

Cross-Sectional Data Analysis of the Outcome after Root Tip Resection with or without Previous Root Canal Revision or Retrograde Root Filling

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Abstract

Purpose: This study aimed to analyze the influence of preoperative root canal revision on the outcome of subsequent root tip resection. Moreover, we investigated the impact of retrograde filling or no retrograde filling in terms of root tip resection.

Methods: Patients with a need of retreatment after initial root canal filling with periapical infection between 2011 and 2017 were enrolled, and 4 groups were formed. Group 1 had a revision before root tip resection, and Group 2 had primary root tip resection (1a/2a with retrograde filling, 1b/2b without retrograde filling). Clinical (tooth still in situ) and radiographic parameters (improved periapical index preoperative 3 or 4 to postoperative 1 or 2) were analyzed.

Results: Forty-eight teeth (Group 1a n=14, 2a n=15; 1b n=8, 2b n=11) underwent a root tip resection (n=17 front teeth, n=16 premolars, n=25 molars) with a mean follow-up interval of 14.8 months. The total clinical success rate was 75.9%. Radiographic success rates were as follows: group 1a (64.3%), 1b (62.5%), 2a (33.3%), and 2b (18.8%).

Conclusion: Within the limits of the cross-sectional study design, preoperative root canal revision and retrograde root canal filling should be considered to maximize the long-term success rate of teeth.

Introduction

Irreversible pulpitis or infected pulpanecroses are the most common indication for endodontic treatment in conservative dentistry. The initial success rate after root canal treatment remains high due to further development of techniques and instruments. Nevertheless, apical inflammations recur in many cases, which is mostly caused by the persistence of microorganisms or their ramifications, especially in the apical third of the root [1]. In this region, the bacteria cannot always be eliminated in a predictable way, despite chemomechanical preparation [1]. Studies have shown up to 64% persistence of pathogens after root canal treatment, which could only be minimized to 36% after drug insertion with calcium hydroxide [2]. The existing inflammatory stimulus due to persistent microorganisms is followed by a cytokine-mediated immunological reaction, bone resorption and finally apical periodontitis [3]. If the initial root canal treatment fails, the first step should be to revise the root canal in order to ensure tooth preservation [4,5]. The goal of a revision remains unchanged, which is to completely disinfect the entire root canal system to prevent reinfections [6,7]. If this treatment also remains a failure and apical inflammation persists, surgical intervention is indicated. Through surgical access via the vestibular bone lamella, the root apex in the last apical third of the root and the granulation tissue are removed. This method also focuses on tooth preservation. After removal of the root tip, retrograde preparation and root canal filling can achieve a bacteria-proof filling and prevent a new inflammatory stimulus [8]. The choice of the appropriate therapy procedure varies between endodontists and surgeons, and the current data situation can shed light on this controversy.

In a review, Torabinejad et al. investigated the clinical success of a surgical intervention and two conservative endodontic treatments. While the surgical success rate was 77.8% over a follow-up of 2-4 years, it was 70.9% for the repeated conservative approach. Over a monitoring period of 4-6 years, the success rate for surgery was 71.8%, while the success rate for revisions was 83.0%. Success was measured by the absence of clinical symptoms and changes in apical radiotranslucence [9]. The authors concluded a higher long-term success rate for revisions [3,10]. Other studies, however, saw no significant difference in long-term success (follow-up > 4 years) between the two therapy approaches [12]. The study criteria are usually very heterogeneous, and there is often a lack of data, especially on the retrograde occlusion. However, this can be significantly associated with higher success rates [13].

Overall, there is currently no clinical evidence to give preference to one therapeutic approach over another. The indication for primary root tip resection might be set too quickly, and the attempt of a previous revision is waived. In the case of a root tip resection, the question of whether to perform retrograde filling also arises.

This study was intended to examine the outcomes after root tip resection with or without a previously performed revision. In addition, the outcome should be analyzed with respect to retrograde preparation and filling or only resection as well as the evaluation of different filling materials.

Materials and Methods

Study design and setup

The data was analyzed in a cross-sectional study design. Patients with a need of retreatment after initial root canal filling and a periapical infection (persistent periapical dolence or painful percussion and apical translucency) between 2011 and 2017 were enrolled. Ethical approval (No. 39_18Bc) was obtained from the ethics committee of the University of Erlangen-Nuremberg.

