The role of the restorative dentist in the success or failure of endodontics

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Abstract

Endodontics and restorative dentistry are a continuum. Endodontic treatment cannot be successful without careful planning and timely execution of the restorative treatment. Restorative dentistry encompasses diagnosis and treatment planning, clinical treatment and maintenance. Each of these phases has an influence on the outcome of endodontic treatment.

Bacteria are widely accepted as the primary cause of apical periodontitis (Kakehashi S, Stanley HR, Fitzgerald RJ, 1965), and endodontic failure (Lin LM, Skribner JE, Gaengler P, 1992). The primary goal of endodontic treatment is to eliminate bacteria from the root canal system. One of our basic goals in restoring endodontically treated teeth should be to prevent re-infection of the root canal system (Heling I, Gorfil C, Slutzky H, Kopolovic K, Zalkind M, Slutzky-Goldberg I, 2002). The root canal procedure is not complete until the tooth has been restored and bacterial contamination has been prevented.

Numerous studies have reported on success and failure rates for endodontics. The one that is perhaps the most often quoted is the Washington Study that reported 94% success (Ingle JI, Beveridge EE, Glick DH, Weichman JA, 1994). However, cross-sectional, longitudinal population studies have reported success rates in the 50-60% range (De Moor RJ, Hommez GM, De Boever JG, Delme KI, Martens GE, 2000; Saunders WP, Saunders EM, 1998). Why is there such a large variation of reported success rates? There are many variables that go into the equation, such as case selection, preoperative diagnosis, isolation and technique issues (Sjogren U, Hagglund B, Sundquist G, Wing K, 1990). One variable that is sometimes overlooked, but is very important, is the timing and execution of the restorative dentistry once the endodontic treatment is complete. This article will discuss the philosophy and critical steps in the endodontic/restorative process and describe the role the restorative dentist plays in determining the success and failure of endodontic treatment.

Diagnosis and prognosis

Careful clinical and radiographic evaluation of a patient should be performed before any clinical procedures are initiated. Included in the evaluation procedures should be assessment of the pulpal status of the teeth. Studies have reported that from 3% to 22% of teeth with existing crowns have necrotic pulps (Karlsson, 1986; Valderhaug J, Jokstad A, Ambjornsen E, Norheim PW, 1997). Undoubtedly, some of these pulps were necrotic before the restorative treatment was initiated. Generally, it is advisable to pulp test all teeth with large restorations or questionable vitality during the initial examination. A cold test provides a simple, effective test of pulpal responsiveness for the vast majority of patients. The teeth should also be tested for tenderness to pressure, percussion and apical palpation. Occasionally, an asymptomatic tooth in need of endodontic treatment can be identified. Karlsson (1986) estimated that the percentage of teeth with crowns and necrotic pulps goes up by about 1% for each year after the crown is placed. For this reason, periodic pulp testing of teeth with crowns or large restorations is also advisable (Saunders WP, Saunders EM, 1998).

Endodontics is usually performed through existing restorations. A study by Abbott (2004) showed that problems such as caries or cracks can be evaluated more effectively if all existing restorations are removed first. The study compared groups of teeth that received root canal treatment with and without removal of the existing restorations and found that a significantly higher percentage of teeth with potential problems were identified in the group in which the existing restorations were removed. When possible, it is advisable to remove all existing restorations, such as amalgam or composite restorations, prior to initiation of endodontics. When this is not possible, caries detector should be applied to all exposed tooth structure in the access cavity to aid in visualization of leakage, caries or cracks (Figure 1).

