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# Radiographic evaluation of preoperative and postoperative quality of root canal retreatments: a retrospective study

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## Abstract

**Background** The aim of this study was to examine radiographic quality of root canal fillings retrospectively in teeth undergoing retreatment compared with primary root canal treatment.

**Methods** The radiographic quality of root canal fillings was retrospectively assessed in the preoperative and postoperative stages of retreatment. Seventy-six teeth were included in the study. The radiographic quality of the treatments was evaluated in terms of length, density, and taper, based on the criteria of the European Society of Endodontology (ESE).

**Results** Across all teeth, 28.9% were classified as having acceptable root canal treatment quality in the preoperative phase, whereas 86.5% were classified as acceptable postoperatively. Moreover, when assessing acceptability for each parameter individually, as well as for all three parameters combined, the postoperative results were significantly more favourable.

**Conclusion** Within the limitations of this retrospective study, the radiographic quality of root canal retreatments demonstrated a statistically significant improvement postoperatively compared with their preoperative state.

**Keywords** Acceptability, Radiographic quality, Retreatment, Root canal filling

## Background

Root canal treatment (RCT) is a fundamental component of high-quality and sustainable dental care. In the literature, the success rates of root canal treatments are reported to vary between 63% and 85% [1, 2].

When endodontic treatment fails and a proper indication exists, it can be managed through non-surgical or surgical approaches. Currently, non-surgical retreatment

procedures are commonly performed [3]. In the literature, the success rate of secondary root canal treatments appears to be between 61.6% and 69.3% [4, 5]. In cases requiring retreatment, the causes of failure must be identified and addressed. One of the causes of failure is the technical quality of the root canal filling. Radiographic methods are typically used to evaluate the quality of root fillings. According to the European Society of Endodontology (ESE), radiographic adequacy of a root canal filling is defined by a tapered shape extending from the coronal third to the apex, no voids between the canal walls and the filling material, and a termination of the filling no more than 2 mm short of the apex [6]. Studies have reported that the proportion of root canal treatments that are considered acceptable is below 50% [7, 8].

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Assessing the failure rates and causes of periradicular diseases based on radiographic quality of root canal treatments is possible to some extent. At the same time, from the perspective of long-term treatment success, improving the radiographic quality of root canal treatments may contribute to reducing apical leakage and supporting the healing of periapical tissues. Additionally, studies are required to assess the failure rates and causes of root canal retreatments based on radiographic quality. The aim of this study was to examine radiographic quality of root canal fillings in teeth undergoing retreatment compared with pRCTs.

## Methods

All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments, and were approved by the Dokuz Eylül University Faculty of Medicine Non-Invasive Research Ethics Committee (Approval No: 8847-GOA). Written informed consents were obtained from all patients prior to treatments for the use of their radiographic images and clinical data for scientific purposes, with personal identifiers kept confidential. Data were collected retrospectively by reviewing periapical diagnostic images, treatment radiographs, and routine clinical follow-up forms of all patients who had an indication for root canal retreatment and completed treatment at the Dokuz Eylül University Department of Endodontics, DEU Oral and Dental Health Application and Research Centre, between 01.01.2022 and 29.02.2024.

In Turkey, the Social Security Institution mandates the acquisition of diagnostic and final radiographs for completed RCT procedures. In this study, these routinely obtained radiographs were used. Radiographic records without treatment forms, with incomplete RCTs, or with poor-quality radiographs were excluded. A total of 84 root canal retreatment cases were identified during the specified period; 8 of these were excluded due to missing or inadequate periapical radiographs.

Radiographs were obtained using a Planmeca ProX™ (Planmeca®, Helsinki, Finland) periapical radiography unit + Periapical radiographs were taken with a phosphor plate system [VistaScan® (Dürr Dental, Bietigheim-Bissingen, Germany)] operating at 70 kVp and 8 mA, with an exposure time of 0.16 s. Ultimately, 76 teeth from 70 patients (27 males, 43 females; mean age approximately 38 years) were included in the study. Of these, 2 teeth were extracted before the completion of retreatment, and thus their postoperative radiographic quality could not be assessed — leaving 74 teeth for the postoperative analysis. In the mandibular anterior region, only one tooth met the inclusion criteria and, therefore, this mandibular

incisor was excluded from intergroup statistical analysis but included in interarch comparison.

