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Outcome of selective root canal retreatment—A retrospective study

João Filipe Brochado Martins[1] | **Olavo Guerreiro Viegas**[2] | **Roberto Cristescu**[2] | **Patrícia Diogo**[3] | **Hagay Shemesh**[1]

[1]Department of Endodontology, Academic Centre for Dentistry Amsterdam, University of Amsterdam and Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

[2]Private Practice Limited to Endodontics, Amsterdam, The Netherlands

[3]Faculty of Medicine, Institute of Endodontics, University of Coimbra, Coimbra, Portugal

Correspondence
João Filipe Brochado Martins, Room 13 N-15, Gustav Mahlerlaan 3004, Amsterdam 1081 LA, The Netherlands.
Email: j.f.brochadomartins@acta.nl

Abstract

Aim: Selective root canal retreatment is when the treatment is limited to root(s) with radiographic evidence of periapical pathosis. The goals of this retrospective study were as follows: (i) evaluate the clinical and radiographic (periapical radiographs [PR] or cone-beam computerized tomographs [CBCT]) outcome of selective root canal retreatment after ≥12 months follow-up; (ii) evaluate the periapical status of the unretreated roots; and (iii) assess tooth survival.

Methodology: A retrospective study (January 2018 to April 2021) was conducted to identify permanent multirooted teeth that underwent selective root canal retreatment. Clinical records, PR and CBCT were examined to ascertain variables of interest. Outcomes (per root and per tooth) were classified into 'favourable' or 'unfavourable' using well-established clinical and radiographic healing criteria. Treatment outcomes for the whole tooth and per root were compared as well as bivariate associations between the treatment outcome of the retreated roots and the treatment-related parameters (quality of root filling, sealer extrusion, iatrogenic mishaps and type of restoration) were analysed using Fisher's exact test ($\alpha = .05$). Survival was recorded in months.

Results: A total of 75 teeth (195 roots) in 75 subjects were available for outcome analysis. The favourable outcome per tooth was 86.7%. At follow-up, 92.6% of the retreated roots had a favourable outcome. From the unretreated roots, 3.5% showed radiographic signs of an emerging periapical lesion. No statistical difference was shown between the outcomes per root and per tooth between both groups. None of the treatment-related parameters had a direct influence on the outcome of the retreated roots. The survival rate at 12–48 months after retreatment was 91.5%.

Conclusions: Selective root canal retreatment is associated with a favourable outcome in a majority of cases. Unretreated roots rarely developed radiographic signs of a new periapical lesion at follow-up. Future high-quality clinical trials with larger sample sizes and longer follow-up periods are required to confirm these findings.

KEYWORDS

cone-beam computed tomography, endodontic outcome, minimally invasive, nonsurgical retreatment, periapical radiography, selective root canal retreatment

INTRODUCTION

Root canal treatment has been shown to be a predictable procedure with a favourable outcome in 86%–98% of cases (de Chevigny et al., 2008; Ng et al., 2011a). Despite the favourable outcomes in prospective studies, large cross-sectional studies have reported that the prevalence of post-treatment disease such as persistent, recurrent or emerging apical periodontitis (AP) can exceed 42% of all root filled teeth (Kirkevang et al., 2014; Meirinhos et al., 2020; Ng et al., 2007; Pak et al., 2012), suggesting a substantial need for further intervention.

Knowledge of the aetiology of failure is pertinent to the treatment of teeth with post-treatment disease because it allows the cause to be adequately addressed. There are several factors that can negatively affect the outcome of root canal treatment. Persistence of microbial infection in the root canal system and/or the periradicular area still remains the major cause of root canal treatment failure (Carr et al., 2009; Ricucci et al., 2009, 2013; Siqueira et al., 2014; Siqueira & Rocas, 2008). Multirooted teeth have an increased risk of post-treatment disease (Hoen & Pink, 2002), particularly because of the complex root canal anatomy and, as a consequence, missed and inadequately disinfected and filled canals and isthmuses. In these cases, root canal retreatment is often regarded as the treatment of choice rather than surgical endodontic treatment (Kraus et al., 2015; Toia et al., 2022). The reported healing rate of root canal retreatment ranges from 57% to 93% (Al-Nuaimi et al., 2017; Davies et al., 2016; Farzaneh et al., 2004; He et al., 2017; Metska et al., 2013; Ng et al., 2011a).

