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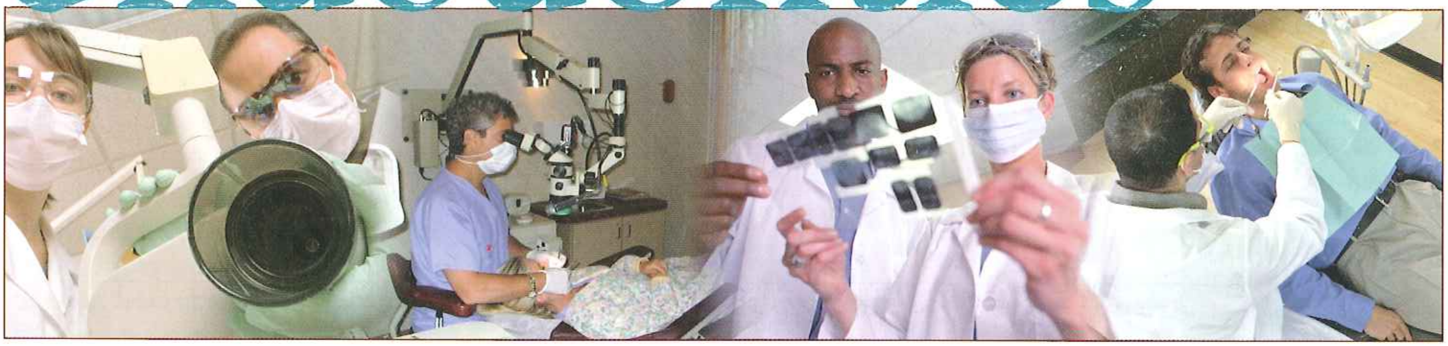

## Treatment Outcome in Endodontics: The Toronto Study

The goal of endodontic treatment is to prevent or treat apical periodontitis (AP), which is caused by an infection of the root-canal system. But epidemiologic studies have shown that 33–60% of root-filled teeth in the population present with AP, suggesting either that the primary infection persists or that new infections emerge after treatment. Apical surgery typically involves periapical curettage followed by root-end resection and root-end filling. However, when bacteria colonize within the entire root-canal system, the root-end filling might not effectively prevent persistence or recurrence of AP after surgery, the result of continued egress of irritants from the root-canal system into the periapical tissues. Consequently, complete healing after apical surgery has been reported in 37–97% of teeth. This wide range of reported outcomes, primarily caused by differences in methodology, obscures the evidence base for the outcome of apical surgery.

Barone et al from the University of Toronto, Ontario, reported on the Toronto study, a 5-phase investigation that assessed healing 4–10 years after apical surgery and identified significant outcome predictors in the pooled samples of all 5 phases. The inception cohort comprised 88 patients who had undergone apical surgery between 1998 and 2003.

Surgeries were performed with the aid of an operating microscope (OM). Using standard data sheets, all clinical and radiographic data pertaining to each treated tooth before and immediately after treatment were recorded. Patients were recalled 4–10 years after treatment for follow-up examination.

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Among the 134 examined teeth in the pooled sample, the authors found the following:

- A total of 99 teeth (74%) were completely healed.
- Among the 35 teeth (26%) with persistent apical lesions, the size of the radiolucency was diminished in 14 teeth, remained unchanged in 5 teeth and increased in 16 teeth.
- Clinical signs or symptoms were recorded in 8 of 35 diseased teeth.

Among the 134 teeth, 124 (94%) were classified as functional. Examination of 5 teeth with persistent disease showed them to be fractured, and they were excluded to avoid their confounding effect on the investigation. A multivariate analysis of the pooled sample showed an increased risk of persistent disease associated with the following 3 variables (Table 1):

- age <46 years
- adequate root-filling length
- crypt size >10 mm

### Conclusion

In summary, 99 of 134 teeth (74%) were completely healed 4–10 years after apical surgery was performed at a university graduate clinic using current techniques. An additional 14 teeth were classified as "healing," bringing the favorable group of "healing and healed" to 84%. All in all, 94% were classified as functional.

*Barone C, Dao TT, Basrani BB, et al. Treatment outcome in endodontics: the Toronto Study—phases 3, 4 and 5: apical surgery.* J Endod *2010;36:28-35.*

**Table 1.** *Logistic regression model identifying significant predictors of persistent disease in the pooled sample*

| Prognostic variable | OR estimate of persistent disease | 95% CI | p value |
|---|---|---|---|
| Age (0 = >45 years; 1 = ≤45 years) | 2.5 | 1.01–6.00 | .047 |
| Preoperative root-filling length (0 = inadequate; 1 = adequate) | 3.4 | 1.34–8.76 | .010 |
| Intraoperative crypt size (0 = ≤10 mm; 1 = >10 mm) | 1.9 | 1.19–3.16 | .008 |

*OR, odds ratio; CI, confidence interval.*

## Histologic Characterization of Regenerated Tissues Inside the Root Canal

Apexification has been the accepted procedure to treat immature teeth with periapical disease. It has recently been shown to be possible to treat such a tooth in a way that promotes the ingrowth of new vital tissue into the pulp space. However, the nature of this new-grown tissue is unclear.

