

# Monitoring the outcomes of root canal re-treatments

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This paper provides a review of clinical protocols and emphasizes the importance of follow-up for re-treated teeth. A clinically useful strategy is presented for review of non-surgical and surgical re-treatments based on best available current evidence.

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## Introduction

The aim of root canal treatment is to prevent and/or treat apical periodontitis (1). Despite recent advances, the goal of treatment is not always achieved, and apical periodontitis might persist or new disease emerge some time following treatment (2). Root canal treatment does not end when the root canal system is filled; rather, the management of the patient encompasses collection of initial data, formulation of a diagnosis, delivery of treatment, and, importantly, observation of treatment outcome (3) or the confirmation that apical periodontitis is prevented or “cured”. Thus, monitoring is a crucial element of and inseparable from root canal treatment, but notwithstanding its significance, there seems to be little instruction on the specific protocols for a monitoring program (4). The American Dental Association’s “Standards for Advanced Specialty Education Program in Endodontics” states only that a specialty training program must include a system for follow-up evaluation of patients to enable students/residents to assess the outcome of their treatment (5) without providing any specific details. The purpose of this paper, therefore, is to review and establish clinical protocols for follow-up and assessment of root-filled teeth which have undergone conventional orthograde re-treatment based on the current best available evidence.

## What is monitoring?

Monitoring, follow-up, review, or recall is a full re-examination after the treatment has been completed.

Monitoring consists of history taking, subjective and objective examination, and all relevant clinical tests including radiographic examination. There are two main biological purposes for monitoring. Firstly, to avert untoward events. For example, if early signs of acute exacerbation, resorption, etc. are detected during the monitoring process, proper management can then be formulated to avoid or alleviate the potential consequences. Secondly, to determine treatment outcome and to determine if further treatment is required and initiate it in a timely manner (6). From a practical viewpoint, monitoring also serves as a “quality control” mechanism determining whether the clinical re-treatment procedures achieve the desired technical and biological result (Figs. 1a and b).

## Monitoring of non-surgical root canal re-treatment

Data of time-course and risk of the development or healing of apical periodontitis specifically in re-treatment cases are not available. A large part of the recommended monitoring protocol of this article is, therefore, an extension or extrapolation of initial treatment data. A small modification to the protocol described below is made when data can be derived directly from studies of re-treatment cases. The protocol is also based on the general principle that, firstly, over the course of time, the change in the size of the lesion reflects the improvement or deterioration of periapical health. Secondly, the reverse course of events

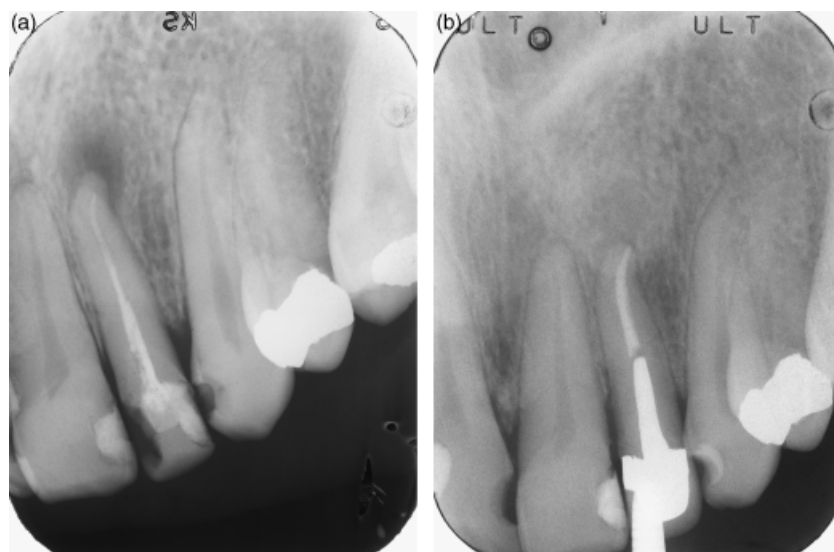


Fig. 1. (a) Maxillary lateral incisor with symptomatic apical periodontitis. (b) 4-year review after orthograde re-treatment showing partial healing after a technically satisfactory result. Patient is asymptomatic and tooth is functional but further review is indicated (see Fig. 2e).

is rare, i.e. if the size of the lesion is smaller than that in the initial visit and further review is made, it is unlikely that the lesion will grow larger (7).