When root canal retreatment is not feasible or fails, or it is unlikely that it might improve on the previous result, surgical endodontic treatment might be indicated. Surgical treatment leads to comparable long-term outcome compared with root canal retreatment (Del Fabbro et al., 2016; Torabinejad et al., 2009).

Despite selective root canal retreatment being clinically performed for many years, it was only recently reported in the scientific literature as an approach for teeth presented with post-treatment disease (Nudera, 2015). This concept allows root canal retreatment to be limited to the root(s) showing periapical pathosis whilst leaving the root(s) with no visible or perceived apical lesion untouched. This procedure has clear advantages when compared with a full root canal retreatment, namely a more conservative access cavity directed to the root(s) to be retreated, preserving tooth structure or indirect restorations; a reduced likelihood for iatrogenic errors and a reduced cost to the patient. Its main drawback is the risk of development of new periapical lesion(s) in the unretreated root(s).

There are neither reports on the outcome nor on the prevalence of new periapical lesions in unretreated roots of teeth previously subjected to selective root canal retreatment. Hence, the goals of this retrospective study were as follows: (i) evaluate the clinical and radiographic (periapical radiographs [PR] or cone-beam computerized tomographs [CBCT]) outcomes of selective root canal retreatment after ≥12 months follow-up; (ii) assess the periapical status of the unretreated roots (with no AP in the initial diagnosis); and (iii) assess tooth survival.

MATERIALS AND METHODS

Study cohort

The present retrospective study was conducted at three private endodontic clinics and the Department of Endodontology at Academic Center for Dentistry Amsterdam (ACTA), Amsterdam, the Netherlands. The study protocol was approved by the Medical Research Ethics Committee of the same university (project ID: 2021-11724). This study was conducted according to the principles of the Declaration of Helsinki (10th version, October 2013, available at www.wma.net). The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist and statement were followed (von Elm et al., 2007).

All nonsurgical root canal retreatments of multirooted teeth performed from January 2018 to April 2021 were retrieved from each database. The clinical and radiographic records of each patient were reviewed, and eligibility for the study was assessed based on inclusion and exclusion criteria.

The inclusion criteria were as follows:

1. Multirooted teeth (maxillary and mandibular premolars and/or molars).
2. Clinical diagnosis of symptomatic AP and previously endodontically treated tooth based on radiographic examination (AAE, 2009).
3. At least one root has no lesion and not retreated.
4. Healthy periodontal status (≤3 mm probing, no mobility or mobility grade I, no bleeding on probing).
5. Clinically intact margins of direct or indirect restorations with no clinical or radiographic signs of recurrent caries or leakage.
6. Absence of signs of fracture and/or cracking in the restoration.
7. Pre-treatment, post-treatment and follow-up radiographic methods (PR or CBCT) ≥ 12 months of good diagnostic value and available information of clinical assessment at follow-up.

The exclusion criteria were as follows:

1. Root canal retreatment of all canals.
2. A vertical root fracture (VRF) identified during root canal retreatment.
3. Surgical endodontic treatment had been performed previously in the root(s) to be retreated.
4. Subjects with pre-treatment CBCT but no follow-up CBCT.
5. Subjects with pre-treatment PR but no follow-up PR.

The process of inclusion and exclusion of cases for the purpose of participation eligibility in the present study is described in Figure 1.

A total of 1545 subjects (1854 teeth and 4738 roots) underwent root canal retreatment from January 2018 to April 2021. Of these, 1463 subjects (1772 teeth and 4523 roots) did not meet the inclusion criteria. Thus, 82 multirooted teeth (215 roots) in the same number of subjects met the inclusion criteria and were used for tooth's survival assessment. The nonendodontic failures were excluded from the outcome analysis (seven subjects, seven teeth, 20 roots). Hence, a total of 75 subjects with 75 teeth (195 roots) were eligible for outcome assessment and divided in two groups depending on the radiographic technique available at follow-up: PR group and CBCT group.

