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Healing after surgical retreatment at four time points: A retrospective study

Amir Weissman | **Ronald Wigler** | **Nuphar Blau-Venezia** | **Tomer Goldberger** | **Anda Kfir**

Department of Endodontology, The Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel

Correspondence
Amir Weissman, Department of Endodontology, The Goldschleger School of Dental Medicine, Tel Aviv University, Ramat Aviv, Tel Aviv 69978, Israel.
Email: amir@microendo.co.il

Abstract

Aim: To evaluate the outcome of surgical retreatment at four time points, that is 6, 12, 24 and 48 months post-operatively, and to search for prognostic factors that may affect the outcome.

Methodology: Clinical records and intraoral periapical radiographs were collected from patients who had undergone surgical retreatment between 2009 and 2015 and attended 6-, 12-, 24- and 48-month follow-up visits. Surgical retreatment was performed by one endodontist and involved minimal root-end resection and maximal length root-end preparation using prebent ultrasonic files. Outcomes were categorized as complete, incomplete, uncertain or unsatisfactory healing, based on clinical and radiographic findings. The complete and incomplete categories were pooled and considered successes, while uncertain and unsatisfactory outcomes were considered failures. Changes in healing outcome were analysed using the McNemar-Bowker test, and prognostic factors were analysed using univariate analysis.

Results: The study cohort included 297 patients with 384 teeth. The overall success rate after 48 months was 90.6% compared with 88.5%, 93% and 92.4% after 6, 12 and 24 months respectively. Age, gender, presence of isthmus and length of canal preparation had no significant influence on the outcome. Lesion size and tooth type had a significant influence only after 6 and 12 months, respectively, with no significant differences at other time points. Fifty per cent of the teeth classified as unsatisfactory or uncertain healing at the 6 months follow-up improved to incomplete or complete healing after 12 months. None of the cases classified as unsatisfactory healing after 12 months subsequently improved, and only 2 cases that were classified as uncertain healing after 12 months improved after 24 months.

Conclusions: Surgical retreatment was found to be a predictable procedure with a high success rate of 90.6% after 4 years. Over the follow-up periods, only a minor regression in the success rate was found. The 12 months follow-up results closely indicated the long-term outcome of surgical retreatment.

KEYWORDS

endodontic surgery, healing assessment, long-term follow-up, outcome study, surgical retreatment

Weissman Amir and Wigler Ronald contributed equally to this work

INTRODUCTION

The treatment options in cases of post-treatment endodontic disease are usually root canal retreatment or endodontic microsurgery (Kim et al., 2016; Von Arx, 2005). Endodontic microsurgery is indicated when root canal retreatment is impractical or is unlikely to lead to healing (Gutmann & Harrison, 1985; Johnson & Fayad, 2016).

Surgical retreatment is a modification of endodontic microsurgery and is characterized by a minimal apical resection and a root-end canal preparation that extends as far coronally as possible (Weissman et al., 2019). Endodontic microsurgery has been reported to have a success rate of approximately 89%–94% after 1 year (Kang et al., 2015; Setzer et al., 2010; Tsesis et al., 2013), which is similar to the 91.8% success rate of surgical retreatment after 1 year that was reported (Weissman et al., 2019). Short-term observation after endodontic microsurgery may overestimate the long-term prognosis (Kruse et al., 2016). A meta-analysis by Kang et al. (2015) and a systematic review by Torabinejad et al. (2015) indicated a 5% and 6% decrease, respectively, in the healing rates 4 years following endodontic microsurgery. Therefore, knowledge of the long-term outcome is important when choosing the appropriate treatment option (Kruse et al., 2016).

The aim of the present study was to evaluate the outcome of surgical retreatment at four time points, that is 6, 12, 24 and 48 months post-operatively, and to search for prognostic factors that may affect the outcome.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee (IEC No. 72.18). The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist and statement was followed.

Case selection

An evaluation of all patients treated in a university setting and a private clinic, between January 2009 and December 2015, was performed. The clinical and radiographic records of each patient were reviewed, and eligibility for the study was assessed on the basis of inclusion and exclusion criteria.