To date, 31 cross-sectional studies conducted in general populations have repeatedly documented that the majority of root fillings are technically inadequate (8). In fact, up to 86% of root fillings have been reported as being inadequate (9). Accordingly, most root canal re-treatments are probably performed on technically inadequate cases. The bacterial milieu or microbiological causes of apical periodontitis in technically inadequate cases are not greatly different from those receiving initial treatment (10, 11). Based on this premise, the extrapolation of data derived from initial treatment seems justified.

A recommended timeframe for monitoring of initial root canal treatment seems to vary from 6 months to 5 years (7, 12–16). A more important question than when a review appointment should be scheduled may be at what point is it *unlikely* that a treatment outcome will change (17). In one study, the peak incidence of healing or emerging (new) apical radiolucency of initial treatment was at one year in both of these clinical sequelae; assessments at two, three, and four years did not indicate an added risk of root-filled teeth developing apical periodontitis during this period (7). In other words, the incidence of newly emerging or persistent disease started to plateau at one year. Accordingly, patients should therefore be examined one year after treatment. In the quest for a proper monitoring

protocol, Reit (12) compared two protocols: (a) one year after treatment and three years later; and (b) review only once at four years after treatment. A formal decision analysis was used based on values of probability and utilities and this revealed that a one-year review protocol had a higher expected utility value, which indicated that clinical decision-making is more accurate with this monitoring regimen. In addition, a cost-effectiveness analysis revealed that a one-year review protocol had a lower cost-effectiveness ratio and hence is the preferred protocol (12).

Radiographic changes take time to develop. Pathohistological changes might have taken place long before radiographic ones (18). It has been reported that a large proportion of teeth progressed to chronic apical periodontitis, as confirmed by radiographic changes, without the patient experiencing symptoms (19). When teeth are symptomatic, it is a rather clear sign of pathosis that will not improve spontaneously and intervention is therefore required. Thus, clinical signs and symptoms take precedence over radiographic appearance in determining if an intervention is required.

### Monitoring details for root canal re-treatment (Fig. 2)

In order to simplify the complex and confusing literature, the following sections summarize and explain the proposed flow charts (Figs. 2 and 3).

