Clinical Update

The management of periapical lesions in endodontically treated teeth

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Abstract

When root canal therapy is done according to accepted clinical principles and under aseptic conditions, the success rate is generally high. However, it has also been reported that 16% to 64.5% of endodontically treated teeth are associated with periapical radiolucent lesions. There are great variations among clinicians when suggesting treatment of these failed endodontic cases. This article will discuss factors influencing treatment decisions on these particular cases, and the pros and cons of nonsurgical retreatment versus surgical retreatment. The advancement of modern endodontic microsurgery will also be discussed.

Introduction

When endodontic treatment is performed to accepted clinical standards, a success rate of around 90% can be expected (1). However, in a recent cross-sectional study of populations in various countries, the prevalence of apical periodontitis associated with root-filled teeth was reported to be as high as 64.5% (2). The two most important factors that could relate the periapical lesion in association with root-filled teeth seem to be the qualities of the root fillings (3) and the coronal restorations (4).

In recent times many practitioners have replaced failed endodontically treated teeth with implants. Are implants a better treatment option for the patient? Are we condemning these teeth too quickly?

The aim of this article is to discuss the reasons for failure of endodontically treated teeth, the current concepts in their management and also the expected treatment outcome of each treatment strategy.

As understanding the disease process is the key to successfully treating the disease, it is important to understand the biological factors that are related to the failure of endodontically treated teeth. There are five main factors that may cause persistent periapical radiolucencies of endodontically treated teeth:

1. Intra-radicular infection (5);
2. Extraradicular infection (6–8);
3. Foreign body reaction (9,10);
4. True cyst (11,12); and
5. Fibrous scar tissue (12).

Among these factors, microorganisms persisting in the root canal should respond to orthograde retreatment. However, lesions associated with extraradicular bacteria, true cysts and foreign bodies can only be managed by periapical surgery. Periapical lesions that heal by fibrous scar tissue require no treatment.

Intra-radicular infection

In most cases, failure of endodontic treatment is due to microorganisms persisting in the root canal system, even in a seemingly well-treated tooth (5). In early studies, Engstrom and Frostell and Möller reported bacterial growth in root-filled teeth with apical periodontitis (13,14). Nevertheless, the microflora in a previously root-filled tooth that has failed differs markedly from that in an infected but previously untreated root canal system. In teeth that have been previously treated, there appears to be a very limited assortment of microorganisms (14). Usually only a few species are recovered (15,16), with a
predominance of Gram-positive microorganisms and facultative anaerobes (more than obligate anaerobes) (17,18). Enterococcus faecalis was the most frequently recovered bacterial species (15–17,19) with streptococci also relatively common. Other species found in high numbers are lactobacilli (17), actinomyces species and pep-tostreptococci (18).

**Coronal leakage**

If the root canal had been unsealed at some point during the treatment, enteric bacteria are found more frequently than in canals with an adequate seal between the appointments. A third of E. faecalis cases in pure culture have also been reported (20). Pinheiro et al. reported a significant positive relationship between the absence of a coronal restoration and the presence of streptococcus spp. and candida spp. in the root canal (15). In 2004, Adib et al. attempted to identify the bacterial flora in root-filled teeth with persistent periapical lesions and a history of coronal leakage. They found the predominant group of bacteria was Gram-positive facultative anaerobes of which staphylococci followed by streptococci and enterococci were the most prevalent. Their results also showed a polymicrobial flora existed (with the number of species recovered per tooth ranging from six to 41 species) when the canal was poorly root filled (21).

**Technically unsatisfactory root fillings with periapical lesions**

In the root canals of teeth with technically inadequate root fillings and asymptomatic periapical lesions, but with an acceptable coronal restoration, one or more obligate anaerobes are usually found and the situation is similar to the infected but previously untreated teeth (22). Peciuliene et al. confirmed that there is a significant association between poorly obturated canals and polymicrobial infections (23). This is in agreement with Sundqvist et al. who reported in 1998 that the polymicrobial flora in a poorly root-filled tooth was similar to the flora found in untreated cases (16). Polymicrobial infections and obligate anaerobes were also frequently found in the canals of symptomatic root-filled teeth (15).