Regarding the inclusion criteria, we defined the presence of pre- and postoperative X-rays as well as the documentation of clinical parameters. We have also defined at least one follow-up visit at least 6 weeks after surgical intervention as an inclusion criterion.

Patients who could no longer be reached or had their aftercare performed by their general dentist and did not want to introduce themselves again were excluded. Moreover, patients with comorbidity factors (diabetes mellitus, immunological diseases, radiation therapy, antiresorptive therapy), smokers or mentally and physically impaired patients, and minors were excluded.

According to the therapy carried out, four groups were retrospectively formed. The first group (1) received a revision of the root canal treatment before root tip resection and either received a retrograde filling (1a) or did not (1b). The second group (2) did not receive a revision before resection and either received a retrograde filling (2a) or did not (2b).

The preoperative assessment of the existing root canal treatment (initial or after revision) was standardized on the basis of the available x-rays according to the following parameters:

1. Root filling in apical third 2mm before apex
2. marginal and bubble-free root canal filling
3. without apical puff of the filling

Only patients who met the criteria were included. All patients were then pseudonymised according to the above criteria.

Data extraction (parameters/examination)

Two researchers (one dentist, one oral surgeon) analysed the patients according to the following parameters. Clinical parameters:

1. Vitality, percussion
2. Periapical dolence
3. Tooth loosening
4. Pocket depth

Radiographic parameter PAI Index

The PAI = periapical index by Orstavik et al. [14], including the following categories: grade 1 (no signs of the apical tissue), grade 2 (minor changes of bone structure), grade 3 (changes of bone structure with loss of mineral), grade 4 (periodontitis with radiotranslucency), and grade 5 (severe apical periodontitis with signs of exacerbation). A postoperative PAI of 1 or 2 was defined as treatment success [15].

Root canal revision

The revisions were performed by dentists at the University Hospital. The tooth was isolated with the help of a latex-free rubberdam (Roeko Dental Dam, Langenau, Germany). The revision of the former root canal filling was done mechanically with the reciproc system (VDW, München, Germany). After removing the filling and disinfecting the root canal system with irrigants (Sodium hypochlorite 3% and citric acid 40%), the length of the root canals was measured with the help of Raypex (VDW München, Germany) before refill. After drying the canals, confectioned gutta-percha and root canal sealer (AH plus DentsplyDeTrey, Konstanz, Germany) were inserted in each canal. The cavity was sealed with a condensable composite (Clearfill majesty Kuraray, Hattersheim, Germany) after selective etch of dentin and enamel with phosphoric acid (40%) and dentin bonding (SyntacIvoclarVivadent, Schaan, Liechtenstein).

Surgical root tip resection

Surgical interventions were performed by different surgeons to reduce the bias. After the formation of a mucoperiosteal flap, the access cavity through the buccal bone to the root tip was prepared with rotating instruments (W&H Dentalwerk, Bürmoos, Austria) and with using a loop glasses. After identification of the causative root tip, it was rotatably separated, and the inflammation was curetted around the cavity. In the

case of a subsequent retrograde preparation of the root and a sufficient root filling, this procedure was done using the piezo ultrasound (Mectron, Cologne, Germany). The retrograde closure was carried out either with Super-EBA (zinc oxide eugenol with addition of ethoxybenzoic acid) cement (3M ESPE, Neuss, Germany) or MTA (mineral trioxide aggregate, ProRoot Dentsply Sirona, Bensheim, Germany). The wound closure was performed with absorbable sutures Vicryl (Johnson & Johnson, Norderstedt, Germany).

Outcomes

Our primary outcomes were defined as clinical success using the mean number of tooth loss in the different treatment approaches in the four groups. As secondary outcomes, we defined the radiographic outcome using the mean improvement of PAI.

Statistical analysis

Two-sided adjusted *p*-values ≤ 0.05 were considered to be significant. The analyses were performed using the Software R (Version 3.6.0) on Linux Kernel (Version 4.4.0-148). The association of the different treatment approach variable with clinical and radiographic outcome was analysed non-parametric Wilcoxon-test and chi-square for categorical variables.

Results

Patient Cohort

Of the analysed patients, $n=48$ teeth with 58 pathologic roots were included. As illustrated in Table 1, we assigned the patients to 4 groups according to the therapy procedure carried out (with/without revision before resection and with/without retrograde filling) (1a, 1b, 2a, 2b). We included 17 front teeth, 16 premolars and 25 roots of molars. The mean follow-up was 14.8 months. The parameter pocket depth was omitted due to lack of continuous documentation.

