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DISTRIBUTION AND RADIOGRAPHIC TECHNICAL QUALITY OF ENDODONTICALLY TREATED POSTERIOR TEETH ON DIGITAL PANORAMIC RADIOGRAPHS: A RETROSPECTIVE CROSS-SECTIONAL STUDY

DISTRIBUIÇÃO E QUALIDADE TÉCNICA RADIOGRÁFICA DE DENTES POSTERIORES TRATADOS ENDODONTICAMENTE EM RADIOGRAFIAS PANORÂMICAS DIGITAIS: UM ESTUDO TRANSVERSAL RETROSPECTIVO

DISTRIBUCIÓN Y CALIDAD TÉCNICA RADIOGRÁFICA DE DIENTES POSTERIORES TRATADOS ENDODÓNTICAMENTE EN RADIOGRAFÍAS PANORÁMICAS DIGITALES: UN ESTUDIO TRANSVERSAL RETROSPECTIVO

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Abstract

Panoramic radiography (PR), by providing a comprehensive view of the maxillary and mandibular structures and being more accessible to patients, is one of the most frequently requested extraoral imaging examinations in dental practice. The aim of this study was to assess the frequency of endodontically treated teeth and the quality of root canal fillings using digital panoramic radiographs (DPR). A cross-sectional study was conducted using DPRs from the archive of the Diagnostic Imaging Clinic at Campus VIII of the State University of Paraíba (UEPB). A total of 135 DPRs containing endodontically treated teeth (n=236) were evaluated. Most of the included radiographs belonged to

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female patients (65.9) aged between 18 and 34 years (65.9%) and most of the treated teeth were posterior (65.2%). A statistically significant association was observed between anatomical location and tooth group, with a higher frequency of endodontically treated premolars in the maxilla and molars in the mandible (p<0.001). The radiographic technical quality of the obturation was considered unsatisfactory (90.9%) in the vast majority of cases. Nevertheless, the frequency of periapical lesions was low in the sample, although these lesions occurred more frequently in the mandible (p<0.001), predominantly involving tooth #37, despite the fact that most endodontically treated teeth were maxillary premolars (42.8%), particularly teeth #14 and #25. Furthermore, most endodontically treated teeth (57.2%) had been restored with direct coronal restorations, which were also predominantly classified as unsatisfactory. In addition, molars exhibited higher frequency of unsatisfactory fixed prosthetic restorations than premolars. DPR allowed a broad retrospective screening of endodontically treated teeth in the studied archive but the findings require confirmation through clinical examination and intraoral radiography.

Keywords: Radiography, Panoramic; Endodontics; Dentistry.

Resumo

A radiografia panorâmica (RP), por fornecer uma visão geral dos maxilares e ser mais acessível ao paciente, representa um dos exames radiográficos extraorais mais solicitados pelos profissionais. A proposta deste estudo foi observar a frequência de dentes tratados endodonticamente e a qualidade das obturações endodônticas em radiografias panorâmicas digitais (RPD). Foi realizado um estudo transversal em RPD do acervo da Clínica de Diagnóstico por Imagem do Campus VIII da Universidade Estadual da Paraíba (UEPB), em que foram avaliadas 135 RPD que apresentavam dentes (n=236) com tratamento endodôntico. A maioria das radiografias incluídas pertencia a pacientes do sexo feminino (65,9%), com idades entre 18 e 34 anos (65,9%) e a maior parte dos dentes tratados era posterior (65,2%). Houve associação estatisticamente significativa entre localização anatômica e grupo dentário, com maior frequência de pré-molares com tratamento endodôntico na maxila e de molares na mandíbula (p<0,000). A qualidade técnica radiográfica da obturação endodôntica mostrou-se insatisfatória (90,9%) na vasta maioria dos casos. Contudo, houve baixa frequência de lesões periapicais na amostra, sendo que essas ocorreram mais em mandíbula (p<0,000), envolvendo principalmente o dente 37, apesar de maioria dos dentes com tratamento endodôntico serem pré-molares superiores (42,8%), principalmente os dentes 14 e 25. Além disso, a maioria (57,2%) dos dentes tratados endodonticamente estava reabilitada com restaurações coronárias simples, que também se apresentaram insatisfatórias. Ainda, os molares apresentaram mais próteses fixas insatisfatórias que os pré-molares. A RPD permitiu uma triagem retrospectiva ampla dos dentes tratados endodonticamente no arquivo estudado, mas os achados requerem confirmação por meio de exame clínico e radiografia intraoral.

Palavras-chave: Radiografia Panorâmica; Endodontia; Odontologia.

