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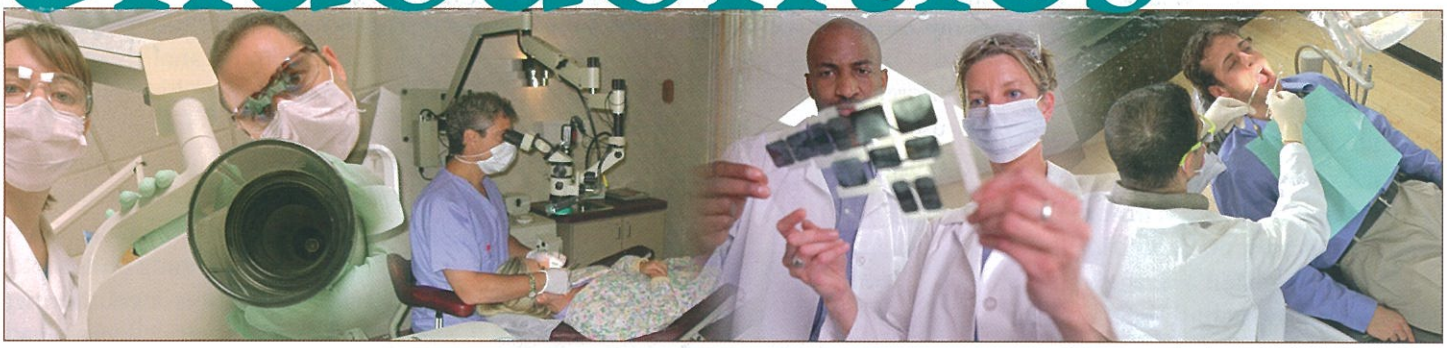

Root-canal Morphology of the Maxillary First Molar

Successful root-canal therapy requires a thorough knowledge of root and root-canal morphology. It is generally accepted that the most common form of the permanent maxillary first molar has 3 roots and 4 canals. The broad buccolingual dimension of the mesiobuccal root and associated concavities on its mesial and distal surface is consistent with the majority of the mesiobuccal roots, having 2 canals, while there is usually a single canal in each of the distobuccal and palatal roots. A wide range of variation is reported in the literature with respect to frequency of occurrence of the number of canals in each root, the number of roots and incidence of fusion. A number of factors contribute to the variation. The root-canal morphology of teeth is often extremely complex, as illustrated by 3-dimensional (3D) models (Figure 1). Variations may be the result of ethnic background, age and gender of the population studied.

Cleghorn et al from Dalhousie University, Halifax, Nova Scotia, reviewed the literature concerning the root and canal systems in the maxillary first molar. Root anatomy studies were divided into laboratory studies (in vitro), clinical root-canal system anatomy studies (in vivo) and clinical case reports of anomalies. More than 8400 permanent maxillary first molars were analyzed in the studies included in this review. The data were analyzed and weighted averages determined for each of the following:

1. Number of roots and the incidence of root fusion;
2. Number of canals and apical foramina for the mesiobuccal root, distobuccal root and the palatal root;
3. Incidence of C-shaped canals; and
4. Summary of case reports of other anomalies.

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The data from 4 anatomical studies indicated that the maxillary molar normally has 3 roots (96%). The canal morphology of the distobuccal and palatal roots was reported in 14 studies that included 2576 teeth. The most common canal system configuration of the distobuccal root was a single canal (98%) with a single apical foramen (98%). The palatal root has a single canal and a single foramen (99% and 98.8%, respectively).

The internal canal morphology of the mesiobuccal root of the maxillary first molar of 8399 teeth was assessed in 34 studies. Two or more canals were present in 57% of the teeth in a weighted average of all 34 studies. One canal was found in 43%. A single apical foramen was found in 62%, while 2 separate apical foramina were present in 38%.

The increasingly common use of microscopes or loupes in recent clinical studies has resulted in increased clinical detection of the second mesiobuccal (MB2) canal. The effect of magnification on the incidence of MB2 was assessed in a clinical study by Buhrley et al (2002). The MB2 canal was found in 71% of cases when using a microscope. The group using loupes found MB2 in 63% of cases, whereas the lowest incidence of finding MB2, 17%, was found by the group performing root-canal treatment without any magnification. Stropko (1999) observed that by scheduling adequate clinical time, by using the recent magnification and detection instrumentation aids, and by having thorough knowledge of how and where to search for MB2, the rate of location can approach 93% in maxillary first molars.

Conclusion

The maxillary first-molar root is predominantly a 3-rooted tooth. Internal root-canal system morphology reflects the external root anatomy. Failure to detect and treat the second MB2 canal system has been shown to result in a poorer long-term prognosis. The mesiobuccal root of the maxillary first molar contains a double root-canal system more often than a single canal. The discovery of 2 canals appears to be increasing with the more routine use of the surgical operating microscope and other aids during the endodontic access opening procedure.