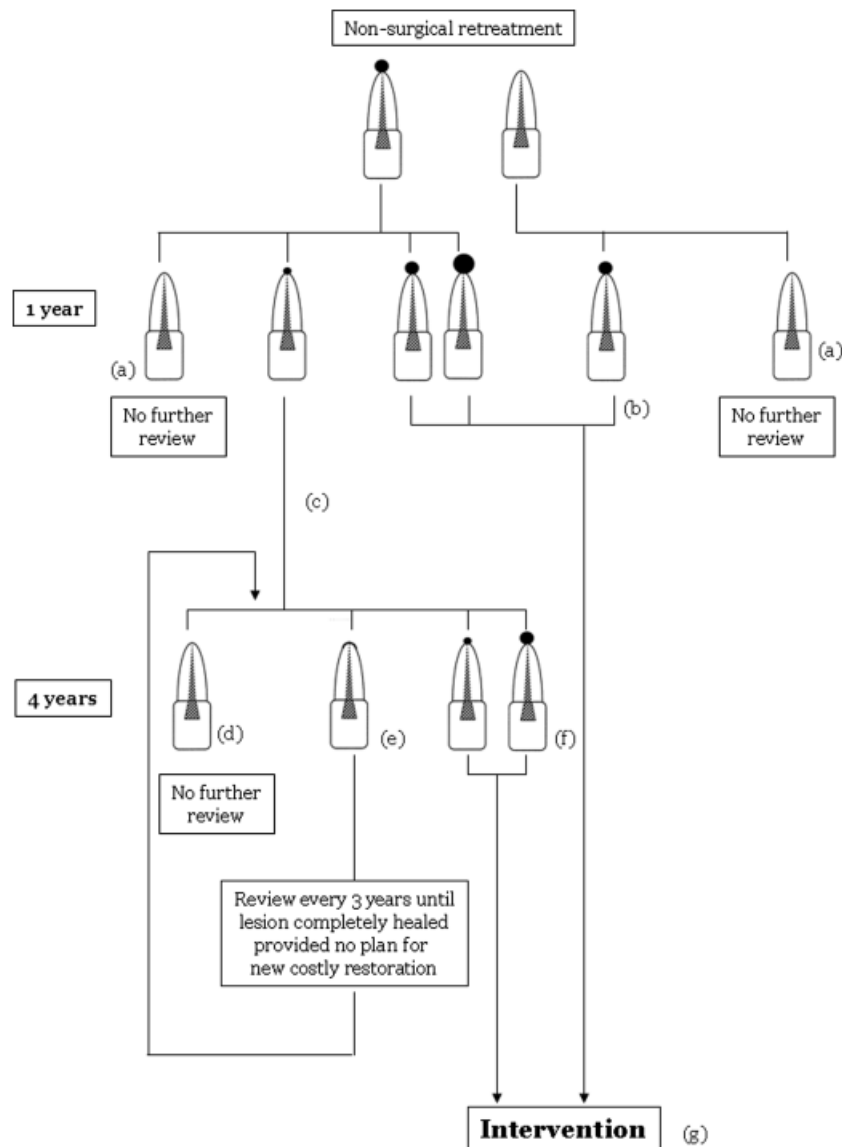


Fig. 2. Monitoring protocol for non-surgical re-treatment.

- (a) At one year after treatment, the patient is free of symptoms and the clinician, after examining the radiographs, is confident that the periapical tissues are free from pathosis, and the case is classified as healed and can be excluded from further diagnostic or therapeutic measures (12) because reversal of the healing process is believed to be rare (7, 20). In fact, no healing-reversal was observed within four years in a study of root canal re-treatment cases (21).
- (b) A new lesion emerges where there was no lesion previously, or the size of a previous lesion is unchanged or becomes larger. These events suggest no improvement in or a deterioration of periapical health. The reverse course of events, i.e. an improvement of periapical status without an intervention, is extremely unlikely (7). Therefore, an intervention is warranted.
- (c) If the lesion has not completely healed at one year, the patient is re-examined three years later (12).
- (d) The lesion has completely healed, suggesting apical periodontitis is “cured”. The tooth is then excluded from further diagnostic or therapeutic measures.
- (e) The lesion is reduced in size but has not completely healed even after four years. A periodic long-term review is recommended because as many as 50% of re-treated teeth which were observed to still have a lesion 10–17 years after treatment were completely