Resumen

La radiografía panorámica (RP), al proporcionar una visión general de los maxilares y ser más accesible para el paciente, representa uno de los exámenes radiográficos extraorales más solicitados por los profesionales. El objetivo de este estudio fue evaluar la frequencia de dientes tratados endodónticamente y la calidad de las obturaciones endodónticas en radiografías panorámicas digitales (RPD). Se realizó un estudio transversal utilizando RPD del archivo de la Clínica de Diagnóstico por Imagen del Campus VIII de la Universidad Estatal de Paraíba (UEPB), en el cual fueron evaluadas 135 RPD que presentaban dientes (*n*=236) con tratamiento endodóntico. La mayoría de las RPD incluidas

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pertenecían a pacientes femeninas (65,9%), con edades comprendidas entre los 18 y los 34 años (65,9%), y la mayoría de los dientes tratados eran posteriores (65,2%). Se observó una asociación estadísticamente significativa entre la localización anatómica y el grupo dentario, con una mayor frequencia de premolares con tratamiento endodóntico en el maxilar y de molares en la mandíbula (p<0,001). La calidad técnica radiográfica de la obturación endodóntica se consideró insatisfactoria en la gran mayoría de los casos (90,9%). Sin embargo, se observó una baja frequencia de lesiones periapicales en la muestra, las cuales ocurrieron con mayor frecuencia en la mandíbula (p<0,001), afectando principalmente al diente 37, aunque la mayoría de los dientes tratados endodónticamente correspondieron a premolares superiores (42,8%), especialmente los dientes 14 y 25. Además, la mayoría (57,2%) de los dientes tratados endodónticamente presentaba rehabilitación mediante restauraciones coronarias directas, las cuales también fueron clasificadas como insatisfactorias. Asimismo, los molares presentaron una frecuencia mayor de prótesis fijas insatisfactorias en comparación con los premolares. La RPD permitió realizar un amplio cribado retrospectivo de los dientes tratados endodónticamente en el archivo estudiado, pero los hallazgos requieren confirmación mediante examen clínico y radiografía intraoral.

Palabras clave: Radiografía Panorámica; Endodoncia; Odontología.

1. Introduction

The longevity of endodontically treated teeth is directly associated with tooth survival, defined as the maintenance of a functional tooth within the oral cavity, and endodontic success, characterized by the absence of clinical signs and symptoms in conjunction with radiographic evidence of periapical tissue healing (López-Valverde *et al*., 2023).

The absence of an adequate coronal restoration or the inadequate performance of endodontic treatment may compromise tooth viability (Mehta *et al*., 2025). According to the American Association of Endodontists (AAE, 2014), long-term sealing of the root canal system depends on the achievement of an effective apical seal combined with a coronal restoration capable of preventing coronal microleakage.

The quality of root canal filling is one of the primary technical parameters used to assess prognosis through radiographic examinations. This evaluation may be performed by individually analyzing the apical extent, homogeneity, and taper of the root canal filling or by using the overall root canal filling quality classification, which integrates these parameters into a single indicator of technical performance. A root canal filling is considered adequate when it ends 0.0-2.0mm short of the radiographic apex (Ahmad, 2025), exhibits homogeneous filling free of voids and presents a continuous taper throughout the entire root canal (Silva *et al*., 2024).

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Radiographic examination is the most accessible and reliable method for identifying inadequate endodontic treatment. Furthermore, it plays a fundamental role in diagnosis and treatment planning in contemporary dentistry by providing detailed information on dental anatomy, pathological alterations, and the outcomes of clinical interventions (Karkle *et al*., 2024). Among the available radiographic imaging modalities, panoramic radiography (PR) stands out as an extraoral technique that provides a comprehensive view of the dental arches, maxilla, mandible, temporomandibular joints, and portions of the maxillary sinuses (Różyło-Kalinowska *et al*., 2021). PR has proven to be an appropriate and efficient diagnostic tool in primary oral healthcare as an adjunct to the clinical examination, offering valuable information that facilitates the establishment of treatment priorities and supports comprehensive treatment planning (Almeida *et al*., 2024).

Preoperative radiographs are an indispensable component of endodontic diagnosis, providing a two-dimensional projection of the tooth. Panoramic radiography, together with other imaging technologies, offers a wide range of software tools that substantially enhance radiographic diagnosis by improving image interpretation capabilities (AAE, 2014). Although periapical radiography remains the gold standard for endodontic assessment (Arslan et al., 2020), PR is highly valuable for diagnosing a wide variety of dental and osseous conditions while enabling the simultaneous evaluation of multiple teeth (Hlongwa *et al*., 2023; Różyło-Kalinowska *et al*., 2021). In addition, digital panoramic radiographs (DPRs) provide enhanced image quality and contrast compared with conventional panoramic radiographs, allowing more accurate image interpretation and reinforcing their value as a complementary clinical tool as well as their potential for population-based assessments (Dias *et al*., 2019; Stera *et al*., 2024).

From a public health perspective, PR has been recognized as an important complementary tool for large-scale screening of oral conditions, particularly in programs targeting populations with limited access to specialized dental services. Moreover, the rapid acquisition of images, lower radiation dose compared with full-mouth periapical radiographic series, and broad anatomical coverage make this imaging modality an efficient alternative for oral health screening and epidemiological

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surveillance programs. The use of PR may increase the detection of periapical lesions, impacted teeth, osseous alterations, and other clinically relevant conditions that are often not identified through clinical examination alone, thereby facilitating more efficient allocation of healthcare resources and improving the organization of public oral healthcare services (Almeida *et al*., 2024; Salari *et al*., 2024).

In light of the foregoing, the aim of this study was to evaluate the frequency of endodontically treated teeth and the quality of root canal fillings using DPR.