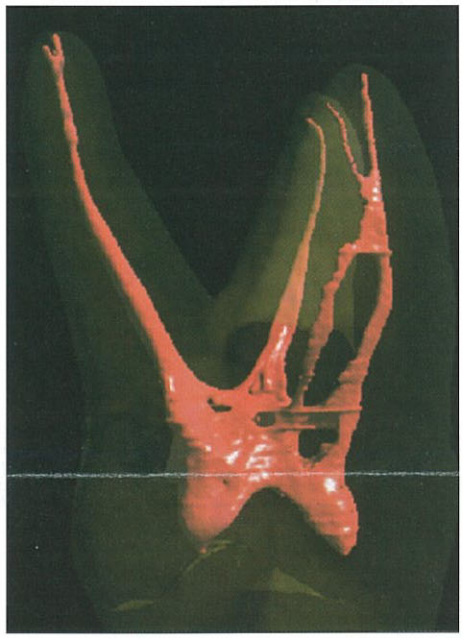

Figure 1. Mesial view of the root-canal system of a maxillary first molar (MB root is at far right). (Reprinted with permission from Brown P, Herbranson E. *Dental anatomy & 3D tooth atlas version 3.0.* Quintessence Publishing, 2005.)

Cleghorn BM, Christie WH, Dong CCS. Root and root canal morphology of the human permanent maxillary first molar: a literature review. J Endod *2006;32:813-821.*

Comparison of Endodontic Treatment and Single-tooth Implants

One of the main objectives in dentistry is the prevention of oral disease and the preservation of natural dentition, frequently achieved with root-canal treatment. When this is not possible, implants play a significant role for patients who have lost their teeth or have hopeless teeth due to periodontal or restorative concerns. There is considerable variation in treatment planning philosophy among clinicians when encountering patients with endodontically involved teeth and a questionable prognosis.

Deciding between retention of these teeth vs extraction and implant treatment requires a careful evaluation of the pre-, intra- and postoperative factors that may influence the outcome of the proposed treatment. Tooth variables (periodontal, restorative and endodontic status), implant variables (site and bone quality/quantity) and patient variables (systemic health status, economics, compliance and motivation) must also be considered.

Doyle et al from the U.S. Air Force, Langley Air Force Base, Virginia, retrospectively compared the outcomes of single-tooth implant restorations with matched teeth receiving initial nonsurgical root-canal treatment (NSRCT) and restoration. Data for this study were obtained from patients treated at the University of Minnesota School of Dentistry from 1993–2002. The authors compared 196 implant restorations and 196

Table 1. *Outcome by group*

Outcome	NSRCT*	Implant†
Success	82.1%	73.5%
Survival	8.2%	2.6%
Survival with intervention	3.6%	17.9%
Failure	6.1%	6.1%

**Success: no periapical lesion and free of clinical symptoms. Surviving: present in the mouth, uncertain healing and those that had subsequent posttreatment intervention. Failure: tooth was extracted or planned for extraction.*

†Success: radiographic healing, functional and free of clinical symptoms. Surviving: present in the mouth with subsequent posttreatment intervention or adjunctive procedures. Failure: implant was removed or planned for removal.

matched initial NSRCT teeth in patients for 4 possible outcomes: success, survival, survival with subsequent treatment intervention and failure (Table 1). Cross classifications/tabulations were analyzed using Pearson's χ^2 test for association of the 2 classifications (endodontic treatment vs implant and outcome).

The authors found that restored endodontically treated teeth and single-tooth implant restorations have similar failure rates, although the implant group showed a longer average and median time to function. There were also more postrestoration complications, such as prosthetic complications, requiring subsequent treatment intervention in the implant group.

Conclusion

Implant reviews have stated that prosthetic complications are quite frequent and patients should be made aware of the potential complications when deciding between treatment alternatives. Knowledge of the clinical complications that can occur with treatment facilitates the communication of realistic expectations to patients and aids in planning time intervals needed for posttreatment care.

Doyle SL, Hodges JS, Pesun IJ, et al. Retrospective cross sectional comparison of initial nonsurgical endodontic treatment and single-tooth implants. J Endod *2006;32:822-827.*

NaOCl/MTAD vs NaOCl/EDTA for *Enterococcus faecalis*

Mechanical instrumentation of the root-canal system without irrigation reduces but does not predictably eliminate bacteria in the canal. Thus, a root-canal irrigant is needed to aid in debridement and disinfection. Various concentrations of sodium hypochlorite (NaOCl) have been used as root-canal irrigants for decades; the main advantages are its ability to dissolve necrotic tissues and its antibacterial properties against most microorganisms. The combined use of EDTA and NaOCl has been recommended for smear-layer removal and has been shown to be more effective at killing bacteria than NaOCl alone.

Biopure MTAD (Dentsply, Tulsa, Okla.) is a mixture of doxycycline, citric acid and Tween 80 (a detergent). When used as a root-canal irrigant, MTAD has been reported to safely remove the smear layer and effectively eliminate *Enterococcus faecalis*, a commonly recovered microbe in failing root canals. It has been reported that using MTAD as a final rinse, in combination with 1.3% NaOCl as a root-canal irrigant, is significantly more effective than 5.25% NaOCl with 17% EDTA in disinfecting root canals contaminated with whole saliva or with *E. faecalis*.