The primary inclusion criteria were as follows:

1. A retrograde root canal retreatment was performed on teeth with apical pathosis.
2. The existing coronal restoration was adequate.
3. No aggressive or moderate-to-severe chronic periodontal disease was present.
4. The patient had an American Society of Anesthesiologists (ASA) score of I or II.
5. The intraoral periapical radiographs documenting pre-treatment, post-treatment and follow-up visits were of good diagnostic quality.

The secondary inclusion criterion was as follows:

The patient attended all the scheduled follow-up appointments, that is 6, 12 months (±1 month), 24 and 48 months (±3 months).

The exclusion criteria were as follows:

1. A vertical root fracture was identified during surgery.
2. Endodontic surgery had been performed previously.
3. A bone graft was used.
4. Extraction of the tooth for other than endodontic reasons.

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 1102 patients with 1405 teeth were treated surgically from January 2009 to December 2015. Of these, 261 patients with 335 treated teeth did not meet the primary inclusion criteria, and 45 teeth in 40 patients were extracted during the study period for other than endodontic reasons. The primary inclusion criteria were satisfied by 801 patients with 1025 teeth. In order to be able to evaluate the changes in healing outcome following surgical retreatment over 4 time points, the secondary strict inclusion criterion was applied. Accordingly, 458 patients with 572 teeth who attended only 1–3 follow-up appointments, and 46 patients with 69 teeth who attended 4 follow-up visits, but not according to the protocol schedule, were excluded. A total of 297 patients with 384 teeth were eligible for the present study.

Surgical procedure

All clinical procedures were performed by a single operator (A.W.) using the surgical retreatment technique described by Weissman et al. (2019). Briefly, the procedure started with an incision, flap elevation, osteotomy and curettage of the pathological tissue. Once this was accomplished, approximately 1 mm of the root-end was resected and the root surface was inspected under high magnification to examine the morphology of the apical root canal system and to verify the absence of cracks and fractures. A retrograde canal preparation extending

