Endodontic failure caused by inadequate restorative procedures: Review and treatment recommendations

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A review of the literature was performed to determine whether prompt placement of coronal restorations, including sealing and placement of posts and cores, can positively influence the long-term prognosis of teeth after root canal therapy. Both hand and MEDLINE searches were employed to identify peer-reviewed articles on radicular apical integrity after coronal restorations, especially where root canal space was used for post and core fabrication. A total of 41 articles published between 1969 and 1999 (the majority from the 1990s) were reviewed. The literature suggests that the prognosis of root canal–treated teeth can be improved by sealing the canal and minimizing the leakage of oral fluids and bacteria into the periradicular areas as soon as possible after the completion of root canal therapy. (J Prosthet Dent 2002;87:674-8.)

The biological rationale for endodontic treatment has been studied extensively. Recently, attention has focused on procedures performed after the completion of root canal treatment (RCT) and their impact on the prognosis of root canal therapy. These procedures may result in delayed failures by allowing the passage of microorganisms and their by-products into the apical portion of the root and into the alveolar bone.

Ray and Trope[1] evaluated the relationship between the quality of coronal restorations and coronal obturation by examining periapical status radiographs of endodontically treated teeth. They observed that a combination of good coronal restorations and endodontic treatment resulted in fewer periradicular inflammatory lesions, whereas poor coronal restorations and endodontic treatment resulted in the absence of periradicular inflammation in only 18.1% of the teeth examined. Furthermore, when poor endodontic treatments were followed by good permanent restorations that radiographically appeared sealed, the resultant success rate was 67.6%. The authors concluded that apical periodontal health depends significantly more on the coronal restoration than on the technical quality of the endodontic treatment.

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During and after the restoration of endodontically treated teeth, contamination of the root canal can occur. A review of the literature was undertaken to identify treatment pitfalls that may compromise the long-term prognosis of teeth with radiographically well-performed endodontic treatments and good coronal restorations. A total of 41 references published in refereed journals between 1969 and 1999 (the majority from the 1990s) were identified through hand and MEDLINE searches. The following influences on apical seal and periapical integrity were reviewed: microleakage of saliva, microleakage after post space preparation, microleakage after post cementation, placement of provisional restorations, placement of permanent restorations, and use of endodontic disinfectants.

MICROLEAKAGE OF SALIVA

Periapical periodontitis may be caused by either bacteria or endotoxins, the latter being cell wall fragments of Gram-negative bacteria that possess potential inflammatory characteristics. It has been shown that endotoxins from mixed bacterial communities can penetrate the root canal system easily and more quickly than bacteria.[2,3]

Salivary microleakage is considered a major cause of endodontic failure due to bacteria and endotoxin penetration along the root canal filling.[4,5] Magura et al[6] assessed salivary penetration through obturated root canals in vitro with 2 methods of analysis: histological stainings (hematoxylin and eosin stain and Brown and Hopps stain) and dye penetration. A significantly greater penetration of saliva was observed after 3 months of incubation than after only 1 month. Khayat et al[7] isolated microorganisms from obturated root canals after 22 days of exposure to saliva. Both lateral and vertical condensation methods of obturation were

evaluated in their study. Leakage of obligate anaerobes and bacterial metabolites along laterally condensed root canals was demonstrated by Chailertvantikul et al.[8,9] In these studies, no significant differences were observed between root canals obturated with gutta-percha (GP) cones and with different sealers.

Based on the literature, it can be concluded that poor coronal restorations, as well as inadequate root canal obturation, may allow bacteria or endotoxins to penetrate the root canal and initiate periapical inflammation.

MICROLEAKAGE AFTER POST SPACE PREPARATION

After post space preparation, the clinician's main concern is the small volume of obturating material that remains in the root canal. This most apical portion of the root canal filling (RCF) serves as the only barrier against penetration of microrganisms that may cause periapical inflammation. The consequences of penetration are contamination of the canal and colonization of bacterial species at the walls of the apical portion of the root canal.[10-12]

The length of GP fill remaining in the root canal has a major effect on the apical seal. It has been demonstrated that a longer filling provides a better seal.[13,14] Wu et al[15] observed that when only the apical 4 mm of the RCF remained, leakage was significantly greater than when the original full-length filling was present. DeCleen[13] reported that 3 mm of remaining GP is the absolute minimum and that 6 mm should be left in the root canal if possible.

Methods of canal obturation and the methods and timing of post space preparation may influence future microleakage. Haddix et al[16] compared the use of heated pluggers, Gates-Glidden drills (Union Broach Corp, Long Island, N.Y.), and GPX instruments (Brasseler, Savannah, Ga.) as post space preparation tools. The remaining length of apical GP fillings was 3 or 5 mm. At these levels, significantly less leakage was observed when the heated plugger technique was used. This may be explained by the additional vertical condensation effect achieved through the use of heated pluggers.