All data were anonymised and extracted for analyses without a reference to subjects. No details about the endodontic techniques (file system, gutta-percha removal, irrigation or obturation technique) were recorded, but all root canal retreatments were performed under rubber dam and with magnification (microscope). All endodontic diagnosis, root canal retreatments and follow-ups were performed by Dutch- and ESE-certified endodontists.

Study parameters

The study parameters were collected from the clinical records as well as from the pre-treatment, post-treatment and follow-up PR or CBCT imaging by one examiner (J.B.M.).

The patient-related parameters were as follows:

- Gender: male or female.
- Age: defined in years at the time of the retreatment.

The following tooth-related parameters were collected:

- Location: maxillary second pre-molar, maxillary first molar, maxillary second molar, mandibular first molar and mandibular second molar.

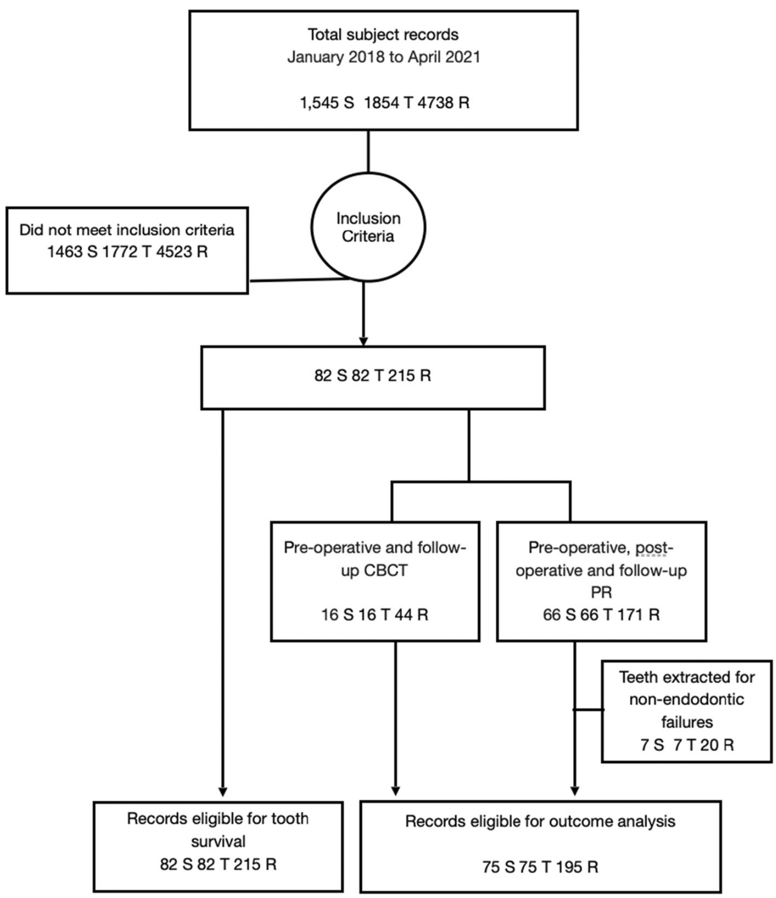

FIGURE 1 Flow chart describing the process of inclusion and exclusion of cases for the purpose of participation eligibility. (S, subjects; T, teeth; R, roots).

The following treatment-related parameters were collected:

- Quality of the root canal filling: adequate (radiographically homogenous root canal filling ending 0–2 mm short of the radiographic apex, no visible voids or space between the material, and the walls of the canal or within the body of the material itself) or inadequate (radiographically inhomogeneous root canal filling, presenting voids, root canal filling ending more than 2 mm short of the radiographic apex or gross overfill) (European Society of Endodontology, 2006; Pirani et al., 2018).
- Sealer extrusion: present or absent.
- Iatrogenic mishaps (ledges, perforations and broken instruments): present or absent.
- Type of coronal restoration: direct (composite) or indirect (crown).

Clinical assessment

The clinical data obtained from the recall record form included signs and symptoms, loss of function, tenderness to percussion and palpation, subjective discomfort, mobility, presence of sinus tract, periodontal status and the quality of coronal restoration.