In summary, the microorganisms causing the initial infection persisted in poorly treated root-filled teeth with periapical lesions. In theory, if these root canals are retreated adequately under a strict treatment regimen, the success rate should be as good as endodontic treatment of the previously untreated teeth with apical periodontitis. We should expect a healing rate of around 85% to 94% (24). Periapical surgery can be avoided if orthograde retreatments are carried out in these cases. Replacement of these teeth that have a reasonable endodontic outcome with implants cannot be justified (Figs 1,2).

However, in teeth with adequate root fillings but with apical periodontitis (with or without history of coronal leakage), there is a higher chance that the pathogens would include E. faecalis and Candida albicans. The treatment regimen in these cases should be viewed differently from the initial endodontic therapy with apical periodontitis. This will be discussed later.

**Extra-radicular infection**

Histologically, there are generally two types of extra-radicular infection:

1. Acute periapical abscess – purulent inflammation in the periapical tissue in response to the egress of virulent
bacteria from the root canal. This is dependent on the intra-radicular infection; once the intra-radicular infection is treated, the extra-radicular infection should subside (25). In most cases, orthograde endodontic retreatment would thus be indicated.

2. Microorganisms become established in the periapical tissues either by adhering to the apical root surface in the form of biofilm-like structures (26) or within the body of the inflammatory lesion, usually as cohesive colonies (27). The microorganisms involved are usually members of the genus actinomyces, propionibacterium propionicum and bacteroides species (7,8,28). Once microorganisms are established in the periapical area, the infection can only be successfully treated by periapical surgery.

Foreign body reaction

Periapical lesions often contain cholesterol crystals, as seen in histopathological sections. These endogenous crystals, which are believed to be released from disintegrating host cells such as erythrocytes, lymphocytes, plasma cells and macrophages in the inflamed periapical connective tissue and/or circulating plasma lipids (29) can act as foreign bodies and provoke a giant cell reaction. Other materials that may elicit a foreign body reaction in the periapical tissues are usually exogenous in nature and include talc-contaminated gutta-percha (9), the cellulose component of paper points, cotton wool and food material of vegetable origin (30,31). Therefore, the initiation of a foreign body reaction in the periapical tissues can be either by exogenous materials or endogenous cholesterol. This is the only non-microbial factor associated with periapical lesions of endodontically treated teeth.

Currently, there are no clinical tests to diagnose the existence of these extraradicular agents associated with post-treatment periapical radiolucencies. Surgical treatment is the only way to remove these agents that can sustain the disease process. Therefore, periapical surgery should be considered a part of the treatment plan, especially in cases that do not respond to conventional orthograde retreatment.

Periapical cyst

Clinically, periapical lesions cannot be differentially diagnosed as cystic or non-cystic lesion based on conventional radiographs (32–34). An accurate diagnosis of radicular cyst is possible only histopathologically through serial sectioning of the lesion (35). In 1980, Simon described two categories of radicular cyst: true cyst, containing cavities completely enclosed in epithelial lining; and Bay cyst or pocket cyst, containing epithelium-lined cavities that are open to the root canals (36). Nair et al., in analysing 256 periapical lesions, found 35% to be periapical abscesses, 50% to be periapical granulomas, and only 15% to be periapical cysts. Among this group of 15%, 9% were true cysts and 6% were pocket cysts (35). Unlike true cysts, periapical pocket cysts may heal after non-surgical root canal therapy. The prevalence of true cysts associated with endodontically treated teeth with periapical lesion may be higher, with Nair et al. reporting about 13% of post-treatment apical lesions to be true cystic lesions (9,11,12).

Current thoughts on retreatment

The main cause of failure of endodontic treatment is generally accepted to be the continuing presence of microorganisms in the root canal system that have either resisted treatment (5) or have reinfected the root canal system through coronal leakage (4,37,38). Conventional orthograde retreatment is thus indicated in many cases to try to eliminate this persistent intra-radicular infection before surgical intervention is contemplated (Figs 3–5).