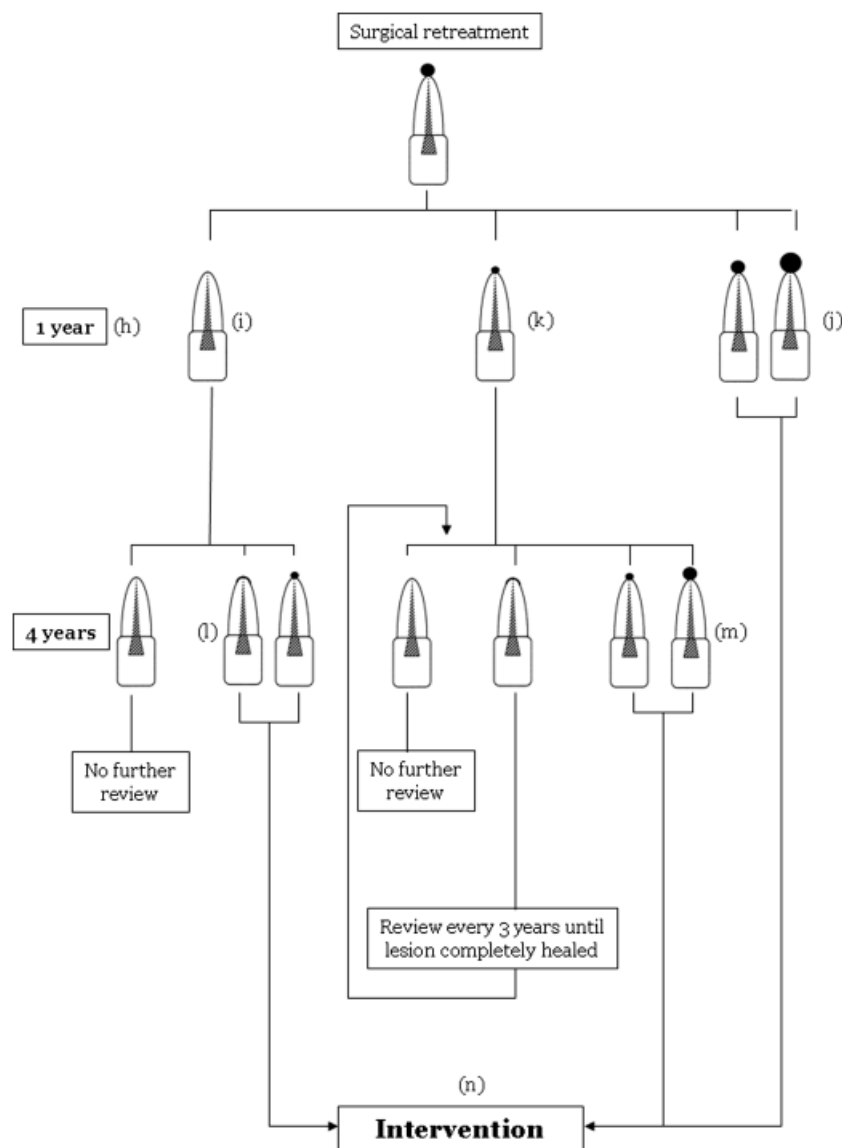


Fig. 3. Monitoring protocol for surgical re-treatment.

healed a decade later (22). The late healing was mainly characteristic of teeth with surplus root filling material (22). In addition, a thickened apical PDL space might not be indicative of unfavorable healing. Of the 22 cases recorded as thickened PDL space 10–17 years after the root canal treatment, only one case changed to an apical radiolucency 10 years later (23). Most often this radiographic appearance represents a relatively stable condition with a favorable prognosis. Perhaps complete re-establishment of normal structure will not always occur (20). Overall, a continuous reduction in the size of the radiolucency (comparing at least two follow-up examinations) may be considered as a

forecast of complete healing at a later time (8). Such evidence of late healing suggests that periodic long-term monitoring of asymptomatic teeth with residual radiolucency is warranted (8). An intervention should not be prescribed indiscriminately at four years unless dictated by a new restorative plan, which is based on practical or precautionary principles rather than biological ones. This point differs from the monitoring protocol of initial treatment cases where a four-year follow-up is recommended as a cut-off point (16). If apical periodontitis was still evident after four years, further treatment would be warranted. A long-term follow-up study of initial root canal treatment

cases after 20–27 years also supports a cut-off point by documenting a low incidence of “late healing”; after the first review at 10–17 years, only 6.4% more of the total cases had a favorable outcome at 20–27 years (24). Caution should be exercised when drawing conclusions from some studies (23, 24) because of the relatively small number of cases.

- (f) The lesion size is unchanged or grows larger; intervention is warranted as discussed previously in (b).
- (g) Despite the repeated attempts to eliminate bacteria during the re-treatment procedure, persistent apical periodontitis may still occur after re-treatment. The fact that repeated canal disinfection does not result in healing increases the probability that the disease process is sustained by factors other than intracanal infection. To address these issues, surgical endodontics may be considered the treatment of choice for persistent apical periodontitis after root canal re-treatment (8). Planned (intentional) replantation is a legitimate alternative to extraction when surgical endodontics is not feasible *in situ* (25). Although most of the clinical studies on planned replantation were conducted more than 20 years ago, survival rates were consistently reported to exceed 80% when performed in a well-controlled environment (8). Repeating orthograde root canal re-treatment for the second time is reasonable where coronal leakage is evident and the diagnosis indicates intra-radicular infection.