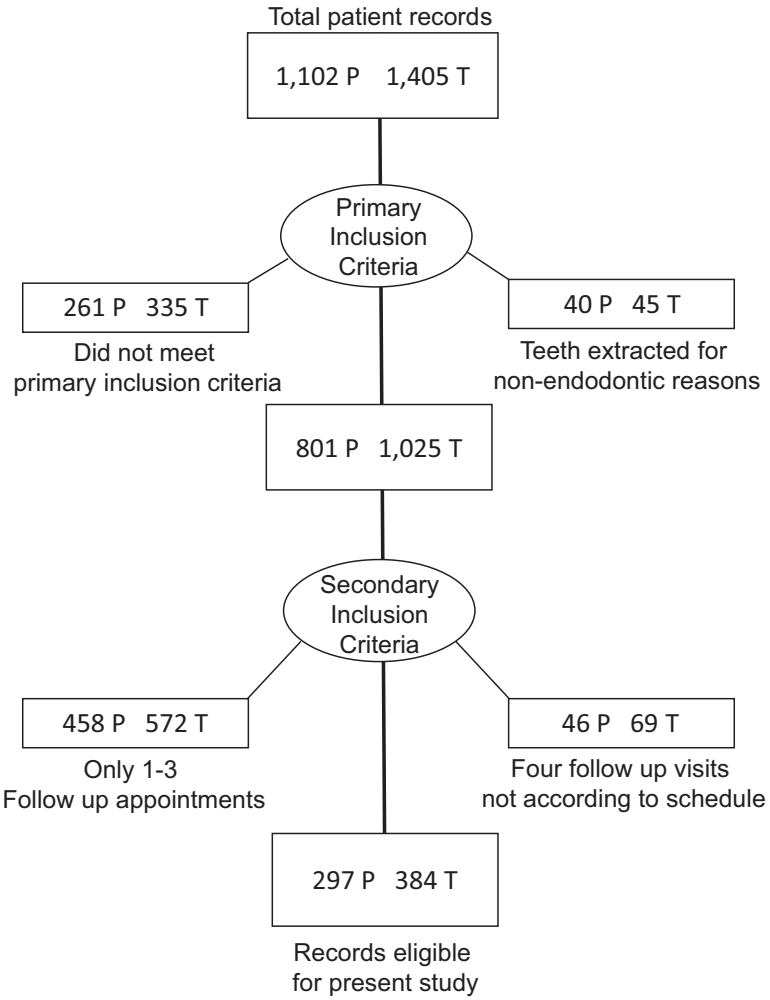

FIGURE 1 Flow chart describing the process of inclusion and exclusion of cases for the purpose of participation eligibility (P, Patients; T, Teeth)

coronally as deep as possible was performed using ultrasonic files (Endosonore; Dentsply Sirona). During the procedure, the files were bent to various angles and lengths according to the internal morphology in order to gain access to unprepared areas such as isthmuses, fins and various canal ramifications. The retrograde preparation was filled with IRM (Dentsply Sirona), a post-operative periapical radiograph was taken, and the flap was repositioned and sutured. The sutures were removed after 7 days.

Clinical and radiographic evaluation

Patients were notified about the importance of the follow-up appointments at the pre-surgery examination, and the first recall was scheduled when the patient returned for removal of the sutures. Clinical and radiographic re-assessments were scheduled at 6, 12, 24 and 48 months post-operatively to determine the healing status of the tooth. A text message was sent to the patient's personal cellular phone, 1 day prior to the recall appointment as a reminder, followed by direct contact by phone call to verify arrival. Patients were informed that their re-evaluation appointments would be without additional charge. Each follow-up visit included a clinical examination, and periapical radiographs were obtained with a digital imaging system (Digora Optime Soredex) using a parallel technique (Rinn XCP system; Dentsply Sirona). Exposures of 0.12 s were obtained with a MinRay dental X-ray unit (Soredex) operating at 60–70 kV and 7 mA. The phosphor plates were immediately scanned after exposure using proprietary software (Dfw v.2.5; Soredex) with a 400-dpi scanning resolution. 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.

The pre-operative, immediate post-operative and follow-up radiographs were evaluated independently by two calibrated endodontic specialists (B.V.N & G.T.). The follow-up radiographs were coded and reviewed in random order, so that the evaluators were not aware of the follow-up period. All radiographs were re-evaluated after 2 months. In case of disagreement, the 2 evaluators discussed the case until a consensus was achieved.

The radiographic and clinical healing classification was based on the criteria established by Rud et al. (1972a) and Molven et al. (1987), that is complete healing, incomplete healing, uncertain healing and unsatisfactory healing.

For multi-rooted teeth, the outcome was determined according to the root with the poorest outcome. Cases presenting with signs and/or symptoms of endodontic origin, and/or a radiographic enlargement of the periapical lesion, occurring anytime between the scheduled appointments were categorized as unsatisfactory healing. The results were included in the statistical analysis, as long as the patient had attended all the previous follow-up visits, or if the failure occurred before the first follow-up appointment.

Assessment of outcome

Patient-related, tooth-related and treatment-related factors were examined to identify prognostic factors that could affect the treatment outcome at each follow-up period. Patient-related factors included age and gender. Tooth-related factors included tooth type and location, that is maxillary or mandibular anteriors, premolars or molars, the size of periapical radiolucency categorized as small lesions ≤5 mm or large lesions >5 mm, and the presence or absence of an isthmus. The treatment-related factor was the length of the retrograde preparation, which ranged from 3 to 12 mm.

Statistical analysis

The association between the length of the retrograde preparation and the outcome was evaluated using a t test. The association between the outcome and patient age, gender, lesion size and the presence of an isthmus was evaluated using Fisher's exact test. The association between tooth type and the outcome was evaluated using the Pearson chi-square test.

Cases with complete and incomplete healing were pooled and considered successful, while uncertain and unsatisfactory healing cases were considered failures. For statistical analysis of the prognostic factors, the dependent variable was the dichotomous outcome (i.e. success versus failure). Inter- and intraobserver analyses were performed using Kappa statistics. The McNemar-Bowker test was performed to examine the transition between the outcome categories over the follow-up periods.