In an in vitro study, Kho and Baumgartner from the Oregon Health & Science University compared the antimicrobial efficacy of irrigating with 1.3% NaOCl/Biopure MTAD vs 5.25% NaOCl/15% EDTA in the apical 5 mm of roots infected with *E. faecalis*. Twenty-five bilaterally matched pairs of human teeth were sterilized and then inoculated with *E. faecalis*. Teeth were randomly assigned to either the NaOCl/MTAD or NaOCl/EDTA groups. After chemomechanical root-canal preparation, the root-ends were resected and pulverized in liquid nitrogen to expose *E. faecalis* in dentinal tubules or other recesses away from the main root-canal system. The number of colony-forming units (CFUs) of *E. faecalis* per milligram was determined from the pulverized root-ends (Table 2). Statistical analysis showed no significant differences between the 2 experimental groups.

Conclusion

This and other studies have shown that disinfection of root dentin is not achieved by chemomechanical prep-

Table 2. *Mean CFU/mg*

Irrigation	Mean CFU/mg	SD
5.25% NaOCl/15% EDTA	1.31×10^2	2.91×10^2
1.3% NaOCl/Biopure MTAD	1.87×10^2	2.37×10^2
Saline	3.77×10^2	3.02×10^2

No significant differences between all groups.

aration alone. Bacteria deep in dentinal tubules are apparently protected from instrumentation and irrigation, making their removal or eradication difficult. The results of this study showed no significant differences in the antimicrobial efficacy of irrigating with 1.3% NaOCl/Biopure MTAD vs 5.25% NaOCl/15% EDTA in the apical 5 mm of roots infected with *E. faecalis*.

Kho P, Baumgartner JC. A comparison of the antimicrobial efficacy of NaOCl/Biopure MTAD versus NaOCl/EDTA against Enterococcus faecalis. J Endod *2006;32: 652-655.*

Electronic Apex Locators and Pulp Testers on Patients With Implanted Cardiac Devices

The increasing use of implanted cardiac pacemakers (ICPs) and cardioverter/defibrillators (ICDs) raises concern about electrical interference that might cause device dysfunction or patient harm. In endodontics, the electric pulp tester (EPT) and electronic apex locator (EAL) are routinely used. Both of these devices apply an electric current directly to the patient's oral tissues. With approximately 16 million root-canal procedures being performed every year, it is likely that patients with ICPs/ICDs needing endodontic care will be encountered frequently.

ICDs and most ICPs sense the intrinsic cardiac electrical activity and deliver appropriate electrical therapy to the heart when indicated. Electromagnetic interference (EMI) may affect the function of these cardiac devices. Currently, EALs and EPTs are not recommended for use on patients with ICPs, but no current recommendations from the manufacturers exist for their use on patients with ICDs. Manufacturers of EPTs and EALs warn against using these devices on patients with ICPs based on speculation of potential risk of EMI rather than on scientific evidence. Therefore, Wilson et al from Oregon Health & Science University conducted a study to evaluate possible interactions of EPT/EAL use on ICPs/ICDs in adult patients.

Twenty-seven patients with ICPs or ICDs had continuous electrocardiogram monitoring and device interrogation to detect interferences during the use of 2 types of EALs and 1 EPT. The following data were obtained for each patient: age, gender, type of implanted cardiac device, manufacturer, date of implant, indication for original implant, and number and position of leads. The dental devices tested were Root ZX, an EAL (Morita Corp., Irvine, Calif.); and Endo Analyzer Model 8005, a dual-function EAL/EPT (Sybron Endo, Orange, Calif.).

With the telemetry wand in place, the surface and intracardiac electrocardiograms were continuously printed during testing, which consisted of 7 phases each lasting 30 seconds. During the test, heart rhythm was continuously observed by a cardiologist. Phase 1 was recorded at rest to serve as a baseline of normal device function. Phase 2 was recorded during stimulation with the Root ZX, followed by phase 3 without stimulation. Phase 4 was during stimulation with the Endo Analyzer in the EAL mode, followed by phase 5 without stimulation. Phase 6 was during stimulation with the Endo Analyzer in the EPT mode, followed by phase 7 without stimulation. Following all recordings, each device was checked for program changes, mode switching or tachyarrhythmia sensing, and all tachyarrhythmia therapies were enabled.

There were no periods of abnormal detection by any pacemaker, no ICD detected any tachyarrhythmia and no artifacts were observed on any of the intracardiac electrocardiograms. No patient experienced palpitations or any cardiovascular symptom. Based on these findings, the authors concluded that EALs/EPTs are safe for use in patients with ICPs/ICDs.

Conclusion

This study was limited to a relatively small patient sample size and definitely not adequate to claim that no device in any patient would result in complications. However, the findings add confidence to allow more widespread study of interactions between these devices and challenge the manufacturers' claim that they not be used with ICPs/ICDs.

Wilson BL, Broberg C, Baumgartner JC, et al. Safety of electronic apex locators and pulp testers in patients with implanted cardiac pacemakers or cardioverter/defibrillators. J Endod *2006;32:847-852.*

In the next issue:

- Bonding in the root-canal system
- Extended apical root-canal enlargement
- One-visit vs 2-visit endodontic therapy: a review

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