## Monitoring of surgical root canal re-treatment

Healing dynamics of surgical and non-surgical re-treatment are different. When all other factors are equal, the evidence suggests that the surgical approach initially provides a higher healing potential than the non-surgical. With longer observation periods, however, the reverse is true (21, 26). This is the basis for a different monitoring protocol following surgical re-treatment.

The recommended monitoring protocol herein (Fig. 3) is based on the assumption that surgical re-treatment is performed following orthograde root canal re-treatment. Generally, data on the dynamics of healing are used as the basis upon which the protocol is formulated. However, data on the dynamics of healing in such a specific scenario are not available. Available data are a mixture of surgical re-treatment after conventional root canal re-treatment and surgical re-treatment as an alternative to conventional root canal re-treatment. It is essentially the same procedure, but performed in a different sequence, aiming to achieve different things, targeting different biological causes and, as such, different healing dynamics should be expected (Figs. 4a, b and c). Unfortunately, it is impossible to accurately untangle the effects of these different approaches on healing dynamics.

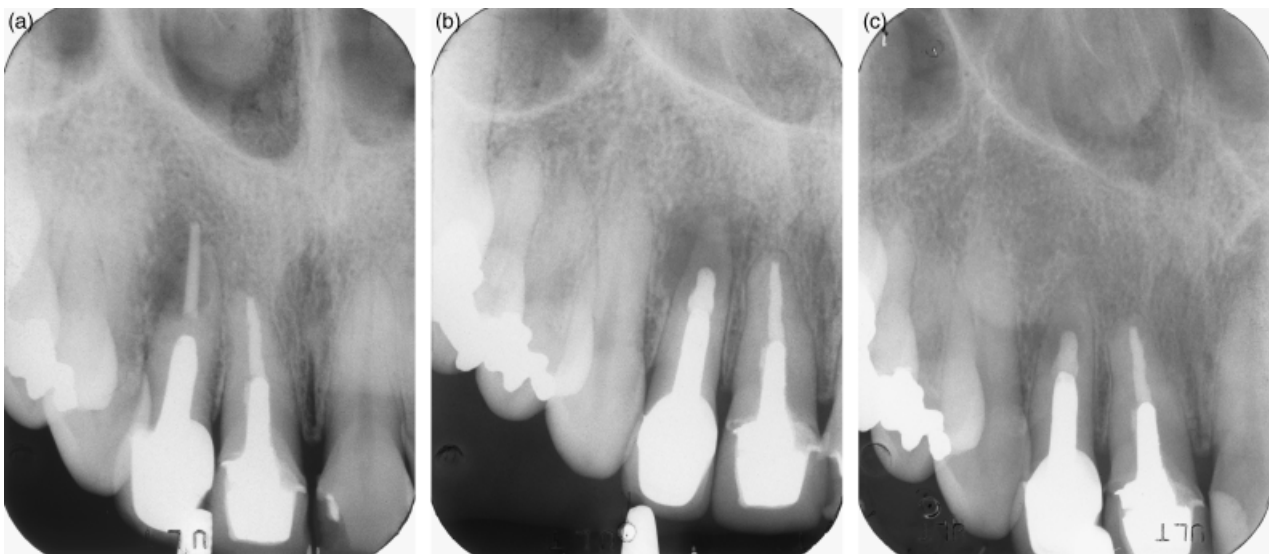


Fig. 4. (a) Maxillary lateral incisor with symptomatic apical periodontitis and extensive apical inflammatory root resorption where orthograde root canal re-treatment was contraindicated because of compromised structural integrity. (b) Immediate post-surgery appearance with EBA root-end filling into the resorptive defect, leaving the palatal wall of the resorbed root intact. (c) 10-year review, probable healing with combination of scar tissue and bone.