2. Materials and Methods

Retrospective cross-sectional observational study, based on archival radiographic analysis, conducted at the Diagnostic Imaging Clinic (DIC) of the Dentistry Course, Campus VIII, at the State University of Paraíba (UEPB).

The sample consisted of DPRs obtained between 2016 and 2022 that presented at least one endodontically treated tooth. Only DPRs with excellent image detail, adequate density, and medium contrast were included. Radiographs with poor image quality, positioning errors, imaging artifacts, duplicate records, or those obtained from individuals under 18 years of age were excluded. No sample size calculation was performed, since all 902 radiographs available in the archive during the period were examined (image census). Duplicate records were excluded, and each included radiograph corresponded to a different patient (n=135 patients).

All DPRs were acquired using the EAGLE 3D Computed Tomography System (Dabi Atlante, Ribeirão Preto, SP, Brazil) under the manufacturer's recommended standard exposure parameters (14 s, 8 mA, 60–85 kVp). Digital images were obtained using the Dental Imaging Software Setup Wizard (Dabi Atlante, Ribeirão Preto, SP, Brazil). All radiographs were captured and analyzed on the same computer.

Data collection was performed by a single trained and calibrated examiner using a structured data collection form. The recorded variables included patients' demographic characteristics (age and sex) and radiographic findings related to posterior endodontically treated teeth, including the radiographic technical quality of

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the obturation, the presence of periapical lesions, the presence of coronal restorations, and their respective quality. The teeth were identified using the two-digit numbering system of the Fédération Dentaire Internationale (FDI). The examiner was calibrated with a reference examiner by evaluating the same five radiographic images, repeated every seven days for three weeks. During the evaluation, the examiner did not have access to the patients' age and sex; the radiographs were pasted into a new folder and renamed using a desktop tool on the computer used to generate the reports, meaning there was blinding regarding these variables.

For the purposes of this study, the apical extension of the obturation was considered adequate when it ended between 0-2.0mm short of the radiographic apex (Ahmad, 2025); under-obturated when it ended more than 2mm short of the apex; and over-obturated when it exceeded the radiographic apex. Homogeneity was assessed by the absence of discontinuities, voids, and adaptation defects between the obturation material and the canal walls. The obturation was classified as satisfactory only when it simultaneously met the criteria for apical extension and homogeneity. In teeth with more than one root canal, the tooth was classified as unsatisfactory when at least one of the canals did not meet these criteria.

The category 'failure/absence of obturation material' corresponded to canal segments without visible radiopaque material in the RPD, which may reflect an untreated canal, a non-visualized canal, overlapping structures, low material density, or a technical defect in the obturation. These situations were not differentiated in the present study.

The presence of periapical lesions was determined exclusively by visual criteria, without the use of a standardized index. Lesions associated with posterior teeth were evaluated individually, and their diameter was measured with an endodontic ruler calibrated with the radiographic image, viewed without zoom (only expanded on the screen). As the image magnification varies within the same PR, the distortion is greater in the horizontal plane than in the vertical plane, and this examination is not indicated for linear measurements (Różyło-Kalinowska, 2021). So, the reported diameters should be interpreted as radiographic estimates.

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In each posterior tooth, the presence and quality (satisfactory or unsatisfactory) of the direct coronal restoration, the single-unit fixed prosthesis, and the intraradicular post were recorded. For unsatisfactory restorations and prostheses, the type of failure was recorded: overcontour, undercontour, and/or radiographic marginal alteration suggestive of marginal infiltration, secondary caries, or fracture; the latter three were recorded in a single category. Because this is an exclusively radiographic evaluation, marginal infiltration cannot be diagnosed solely from the image. The quality of restorations in endodontically treated teeth was classified as satisfactory or unsatisfactory. They were considered unsatisfactory when they presented undercontour, fracture, overcontour, step, or secondary caries. Intraradicular posts were classified as unsatisfactory in the presence of inadequate length or positioning, maladaptation, and radiolucent spaces around the post. In fixed prostheses, the classification as unsatisfactory was assigned in the presence of marginal adaptation failure, overcontour, undercontour, or the presence of secondary caries.

In this study, the classifications referred to the radiographic appearance observed in the RPD and did not constitute a definitive clinical diagnosis.

Initially, each DPR was evaluated as a whole, and the number of endodontically treated teeth was recorded for both anterior and posterior teeth. Subsequently, endodontically treated posterior teeth (premolars and molars) were individually assessed for qualitative analysis. In this initial stage, periapical lesions were visually identified in anterior and posterior teeth; however, only lesions associated with posterior teeth were evaluated individually. Lesions in anterior teeth were not evaluated separately due to distortion and overlapping structures in the anterior region of the RPD.

The data were analyzed using descriptive and inferential statistics, including Pearson's chi-square test and Fisher's exact test, with the Statistical Package for the Social Sciences (SPSS), version 22.0. Statistical significance was established at a 95% confidence level ($p<0.05$). The unit of analysis was the tooth. All p-values presented are two-sided.