Radiographic evaluations were performed by four investigators with a minimum of two years of experience; in cases of disagreement, a fifth investigator was consulted. The evaluations were performed digitally on high-resolution monitors. To ensure diagnostic accuracy, investigators utilized digital image processing software features, such as magnification and contrast/brightness enhancement tools. The working length, density, and taper of each root canal were radiographically assessed according to the ESE criteria. Additionally, the presence or absence of separated instruments, periapical lesions, untreated canals, and the type of coronal restoration (e.g., filling, crown) were evaluated using both radiographs and clinical treatment forms to interpret the cases more clearly.

Root canals that simultaneously met all three criteria of taper, density, and working length as indicated in the guideline recommended by the ESE were classified as “acceptable”. Criteria recorded at the pRCT stage were defined as “preoperative”, while those assessed after retreatment (sRCT) were defined as “postoperative”.

Teeth were evaluated based on their arch location (maxilla and mandible), or group (maxillary anterior, maxillary premolar, maxillary molar; mandibular premolar, mandibular molar). To determine the difference in radiographic quality between pRCT and sRCT and to evaluate the success of retreatment relative to tooth location, Chi-square, Fisher’s exact test, and McNemar’s test were used. Statistical analyses were performed using SPSS version 24.0 (IBM Corp., Armonk, NY: USA), and the significance level was set at  $p < 0.05$ .

To evaluate intra-examiner reliability, 20% of the radiographs were randomly selected and re-analyzed by the same investigators after a 15-day interval. The results demonstrated a high level of consistency, with weighted Kappa coefficients ranging from 0.82 to 0.91, indicating substantial to almost perfect agreement across all radiographic criteria.

## Results

Among the 76 teeth that underwent root canal retreatment, no statistically significant difference was found between the arches or tooth groups in terms of gender ( $p > 0.05$ ). When all teeth were evaluated, the proportion of teeth categorised as acceptable in the preoperative stage was 28.9%, while the postoperative acceptability rate was 86.5%. There was a statistically significant difference between preoperative and postoperative acceptability ( $p < 0.05$ ), with postoperative root canal treatments found to be more radiographically acceptable. When all teeth were assessed in terms of working length, density, and taper preoperatively and postoperatively, all three

**Table 1** Radiographic quality according to archs in preoperative/postoperative situations

ARCH	WORKING LENGHT <i>n</i> (%)		TAPER <i>n</i> (%)		DENSITY <i>n</i> (%)		ACCEPTABLE <i>n</i> (%)	
	Adequate	Inadequate	Adequate	Inadequate	Adequate	Inadequate	Adequate	Inadequate
PRE ( <i>n</i> )								
Maxilla (49)	27 (55,1)	22 (44,9)	33 (67,3)	16 (32,7)	21 (42,9)	28 (57,1)	18 (36,7)	31 (63,3)
Mandible (27)	4 (14,8)	23 (85,2)	14 (51,9)	13 (48,1)	6 (22,2)	21 (77,8)	4 (14,8)	23 (85,2)
POST ( <i>n</i> )								
Maxilla (49)	44 (89,8)	5 (10,2)	49 (100)	0	48 (98)	1 (2)	44 (89,8)	5 (10,2)
Mandible (25)	21 (84)	4 (16)	23 (92)	2 (8)	24 (96)	1 (4)	20 (80)	5 (20)

**Table 2** Radiographic quality according to tooth groups in preoperative/postoperative situations

	WORKING LENGHT <i>n</i> (%)		TAPER <i>n</i> (%)		DENSITY <i>n</i> (%)		ACCEPTABLE <i>n</i> (%)	
	Adequate	Inadequate	Adequate	Inadequate	Adequate	Inadequate	Adequate	Inadequate
Anterior ( <i>n</i> )								
Preoperative (16)	10 (62,5)	6 (37,5)	8 (50)	8 (50)	5 (31,25)	11 (68,75)	4 (25)	12 (75)
Postoperative (16)	14 (87,5)	2 (12,5)	15 (93,75)	1 (6,25)	16 (100%)	16 (100)	13 (81,25)	3 (18,75)
Premolar ( <i>n</i> )								
Preoperative (28)	10 (35,7)	18 (64,3)	18 (64,3)	10 (35,7)	13 (46,4)	15 (53,6)	9 (32,1)	19 (67,9)
Postoperative (27)	24 (88,9)	3 (11,1)	27 (100)	0	27 (100)	0	24 (88,9)	3 (11,1)
Molar ( <i>n</i> )								
Preoperative (32)	10 (31,25)	22 (68,75)	21 (65,6)	11 (34,4)	9 (28,1)	23 (71,9)	8 (25)	24 (75)
Postoperative (31)	27 (87)	4 (13)	30 (96,8)	1 (3,2)	29 (93,5)	2 (6,5)	27 (87)	4 (13)

parameters showed significant improvement in the postoperative stage ( $p < 0.05$ ).