All statistical analyses were performed with SPSS v 25.0 software (IBM Corp), and the level of significance was set at $p < .05$.

RESULTS

The Kappa values for the intraobserver agreement were 0.972 and 0.967 for B.V.N. and G.T., respectively, and 0.908 for the interobserver agreement.

Age, gender, the presence of an isthmus and length of the retro-preparation had no significant effect on the outcome. The size of the lesion had a significant influence on the outcome after 6 months, where large lesions were associated with a lower success rate ($p = .007$), but the significance was lost after 12, 24 and 48 months. Regarding tooth type, mandibular anterior and premolar teeth had a lower success rate after 12 months ($p = .036$), but there were no significant differences at the 6-, 24- and 48-month follow-up visits.

The outcomes of the surgical retreatment procedure over time are described in Table 1. The short- and long-term overall success rates of surgical retreatment were 93.0% (12 months) and 90.6% (48 months).

There was a significant positive change in the healing outcome between the 6- and 12-month follow-up visits, with the grades of 42 teeth improved, while the grades of only 10 teeth worsened ($p < .001$). There was also a significant positive change between the 12 and 24 months follow-up periods with the grades of 13 teeth improved while the grades of 7 teeth worsened ($p = .018$). There was a significant negative change between the 24 and

TABLE 1 Healing outcome of surgical retreatment after 6, 12, 24 and 48 months

	Treatment outcome					
F.U. (mo.)	Complete	Incomplete	Uncertain	Unsatisfactory	Success	Failure
6	80.7%	7.8%	5.5%	6.0%	88.5%	11.5%
12	87.0%	6.0%	2.6%	4.4%	93%	7%
24	88.8%	3.6%	2.1%	5.5%	92.4%	7.6%
48	87.0%	3.6%	1.8%	7.6%	90.6%	9.4%

Abbreviations: Complete, Complete healing; F.U., Follow-up; Failure, Uncertain + Unsatisfactory healing; Incomplete, Incomplete healing; mo., months; Success, Complete + Incomplete healing; Uncertain, Uncertain healing; Unsatisfactory, Unsatisfactory healing.

48 months follow-up periods with the grade of only one tooth improved while the grades of 11 teeth worsened ($p = .040$). When the short-term 12-month follow-up visit was compared to the long-term 48-month follow-up visit, there was a significant negative change in the outcome, with the grades of 14 teeth improved while the grades of 16 teeth worsened ($p = .001$) (Tables S1–S4).

DISCUSSION

The present study evaluated retrospectively the outcome of 384 teeth treated with surgical retreatment and followed-up for 48 months. The strengths of the study were (a) a large number of cases, (b) all cases were treated by a single operator, and (c) all cases were examined strictly after 6, 12, 24 and 48 months. The weaknesses were (a) a retrospective study, (b) all cases were treated by a single operator, posing a potential bias, (c) a single observer clinically assessed the patients and (d) a lack of control group treated by endodontic microsurgery.

The success rates after the 6-, 12-, 24- and 48-month follow-up visits were 88.5%, 93%, 92.4% and 90.6% respectively. Overall, very few cases categorized as 'success' exhibited regression to 'failure'. It may be concluded that the high success rate of surgical retreatment was maintained in the long term.

Fifty per cent of teeth classified as unsatisfactory or uncertain healing after 6 month subsequently improved to incomplete or complete healing after 12 months.

None of the cases that were classified as unsatisfactory healing after 12 months improved afterwards, and only 2 cases classified as uncertain healing improved after 24 months. This suggests that cases categorized as unsatisfactory healing after 12 months are unlikely to exhibit further improvement and should be considered as having post-treatment disease.

