failures occur when treatment procedures, primarily of a technical nature, do not reach satisfactory levels regarding the control and elimination of infection.<sup>40</sup> The apical anatomy consists of the largest foraminal opening and smallest constriction diameter, located on average 0.5 mm from the root apex, and is extremely important to the apical limit of the obturation.<sup>41</sup> The results of the present study reveal a correlation between the presence of periapical change and obturation quality. When obturation

quality was considered inadequate, periapical changes were present in 45% of cases. When deemed adequate, they were present in only 7% of cases. Correlating the presence of periapical change and the apical limit of the obturation, when this last one was considered adequate, apical changes were present in 10% of cases, and when inadequate, in 42%. Periapical changes were present in 52% of cases, regardless of quality and the apical limit of the obturation.

The quality of both endodontic treatment and coronal restoration affects treatment success.<sup>10,42,43</sup> Bacterial elements can penetrate through the obturation, from the coronal portion to the apical tip after a period of exposure to artificial saliva or bacterial culture.<sup>44,45</sup> Coronal sealing between sessions and final restoration represents a critical moment during which all the care taken during the clinical procedure can be jeopardized.<sup>46</sup> Furthermore, definitive restoration following the completion of endodontic treatment is of vital importance for endodontic success.<sup>47,48</sup>

Data collection has revealed that concerning age, an increased presence of periapical changes was observed with aging. Inadequate obturation quality percentage also increased with age. The prevalence of AP increased with age, and the disease appears to be associated mainly with previously endodontically treated teeth.<sup>49</sup> The difference in periapical status is most related to age and root canal obturation quality.<sup>18</sup>

Root canal treatment quality is shaped by the knowledge, attitude, and skills of the dentist; changes of opinion and clinical performance in the context of dental practice must be justified.<sup>50</sup> The obvious interrelationship between the factors analyzed in the present study demonstrates an old concern that remains today, despite technological advances in materials, equipment, automated preparation techniques, apical locators, surgical microscopes, CBCT for diagnosis, and dissemination of knowledge in an accessible way. The results indicate that there is a long way to go before the desired success in endodontic treatment is achieved.

## CONCLUSION

Based on the methodology used, it can be concluded that AP is associated with the quality of both endodontic treatment and coronal restoration and significantly affects the success rate of endodontic treatment.

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