Radiographic Assessment

Calibration of examiners

Before assessing the experimental material, each examiner was asked to grade the outcome of root canal retreatment of 20 cases using PRs and 10 cases of reconstructed CBCT images. These cases were not part of the experimental material. The PR and CBCT data sets were viewed on a PowerPoint (Microsoft Corp.) slide and viewed on a laptop screen (64 bit, 1920 × 1080 pixels, Portege Z30-C1320 Ultrabook; Toshiba America, Inc.) in a dimly lit room. The radiographic diagnostic outcome of each root was classified into six categories (Patel et al., 2012; Table 1). The outcome per root was discussed with the principal investigator (J.B.M) to allow for proper calibration of each individual observer.

Assessment of experimental data

The latest available PR or CBCT image was extracted from the database and de-identified. To determine the radiographic outcome immediate post-treatment and follow-up PR were mounted on a PowerPoint (Microsoft Corp.) slide and viewed on the same laptop screen (64 bit, 1920 × 1080 pixels, Portege Z30-C1320 Ultrabook; Toshiba America, Inc.) used for calibration, in a dimly lit room. Examiners were able to visualize all PRs of each case at the same time and could adjust brightness and contrast as desired. In case of available pre-treatment and follow-up CBCT, the full volumes were evaluated.

The two calibrated, blinded examiners (two specialist endodontists) separately performed visual analysis of all the radiographic images using the same six-point classification as during calibration to record the outcome of the treatment *per root* .

The outcome *per root* was based on the combination of the radiographic assessment of the specific root and the clinical assessment per tooth as follows:

- favourable—complete absence or reduction in size of periapical radiolucency (i.e. outcomes 4–6) and the absence of clinical signs and/or symptoms (Figure 2a,b);
- unfavourable—when a periapical radiolucency appeared after root canal retreatment, or a pre-existing periapical radiolucency remained unchanged or increased/enlarged in size (i.e. outcomes 1–3), and/or the presence of any clinical signs and/or symptoms (Figure 2c).

The outcome *per tooth* was defined according to the root (retreated or unretreated) with the poorest diagnostic outcome. In the event of disagreement, the examiners discussed until consensus was reached.

TABLE 1 Outcome categories used for root canal retreatment assessment

Score	Outcome
1	New periapical radiolucency
2	Enlarged periapical radiolucency
3	Unchanged periapical radiolucency
4	Reduced periapical radiolucency
5	Resolved periapical radiolucency
6	Unchanged healthy periapical status (no radiolucency before and after retreatment)

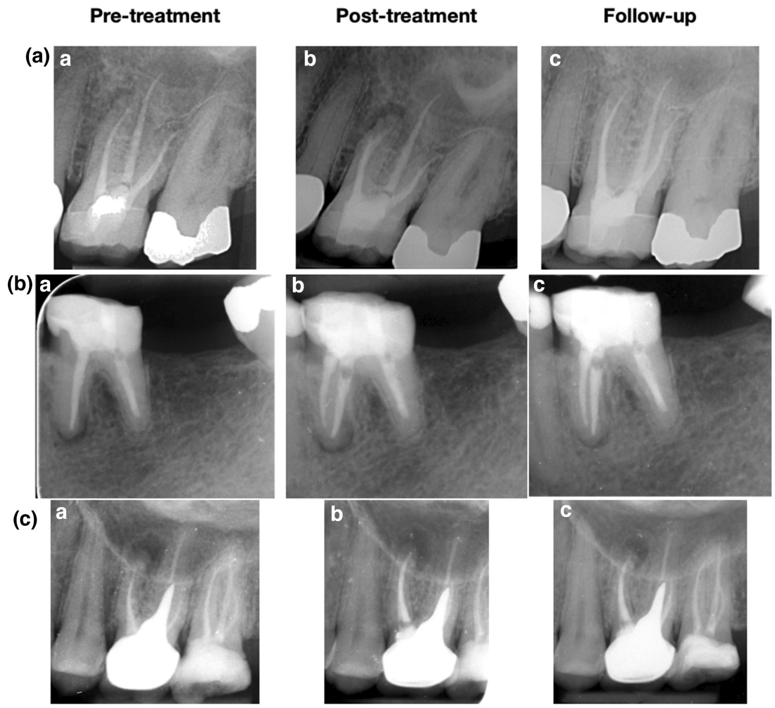

FIGURE 2 Pre-treatment (a), post-treatment (b) and follow-up (c) periapical radiographs used for outcome assessment. 2A reveals an example of complete resolution of periapical radiolucency of tooth 26 after selective retreatment of the mesiobuccal and distobuccal roots at 15 months follow-up; 2B shows an example of a case with a reduction in size of the periapical radiolucency after selective retreatment of the mesiolingual canal on the mesial root of tooth 36, at 12 months follow-up; 2C shows an example of an unfavourable case – at 24 months follow-up, a pre-existing periapical radiolucency remained unchanged after selective retreatment of the mesiobuccal root of tooth 26.