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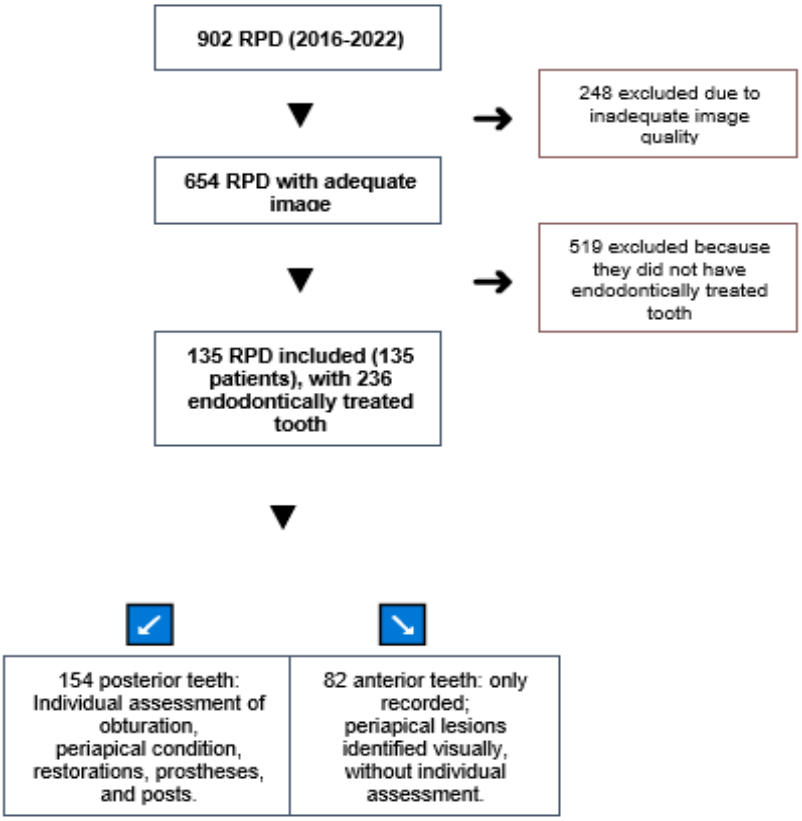
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This study complied with all ethical principles for research involving human participants and was approved by the Research Ethics Committee of the State University of Paraíba (CAAE No. 69887423.4.0000.5187).

3. Results and Discussion

Of the 902 DPRs available in the DIC archive, 767 were excluded for failing to meet the predefined eligibility criteria (248 due to inadequate image quality and 519 because they did not include endodontically treated teeth). Consequently, 135 DPRs (14.9%) presenting at least one endodontically treated tooth in a dental quadrant were included in the analysis.This proportion corresponded to 15.0% (135/902) when calculated over the entire file-the minimum value, since the 248 images of inadequate quality did not allow confirmation of the absence of treatment-and to 20.6% (135/654) when calculated over the interpretable radiographs, an estimate considered more appropriate. So, the 135 radiographs corresponded to 135 different patients (Figure 1).

Figure 1 – Flowchart for selecting digital panoramic radiographs (DPR) and teeth evaluated.



Source: The authors, 2026.

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Participants' ages (at the time of the DPR) ranged from 18 to 64 years, with the highest proportion of individuals (65.9%) belonging to the 18–34-year age group. The mean age was 31.6 years (Table 1). This mean age was lower than that reported by Al-Awasi *et al.* (2022), who found a mean age of 41.5 years. However, the age range in their study (17–81 years) was substantially broader than that of the present investigation.

Most participants were female (65.9%) (Table 1). This sample composition was similar to that observed by Al-Awasi *et al.* (2022), who reported that women accounted for 59.2% of endodontic treatments in a sample of Saudi adults. Likewise, El Quarti *et al.* (2021) observed that 75.7% of their study population were women while investigating risk factors for apical periodontitis. In contrast, Khan et al. (2017), in a study conducted in Saudi Arabia, reported a slightly higher prevalence of endodontic treatment among men (52.0%).

Table 1 - Demographic characteristics of the studied sample.

Age Group (years)	**N**	**%**
18-34	89	65.9
35-44	29	21.5
45-60	15	11.1
≥ 61	2	1.5
Total	**135**	**100.0**
Gender		
Female	89	65.9
Male	46	34.1
Total	**135**	**100.0**

Source: The authors, 2026.

Among the 135 DPRs evaluated, a total of 236 endodontically treated teeth were identified. Most of these teeth (65.2%, *n* = 154) were posterior teeth, whereas only 82 were anterior teeth, corresponding to a mean of 1.7 endodontically treated teeth per DPR. These findings are consistent with those reported by El Merini *et al.* (2017), who found that 71.5% of endodontically treated teeth were located in the posterior region. Furthermore, those authors reported that maxillary premolars (26.0%) were the most frequently treated teeth, which is in agreement with the present study, in which

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maxillary premolars also exhibited the highest frequency (42.8%; 66 of the 154 endodontically treated posterior teeth) (Table 2). In contrast, Khan *et al.* (2017) reported that maxillary molars (17.3%) were the teeth most frequently subjected to endodontic treatment, followed by mandibular molars (14.3%). This finding may be partially explained by the anatomical characteristics of posterior teeth, particularly maxillary premolars and molars, which exhibit considerable variability in root morphology and root canal system configuration (Martins *et al*., 2019). The maxilla presented approximately three times more endodontically treated teeth (mean=1.34 teeth) than the mandible (mean=0.40 teeth), and this difference was statistically significant, as shown in Table 2.