Crown-root fractures are a particular problem in endodontics and must be identified early in the process. Most significant crown-root fractures start in the mesial or distal marginal ridge and extend apically. Many root canal failures result from undiagnosed fractures that were present when the root canal treatment was performed. Prior to root canal treatment, posterior teeth should be viewed carefully with magnification, good lighting and transillumination. If a vertical fracture is seen

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Figure 1: If endodontic treatment is performed through a crown, caries detector should be applied to the internal tooth structure. In this picture caries is seen adjacent to the composite buildup (photo courtesy of Dr Gary Carr, San Diego)

Figure 2: Vertical fractures must be identified because they can affect the prognosis of treatment (photo courtesy of Dr Sashi Nallapati, Ocho Rios, Jamaica)

Figure 3: Dyes such as methylene blue can help in identifying the location and extent of cracks. Here a horizontal fracture is highlighted that extends across the base of the cusp (photo courtesy of Dr Nallipati)

Figure 4: A tooth with a vertical fracture than tracks down a canal has a poor prognosis. In most cases extraction is indicated (photo courtesy of Dr Carr)

a dye such as methylene blue may help to determine the apical extent of the fracture (Figure 2). If the crack extends apical to the CEJ, or across the floor of the pulp chamber, the long-term prognosis is guarded. If there is bone loss adjacent to the crack, detected by probing or visible on radiographs, the prognosis is poor (Pitts DL, Natkin E, 1983) (Figure 3). The key is early diagnosis, determining the prognosis, and, with the patient's input, deciding between endodontic treatment and extraction.

It is important to distinguish between crown-root fractures that extend apically onto the root and horizontal fractures that extend across the base of a cusp. Both may look the same when viewing the marginal ridge, but with good light and magnification it is easy to distinguish them from each other once the existing restorations have been removed (Figure 4). A tooth with a horizontal fracture has a good prognosis and, in many cases, has a normal pulp that does not require root canal treatment. Be suspicious of a crown-root fracture when a tooth presents with signs or symptoms of pulpitis or apical periodontitis, but is without any obvious reason for the associated pathosis (Figure 5).

Treatment planning

It is the restorative dentist's responsibility to develop an overall treatment plan prior to initiation of endodontic treatment or referral to an endodontist. It is the restorative dentist's responsibility to evaluate restorability, periodontal status, the need for crown lengthening and where the tooth fits into the overall treatment plan. Sometimes restorability cannot be

be determined until all the caries is removed and/or crown lengthening is performed. It is important for the restorative dentist to carefully evaluate these factors before the start of treatment. Too often root canal treatment is performed and the tooth is later extracted because of problems with restorability or periodontal concerns.

If restorability is not an issue, and the tooth can be isolated adequately, it is advisable to perform the endodontics early in the treatment plan. With good illumination and magnification, fractures can be identified and their extent and significance can be determined. Caries can be identified and totally removed. The likelihood of successful endodontic treatment can be accurately assessed. If it is determined that the prognosis is poor, the treatment plan can be modified before additional expensive procedures have been performed, such as crown lengthening or bone grafts. The presence of apical periodontitis can cause failure of periodontal procedures. It can cause bone grafts to fail, can effect the integration of implants, or once integrated, can cause the implants to fail. In most cases, endodontics should be completed before these procedures are performed.

The best method to restore endodontically treated teeth has been a subject of debate for many years, and it is a debate that continues to this day. However, several principles are generally accepted and should be considered in the treatment plan.

Sound natural tooth structure should be retained whenever possible (Cheung GS, Chan TK, 2003; Mezzomo E, Massa F, Libera SD, 2003). There should be minimal removal of radicular dentin for posts (Heydecke G, Butz F, Strub JR, 2001), and an external ferrule is highly desirable (Stankiewicz ANR, Wilson PR, 2002).

Posterior teeth should receive cuspal coverage. A classic study by Sorensen and Martinoff (1984) investigated the effects of many restorative variables on the survival of teeth after root canal treatment. The only variable that made a difference was cuspal coverage. A retrospective study by Cheung and Chan (2003) reported similar results. A retrospective study by Aquilino and Caplan (2002) reported the survival rate of endodontically treated teeth was six times greater with cuspal coverage than without.

From a structural and functional standpoint, a sound anterior tooth with minimal restorations and a conservative access opening requires only restoration of the access opening (Heydecke G, Butz F, Strub JR, 2001). However, these teeth may be restored with crowns or veneers for other reasons.