Clinical Outcome

Of the root tip resections that we considered, 14 teeth clinically failed across all patient groups because they had to be extracted during follow-up, which resulted in a total success rate of 75.9% with the mean follow-up of 14.8 months. In patient group 1a, a success rate of 85.7% was calculated for the patients who received a root canal revision before the operation and a retrograde root filling. In patient group 1b, a success rate of 77.7% was observed.

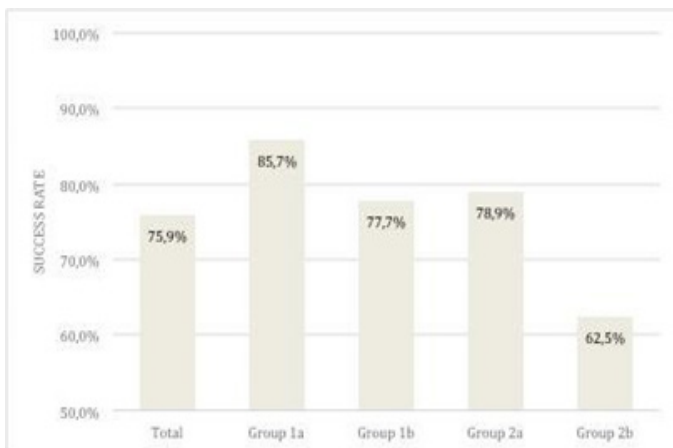
Table 1. Showing the patient cohort and related outcomes

| Group | Teeth/roots | Front teeth | Premolars | Molars | Clinical success rate | Radiological success rate |
|-------|-------------|-------------|-----------|--------|-----------------------|---------------------------|
| 1a | n=14/n=14 | n=6 | n=7 | n=1 | 85.7% | 64.3% |
| 1b | n=8/n=9 | n=3 | n=2 | n=4 | 77.7% | 62.5% |
| 2a | n=15/n=19 | n=4 | n=6 | n=9 | 78.9% | 33.3% |
| 2b | n=11/n=16 | n=4 | n=1 | n=11 | 62.5% | 18.8% |
| total | n=48/n=58 | n=17 | n=16 | n=25 | 75.9% | 42.0% |

Patients who did not receive a root canal revision but received a retrograde root canal filling were in group 2a, in which we observed a clinical success rate of 78.9%.

In patient group 2b, with neither a root canal revision nor a retrograde root filling, clinical success was observed in only 62.5% of the cases. These observations are without statistical significance and are illustrated in (Figure 1).

Figure 1: Presentation of the clinical survival rates depending on the chosen treatment concept within the patient groups.



Regardless of the treatment procedure and the jaw, anterior teeth performed significantly better with 88.2% clinical success rate compared to premolars, which had only 50.0% clinical success rate ($p=0.02$). The success rate for molars was 84.0%. This result was statistically significant ($p=0.03$), as seen in (Figure 2).

We also observed the clinical outcome depending on the retrograde filling material in groups 1a and 2a. Two root filling materials were used for the selected patient cases: MTA and Super-EBA. The success rate was 50.0% for MTA and 88.8% for Super-EBA ($p=0.05$), as seen in (Figure 3).

Figure 2: Clinical success rate of all included roots depending on the tooth position. Mean follow-up intervals = 17.5 months for anterior teeth, 14.2 months for premolars and 13.5 months for molars.