Table 2- Anatomical distribution of root canal fillings according to the group of endodontically treated posterior teeth.

Variable	**Posterior Tooth Groups**			
	Premolar n (%)	**Molar n (%)**	**Total n (%)**	***p* value**
Anatomical Location				
Maxilla	66 (65.3)	35 (34.7)	**101 (65.6)**	
Mandible	13 (24.5)	40 (75.5)	**53 (34.4)**	
Total	79 (100.0)	75 (100.0)	**154 (100.0)**	**<0.000***

Pearson's chi-square test. ***Statistically significant**. Source: The authors, 2026.

Among the 154 endodontically treated posterior teeth evaluated in the present study, most (65.6%) were located in the maxilla, corroborating the findings of El Merini *et al*. (2017) and Khan *et al*. (2017), who reported prevalences of 68.7% and 60.7%, respectively, for endodontically treated teeth in the maxilla. A statistically significant association was observed between the affected jaw and tooth group, with a higher frequency of endodontically treated premolars in the maxilla (65.3%) and endodontically treated molars in the mandible (75.5%), as shown in Table 2. Among the premolars (n=79; 51.3%), teeth #14 and #25 were the most frequently endodontically treated, with 19 cases each. Of the 75 endodontically treated molars, most (53.3%, n=40) were located in the mandible, with tooth #36 accounting for the highest number of cases (16). In the maxilla, tooth #16 presented the highest frequency of endodontic treatment (18 cases). Mashyakhy *et al*. (2021), after evaluating 3,046 posterior teeth (1,529 maxillary and 1,517 mandibular), identified 165 (5.4%)

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endodontically treated teeth, with the highest prevalence occurring in the maxillary first molars (40.6%) and mandibular first molars (25.0%). These findings are consistent with the high frequency of posterior teeth observed in the present study, although maxillary premolars were the most frequently treated teeth in our sample.

Evaluation of the quality of root canal fillings in posterior teeth revealed that most treatments (90.9%, n=140) were classified as unsatisfactory (Table 3). Filling deficiencies were most frequently observed in teeth #14 and #25 (18 cases each) and tooth #36 (16 cases). These findings are consistent with those reported by El Merini *et al.* (2017), who also found that most endodontic treatments were technically inadequate. It is important to note that their study assessed both panoramic and periapical radiographs, the latter being the preferred imaging modality for endodontic evaluation, whereas the present study was based exclusively on digital panoramic radiographs.

Among the 140 root canal fillings classified as unsatisfactory, the following technical deficiencies were identified: 87 (62.1%) teeth presented only filling defects or absence of filling material; 38 teeth (27.2%) exhibited both filling defects/absence of filling material and underfilling; 10 teeth (7.1%) showed underfilling alone; and five teeth (3.6%) presented both filling defects/absence of filling material and overfilling. Unsatisfactory root canal fillings were more frequently observed in the maxilla (63.6%) than in the mandible (36.4%), as shown in Table 3, with molars accounting for most of these deficiencies (Table 4).

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Table 3- Quality of root canal fillings, periapical lesions, coronal restorations, fixed prosthetic crowns, and intraradicular posts according to anatomical location.