De Nys et al[17] compared the effects of 5 different obturation methods on post preparation 48 hours after obturation. The root canals were obturated with one of the following techniques: silver point, lateral GP condensation, warm vertical GP condensation, Hygenic ultrafil injection (Hygenic Co, Akron, Ohio), or Obtura (Unitek, Monrovia, Calif.). No significant difference in the amount of dye penetration along the different RCFs was found.

Karapanou et al[18] compared the amount of dye leakage after post space preparation along root canals obturated with GP with either AH26 (DeTrey, Zurich, Switzerland) or a zinc oxide–eugenol (ZOE)–based sealer. The post space was prepared either immediately after obturation or 1 week later. The only significant difference was that the delayed preparation group, in which a ZOE-based sealer was used, showed greater leakage. Using a fluid transport device, Fan et al[19] found more leakage after delayed post preparation than after immediate preparation. The root canals were obturated with laterally condensed GP cones and either AH26 or Pulp Canal Sealer (Kerr, Romulus, Mich.); no significant difference between the sealers was noted.

Wu et al[15] suggested that the cemented post may compensate for leakage after removal of the coronal portion of the RCF during post space preparation.

Based on the literature, it appears that microleakage can be minimized when post preparation is performed with a heated instrument as soon as possible after canal obturation and when a minimum of 3 mm filling is conserved at the apical portion of the root canal.

MICROLEAKAGE AFTER POST CEMENTATION

Bachicha et al[20] observed that the use of different post types had no effect on microleakage. A significant difference in microleakage was recorded, however, in relation to the different cements used to lute the posts. Fogel[21] compared the microleakage associated with stainless steel posts cemented with one of the following: zinc phosphate cement, polycarboxylate cement, a composite, a composite after use of a dentin bonding agent, and a composite after use of a dentin conditioner and a dentin bonding agent. Evaluation of the microleakage results with the fluid filtration system showed that none of the post/cement combinations tested were capable of consistently achieving a fluid-tight seal. Fox and Gutteridge[22] reported that significantly greater leakage occurred in provisional restorations than in cast posts and cores luted with zinc phosphate cement or prefabricated posts and cores luted with composite cement.

Results of the studies cited above indicate that cementation of the post as soon as possible after canal preparation may help minimize microleakage.

PROVISIONAL RESTORATIONS

Provisional restorations, in teeth undergoing root canal treatment or before completion of the final restoration, must provide an effective barrier against salivary contamination of the root canal. Commonly used provisional restorative materials include reinforced zinc oxide–eugenol with polymethyl methacrylate (IRM; LD Caulk, Milford, Del.), zinc oxide and calcium sulfate (Cavit; ESPE, Seefeld, Germany), and light-polymerized composite based on the urethane dimethacrylate polymer (TERM; LD Caulk).[23] A variety of other materials are also in use.

IRM is used because of its high compressive strength.[24] However, Deveaux et al[23,25] demonstrated in bacterial leakage studies that IRM was less leakproof than Cavit and TERM. Their results were similar to those reported by others who performed experiments with the fluid filtration[26,27] and dye penetration techniques.[28] Substantial differences in microleakage also were found after mixing IRM in varying powder/liquid ratios. In a study by Anderson et al,[29] the lowest microleakage measurements were obtained with a powder/liquid ratio of 2 g/mL. These results were better than those obtained when the manufacturer's recommended quantities were used. Conversely, Lee et al[30] found no statistical differences in microleakage between IRM at powder/liquid ratios of 6 g/mL and 2 g/mL .

PERMANENT RESTORATIONS

Dental practitioners often debate whether it is preferable to place a permanent restoration immediately after completion of the endodontic treatment or to await the resolution of the rarefying osteitis. Safavi et al[31] examined the influence of delayed coronal permanent restoration placement on the prognosis of endodontically treated teeth. A total of 464 endodontically treated teeth were evaluated with the use of follow-up radiographs. A higher success rate was found in teeth with permanent restorations (amalgam, composite filling, or cast crowns with or without posts and cores) than in teeth with provisional restorations (IRM or Cavit). Although the difference was not significant, Safavi et al suggested that an appropriate and prompt permanent restoration after completion of endodontic treatment should be performed. In a more recent study, Uranga et al[32] discovered significantly more leakage after placement of a provisional restoration than after placement of a permanent restorative material to seal access cavities. They suggested that it may be prudent to use permanent restorative materials for provisional restorations in order to prevent inadequate canal sealing and the resulting risk of salivary penetration.

ENDODONTIC DISINFECTANTS

The bacteria present in infected root canals include a limited group of species compared with flora in the periodontal sulcus. Conditions in the root canal permit the growth of anaerobic bacteria, whereas aerobic bacterial growth is restricted by the lack of available nutrients.