### Monitoring details for surgical re-treatment (Fig. 3)

Clinical signs and symptoms also take precedence over radiographic appearance in determining if an intervention is required during monitoring of surgical re-treatment as in conventional root canal re-treatment. Further, it must be noted that an occasional sequel to surgical re-treatment is apical scar formation (Fig. 5), although this can also occur subsequent to orthograde re-treatment (Figs. 6a and b). In the following discussion, this phenomenon is considered to exhibit a characteristic appearance and to be a sign of healing. This is discussed in greater detail later on in this article.

- (h) The peak incidence of healing of surgical re-treatment is also at one year after treatment (21, 27), similar to root canal re-treatment (7); hence, a recommended one-year review.
- (i-j) The majority of teeth that are associated with either healed or diseased apical tissues at one year demonstrate the same outcome at 3–5 years (27, 28).



Fig. 5. Characteristic appearance of healing by apical scar tissue following surgical management of a lesion perforating buccal and palatal cortical plates.

- (k) Based on these findings, a one-year follow-up may be considered definitive for the majority of cases, while further follow-up is required only for those cases which appear to be still healing (27, 29). However, recurrence of disease in the long-term or “late failure” has been reported in 5% to over 40% of healed cases (these did not include cases of evident coronal leakage) (21, 27, 28, 30). Further follow-up is therefore advisable even for teeth which appear healed at the one-year examination (8).
- (l) The evidence of periapical health deterioration or the development of periapical radiolucency is clear and spontaneous reversal is not expected. Intervention is therefore required.
- (m) No change or an increase in the size of the lesion suggests no improvement in or deterioration of periapical health, and intervention is required.
- (n) Provided coronal leakage is not a cause, treatment options are limited to resurgery, intentional replantation or extraction. A systematic review on the outcome of repeat endodontic surgery showed a 36–62% healing rate (31). While the healing rates were not particularly high, six out of eight studies included in this review were conducted in the 1970s with techniques, instruments, and materials that would be considered obsolete by today’s standards. With a better understanding of the biological causes of persistent apical periodontitis and the advent of the operating microscope, ultrasonic root-end cavity preparation, biocompatible root-end filling materials, and improved hemostasis techniques, higher healing rates should be expected. Although the clinical data supporting this notion (28, 32) are not yet conclusive, repeat endodontic surgery should be considered as an alternative to extraction, especially where previous surgical conditions (e.g. amalgam root-end filling) can be improved.

### Alternative concepts of non-intervention (Fig. 3n)

Continued monitoring (non-intervention) of asymptomatic functional teeth with apical periodontitis which have undergone orthograde root canal re-treatment followed by surgical re-treatment and a four-year review period has been recommended over extraction and replacement. The number of teeth that fall into this category will be very small considering the

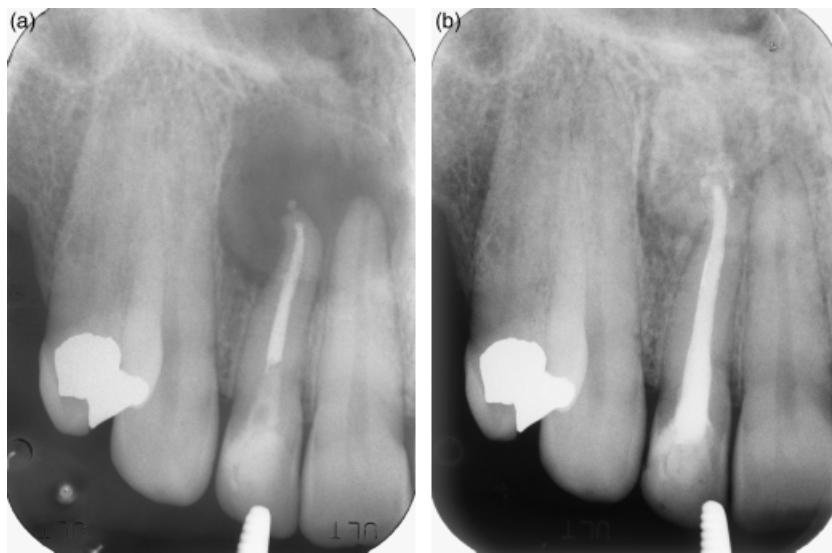


Fig. 6. (a) Maxillary lateral incisor with symptomatic apical periodontitis, managed by orthograde root canal re-treatment. (b) 4-year review indicating unusual pattern of healing with calcified tissue, possibly with some concomitant fibrous healing.