Irrigants and medicaments

Numerous studies have shown that many of our current irrigating solutions and intra-canal medicaments, including sodium hypochlorite (NaOCl) and calcium hydroxide are ineffective against C. albicans and E. faecalis (39–41) Molander et al. (17) questioned the use of calcium hydroxide in retreatment cases and Peciuliene suggested a different treatment regimen should be used to target E. faecalis in retreatment cases (23).
Chlorhexidine gluconate (CHX)

Chlorhexidine gluconate (CHX) has been proposed for use both as an irrigant and as a medicament especially in endodontic retreatment. As a medicament, it is more effective than calcium hydroxide in eliminating *E. faecalis* infection inside dentinal tubules (42). As an irrigant, it appears as effective or superior to sodium hypochlorite (NaOCl) (43–45), especially in the elimination of *E. faecalis* (45,46). Irrigating solutions of 0.5% CHX were reported to be more effective at killing *C. albicans* than calcium hydroxide, 0.5% and 5% NaOCl and 2% iodine potassium iodide (IKI) (47). Chlorhexidine also has the added advantage of substantivity with the antimicrobial activity of 2% CHX found to be retained in root canal dentine and effective against *E. faecalis* for up to 12 weeks (48).

Two per cent CHX in both gel and liquid forms performed as well as 5.25% NaOCl against *C. albicans* and *E. faecalis* (44,45,49). However, Dametto et al. demonstrated that 2% CHX gel and liquid were more effective than 5.25% sodium hypochlorite in preventing regrowth of *E. faecalis* for 7 days after biomechanical preparation of the root canals. Two per cent CHX is also less toxic than 0.5% NaOCl (50).

One *in vitro* study found 2% CHX gel produced cleaner dentine walls when compared with 5.25% NaOCl and 2% CHX liquid used as an endodontic irrigant. The viscosity of the CHX gel seemed to compensate for its inability to dissolve pulp tissue by promoting a better mechanical cleansing of the root canal and aiding the removal of dentine debris and tissue remnants (51). Other studies also suggest CHX gel has more clinical advantages than the liquid (45,51,52).

However, CHX is unable to dissolve organic matter or pulp tissue (53) and it does not remove smear layer (54). Therefore, White et al. suggested the combination of CHX and NaOCl as an irrigant to takes advantage of each individual irrigant’s properties, without impairing or compromising the substantivity of CHX and the tissue-dissolving action of NaOCl (55). This is further supported by Kuruvilla and Kamath, who showed that the combination of 2.5% NaOCl and 0.2% CHX resulted in significantly greater bacterial reduction than when each irrigant was used alone (56). Zamany et al. showed that a better disinfection of the root canals occurred when CHX was used as a final rinse after chemo-mechanical preparation with NaOCl (57).

Calcium hydroxide and chlorhexidine as a combined medicament

As calcium hydroxide is ineffective against *E. faecalis*, combining calcium hydroxide with CHX has been advocated in
recent years (58,59). CHX as an aqueous vehicle may raise the pH of the mixture during the first 2 days (60,61). However, calcium hydroxide could decrease the antibacterial activity of the CHX because of the competition between the positive charge of the CHX and calcium ions for common binding sites (negatively charged phosphate groups) on the bacterial cell wall (47,62). Therefore, calcium hydroxide powder might reduce the immediate antimicrobial efficacy of CHX (63). The substantive antimicrobial activity of CHX in human root dentine in killing E. faecalis could also be affected when it is mixed with calcium hydroxide (64,65). Gomes et al. reported that 2% CHX gel alone was more effective against E. faecalis than calcium hydroxide and its antibacterial activity depended on how long it remained inside the root canal (60). Waltimo et al. reported the combination of calcium hydroxide and 0.05% CHX to be more effective in killing C. albicans than pure calcium hydroxide. However, this combination was less effective than 0.05% CHX alone in killing C. albicans (47).

Iodine potassium iodide (IKI)

This iodine-based medicament was suggested as an endodontic medicament in the early 1970s, but its use is not widespread owing to its ability to discolour teeth. There has been renewed interest in IKI in recent years owing to its seemingly superior antibacterial properties compared with calcium hydroxide. Studies have shown that IKI was able to penetrate the dentinal tubules and was more effective than calcium hydroxide in killing E. faecalis in both in vitro (66), and in vivo studies (17,67). It was also more effective than calcium hydroxide against C. albicans. The efficacy of IKI was reduced when combined with calcium hydroxide but was still more effective than calcium hydroxide alone (47). Recently, a study also reported that calcium hydroxide mixed with iodoform and silicone oil was more effective than calcium hydroxide plus IKI and calcium hydroxide alone in killing E. faecalis (68).