For statistical analysis, the dichotomised outcome (favourable and unfavourable) was used. For inter- and intraobserver reliability (Cohen kappa coefficient—κ), all the PR and CBCT's were reassessed 6 weeks later in the same conditions as reported previously.

Outcome assessment

Treatment-related parameters were examined to identify prognostic factors that could affect the treatment outcome at follow-up.

Tooth survival was defined as presence of the retreated tooth at the time of follow-up (assessed in the clinical records), regardless of the clinical or radiographic findings. The reason for extraction was registered. If the tooth was lost due to 'nonendodontic failures' as root fractures or periodontal abscesses it was not included in the treatment outcome analysis but only in the tooth's survival.

Statistical analysis

All data were collected in Excel (Microsoft) spreadsheets. All statistical analysis were performed with SPSS-24.0 software (IBM Corp), and the level of significance was set at a $\alpha = .05$.

Percent frequencies were generated to characterize the study sample with regard to the following parameters: patient-related (age, gender) and tooth-related parameters (location). Percentage healing rates based on radiographic (PR and CBCT) and clinical findings were calculated for individual roots and teeth. Comparisons of the treatment outcomes for both roots and teeth as a whole as well as bivariate associations between the treatment outcome of the retreated roots and the treatment-related parameters (quality of root filling, sealer extrusion, iatrogenic mishaps and type of restoration) were analysed using Fisher's exact test. Inter- and intraobserver analyses were performed using Kappa statistics.

For survival, the observation time was defined as the period between treatment and the target event (extraction) or last follow-up, in months.

RESULTS

As the number of cases in each group is skewed ($n = 59$ teeth, 151 roots in PR group and $n = 16$ teeth, 44 roots in the CBCT group), the groups were combined and the results are presented for the total sample. The demographic information of the total sample is summarized in Table 2.

The study cohort included 75 teeth (195 roots) in 75 subjects. Eighty-two roots were retreated, whilst 113 were left unretreated. The most frequently retreated tooth was the maxillary first molar (n = 42; 56%). The most frequently retreated root (n = 40, 48.7%) was the mesiobuccal (MB) root of the maxillary first molar due to missed anatomy (missed MB2 canal in 29 [72.5%] retreated roots).

At follow-up, 92.7% (n = 76) of the retreated roots had a favourable outcome whilst 7.3% (n = 6 roots) were classified as having an unfavourable outcome. The estimated probability of developing new periapical pathosis in the unretreated roots was 0.035 (4/113 unretreated roots) (Table 3). The favourable outcome per tooth was 86.7% (n = 65).

None of the treatment-related parameters had a direct influence on the outcome of the retreated roots ($p > .05$). Also, no statistical difference was shown between the outcomes per root and per tooth ($p > .05$).

Results of the treatment outcome were assessed in two groups according to the radiographic technique available at follow-up. The intraobserver agreement was considered very good for PR (k = 0.91, $p < .05$) and for CBCT (k = 0.88, $p < .05$). The two evaluators demonstrated a moderate level of agreement for PR (k = 0.41, p = .004) and CBCT (k = 0.65, $p < .05$). The interobserver agreement is better whilst assessing the retreated roots (k = 0.73, $p < .05$) compared with the assessment of the unretreated roots (k = 0.4, p = .004).