VARIABLE	ANATOMICAL LOCATION			*p* value
	Maxilla n (%)	Mandible n (%)	Total n (%)	
Root Canal Filling				
Quality of Root Canal Filling				
Satisfactory	12 (85.7)	2 (14.3)	**14 (9.1)**	
Unsatisfactory	89 (63.6)	51 (36.4)	**140 (90.9)**	
Total	**101 (65.6)**	**53 (34.4)**	**154 (100.0)**	0.81[b]
Root Canal Filling Failure				
Filling defect[#]/absence of filling material	53 (60.9)	34 (39.1)	**87 (62.1)**	
Underfilling	6 (60.0)	4 (40.0)	**10 (7.1)**	
Filling defect/absence of filling material + Underfilling	26 (68.4)	12 (31.6)	**38 (27.2)**	
Filling defect/absence of filling material + Overfilling	4 (80.0)	1 (20.0)	**5 (3.6)**	
Total	**89 (63.6)**	**51 (36.4)**	**140 (100.0)**	0.794[b]
Periapical Lesion				
Absent	98 (70.5)	41 (29.5)	**139 (90.3)**	
Present	3 (20.0)	12 (80.0)	**15 (9.7)**	
Total	**101 (65.6)**	**53 (34.4)**	**154 (100.0)**	**<0.001***
Direct Coronal Restoration				
Absent	18 (66.7)	9 (33.3)	**27 (17.5)**	
Present	83 (65.4)	44 (34.6)	**127 (82.5)**	
Total	**101 (65.6)**	**53 (34.4)**	**154 (100.0)**	0.543[a]
Quality of coronal restoration				
Satisfactory	29 (34.9)	10 (22.7)	**39 (30.7)**	
Unsatisfactory	54 (65.1)	34 (77.3)	**88 (69.3)**	
Total	**83 (65.4)**	**44 (34.6)**	**127 (100.0)**	0.111[a]
Coronal Restoration Failure				
Marginal leakage[+]/secondary caries/fracture	29 (58.0)	21 (42.0)	**50 (56.8)**	
Overcontouring	10 (83.3)	2 (16.7)	**12 (13.6)**	
Overcontouring+Marginal leakage/secondary caries/fracture	9 (75.0)	3 (25.0)	**12 (13.6)**	
Undercontouring+Marginal leakage/secondary caries/fracture	4 (33.3)	8 (66.7)	**12 (13.6)**	
Undercontouring	2 (100.0)	0 (0.0)	**2 (2.3)**	
Total	**54 (61.4)**	**34 (38.6)**	**88 (100.0)**	0.070[b]
Fixed Prosthesis				
Absent	90 (65.2)	48 (34.8)	**138 (89.6)**	
Present	11 (68.8)	5 (31.2)	**16 (10.4)**	
Total	**101 (65.6)**	**53 (34.4)**	**154 (100.0)**	0.508[a]
Quality of Fixed Prosthesis				
Satisfactory	6 (100.0)	0 (0.0)	**6 (37.5)**	
Unsatisfactory	5 (50.0)	5 (50.0)	**10 (62.5)**	
Total	**11 (68.7)**	**5 (31.3)**	**16 (100.0)**	0.05[b]
Fixed Prosthesis Failure				
Overcontouring	2 (33.3)	4 (66.7)	**6 (60.0)**	
Undercontouring	3 (75.0)	1 (25.0)	**4 (40.0)**	
Total	**5 (50.0)**	**5 (50.0)**	**10 (100.0)**	0.262[b]
Intraradicular Post				
Absent	92 (65.7)	48 (34.3)	**140 (90.9)**	
Present	9 (64.3)	5 (35.7)	**14 (9.1)**	
Total	**101 (65.6)**	**53 (34.4)**	**154 (100.0)**	0.564[b]
Quality of Intraradicular Post				
Satisfactory	3 (100.0)	0 (0.0)	**3 (21.4)**	
Unsatisfactory	6 (54.5)	5 (45.5)	**11 (78.6)**	
Total	**9 (64.3)**	**5 (35.7)**	**14 (100.0)**	0.231[b]

[a]Pearson's chi-square test. [b]Fisher's Exact Test. [#]Filling defect: segment without visible radiopaque obturing material. [+]Marginal leakage: radiographic marginal change suggestive of marginal infiltration. ***Statistically significant** (p<0,05). Source: The authors, 2026.

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Table 4- Quality of root canal fillings, periapical lesions, coronal restorations, fixed prosthetic crowns, and intraradicular posts according to posterior tooth groups.

VARIABLE	TOOTH GROUPS			*p value*
	Premolars n (%)	**Molars n (%)**	**Total n (%)**	
Root Canal Filling				
Quality of Root Canal Filling				
Satisfactory	10 (71.4)	4 (28.6)	**14 (9.1)**	
Unsatisfactory	69 (49.3)	71 (50.7)	**140 (90.9)**	
Total	**79 (51.3)**	**75 (48.7)**	**154 (100.0)**	0.096[a]
Root Canal Filling Failure				
Filling defect[#]/absence of filling material	43 (49.4)	44 (50.6)	**87 (62.1)**	
Underfilling	3 (30.0)	7 (70.0)	**10 (7.2)**	
Filling defect/absence of filling material + Underfilling	22 (57.9)	16 (42.1)	**38 (27.1)**	
Filling defect/absence of filling material + Overfilling	1 (20.0)	4 (80.0)	**5 (3.6)**	
Total	**69 (49.3)**	**71 (50.7)**	**140 (100.0)**	0.247[b]
Periapical Lesion				
Absent	74 (53.2)	65 (46.8)	**139 (90.3)**	
Present	5 (33.3)	10 (66.7)	**15 (9.7)**	
Total	**79 (51.3)**	**75 (48.7)**	**154 (100.0)**	0.116[a]
Direct Coronal Restoration				
Absent	13 (48.1)	14 (51.9)	**27 (17.5)**	
Present	66 (52.0)	61 (48.0)	**127 (82.5)**	
Total	**79 (51.3)**	**75 (48.7)**	**154 (100.0)**	0.441[a]
Quality of coronal restoration				
Satisfactory	21 (53.8)	18 (46.2)	**39 (30.7)**	
Unsatisfactory	45 (51.1)	43 (48.9)	**88 (69.3)**	
Total	**66 (52.0)**	**61 (48.0)**	**127 (100.0)**	0.096[a]
Coronal Restoration Failure				
Marginal leakage[+]/secondary caries/fracture	28 (56.0)	22 (44.0)	**50 (56.8)**	
Overcontouring	4 (33.3)	8 (66.7)	**12 (13.6)**	
Overcontouring+Marginal leakage/secondary caries/fracture	8 (66.7)	4 (33.3)	**12 (13.6)**	
Undercontouring+Marginal leakage/secondary caries/fracture	4 (33.3)	8 (66.7)	**12 (13.6)**	
Undercontouring	1 (50.0)	1 (50.0)	**2 (2.3)**	
Total	**45 (51.1)**	**43 (48.9)**	**88 (100.0)**	0.300[b]
Fixed Prosthesis				
Absent	73 (52.9)	65 (47.1)	138 (89.6)	
Present	6 (37.5)	10 (62.5)	16 (10.4)	
Total	**79 (51.3)**	**75 (48.7)**	**154 (100.0)**	0.184[a]
Quality of Fixed Prosthesis				
Satisfactory	5 (83.3)	1 (16.7)	**6 (37.5)**	
Unsatisfactory	1 (10.0)	9 (90.0)	**10 (62.5)**	
Total	**6 (37.5)**	**10 (62.5)**	**16 (100.0)**	**0.008***
Fixed Prosthesis Failure				
Overcontouring	0 (0.0)	6 (100.0)	**6 (60.0)**	
Undercontouring	1 (25.0)	3 (75.0)	**4 (40.0)**	
Total	**1 (10.0)**	**9 (90.0)**	**10 (100.0)**	0.400[b]
Intraradicular Post				
Absent	72 (51.4)	68 (48.6)	**140 (90.9)**	
Present	7 (50.0)	7 (50.0)	**14 (9.1)**	
Total	**79 (51.3)**	**75 (48.7)**	**154 (100.0)**	0.570[a]
Quality of Intraradicular Post				
Satisfactory	3 (100.0)	0 (0.0)	**3 (21.4)**	
Unsatisfactory	4 (36.4)	7 (63.6)	**11 (78.6)**	
Total	**7 (50.0)**	**7 (50.0)**	**14 (100.0)**	0.096[b]