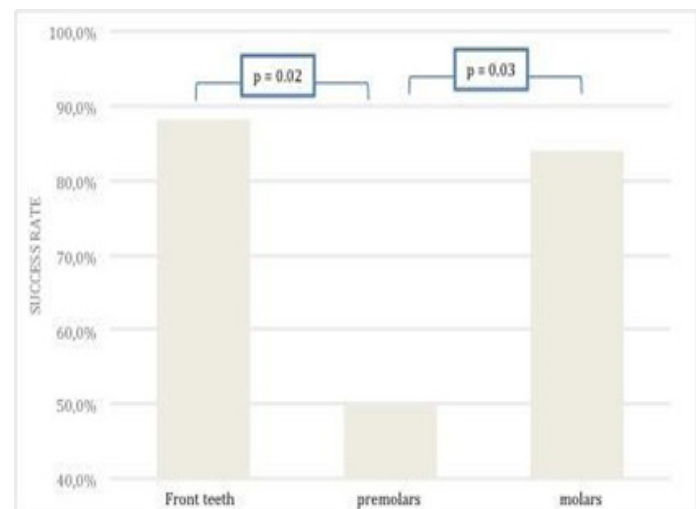
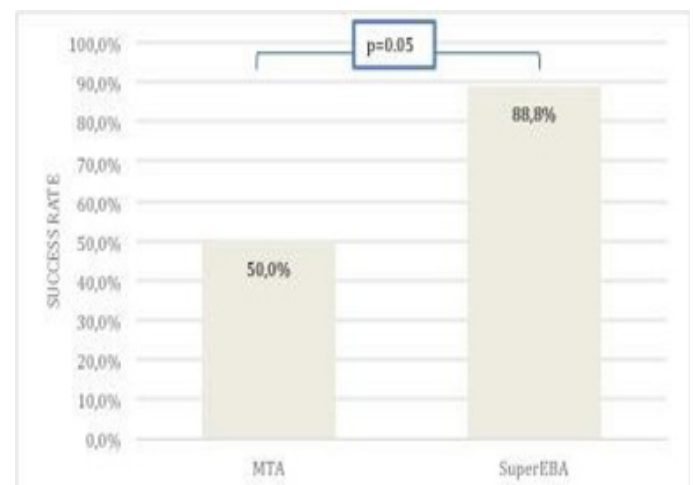


Figure 3: Clinical success rate of root tip resection depending on the material used for retrograde root filling.

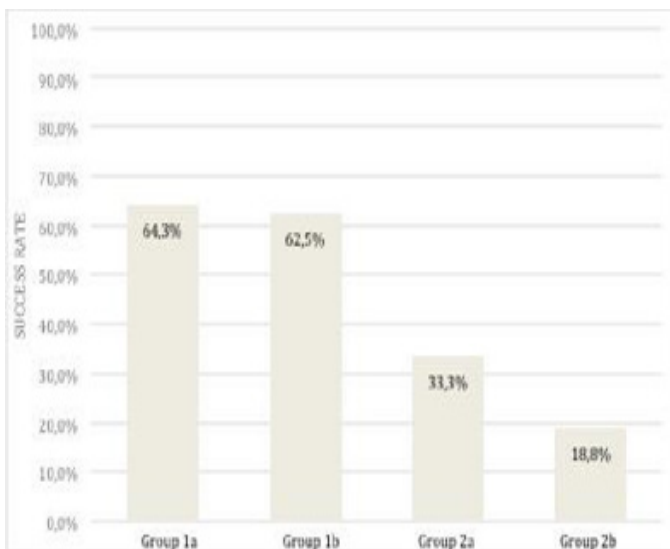


Radiographic Outcome

All roots with a preoperative PAI of 3, 4 or 5 (50 roots in total) were selected for evaluation within the patient population. Roots with a preoperative PAI of 1 or 2 were not included in the evaluation (8 roots in total) to reach better comparability. Treatment success was observed when the included roots had dropped to PAI 1 or 2.

In the first group (1a), 64.3% of all roots with a preoperative PAI > 2 were treated successfully. The success rate was 62.5% in the second group (1b), 33.3% in the third group (2a), and only 18.8% in the fourth group (2b), which did not receive either a root canal revision or a retrograde root filling. These findings were not significant and are illustrated in (Figure 4).

Figure 4: Radiological outcome of the treatment success with in the patient groups taking into account the radiographic PAI evaluation.



Discussion

The therapy approaches for persistent apical inflammations are manifold. The decision between conventional revision before surgical intervention and surgical procedure clearly depends on the qualifications of the practitioner, the equipment, and the size of apical inflammation. A surgical approach is usually prematurely indicated due to the rapid growth of implant dentistry. To the best of our knowledge, there is currently no evidence in the literature and no medical guideline can be derived for or against one therapy concept over another. For this reason, this cross-sectional study was designed. The aim of this study is to determine the success rates of two different approaches: root tip resection after revision or immediate root tip resection. There have already been investigations in the literature as to whether the root canal should undergo retrograde filling in the case of a resection.