TABLE 2 Frequency of variables age, gender and location/tooth type in the total sample

(Total sample, n = 75)		
	Min/max	**Mean (SD)**
Age	18–77	50.6 (14.1)
Follow-up time (months)	112–40	15.6 (7.3)
	n	**%**
Gender		
Masculine	32	42.7
Female	43	57.3
Location		
Mandibular first molar	25	33.3
Mandibular second molar	4	5.3
Maxillary first molar	42	56.0
Maxillary second molar	3	4.0
Maxillary second pre-molar	1	1.3

Tooth survival

The total survival rate was 91.5% at 12–48 months after treatment (endpoint of the study). The subject's chart was examined to establish the date and the reason for extraction. A total of seven teeth were extracted within 2–12 months post-treatment (two mandibular first molars and five maxillary first molars). All of these were considered 'nonendodontic failures', and the reason for extraction noted in the charts was VRF.

DISCUSSION

The results of the present retrospective study show a favourable outcome of 86.7% of teeth subjected to selective root canal retreatment which is comparable to outcomes reported of full root canal retreatment in teeth with AP when loose radiographic criteria (reduction or absence of radiolucency at recall) are used (Al-Nuaimi et al., 2018; Davies et al., 2016; Farzaneh et al., 2004; Liang et al., 2013; Metska et al., 2013; Ng, Mann, & Gulabivala, 2008; Patel et al., 2012; Torabinejad et al., 2009; van der Borden

TABLE 3 Outcomes per tooth and per retreated and unretreated root(s) in the total sample

(Total sample, n = 75 teeth; 195 roots)	n	%
Outcome (per tooth)		
Unfavourable	10	13.3
Favourable	65	86.7
Outcome per retreated root		
Mesial root		
Unfavourable	6	9.0
Favourable	60	89.6
Distal root		
Favourable	12	100.0
Palatal root		
Favourable	3	100.0
Bucal root		
Favourable	1	100.0
Outcome per unretreated root		
Mesial root		
Favourable	8	100.0
Distal root		
Unfavourable	1	1.6
Favourable	61	98.4
Palatal root		
Unfavourable	3	7.1
Favourable	40	95.2

et al., 2013). These findings can encourage clinicians to consider selective root canal retreatement as a legitimate approach for teeth with post-treatment disease.

The current study included only multirooted teeth (maxillary and mandibular molars and one maxillary premolar) with a pulpal and periapical diagnosis of previously treated tooth and symptomatic AP (von Elm et al., 2007). Molar teeth demonstrate a higher failure rate compared with single-rooted teeth when assessed either by CBCT and PR (Fernandez et al., 2013; Gomes et al., 2015; Imura et al., 2007). This is in contrast with other studies (Hoskinson et al., 2000; Liang et al., 2011; Ng et al., 2011a) which have used PR to compare healing rates for different tooth types showing a better outcome for molars. The differing results of these studies could be attributed to the limitations of PR to diagnose AP in the posterior maxillary and mandibular regions (Low et al., 2008; Shahbazian et al., 2015). In fact, PR has been shown to significantly underestimate the detection of periapical lesions when compared to CBCT, with false-negative values ranging from 38% to 62% (Kiarudi et al., 2015), which could lead to an overestimation of the favourable outcomes of the treatment (Al-Nuaimi et al., 2018). By contrast, the accuracy of CBCT for detecting mildly inflamed or healthy periapical tissues is lower in root filled teeth (70% - 80%) (Kanagasingam et al., 2017; Kruse et al., 2019) which could lead to over-treating previously root filled teeth that have radiolucencies identified on CBCT images.

In the present study, the change in size of a periapical radiolucency at follow-up was determined by comparing pre- and post-treatment radiolucencies without using any measurements. Similar to other retrospective studies (Ng et al., 2007), the orientation of the preoperative PR was not registered. It is known that a different orientation at recall could affect the accuracy of assessing lesion changes. Furthermore, in patients with CBCT, information serial sets of linear and volumetric measurements could be used to provide a more objective and accurate representation of osseous changes over time (Metska et al., 2013; van der Borden et al., 2013) and improved the objectivity of outcome assessment (Patel et al., 2009; Pinsky et al., 2006). The current use of a visual comparison is however in line with many endodontic outcome studies (de Chevigny et al., 2008; Ng et al., 2011a).