[a]Pearson's chi-square test. [b]Fisher's Exact Test. [#]Filling defect: segment without visible radiopaque obturing material. [+]Marginal leakage: radiographic marginal change suggestive of marginal infiltration. ***Statistically significant** ($p<0,05$). Source: The authors, 2026.

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These findings are comparable, although less frequent, to those reported by Nouroloyouni *et al.* (2023), who evaluated 1,308 endodontically treated maxillary posterior teeth using cone-beam computed tomography (CBCT) and identified a high frequency of technical inadequacies, including underfilling (50.0%), untreated canals (27.5%), and overfilling (12.5%). Their study also demonstrated a marked predominance of technical errors in maxillary posterior teeth, particularly maxillary molars, which exhibited a higher prevalence of endodontic procedural errors compared with other posterior teeth. These teeth exhibited a higher prevalence of endodontic procedural errors than premolars. Although Nouroloyouni *et al.* (2023) evaluated only maxillary teeth using cone-beam computed tomography (CBCT), their findings corroborate the high proportion of maxillary teeth, particularly maxillary molars, presenting unsatisfactory root canal fillings, as also observed in the present study. It should be noted, however, that failure frequencies obtained by CBCT are not directly comparable to those obtained in RPD, due to differences in sensitivity and resolution between the imaging methods (Antony *et al*., 2020).

Furthermore, 23 (17.0%) periapical lesions were identified in the evaluated DPRs, involving both anterior (n=8) and posterior regions (visually identified; 15 of them in posterior teeth, which were evaluated individually), corresponding to a mean of 0.17 periapical lesions per DPR. Among the posterior teeth, most endodontically treated teeth (90.3%) showed no evidence of periapical lesions, at the time of the radiographic examination, corroborating the findings of Rouhani *et al*. (2023), who reported that 70.6% of the teeth in their sample were free of periapical lesions. In addition, those authors observed a higher prevalence of lesions in the maxilla (65.7%) than in the mandible (35.3%), with mandibular lateral incisors being the teeth most frequently affected.

In contrast, the present study demonstrated a significantly higher frequency of periapical lesions in the mandible (80.0%; $p<0.001$, Table 3) predominantly involving mandibular molars (n=10; 66.7%). Among the molars presenting periapical lesions, tooth #37 exhibited the highest frequency (four cases), followed by teeth #36 and #46 (three cases each). The mean diameter of the periapical lesions was 7.2mm, being 7.0mm in maxillary lesions (n=3) and 7.25mm in mandibular lesions (n=12). However,

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these values should be interpreted as radiographic estimates. Moreover, most periapical lesions affecting posterior teeth (80.0%) were associated with unsatisfactory root canal, and 66.6% occurred in teeth presenting filling defects or absence of filling material. It should be noted that this percentage partly reflected the high proportion of unsatisfactory fillings in the sample (90.9%). Similarly, Hao *et al.* (2023) reported that mandibular first molars (69.6%) were among the tooth groups most frequently affected by periapical lesions, while the prevalence of lesions was comparable between the maxilla (50.2%) and the mandible (49.8%).

It is important to emphasize that the present study did not individually assess periapical lesions in anterior teeth, which were only visually identified and included in the total count of 23 lesions, because image distortion and superimposition in the anterior region of DPRs may hinder accurate diagnosis. In contrast, Rouhani *et al*. (2023) used CBCT for endodontic evaluation, an imaging modality that provides greater accuracy in detecting periapical lesions than conventional radiographic techniques, including panoramic and periapical radiography (Antony *et al.*, 2020).