MTAD

MTAD is a mixture of a tetracycline isomer, citric acid and a detergent. MTAD has been reported to be more effective than NaOCl in killing E. faecalis in vitro (69,70). Its effectiveness seems to be further enhanced when used in combination with NaOCl (71).

Rotary instrumentation

Studies have clearly shown that mechanical instrumentation alone will not predictably eliminate bacteria from an infected root canal. Rotary nickel-titanium (NiTi) instrumentation has gained popularity owing to its efficiency and ability to maintain the original canal curvature better, especially in the apical third of the root canal compared with hand instruments made of stainless steel (72,73). However, from a biological perspective, rotary instrumentation does not seem to have produced significant real advantages over hand instrumentation (74). Dalton et al. compared intra-canal bacterial reduction in teeth instrumented with 0.04 tapered NiTi rotary instruments to teeth prepared using stainless-steel K-files with the step-back technique. The study found no significant difference between the two techniques in their ability to reduce intra-canal bacteria (75). Shuping et al. used a similar experimental model to Byström and Sundqvist in 1983 (39) to evaluate the extent of bacterial reduction with nickel-titanium rotary instrumentation and 1.25% NaOCl irrigation. Their results indicate the use of NaOCl irrigation with rotary instrumentation during endodontic treatment is the more important factor in reducing bacterial numbers. However, the authors were still unable to consistently remove all the bacteria in the root canals and thus suggested the use of calcium hydroxide as an intra-canal medicament to attain the goal of total bacterial elimination more predictably (76).

In summary, the use of intra-canal medicament is still the most predictable way to eliminate bacteria in the root canal system in orthograde retreatment cases. As the use of chlorhexidine as a medicament or irrigant has clearly shown to be more effective in killing E. faecalis and C. albicans in vitro, it should therefore be used in retreatting failed endodontic cases. IKI and MTAD appear promising in early in vitro studies and they may be the medicament/irrigant of choice in the future.

Outcome of endodontic retreatment

Many studies looking at the outcome of endodontic retreatment have been published but there are probably only a handful of published studies that have met the evidence-based dentistry (EBD) criteria which were defined by American Dental Association (77). These studies reported the success rate of endodontic retreatment to be around 74–88% (78,79). Interestingly, the percentage of teeth still in ‘function’ ranged from 78% to 97%. This is a similar term to ‘implant survival’ which many implant studies have used as a measure of implant treatment outcomes. The survival rate of dental implants has been reported as ranging from 76% to 94% (80,81). ‘Survival’ or ‘functional’, however, do not necessarily equate to biological success.

Based on the literature, the factors affecting the outcome of retreatment are as follows:
1. Teeth with root canal morphology altered by previous endodontic treatment have a lower success rate (82).
2. Teeth with periapical pathosis have considerably less predictable treatment outcome (1,83).
3. The greater the size of the peripical lesion, the lower the success rate of treatment (84).
4. Preoperative perforation results in a poorer prognosis (79).
5. The outcome in ‘failed’ teeth with an adequate root filling was poorer (16,79).
6. The outcome was better if retreatment was performed to an adequate length (79).
7. The outcome was poorer when teeth had not been definitively restored (4).
8. Over-instrumentation and overfilling could delay periapical healing (85,86).

**Periapical surgery**

Periapical surgery attempts to contain any microorganisms within the canal by sealing the canal apically (at the same time the periapical lesion, if present, can be curetted and histologically investigated further). The objective is to optimise the conditions for periapical tissue healing and regeneration of the attachment apparatus.