The intraobserver agreement was very good (k = 0.91 and k = 0.88) for both radiographic techniques demonstrating the successful calibration of each examiner. The interobserver agreement was moderate and lower with PR compared with CBCT. Given the well-documented problem of observer variability (Al-Nuaimi et al., 2018; Pope et al., 2014), the observers were shown standard reference PRs and CBCTs, but this did not improve the Kappa correlation (0.4–0.65). Nevertheless, these observations are in agreement with the results reported by other studies assessing detection of periapical radiolucencies with PR and CBCT (Al-Nuaimi et al., 2018; van der Borden et al., 2013). Interestingly, the interobserver agreement is good when only the retreated roots are considered (k = 0.73, $p < .05$) compared with the assessment of the unretreated roots (k = 0.4, $p = .004$). This could be explained by the presence of an apical lesion in the retreated root making the assessment of its change (healing) easier as compared to the evaluation of a normal periodontal space.

Recent guidelines for the timing of outcome assessment are still based only on PR evaluation. However, the higher accuracy of CBCT in detecting apical lesions should be considered for outcome evaluation timing (the same lesion might demonstrate slower healing rate in the CBCT than in the PR), if strict criteria are used. In fact, a 12 months period of time might be insufficient to see full healing with CBCT; thus, new follow-up guidelines are needed if this method is to be used for outcome assessment. Regardless, the choice for minimum 12 months follow-up time in the current study complies with the quality guidelines for nonsurgical treatment of AP for outcome assessment (European Society of Endodontology, 2006). Some authors (Ng et al., 2011a) recommend that cases with incomplete healing after 1 year should be followed for longer periods of time. However Ørstavik (Orstavik, 1996) reported that any tooth that has healed will have already shown signs of healing 1 year after treatment. Thus, the minimum follow-up time at 12 months was followed as this has a good predictive value to the long-term healing rates.

In the present study, from the 10 unfavourable cases (13.3% of the teeth), six teeth had an unchanged periapical lesion whilst patients were asymptomatic. Those six subjects opted for monitoring the treated tooth due to the absence of complaints. The absence of symptoms (in a tooth previously symptomatic) is usually a satisfactory result for a patient.

Reporting the outcomes in terms of individual roots is controversial. Due to the selective character of the intervention, the use of Patel's classification (Patel et al., 2012) for outcome assessment per root proved to be of great value in our study. Each root could be assessed independently allowing effective evaluation of the treatment and, at the same time, the fate of the unretreated root(s). Nevertheless, from a patient's perspective, a single symptomatic root indicates treatment failure for a tooth resulting in an indication for clinical intervention. Thus, we decided to report both outcomes—per root and per tooth, as the healing rate is expected to be higher if only the root was used as the unit of evaluation. However, no statistical difference could be demonstrated between the outcomes per root and per tooth between groups.

The identification of preoperative complications, especially for missed canals, is enhanced by CBCT. The incidence of missed canals in failed endodontic treatments was found to be 23.04%, with the highest incidence in upper molars. Teeth with a missed canal had 4.38 more likelihood of having a PA lesion (Karabucak et al., 2016). At a root level, the MB root(s) of maxillary first molars had more periapical lesions (Meirinhos et al., 2020) with the MB2 canal being the most frequently missed canal (65%) (Karabucak et al., 2016). In our study, 72.5% of the retreated MB roots of the first maxillary molar had an untreated MB2 canal. This finding can explain the persistent or emergence of AP only in the MB root of maxillary molars where the incidence of missed anatomy is more likely.

It is noteworthy that in the current study, direct or indirect restorations were retained only if they had clinically intact margins, with no clinical or radiographic signs of recurrent caries or leakage. This is particularly important because longitudinal studies show that the quality of the postoperative coronal restoration is one of the strongest predictors of periapical healing after root canal (re) treatment (Ng, Mann, & Gulabivala, 2008; Ng, Mann, Rahbaran, et al., 2008). Recent evidence has shown however that the quality of crown margin adaptation does not affect periapical healing (Ferrandez et al., 2021). Despite that, crown removal would risk damage to the tooth and crown, whilst cutting the crown off would commit the patient to the expense of a new restoration. Patients are often unwilling to assume the financial and/or psychological burden of restoration removal and reconstruction. Thus, during selective root canal retreatment, a smaller precision slot access through the prosthetic crown to the root(s) to be retreated can be designed to minimize damage to the restoration and maximize its current structural integrity and tooth-structure saving (Nudera, 2015) without impairing the outcome of the treatment.