During the course of infection, interrelationships between microbial species result in bacterial population shifts.[33,34] Therefore, after removal of the coronal portion of the filling, the root canal presents different environmental conditions for bacteria that may have remained in the dentinal tubuli or entered the root canal during post space preparation or through leaky restorations. The purpose of antibacterial irrigants is to eliminate these bacteria.

Sodium hypochlorite and chlorhexidine are potent antimicrobial agents.[35] Different concentrations of these irrigants have been suggested as useful for disinfecting dentin tubules.[36] Ayhan et al[37] compared the antimicrobial abilities of various endodontic irrigants against *Enterococcus faecalis, Streptococcus salivatius*, *Streptococcus pyogenes, Escherichia coli,* and *Candida albicans.* They found that 5.25% NaOCl was superior to 0.5% NaOCl and to 2% chlorhexidine. The major advantage of chlorhexidine is that it prevents microbial activity with residual effects in the root canal system for 48 to 72 hours.[38] Moreover, specific combinations of chlorhexidine and hydrogen peroxide have synergistic effects.[35]

Medicaments used for cleaning, disinfecting, and irrigating the canal during endodontic treatment can be used for the same purpose during post space preparation. Orstavik and Haapasalo[39] showed that, in infected dentin specimens, camphorated para-monochlorophenol was generally more efficient than a calcium hydroxide paste. In a study by Tanriverdi et al,[40] camphorated parachlorophenol was more effective against *E faecalis* than $Ca(OH)^2$. *E faecalis* is the bacteria most commonly associated with endodontic treatment failures.[41]

Camphorated parachlorophenol has a wide spectrum of antimicrobial activity despite its short-term activity. It may be sufficient for the short duration between post space preparation and cementation. Unlike calcium hydroxide, it will not alter the anatomy of the post space when removed.

DISCUSSION

Approximately 300 species of microorganisms inhabit the oral cavity, but only a few inhabit the root canal space.[33,34] Those causing periapical inflammation enter the root canal space from the coronal aspect, not only before or during the endodontic treatment but also after its completion. The need for an immediate and proper restoration after endodontic treatment is therefore reinforced.[3] If the use of a provisional restoration cannot be avoided after completion of the RCF, it has been suggested that Cavit or a similar material with good sealing abilities be placed first and followed by a second layer of IRM (due to its high compressive strength).[28]

The space prepared for a cast post should be regarded as an unsealed root canal. It may become contaminated by bacteria originating in the saliva during post preparation or through a leaky provisional restoration. Bacteria originating in the saliva may inhabit this space and later invade the dentinal tubules. Through a shortened RCF, bacteria may reach the api-

cal portion of the root and periapical tissues much faster. The post space therefore should be disinfected after post space preparation, dressed between appointments, and irrigated again with disinfecting solution before the custom cast or prefabricated post is cemented, preferably with the use of a rubber dam.[19] The same disinfecting solutions used during RCT can be employed for irrigation of the post space.

An appropriate and prompt restoration of the tooth after completion of endodontic treatment is highly recommended,[3,31] even as early as immediately after completion of obturation. Endodontic retreatment should be considered in teeth that have lost their provisional or permanent coronal seal. Based on the rate of bacterial[3,6,11] and endotoxin[2] penetration, obturated canals that have been exposed to the oral environment for 2 to 3 months or longer need endodontic retreatment.

SUMMARY

In summary, the following clinical recommendations are offered: (1) Post space preparation and cementation should be performed with rubber-dam isolation. (2) The post space should be prepared with a heated plugger. (3) A minimum of 3 mm of RCF should remain in the preparation. (4) The post space should be irrigated and dressed as during root canal treatment. (5) Leak-proof restorations should be placed as soon as possible after endodontic treatment. (6) Endodontic retreatment should be considered for teeth with a coronal seal compromised for longer than 3 months.

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Noteworthy Abstracts of the Current Literature

Obstructive sleep apnoea: a review of the orofacial implications.
Sherring D, Vowles N, Antic R, Krishnan S, Goss AN. Aust Dent J 2001;46:154-65.

Purpose. This review was designed to provide the dental practitioner with an introduction to obstructive sleep apnoea, with a particular emphasis on orofacial aspects of the condition.
Review. The authors reviewed 49 articles and drew upon their own experiences in the sleep units of the Royal Adelaide, Queen Elizabeth, Burnside, and Daw Park Repatriation hospitals.
Article topics include normal sleep, sleep laboratories, morbidity and mortality, anatomic and physiological considerations, and treatment modalities. The causes and diagnosis of obstructive sleep apnoea are discussed, and noninvasive and surgical approaches to care are evaluated. The section on morbidity and functional states of obstructive sleep apnoea is useful to all practitioners regardless of their desire to treat patients with this condition.
Conclusion. The authors call for the dental profession to be aware of the consequences of nontreatment of obstructive sleep apnoea. They also make a compelling argument for a step-wise, multidisciplinary treatment of affected individuals. Functionality and social issues should be addressed along with pathology of the upper airway. 49 References.—ME Razzoog