This histological approach takes only 2 to 3 visits within a span of a few weeks, and it gains root thickness and, potentially, root length. Overall, the histological approach appears to be superior to apexification, which takes multiple visits during a 1- to 1.5-year time span. Although the recent modification of apexification using mineral trioxide aggregate as the apical plug saves time, the outcome measure still falls short, considering the gain of root thickness and length. Thus, it has been proposed that apexification is no longer the treatment of choice for immature teeth with apical periodontitis.

Based on the samples of a previously reported study on dogs, Wang et al from Columbia University, New York, further investigated histologically the types of tissues that had grown into the canal space. Using 60 double-rooted premolars from 6 mixed breed dogs, the authors divided the premolars into 4 experimental groups and 1 negative control group. The teeth were monitored radiographically for 3 months, after which the animals were euthanized and tissues harvested for examination.

The authors found that the canal dentinal walls were thickened by the apposition of newly generated cementum-like tissue (intracanal cementum [IC]). One specimen showed partial survival of pulp tissue juxtaposed with fibrous connective tissue that formed IC on canal dentin walls. The IC may also form a bridge at the apex, in the apical third or middle third of the canal. The root length in many cases was increased by the growth of cementum.

The generation of apical cementum (AC) may occur despite the presence of inflammatory infiltration at the apex or in the canal. These cementum or cementum-like tissues were similar to cellular cementum. Bone or bone-like tissue was observed in the canal space in many cases and is termed intracanal bone (IB). Connective tissue similar to periodontal ligament was also present in the canal space surrounding the AC and/or IB.

### Conclusion

In the dog model, the revitalization approach for managing immature permanent teeth with infected pulp and/or apical periodontitis allows ingrowth of vital tissue resembling cementum, periodontal ligament and bone. These tissues are not pulp tissue nor do they function like pulp tissue. At least in the dog model, revitalization is not tissue regeneration but wound repair.

*Wang X, Thibodeau B, Trope M, et al. Histologic characterization of regenerated tissues in canal space after the revitalization/revascularization procedure of immature dog teeth with apical periodontitis*. J Endod 2010; 36:56-63.

## Modern Technique For Surgical Endodontic Treatment

Surgical endodontic treatment aims to prevent bacteria and their by-products from invading the infected root-canal system into the periradicular tissues. This process would perpetuate the inflammatory process in the affected apical tissues. Surgical endodontic treatment is indicated when nonsurgical retreatment is impractical or unlikely to improve the previous results, or when a biopsy is needed.

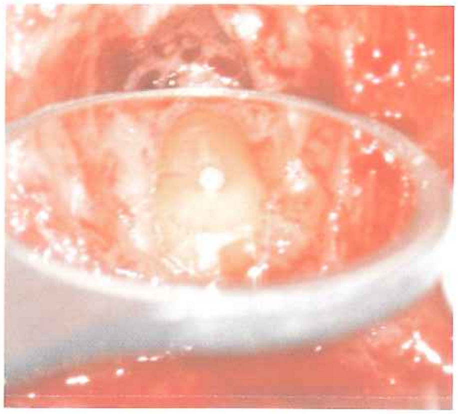

**Figure 1.** Clinical photograph of surgical site viewed through the OM. The root end has been beveled at a near 0° angle. (*Photograph courtesy of Dr. Fred Barnett.*)

Traditional surgical endodontic treatment is performed by means of root-end resection with a 45° bevel, retrograde preparation with a bur and the placement of a root-end filling. This technique has a reported 60% success rate; the unpredictable outcome might be related to the difficulties in locating, cleaning and sealing the apical part of the root-canal system with less-than-optimal visualization.

The introduction of the dental operative microscope (OM) in the early 1990s led to a new era in surgical endodontics. The modern surgical endodontic treatment uses a dental OM to allow a more precise procedure with no or minimal bevel of root-end resection and retrograde canal preparation with the aid of an ultrasonic tip to a depth of 3–4 mm (Figure 1).

The advantages of this modern technique include easier identification of root apices, smaller osteotomies and shallower resection angles that preserve cortical bone and root length. In addition, a resected root surface under high magnification and illumination readily reveal more isthmi, canal fins, microfractures and lateral canals.

The modern technique has shown a much higher success rate compared with the traditional technique. However, in numerous published studies, the treatment protocols were variable. These significant differences in study designs and treatment protocols make it difficult to evaluate the factors influencing the outcome and to establish an acceptable protocol for the modern surgical endodontic treatment.