The indications for surgical treatment can be summarised as:
1. Where retreatment is impossible owing to fractured instruments, ledges, blockages, filling material impossible to remove and so on.
2. With failure of orthograde retreatment: bacteria located in areas such as isthmuses, ramifications, deltas, irregularities and dentinal tubules may be unaffected by endodontic disinfection procedures (87,88). Bacteria may also remain in the space created by dentinal resorption owing to the periapical lesion having eluded intra-canal irrigation and medicament, as well as systemic antibiotics (89).
3. Where the prognosis of non-surgical retreatment is unfavourable or impractical (such as an extensive coronal restoration that may have to be sacrificed and remade).
4. With patients who may not prefer the routine retreatment owing to financial and/or time constraints.
5. Where biopsy is needed.

There have been great improvements in endodontic surgery in the past 20 years owing to advances in techniques, equipments and materials (90–94). The advancement of modern endodontic surgery as compare with traditional endodontic surgery is summarised in Table 1. The operating microscope enhances visibility and provides the surgeon with a better understanding of canal anatomy, a better surgical view and the ability to undertake more complex but predictable apical resection techniques. The advancement of surgical ultrasonic instruments has also allowed a more conservative, precise and coaxial root-end preparation (Figs 6–10).

**Mineral trioxide aggregate (MTA)**

Mineral trioxide aggregate was introduced as a retrograde filling material in the mid-1990s (96–98) and its use appears to have improved the clinical success of periapical surgery. The success rate for periapical surgery with MTA as the retrograde filling material has been reported to be around 84% after 12 months and 92% after 24 months, which is higher than IRM (99).

Mineral trioxide aggregate has been shown to induce hard tissue formation (100), including deposition of cementum (101,102). MTA also has an antibacterial effect on some facultative bacteria (freshly mixed and 24 h set) and *C. albicans* (103).

Apaydin et al. found no significant difference in the quantity of cementum or osseous healing associated with freshly placed or set MTA when used as a root-end filling material and thus even suggested using MTA to root-fill teeth prior to surgery (and subsequent root-end resection without the retrofilling procedure) to simplify the surgical process (104).
Prognosis of endodontic surgery

A summary of studies with an adequate level of evidence reporting on the outcome of endodontic surgery is outlined in Table 2 (105).

These studies suggest that the healing rates of periapical surgery range from 60% to 91%. Important factors that may significantly affect the outcome are summarised as follows:

1. Retrofilling: Hirsch et al. stated the retrograde filling is a major prognostic factor (112). If we accept that apical lesions result primarily from bacterial infection in the root canal, the presence/absence of an apical barrier will therefore affect the long-term prognosis of surgical treatment. The success rate can be increased by 10% to 13% if a retrograde filling is used (113–115).

Table 2. Summary of studies with an adequate level of evidence reporting on the outcome of endodontic surgery

<table>
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<tr>
<th>Follow-up years</th>
<th>No. of cases observed</th>
<th>Orthograde and surgery (%)</th>
<th>Surgery only (%)</th>
<th>Healed (%)</th>
<th>Healing (%)</th>
<th>Functional (%)</th>
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<td>Molven et al. (106)</td>
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<td>222</td>
<td>50</td>
<td>96</td>
<td>3</td>
<td>99</td>
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<td>Jansson et al. (107)</td>
<td>0.9–1.3</td>
<td>62</td>
<td>100</td>
<td>73</td>
<td>14</td>
<td>87</td>
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<td>Kvist and Reit (108)</td>
<td>4</td>
<td>45</td>
<td>100</td>
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<td>Zuolo et al. (109)</td>
<td>1–4</td>
<td>102</td>
<td>100</td>
<td>91</td>
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<tr>
<td>Rahbaran et al. (110)</td>
<td>&gt;4</td>
<td>129</td>
<td>100</td>
<td>37</td>
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<td>70</td>
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<tr>
<td>Wang et al. (111)</td>
<td>4 to 8</td>
<td>155</td>
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<td>74</td>
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2. Size of the apical lesion: The healing rate is significantly higher for teeth with smaller (<5 mm) rather than larger preoperative lesions (106, 111, 116).

3. Quality of root fillings: Teeth with preoperative long or short root fillings have a higher healing rate compared with those with adequate root fillings (111, 117).

4. Tooth location: Maxillary lateral incisors demonstrate the highest rate of healing by scar tissue (116, 118). There appear to be poorer outcomes with maxillary premolars than with anterior teeth (119); better outcomes occur for posterior teeth compared with anterior teeth (mandibular incisors have the worst outcome) (120).