effectiveness of initial root canal treatment (33), orthograde re-treatment (8, 34), and surgical re-treatment (26). Nevertheless, the lack of guidelines for this clinical scenario warrants discussion.

In medicine, patients with chronic and debilitating disease are periodically monitored for the rest of their lives. The idea of “treatment success/patient discharged” or “treatment failure/intervention warranted” is non-existent. Rather, disease is controlled and patients are managed to live and function comfortably. Practitioners provide health care services on a continual basis. Monitoring of any disease is realistically a long-term exercise. Endodontics as a discipline may benefit from embracing the idea of chronic disease requiring long-term monitoring as in medicine and completely abolish the terms “success” or “failure” (7, 35) as treatment descriptors. As a result, communication with lay people will be more effective.

If apical periodontitis is considered a chronic disease, it may actually be unrealistic and irrelevant to assign a cut-off point or time-frame limit on healing, after which intervention will be required if complete healing does not occur.

It has been suggested that a four-year review interval is not justified and not evidence-based (36). These authors argued that in the absence of bacteria after tooth removal, complete healing can occur in the ferret model within a month (37, 38). Also, 97% of surgical endodontic cases healed within a year (39). In essence,

it was proposed that a cut-off point determining success or failure of treatment should be shorter than four years and that a persistent lesion after a year should be considered disease and treated. However, the evidence is clear that it is unlikely that bacteria will ever be entirely eradicated considering the complexities of root canal anatomy (40, 41). Indeed, it has been demonstrated that negative root canal cultures did not necessarily indicate sterility of the root canal (42). In this study, 20 infected human teeth were extracted. Canals were accessed and prepared extra-orally. External root surface sterility was carefully controlled. Root canal samples were taken and were cultured aerobically and anaerobically. Teeth were then crushed and the tooth powder was cultured. Viable bacteria were repeatedly found despite three consecutive negative cultures after complete canal preparation and medication. It should be accepted that root canal treatment aims to reduce the bacterial load below the patient’s immunological threshold. The healing process begins when the host defense can overwhelm bacteria and their by-products, not when bacteria are eradicated. In medicine, the treatment of tonsillitis with antibiotics does not aim for complete eradication of bacteria in the tonsils but rather shifting the balance in favor of the patient’s defense mechanisms and allowing the body to do the rest, i.e. heal itself. Absence of bacteria in a ferret model does not seem to fit well with clinical reality.

## Functionality

Although curing of disease is the ultimate goal of therapy, patients and health professionals often have different views on and preferences for treatment because they look at treatment from different standpoints. The direction and magnitude of these differences do not appear to be consistent and may vary with the clinical condition of interest (43).

From the patient's point of view, the burden of asymptomatic apical periodontitis can be low. The value judgement (or in this case, the burden) can be measured based on an assumption that one may "apprehend values in the act of preferring" (44). This means that, when faced with a choice, the values of individuals are reflected in their behavior preference. For example, the value of health is given in preferring it to disease (45). Using a standard gamble and rating scale technique, Reit & Kvist (45) measured the burden of asymptomatic apical periodontitis. In 29 of the 164 judgements, no value difference was recorded between these two particular health states: (a) if the tooth has a "good-quality" root filling and there are no clinical symptoms or any radiographically visible signs of periapical pathology and this situation is not expected to change for the rest of the subject's life; and (b) where the clinical scenario is identical to state (a) except that the radiograph shows a 5 mm large periapical radiolucency. Although, not surprisingly, large inter-individual variations in value judgements were found, this finding suggested that some individuals may be indifferent to chronic and non-symptomatic periapical health states (45). In practice, this study also suggested that perhaps patients' expectations should be gauged so that the management plan can be formulated accordingly.