Teeth with indications for retreatment were found more frequently in the maxillary arch than in the mandibular arch ( $p < 0.05$ ).

A significant difference was observed between maxillary and mandibular teeth in terms of preoperative working length adequacy ( $p < 0.05$ ). Maxillary teeth were more adequate than mandibular teeth regarding preoperative working length. The percentages of preoperatively acceptable root canal treatments by arch were 36.7% in the maxilla and 14.8% in the mandible. Preoperative acceptability was significantly higher in maxillary teeth than in mandibular teeth ( $p < 0.05$ ). No significant difference was found between the arches regarding other preoperative criteria ( $p > 0.05$ ) (Table 1).

No significant difference was observed between the maxillary and mandibular teeth in terms of postoperative working length, density, taper adequacy, presence of fractured instruments, or overall acceptability ( $p > 0.05$ ). When both arches were evaluated individually, postoperative values were found to be significantly more favourable than preoperative values for working length, density, taper adequacy, and overall acceptability ( $p < 0.05$ ) (Table 1).

Among retreated teeth, there was a significant difference between tooth groups regarding preoperative working length adequacy ( $p < 0.05$ ). Maxillary anterior teeth were more favourable in terms of preoperative working length adequacy compared to other groups. Regarding preoperative density adequacy, maxillary premolars were significantly more favourable than other groups ( $p < 0.05$ ).

No significant differences were observed between tooth groups in terms of preoperative taper adequacy or preoperative acceptability ( $p > 0.05$ ). Postoperatively, there were no significant differences between tooth groups for working length, taper, density, or overall acceptability ( $p > 0.05$ ).

When working length adequacy was assessed by tooth group, the preoperative rates were 62.5% for anterior, 35.7% for premolars, and 31.25% for molars, while the postoperative rates were 87.5%, 88.9%, and 87%, respectively. When preoperative and postoperative working length adequacy was evaluated within each group, all groups except maxillary anterior teeth showed statistically significant improvement ( $p < 0.05$ ) (Table 2).

Preoperative density adequacy rates were 31.25% for anterior, 46.4% for premolars, and 28.1% for molars, while postoperative rates were 100%, 100%, and 93.5%, respectively. Postoperative values were significantly more favourable in all groups ( $p < 0.05$ ) (Table 2).

Preoperative taper adequacy rates were 50% for anterior, 64.3% for premolars, and 65.6% for molars, while postoperative rates were 93.75%, 100%, and 96.8%, respectively. In all tooth groups except maxillary anterior teeth, a significantly more tapered root canal filling was observed postoperatively ( $p < 0.05$ ) (Table 2).

Preoperative overall acceptability rates were 25% for anterior, 32.1% for premolars, and 25% for molars. Postoperative acceptability rates were 81.25%, 88.9%, and 87%, respectively. In all groups, postoperative values were significantly more favourable ( $p < 0.05$ ) (Table 2).

Although there was no significant difference between the arches in terms of missed canals preoperatively

( $p > 0.05$ ), a significantly higher rate of missed canals was detected in maxillary molars compared to other tooth groups ( $p < 0.05$ ).

The preoperative rate of periapical lesion presence among all teeth was 51.31%. Among teeth that were radiographically acceptable, 23.8% still presented with periapical lesions. In terms of preoperative lesion presence, mandibular teeth exhibited significantly more lesions compared to maxillary teeth, and mandibular premolars showed significantly more lesions than other tooth groups ( $p < 0.05$ ).

Of the teeth that underwent retreatment, 61 (80.3%) had restorations in place before retreatment; however, 13 of these lacked restorations upon presentation to the clinic. Fifteen teeth (19.7%) had prosthetic crowns, but 3 of these had no visible coronal structure at the time of examination.