Figure 5: Be suspicious of a vertical fracture when a tooth with a small restoration presents with signs or symptoms of pulpitis. A vertical fracture was suspected in the symptomatic lower left first molar. A root canal was started, and the crack could be visualized extending into one of the canals. The distal bone loss provided a clue that the tooth would be non-restorable. The tooth was sectioned and extracted

It is very helpful to the dentist performing the root canal treatment to know the restorative treatment plan. When referring a patient for endodontic treatment, or to any specialist for that matter, the restorative dentist should send a copy of the treatment plan. At the very least, it provides the specialist a better understanding of the patient, and it helps in decision making for the specialist's portion of the treatment. In many cases, the specialist may have suggestions or input into the overall treatment plan, and may be able to help in the patient's decision process.

Coronal leakage

Contamination of the root canal space by saliva, often referred to as 'coronal leakage' or 'coronal microleakage', is a well-accepted cause of endodontic failure (Saunders WP, Saunders EM, 1994). Recurrent caries or fractured restorations may lead to recontamination of the root canal space. Under the best of conditions, the oral environment is harsh and dental restorations must withstand physical, chemical and thermal stresses. It is a difficult environment in which to maintain a leak free system. In-vitro studies have shown that exposure of coronal gutta percha to bacterial contamination can lead to migration of bacteria to the apex in a matter of days (Swanson K, Madison S, 1987; Magura ME, Kafrawy AH, Brown CE, Newton CW, 1991). Bacterial by-products and endotoxin can penetrate to the apex in an even shorter time than bacteria (Alves, J, Walton R, Drake D, 1998). When the root canal space has been grossly contaminated, retreatment should be considered. This is especially true if there has been persistent contamination for more than a few days (Heling I, Gorfil C, Slutzky H, Kopolovic K, Zalkind M, Slutzky-Goldberg I, 2002). Recent studies by Riccuci and co-workers (Ricucci D, Grondahl K, Bergenholtz G, 2000; Ricucci D, Bergenholtz G, 2003) in a clinical setting have questioned the importance of coronal

Figure 6: When sealing the canal orifices, excess gutta percha is removed and the floor of the chamber is cleaned (photo courtesy of Dr Bill Watson, Wichita, Kansas

Figure 7: The floor of the chamber is then etched, bonded and sealed with a layer of clear resin. Note how the gutta percha is clearly visible through the resin (photo courtesy of Dr Watson)

microleakage as a cause of endodontic failure. Nonetheless, there are no benefits but there are potential negative effects from coronal microleakage.

Contamination should be prevented during the endodontic treatment by employing strict aseptic clinical techniques, which should always include use of a rubber dam. Use of a rubber dam is also highly desirable for restorative procedures. Once root canal treatment is completed, immediate restoration of the tooth is recommended when possible, because 'permanent' restorations leak less than temporary restorations (Uranga A, Blum JY, Esver S, Parahy E, Prado C, 1999). When this is not possible, the root canal space should be protected with intracoronal barriers and adequate temporization. Bonded restorations should be used to seal the root canal space (Howdle MD, Fox K, Youngson CC, 2002). The quality of the restorative dentistry performed after root canal treatment has a direct effect on the success of the endodontics (Ray HA, Trope M, 1995; Hommez GM, Coppens CR, De Moor RJ, 2002; Tronstad L, Asbjornsen K, Doving L, Pedersen I, Eriksen HM, 2000).

Orifice barriers

Immediate restoration of the tooth after completion of the root canal procedure is the best approach to prevent contamination. When restoration of the tooth must be delayed, the canal orifices and floor of the pulp chamber should be sealed as a separate step of temporization, especially when most of the chamber is filled with a cotton pellet. A bonded orifice barrier is preferred, either composite resin (Wolanek GA, Loushine RJ, Weller RN, Kimbrough WF Volkmann KR, 2001) or a glass ionomer material (Wolcott JF, Hicks ML, Himel VT, 1999). If composite is used, standard bonding procedures are performed and a clear resin material is preferable, so that the gutta percha is visible through the resin. This allows the restorative dentist to visualize the gutta percha and use it as a guide if entry is needed into the canals for restorative purposes. If a glass ionomer material is used, a shade should be selected that is easily distinguished from dentin in the floor of the pulp chamber. Concerns have been expressed about bonding resin to dentin that has been exposed to a eugenol containing sealer. However, this is not a problem if the 'total etch' technique is used (Wolanek GA, Loushine RJ, Weller RN, Kimbrough WF, Volkmann KR, 2001).