Looking at the current literature, the success rates of different approaches vary greatly. Friedman et al. performed a review in 2011, in which he included 7 studies demonstrating the success rate to be between 37% and 91%. Nonetheless, this is a large interval, and the studies are difficult to compare [16]. The follow-up intervals are not uniform as is the definition of treatment success [17]. To obtain meaningful results over a defined period of time, at least 80% of the included patients must appear at the scheduled recall appointment [18]. Therefore, patients in our patient population who did not appear for check-up were re-examined due to the cross-sectional design. We recorded a mean follow-up of 14.8 months. This follow-up period is notably short compared to the documented data in the literature [9,11,12]. Due to the study design, however, no longer observation period could be determined. Clinical and radiological parameters are used to assess the success of the treatment and are separated from each other [19,20]. The reason for the separation is that in many cases, patients do not describe clinical symptoms despite radiological correlates [27]. In addition, the clinical symptoms, such as periapical pressure, dolence or pain, are also subjective, which is why tooth loss was used to determine the clinical failure and respective success. For radiological diagnosis and evaluation of healing, two-dimensional X-ray diagnosis in the form of panoramic tomography or single-tooth films are sufficient according to the literature. However, the magnification angles on panoramic images or eccentrically X-rayed images make uniform evaluation somewhat difficult, as well. For a better assessment of the root tips or root canal treatments, three-dimensional diagnostics, e.g. cone-beam computed tomography (CBCT), can be considered [21]. In this study, we analyzed panoramic X-rays or tooth films and evaluated the PAI Index.

The clinical treatment success was defined by whether the resected tooth was still in situ within the follow-up interval. In an average follow-up interval of 14.8 months, we were able to record an overall success rate of 75.9%, which largely corresponds to the figures from the literature. As we separately interpreted the clinical outcome from the radiological outcome, we had other success rates regarding the radiological outcome defined by PAI. In the first group (1a), 64.3% of all roots with a preoperative PAI > 2 were treated successfully. The success rate was 62.5% in the second group (1b), 33.3% in the third group (2a), and 18.8% in the fourth group (2b), which did not receive either a root canal revision or a retrograde root filling.

It is well-known from the literature that retrograde preparation after resection has a positive effect on the prognosis of tooth preservation [11,21]. In our patient population, we have therefore compared retrograde prepared teeth with

teeth that have not been prepared in a retrograde fashion. We achieved a 16.4% higher clinical success rate and a 14.5% higher radiological success rate. These results correlate with other studies, which recorded a 31% higher success rate [21,22], although the evidence in this aspect must be critically assessed [4,23] Regarding the retrograde filling material, a number of studies have already shown that MTA is superior to Super-EBA in terms of sealing capacity in particular, apart from the poor process ability (especially due to incorrect mixing) [2,5,7,24-27]. On the other hand, we were able to record a significant difference between Super EBA and MTA, which must be viewed critically; however, the applications were not comparably high (18 times Super EBA compared to 6 times MTA).

The previous revision of an unsuccessful root canal treatment prior to initiation of surgical therapy has already been investigated in several studies. Wang et al. described a 10% higher healing chance for resected teeth which were previously orthograde revised [28]. A further study gave a 91% healing rate with at least one previously performed revision [29]. This number corresponds to our results for the groups, which were previously revised, and a clinically higher success rate of 15.2% resulted. Radiologically, this was 31% (without retrograde root canal treatment) or 43.7% (with retrograde root canal preparation). The success rate can be further increased if the orthograde revision is performed once during root tip resection. Even if the revision entails the risk of an iatrogenic root fracture (broader preparation), it should be considered as a pre-surgical concept [10].

The tooth position is also known to influence the outcome of tooth preservation after root tip resection. In contrast to maxillary and mandibular anterior teeth, mandibular molars perform worse [30]. On the other hand, other authors showed no significant difference [31]. In our patients, the anterior teeth and molars performed significantly better than the premolars, exhibiting a success rate of 80%. This finding was independent of the type of therapy and the jaw. Premolars are usually underestimated in the root anatomy. More than one-third of the mandibular premolars have more than one root canal [13]. As a result, the initial root canal treatment is usually doomed to failure and can also complicate subsequent surgical intervention. Thus, the factor of tooth position or tooth form also plays a role in the decision for a previous revision or immediate root tip resection.

within the limits of the study design, we were able to demonstrate that prior revision in persistent apical processes and retrograde preparation in surgical root tip resection should be considered to maximize treatment success. Due to the low evidence from the literature, prospective studies are needed to

facilitate treatment decisions.

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