The results suggest that patients should be scheduled for a follow-up visit after 12 months as the results at this time point are likely to indicate the long-term outcome of the surgical retreatment. The importance of the 1 year follow-up examination was demonstrated by Rud et al. (1972b) and emphasized by Halse et al. (1991) who reported that it provides a valid diagnosis for the majority of cases. This approach is also in accordance with the quality guidelines for assessment of surgical endodontics published by the European Society of Endodontology (2006). It is the opinion of the authors that the 6-month follow-up visit is redundant as it does not accurately reflect the long-term treatment outcome and may mislead and result in additional unnecessary treatments. The results of the univariate analysis support this statement since there was a significant difference in the outcome for large and small lesions only at the 6-month follow-up visit. At this point, lesions with a radiographic size of ≤5 mm were associated with a significantly higher healing rate than lesions >5 mm in size. This could be explained by the fact that the healing time for large lesions is longer than for small lesions (Pallarés-Serrano et al., 2020).

The results corroborate previous findings of endodontic microsurgery meta-analyses that reported a successful outcome after 1 year in approximately 90% of cases (Kang et al., 2015; Tsesis et al., 2009, 2013). However, the results of the long-term follow-up visits revealed a difference in the decline of the success rate compared to endodontic microsurgery studies. In a meta-analysis by Kang et al. (2015), the weighted pooled success rate of endodontic microsurgery was 95% up to 2 years and declined to 90% after 2 to 4 years. A systematic review reported an approximately 6% drop in the success rates of endodontic microsurgery from 90% to 84% between the short- and long-term follow-ups (Torabinejad et al., 2015). In the present study, a lower regression of only 2.4% in the success rates between the 1 and 4 year follow-ups was found. Since endodontic microsurgery is limited to the apical part of the root canal system and post-treatment apical periodontitis is associated with intra-radicular polymicrobial infection, the difference in regression may be explained by bacteria remaining in the middle or coronal areas of the canal that can slowly percolate towards the apex, and eventually egress and cause inflammation (Blome et al., 2008; Danin et al., 1999; Kim & Kratchman, 2006; Riccuci et al., 2009; Torabinejad et al., 2015). According to Torabinejad et al. (2015), nonsurgical retreatment has a conceptual advantage in that the entire root canal system is addressed. Johnson and Fayad (2016) have stated that endodontic microsurgery should be considered an extension of nonsurgical retreatment, because the underlying aetiology of the disease process and the objectives of treatment are the same. The concept of surgical retreatment, which was originally suggested by Nygaard-Östby (1971) and clinically explored by Reit and Hirsch (1986), is aimed at debriding the root canal space as coronally as possible in order to adhere to the aforementioned objectives (Jonasson et al., 2017; Nygaard-Östby, 1971; Reit & Hirsch, 1986; Weissman et al., 2019).

Kang et al. (2015) and Pallarés-Serrano et al. (2020) reported that the success rate of endodontic microsurgery regressed further and reached a rate of 82% and 81.1%, respectively, after more than 4 years. Knowledge of the long-term prognosis of endodontic surgical procedures is essential when weighted against other treatment options. Therefore, a study investigating the outcome of surgical retreatment after more than 4 years is indicated.

CONCLUSIONS

Surgical retreatment performed by a single clinician demonstrated a high success rate of 90.6% after 4 years. Over the four time points, only a minor regression in the success rate occurred. The 12 months follow-up results closely indicated the long-term outcome of surgical retreatment. None of the prognostic factors had a significant influence on the outcome after 48 months.

CONFLICT OF INTEREST

The authors have stated explicitly that there was no conflict of interests in connection with this article.

ETHICAL APPROVAL

The Ethics Committee approval by the University of Tel Aviv was submitted together with all other documents to the IEJ.

AUTHORS CONTRIBUTION

Amir Weissman: conceived and designed the analysis, collected the data and wrote the paper. Ronald Wigler: conceived and designed the analysis and wrote the paper. Nuphar Blau-Venezia: performed the analysis – evaluated the cases. Tomer Goldberger: performed the analysis – evaluated the cases. Anda Kfir: other contribution – performed the statistical analysis.

ORCID

Amir Weissman https://orcid.org/0000-0001-6022-4119
Ronald Wigler https://orcid.org/0000-0002-3522-2194
Anda Kfir https://orcid.org/0000-0001-6952-4150

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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