## Discussion

In the literature, numerous studies have evaluated the aetiology and prognosis of both pRCT and sRCT, including assessments of success rates, survival outcomes, and causes of failure [9, 10]. While various studies have focused on the radiographic quality of pRCTs [11, 12], no previous study has specifically examined the extent to which the radiographic quality of a pRCT can be improved following sRCT.

Conventional periapical radiographs are preferred in quality assessments owing to their ability to provide more detailed imaging [13]. In the present study, the extent to which the quality of retreatment cases could be improved in comparison to the initial pRCT was evaluated using periapical radiographs.

Several studies in the literature report radiographic evaluations conducted by two or three experts [14, 15]. In this study, to ensure more reliable assessments, radiographs were evaluated by four investigators from Oral Diagnosis & Radiology and Endodontics departments, and in cases of disagreement, a fifth investigator, an experienced endodontist, was consulted. Evaluating the radiographic quality of sRCT is considered more challenging than that of pRCT. Retreated root canal fillings are expected to meet the same technical standards required for pRCT. However, there is currently no specific method proposed for evaluating the radiographic quality of sRCT. In this study, criteria used in the evaluation of pRCT complied with the guidelines published by the European Society of Endodontology (ESE) [6].

In addition to the evaluation criteria used, remaining root canal filling material prior to obturation in sRCTs is also important. Due to the retrospective design of the study and the insufficient number of interim radiographs, this criterion could not be assessed.

The use of the paralleling cone technique could have provided more consistent and reliable results, particularly in the comparison of working length and other radiographic criteria between preoperative and postoperative images. However, due to the retrospective nature of the study, this method could not be implemented and should be considered a limitation of the study.

In a previous study evaluating the radiographic acceptability of pRCTs was found to be 29.6% [16]. These findings are consistent with the 28.9% preoperative acceptability rate reported in the present study. Postoperatively, the rate of acceptable sRCTs showed a clear improvement, reaching 86.5%. This increase may be attributed to the fact that all retreatments in this study were performed by endodontic specialists or postgraduate students who employed a more experienced and meticulous approach in determining working length, taper, and density. According to the literature, the most common reasons for the failure of RCTs are related to the inability to achieve adequacy in these parameters [17].

In a previous study, radiographic homogeneity of pRCTs was found to be 48.9% and working length adequacy in 77.6% of cases [18]. In the present study, the radiographic homogeneity was observed to be 35.5% preoperatively and 97.3% postoperatively, and working length was 40.8% for preoperative cases and 87.8% for postoperative counterparts.

No significant difference was found between the maxilla and mandible in terms of acceptable root canal treatments in pRCTs, with rates of 56% and 58%, respectively [7]. However, in the present study, when teeth with failed pRCT are considered, maxillary teeth showed significantly higher preoperative acceptability (36.7%) compared to mandibular teeth (14.8%). These findings suggest that even though RCTs that are considered acceptable radiographically may require retreatment for other reasons, causing maxillary teeth to undergo retreatment more frequently than mandibular teeth.

Although teeth in both arches appear acceptable postoperatively (maxilla: 89.8%, mandible: 80%), improvement was observed across all tooth groups.

Maxillary teeth demonstrated significantly better preoperative working length adequacy compared to mandibular teeth. Although no significant difference was observed postoperatively between arches, a higher proportion of maxillary teeth were considered adequate in terms of root filling quality. This difference was attributed to a relatively greater incidence of curved and narrow root canals in mandibular molars, which may reduce the accuracy of electronic apex locators [19]. Additionally, the proximity of canals and anatomical superimpositions in mandibular molars may present challenges in access and visibility for the clinician.

In a study, the cases with primary root canal fillings of acceptable quality by group were 34.2% for anterior, 23.8% for premolars, and 16.2% for molars [8]. Similarly, in the present study, the preoperative acceptability rates were 25%, 32.1%, and 25%, respectively. Postoperatively, these rates increased to 81.25%, 88.9%, and 87%. This improvement may be attributed to better working length control and higher density of fillings in all tooth groups.