The modern philosophy of health care gives individuals greater autonomy in their treatment choices. They are autonomous to set less demanding goals for therapy, such as prevention or elimination of symptoms, or retention of the tooth rather than *restitutio ad integrum* or the complete re-establishment of the periapical tissue, which clinicians tend to aim for. The term "functional retention" has been coined specifically to address the different goals of patients and clinicians (46). An asymptomatic functional state (where the clinical presentation is normal, while a radiolucency may be absent, present newly-emerged or persisting), although not a measure of healing, allows

the tooth to be retained without necessitating extraction. This clear benefit, even if not optimal, should be communicated to the patient when maintaining the status quo (non-intervention) is weighed against tooth extraction and replacement with an artificial prosthetic device, which might have higher risks of complications requiring further intervention (47).

A valid question that arises from this argument is why intervention is recommended when considering conventional or surgical re-treatment as a treatment of apical periodontitis, but is not recommended when considering extraction and replacement. While it is the same disease in both cases, the interventions are different and they are offered at different points in time. The risks and benefits of maintaining the status quo versus those of the interventions have to be weighed for every single clinical decision-making point. The risks of untreated apical periodontitis are the same, but the benefits and risks of re-treatment and extraction plus replacement are different. For the latter, a patient may be left with a less functional prosthetic unit requiring a more complicated maintenance regimen, which may have a greater risk of complications necessitating further interventions compared to re-treatment (47).

The natural history of (or risks of untreated) asymptomatic apical periodontitis is poorly understood. It has been estimated that an annual exacerbation rate probably does not exceed 5% (48). To our knowledge, this is the only source of information on the issue, and therefore further research is urgently required to help provide a basis for clinical decision-making.

## Scar tissue

Scar tissue poses a challenge to diagnosis and the clinical decision-making process because it may be difficult to differentiate it from a radiolucency of pathological origin (apical periodontitis). Although the overall prevalence of healing by scar tissue is not particularly high (less than 7% in surgical cases) (29), clinicians should be aware of this clinical entity and take it into account when making a clinical decision as to whether an intervention is required when an apical radiolucency is detected. Scar tissue develops when the destruction (pathologically or iatrogenically) involves a considerable portion of the buccal and/or lingual/palatal cortical plates. The periosteum has been destroyed, and dense connective tissue develops in

the cavity. Bone formation will not take place within this tissue because it has no potential to promote osteogenesis.

After the endodontic therapy (either non-surgical or surgical), apical periodontitis can heal in the form of scar tissue (49, 50). It is important to note, however, that scar tissue mainly relates to surgical treatment, and that evidence relating it to non-surgical orthograde root canal re-treatment is lacking. Radiographically, it has a round, punched-out appearance with normal bone surrounding the defect and the root apex or an asymmetric and reduced-in-size radiolucency (Fig. 5). Histologically, it is dense, collagenous, soft connective tissue which is free of any signs of inflammatory reaction, indicating no form of irritation in the area. Twenty-four cases of surgical root canal treatment were judged as “healed with scar tissue” after 2–6 years. These cases were re-examined 8–12 years after surgery; only one case turned into unsatisfactory healing (failure). The scar tissue should be regarded as a final result, a static or permanent situation (29).

## Final remarks

This review has identified a lack of evidence concerning the natural history of apical periodontitis but has interpreted and summarized the best available evidence to arrive at a clinically-realistic protocol for the monitoring of root canal re-treatments.

Whether a clinician is defining a disease, assessing probabilities, making a diagnosis, selecting a procedure, or even monitoring a treatment outcome, uncertainty creeps into clinical practice (51). As clinicians we should learn to work under the absence of absolute certainty, and we should also accept the clinical imperative that we are treating infectious disease with a complex nature (apical periodontitis) in a hostile environment (difficult and highly complex root canal anatomy) on a multifaceted human being with a unique immune system.

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