None of the treatment-related parameters were shown to have a direct influence on the favourable outcome of the retreated roots. Nonetheless, results must be carefully interpreted because of the small sample size.

Based on a recent publication (Duncan et al., 2021), the most critical outcome for nonsurgical root canal treatment was defined as the patient-reported outcome measure 'tooth survival'. In the current study, the survival rate was 91.5% at 12–48 months after selective retreatment which is in line with the values reported by other studies (Ng et al., 2011b) regarding tooth survival after root canal retreatment.

Nudera (2015) states that selective root canal retreatment might be recognized as a suitable treatment option only when CBCT is used as a diagnostic tool (Nudera, 2015). Crowns, bridges, fillings and intracanal posts can mimic endodontic complications or hide existing ones (Lofthag-Hansen et al., 2011) which is the case in most of the teeth presented for retreatment. It is important to mention, that in Nudera's article, the CBCT was inconclusive regarding the identification of the root involved in AP and the final decision not to treat a specific root relied on the presence of cast post and core in one of the canals. Additionally, the author stated that for access orientation, the clinician must rely on experience when CBCT measurements cannot be made due to artefacts (e.g. metal-ceramic crowns). Nevertheless, CBCT enables clinicians to consider selective root canal retreatment, addressing only the roots with radiographic evidence of disease (Nudera, 2015; Uraba et al., 2016) with more confidence and with minimal to no risk compared to a diagnosis based exclusively on PR.

In the current study, the main reasons to perform a selective retreatment without a preoperative CBCT were related with a higher cost and/or additional radiation exposure. Indeed, insurance companies in some countries do not yet recognize CBCT imaging as a 'covered benefit' which puts the financial burden on the patient, who may be reluctant to make this additional expense. The additional costs played a considerable role for patients who selected this treatment option rather than full retreatment, despite being informed of the eventual risks of nonhealing or development of disease in the unretreated roots.

Given the retrospective nature of this study, the limitations in reliability on data collection and selection bias should be noted. Other limitations are the small sample size and the lack of a control group of retreatment of all canals. Furthermore, the pre-calibration of the observers might be pointed out as a weakness as no interobserver calibration was performed before the assessment of the experimental data. Another possible limitation is the parameters used to assess the quality of root canal filling. It is important to note that the range of adequate length of root filling used in this study (0–2 mm) (European Society of Endodontology, 2006; Pirani et al., 2018) is challenged by some other studies that suggest a stricter level of root filling as adequate and a possible impact on endodontic outcome (Azim et al., 2016; Chugal et al., 2003; Mello et al., 2019). Despite these limitations, this study has several strengths. First, its novelty, being the first report of outcome of selective root canal retreatment as well as the fate of the unretreated roots. Secondly, the outcome assessment was done per root and per tooth. Finally, all treatments were conducted in various clinics by different endodontists, and not under a controlled setting—of a randomized clinical trial—showing treatment effectiveness relevant to the actual clinical situation. Since outcomes of retreatment were shown to be significantly influenced by the operator's training background and clinical experience (Torabinejad et al., 2009) the present results cannot be extrapolated for application in general dental practice without advanced training in endodontics and the use of microscope.

CONCLUSION

A favourable outcome for selective root canal retreatment was achieved in the great majority of cases (86.7%). No statistical difference was shown between the outcomes per root and per tooth between both groups ($p > .05$). Unretreated roots rarely (3.5%) developed radiographic signs of a new periapical lesion at follow-up. The survival rate was 91.5% at 12–48 months after retreatment.

According to these results, selective root canal retreatment could be a reliable treatment option for teeth presenting with post-treatment disease. Future high-quality clinical trials with larger sample sizes and longer follow-up periods are required to confirm these findings and shed more light on specific clinical situations where selective root canal retreatment could be indicated.

AUTHOR CONTRIBUTIONS

Brochado Martins JF contributed to the conceptualization, investigation, methodology, formal analysis, original draft, and review and editing. Viegas O contributed to the conceptualization, methodology and formal analysis. Cristescu R wrote—review and editing. Diogo P contributed to the original draft and writing—review and editing. Shemesh H contribution to the methodology, supervision, original draft, and writing—review and editing.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest in relation to this study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

João Filipe Brochado Martins https://orcid.org/0000-0002-3473-5801

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