In this study, working length adequacy significantly improved in all groups except maxillary anterior teeth, increasing from 62.5%, 35.7%, and 31.25% (preoperatively) to 87.5%, 88.9%, and 87% (postoperatively) in the anterior, premolar, and molar groups, respectively. In another study, adequacy rates for working length were reported to be 55.9%, 44.4%, and 27.9%, respectively [20]. These findings indicate that molars tend to have root canal fillings that do not fit the quality standards emphasised by the ESE criteria, likely due to their complex anatomy.

When the taper of primary root canal fillings was evaluated in our study, it was 50% for anterior, 64.3% for premolars, and 65.6% for molars, increasing to 93.75%, 100%, and 96.8% postoperatively. Adequacy in density rates preoperatively were 31.25%, 46.4%, and 28.1%, increasing to 100%, 100%, and 93.5% postoperatively. A study evaluating root canal treatments performed by dental students found that mandibular molars had the most acceptable taper and density values [21]; however, in another study conducted more recently, adequacy in taper was found to be 80%, 78%, and 44%, and in density was 75%, 70%, and 40% for anterior, premolar, and molar teeth, respectively [22]. Greater quality that meets the ESE standards was detected postoperatively in the present study owing to the retreatments being performed by experienced clinicians, suggesting that treatment outcomes may improve when performed by specialists. In this context, the implementation of specialist training and structured quality control processes in endodontic practice may be considered an important parameter in improving treatment success by ensuring and maintaining high technical standards. However, further research is required to support this observation.

Preoperatively, missed canals were most commonly observed in maxillary molars (58.3%), which is consistent with the literature 40.1% [23]; 71.8% [24]. Among these teeth with missed canals, periapical lesions were present in 50% of cases in the present study. Missed canals are known to negatively affect periapical tissues and increase the prevalence of lesion development.

In this study, 51.31% of the teeth requiring retreatment showed preoperative periapical lesions. Previous studies reported the prevalence of apical periodontitis in root-filled teeth ranging from 31.7% to 72.1% [25, 26]. In our study, mandibular premolars showed the highest rate of

preoperative periapical lesions; likewise, the literature has more commonly reported molars [20], likely due to the greater technical difficulty associated with their complex anatomy. Because the number of follow-up cases was insufficient, no postoperative periapical status could be reported for sRCTs in the present study. Among the cases with pRCTs that fit the ESE criteria in terms of radiographic root canal filling quality, periapical lesions were still detected in 23.8% of the cases. According to the literature, this rate ranges between 10.2% and 25.2% [25, 27]. These findings suggest that high technical quality alone does not guarantee treatment success, which must be consolidated by managing canal anatomy complexity, disinfection, longevity and sealing of the coronal restoration, and other required clinical parameters that significantly influence treatment outcomes. The absence of postoperative clinical and radiographic periapical healing assessment is another limitation in present study.

## Conclusion

Within the limitations of this retrospective study, it was observed that root canal retreatment procedures led to a statistically significant improvement in the radiographic quality of root canal fillings compared to the preoperative condition. However, the fact that ideal technical standards were not achieved in all cases reveals the challenges and technical sensitivity required for retreatment procedures.

Although the findings suggest that performing root canal retreatments by experienced clinicians may improve radiographic quality, this must be further supported by prospective studies that include clinical examination and follow-up.

## Abbreviations

ESE	European Society of Endodontology
RCT	Root Canal Treatment
pRCT	Primary Root Canal Treatment
sRCT	Secondary Root Canal Treatment

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## Authors' contributions

B.S. has written the entire manuscript, performed the data collection, O.E. set the hypothesis, performed data collection and literature review. B.A. performed data collection and evaluation, and proof reading. F.A. performed data collection and evaluation, proof reading, and statistics. G.I. performed data collection and evaluation.

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## Data availability

The datasets used and/or analyzed during the current study are available in the institutional archive of Dokuz Eylul University, Department of Endodontics. Data can be obtained from the corresponding author upon reasonable request.

## Declarations

### Ethics approval and consent to participate

Institutional consent was obtained from all patients treated at Dokuz Eylül University Department of Endodontics, DEU Oral and Dental Health Application and Research Centre (Noninvasive Research Ethics Committee of Dokuz Eylül University, Faculty of Medicine (8847-GOA)). All procedures were conducted in accordance with the 1964 Declaration of Helsinki and its later amendments. Data were anonymized prior to analysis to ensure the protection of patient confidentiality. Written informed consents to participate were obtained from all patients prior to treatment.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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