5. Alveolar bone loss: Considerable loss of the bony plate or marginal bone impairs the successful outcome of periodontal surgery (112, 118, 121, 122).

6. The outcome of treatment is significantly impaired in the presence of temporary restorations (114), posts (117) and crowns (123).

Prognosis of surgical treatment versus non-surgical retreatment

There seems to be a general view that surgical retreatments have a higher failure rate (113, 124) than orthograde retreatment; however, recent studies have shown no significant difference in outcome when treating endodontic failures either by surgery or conventional retreatment (125).

In 1999, Kvist and Reit studied 95 incisors and canines that were classified as failures and which were treated either by surgical or non-surgical retreatment. They found the cases which were treated surgically had a significantly higher healing rate at 12 months. But at the final 48-month examination, no difference was found in the healing rate between teeth that were treated surgically and those treated non-surgically (108).

Importantly though, it has been shown that when teeth are retreated conventionally before periapical surgery, there is a 24% higher success rate compared with teeth where only periapical surgery is performed (116). Therefore, if orthograde retreatment can be done immediately prior to surgery, then an approximately 90% success rate can be expected (106, 118).

Recent developments in endodontic surgery such as the use of the surgical microscopes, ultrasonic retrofills, and new retrofilling materials should enable us to achieve a more predictable surgical treatment outcome and thus a higher success rate. Maddalone and Gagliani reported modern surgical endodontic procedures with EBA root-end fillings were successful over 3 years in 92.5% of cases (126). Rubinstein and Kim (127) reported a 91.5% success rate over 5–7 years. These percentages are significantly better than those quoted in the earlier studies of endodontic periodontal surgery (94, 99, 126, 128).

In summary, the best success rate can be achieved if orthograde retreatment is done first followed by periapical surgery, if indicated. Endodontic surgery should be carried out with the aid of a surgical microscope, micro-instruments and ultrasonic instrumentation, and a retrograde filling material should be placed.
Retreatment, surgery or extraction?

Once the initial diagnosis is established, the clinician should undertake the appropriate treatment based on the understanding of the disease process. As persistent intraradicular infection appears to be the major cause of post-treatment disease, conservative orthograde retreatment should be our first treatment choice. However, as the bacterial flora is different from the flora found in a previously untreated tooth, we should establish a different medication regimen to achieve a better outcome. An even better outcome would also be achieved for surgical treatment if the tooth can be retreated conservatively first.

However, retreatment might be time-consuming and costly if replacement of an extensive restoration is required. Periapical surgery may be the most practical treatment option for managing these cases. With the advances of our surgical techniques, the outcome of surgical endodontic treatment appears to be more promising and more predictable than before (Figs 11–15).

Our patients should also provide an input in the decision process. Friedman in 2000 emphasised the important role of the clinician in providing the patient with information and facilitating their choice of the appropriate treatment option (129). This is important, as the involved treatment may be lengthy and expensive. For example, the surgical option would be favoured if the patient is reluctant to undergo a retreatment process which could be relatively more complex and time-consuming. However, the patient should also understand and accept the possible compromised long-term prognosis of a surgical procedure.

Figure 11 Periapical lesion associated with tooth 21 restored with a post-core crown.

Figure 12 Surgical access to the infected root apex of tooth 21.

Figure 13 Surgical retrograde preparation of the root apex of tooth 21, showing the apical end of the post. The image was taken under high magnification through a microscope with the help of a surgical micro-mirror.
alone. When the motivation for retaining the tooth is lacking, then extraction and perhaps replacement with an implant maybe the most appropriate treatment option (Table 3). Effective communication before treatment decisions will avoid future misunderstandings, disappointment and possible litigation.

**Conclusion**

Our greater understanding of post-endodontic treatment disease and technological advances has enabled us to manage these cases more effectively. Many endodontically treated teeth that have failed still have a reasonable chance of success if they are managed appropriately. The extraction of these teeth and subsequent replacement by implants does not seem justified when one considers the favourable prognosis of retreatment and the biological costs of implant replacement. A more careful and thoughtful approach in assessing and treatment planning each case, with the patient being involved in the decision-making, is strongly recommended.

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