Tsesis et al from Tel Aviv University, Israel, reviewed the literature to evaluate the outcome of surgical endodontic treatment performed by a modern technique and to evaluate the factors influencing the outcome. To perform this meta-analysis, a literature search was undertaken to identify prospective case series or randomized clinical trials that deal with surgical endodontic treatment.

The meta-analysis showed that successful outcome at a follow-up of >1 year postoperatively was 91.6%. Age, gender, tooth type, root-end filling material and magnification type had no significant effect on the proportion of success.

### Conclusion

Surgical endodontic treatment performed with a modern technique is highly predictable, with a success rate >90%. Additional large-scale studies are needed to evaluate possible predictors of success or failure.

*Tsesis I, Faivishevsky V, Kfir A, Rosen E. Outcome of surgical endodontic treatment performed by a modern technique: a meta-analysis of literature*. J Endod 2009;35: 1505-1511.

# Eradication of *Enterococcus Faecalis* Biofilms

The microbial flora found in teeth with primary endodontic disease are quite different from those in teeth with persistent disease. *Enterococcus faecalis* are the most commonly isolated bacteria from root canals of these failing teeth. Their ability to grow as a biofilm impedes their elimination when traditional irrigating solutions are used.

Biofilms are microbial communities of surface-attached cells embedded in an extracellular polymeric matrix (Figure 2). This matrix produces mechanical stability of the biofilm, and it might impede any direct contact of antimicrobial agents with the microorganisms, thereby diminishing their bactericidal efficacy.

Several irrigating solutions have been used during the treatment of infected root canals. Traditionally, sodium hypochlorite and EDTA have been used and, more recently, chlorhexidine (CHX) has been recommended.

Ideal properties of endodontic irrigants should include tissue-dissolving and antimicrobial properties. These traditional irrigants have shown variable effectiveness against root-canal biofilms. Therefore, it is necessary to search for biofilm removal strategies that are not only active against microorganisms but also exert an effect on the extracellular matrix.

Cetrimide is a cationic surfactant that produces little tissue irritation and reduces the surface tension of liquids, thereby facilitating their entry into places difficult to access. It also has the ability to decrease the biofilm's mechanical stability.

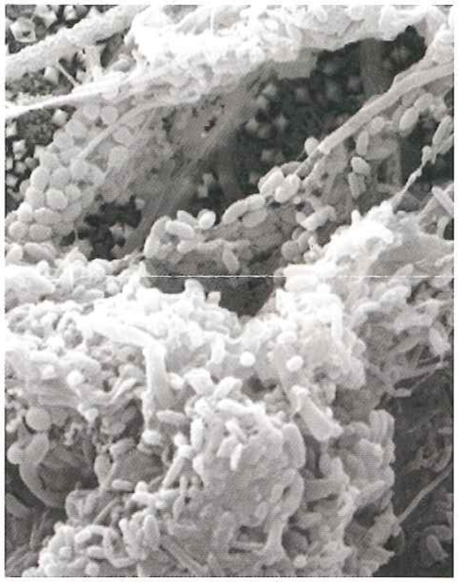

**Figure 2.** Microscopic view of *E faecalis* biofilm. (*Photograph courtesy of Dr. Fred Barnett.*)

Arias-Moliz et al from the University of Granada, Spain, assessed the efficacy of cetrimide and CHX, alone and in combined and alternating form, to eradicate biofilms of *E faecalis*. Biofilms grown in a minimum biofilm eradication concentration–high-throughput device for 24 hours were exposed to irrigating solutions for 30 seconds, and at 1 and 2 minutes. Eradication was defined as 100% kill of biofilm bacteria. The Student *t*-test was used to compare the efficacy of the irrigants.

Cetrimide eradicated *E faecalis* biofilms at the following times and concentrations:

- 0.05% concentration at 30 seconds of contact time
- 0.0312% concentration at 1 minute of contact time
- 0.0078% concentration at 2 minutes of contact time

CHX did not eradicate the biofilms at any of the concentrations or times assayed. The association of 0.1% and 0.05% cetrimide with any concentration of CHX, whether in combined or alternating application, effectively eradicated *E faecalis* biofilms at all contact times tested.

Eradication was also achieved with 0.02% and 0.01% cetrimide at 2 minutes. Statistical analysis revealed significantly better results with alternating rather than combined use of cetrimide and CHX ($p < .05$).

### Conclusion

The associated use of cetrimide and CHX produced better results against *E faecalis* biofilms than their applications as single agents. In addition, the alternating application was significantly more effective than the combined mode of application.

*Arias-Moliz MT, Ferrer-Luque CM, González-Rodríguez MP, et al. Eradication of* Enterococcus faecalis *biofilms by cetrimide and chlorhexidine.* J Endod *2010;36:87-90.*

### In the next issue:

- Treatment outcome of mineral trioxide aggregate
- Fracture necrosis
- Does mechanical agitation improve effectiveness of chlorhexidine against biofilm?

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