Regarding coronal rehabilitation, most endodontically treated teeth (82.5%) presented direct coronal restorations. Of the 127 teeth restored with direct restorations, most (n=88; 69.3%) were classified as unsatisfactory, particularly those located in the maxilla (n=54; 61.4%) and in premolars (n=45; 51.1%) (Tables 3 and 4). The most frequent restorative failures were radiographic marginal changes suggestive of marginal infiltration, secondary caries, or fracture, which together accounted for 56.8% of all defective restorations (Table 4). Teeth #15 and #36 were the most frequently affected by unsatisfactory coronal restorations, with 12 cases each. Similarly, El Quarti *et al*. (2021) reported that 55.6% of coronal restorations were inadequate, a frequency comparable to that observed in the present study. This similarity reinforces the high frequency of restorative deficiencies in endodontically treated teeth across different populations. Furthermore, the predominance of radiographic marginal changes suggestive of marginal infiltration, secondary caries, or fracture as the principal restorative failures highlights, as also discussed by El Quarti *et al*. (2021), the critical importance of coronal restoration quality for the long-term prognosis of endodontically treated teeth.

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Overall, among the 135 DPRs containing endodontically treated anterior and posterior teeth, most (*n*=116; 85.9%) showed no intraradicular post. Only 19 DPRs included teeth restored with intraradicular posts, and most of these radiographs (*n*=14; 73.7%) contained only one post. Among the posterior teeth restored with intraradicular posts (*n*=14), most (*n*=11; 78.6%) were classified as unsatisfactory.

Regarding fixed prosthetic crowns, 29 crowns (21.5%) were identified in the DPR sample, of which 16 (55.2%) were placed on posterior teeth. This frequency was lower than that reported by Elmahdi *et al.* (2023), who found fixed prosthetic crowns in 73.2% of posterior teeth. A possible explanation for this difference is the predominance of direct coronal restorations over fixed prosthetic rehabilitations in the present study. This difference may be related, among other factors, to the amount of remaining coronary structure, a variable that was not measured in this study.

Among the 16 posterior teeth restored with single-unit fixed crowns, most (n=10; 62.5%) were classified as unsatisfactory, primarily because of crown overcontouring (n=6; 60.0%) (Tables 3 and 4).

It is important to acknowledge several limitations of the present study that should be considered when interpreting the findings. These include the lack of relevant clinical information, such as the clinical status of the tooth and periradicular tissues, the presence of periapical lesions before endodontic treatment, and the time elapsed between completion of treatment and radiographic examination.

Besides, the presence of periapical lesion was defined only by visual criteria, without a standardized index. Additionally, the absence of lesion at the time of examination did not confirm the success of the treatment, just as the presence of radiolucency did not confirm its failure, since the preoperative condition of the teeth was unknown. Furthermore, the success of endodontic treatment depends both on the absence of clinical signs and symptoms and on the radiographic integrity of the apical periodontium.

An additional limitation related to the inherent distortions associated with DPRs, which may compromise the diagnostic accuracy of certain endodontic conditions. The diagnostic accuracy of PR for the detection of apical periodontitis is slightly lower than that of periapical radiography (Stera *et al.,* 2024), and the present study did not

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compare PDR with periapical radiographs, tomography, or clinical examination; thus, the findings represented a radiographic screening and did not assess the diagnostic accuracy of the method.

Nevertheless, the analysis of DPRs provided a comprehensive overview of the oral cavity, with particular emphasis on endodontically treated teeth, the quality of root canal fillings, and coronal rehabilitations, allowing a broad assessment of the endodontic profile of the studied sample.

Since several patients contributed more than one tooth to the evaluation in this study, the tooth was considered the evaluative unit, as the study did not intend to evaluate each patient individually (via radiograph). Therefore, the inferential results should be interpreted as exploratory. Furthermore, the small number of events in some comparisons, especially fixed prostheses, intraradicular posts, and periapical lesions, limited the precision of the estimates.

Finally, the sample came from a single university clinic and consisted of patients with an indication for PR, which did not necessarily represent the population of the municipality or region; The results are therefore limited to the sample and service investigated.

The findings of the present study have both clinical and epidemiological relevance, as they provide information on the frequency of endodontically treated teeth, the technical quality of root canal fillings, and the occurrence of periapical alterations in patients treated at a public dental care service. These findings contribute to a better understanding of the endodontic profile of the studied sample and may support the planning of strategies aimed at preventing tooth loss, monitoring the quality of endodontic treatment, and guiding continuing education initiatives for dental professionals. In addition, they can assist in selecting patients for clinical and intraoral radiographic re-evaluation of endodontically treated teeth.

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4. Conclusion

In the radiographic sample evaluated, the majority of radiographs with endodontically treated teeth belonged to female patients aged between 18 and 34 years at the time of the examination; the treated teeth were most frequently in the maxilla, particularly the upper premolars.

Most treated teeth were located in the posterior region. Most posterior teeth exhibited radiographically unsatisfactory root canal fillings, as well as a high frequency of inadequate coronal restorations, findings that indicated the need for clinical and radiographic re-evaluation of these teeth. Although the overall frequency of periapical lesions was low, these lesions occurred significantly more frequently in the mandible, predominantly affecting mandibular molars. Collectively, these findings emphasize the importance of achieving high-quality root canal treatment and adequate coronal rehabilitation to improve treatment outcomes and support the long-term preservation of endodontically treated teeth. Because this is a retrospective screening based on RPD, these findings require confirmation by clinical examination and intraoral radiography.

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