Sealing the floor of the pulp chamber provides an extra measure of protection to the root canal system in the period of temporization and during restorative procedures, particularly if they are performed without the rubber dam. It adds very little cost or time to the procedure. After completion of root canal treatment, countersink the orifices slightly with a round bur, and then thoroughly clean the chamber with a combination of air abrasion, a detergent or alcohol to remove debris and excess sealer (Figure 6). If resin is to be used, the dentin is etched and prepared with a dentin adhesive system (some are self-etching) and a clear resin is placed and light cured (Figure 7). There are several clear 'flowable' composite resins available. Clear sealants may also be used.

Temporization

A superficial search of the literature turned up 29 articles that evaluated the sealing properties of temporary restorative materials for endodontic access openings. Studies were done with dyes, radioactive isotopes, fluid filtration, bacteria or an electrochemical technique. They were done in-vitro and in-vivo on previously restored teeth and unrestored teeth. Materials tested included zinc oxide and eugenol preparations, Cavit, zinc phosphate cement, glass ionomer cements and composite resin. A study could be found that ranked any of these materials as the best or the worst. Therefore, it is probably fair to say that

Figure 8: Temporary post and crowns do a poor job of protecting the root canal system from contamination. A barrier may be placed over the obturating material to protect it.

Figure 9: Immature roots with thin dentin walls should be restored with bonded composite, extending apical to the crest of bone. This imparts additional resistance to fracture (endodontics by Dr Gary Glassman, Toronto)

any of these materials can be used successfully for temporization.

Whatever material is used for temporization, some guidelines should be followed:

• If a cotton pellet or small sponge is placed in the chamber to make re-entry easier, it should be of minimal thickness, and the temporary material should be of maximum thickness (Naoum HJ, Chandler NP, 2002)

• If intermediate term temporization is planned, for example one to two months, consider placing temporary material in each orifice in addition to the access opening to provide a double barrier

• If long term seal is needed, for example during apexification procedures with calcium hydroxide, consider using a 'permanent' restorative material such as bonded composite or resin modified glass ionomer.

Teeth which require a post can present special challenges for temporization. Fox and Gutteridge (1997) showed that the degree of contamination of a post space was approximately equal whether it contained a temporary post and crown or was left open. Demarchi and Sato (2002) reported similar results. Therefore, when a post space is not restored immediately, an extra step is needed prior to temporization. If adequate root length is present, several millimeters of self-curing barrier material may be placed over the gutta percha (Figure 8). Self-curing glass ionomer materials or traditional temporary cements may be used. If there is not adequate root length, and a post is needed to retain the temporary crown, another alternative is to pack the apical 3-4mm with mineral trioxide aggregate, a cement that seals well, rather than gutta percha. The tooth should be restored with a post and core as soon as possible.

Studies have shown that bacteria multiply rapidly in empty spaces within a tooth after endodontic treatment (Bystrom A, Sundqvist G, 1981). Therefore, when a post space is created but not restored immediately, it is advisable to fill that space with CaOH paste or some other antimicrobial material prior to temporization. The post space should then be irrigated with an antimicrobial solution prior to cementation of the post (Heling I, Gorfil C, Slutzky H, Kopolovic K, Zalkind M, Slutzky-Goldberg I, 2002).

Restoring access openings

The best time to restore the access opening is immediately after completion of the root canal. In most cases, a bonded restoration should be used to minimize the potential for leakage. Trautmann (2001) showed that a perfect seal is not achieved with any of the current materials, although in his study the results might have been better if the occlusal porcelain had been etched prior to bonding procedures. He also showed that leakage occurred at the crown margins, particularly with all-ceramic crowns. His studies emphasize the importance of careful evaluation of existing restorations when doing endodontics, and the benefit of removing existing restorations whenever possible prior to endodontic procedures.

When access openings are restored, all available tooth structure should be etched and restored with a bonded material. Existing restorative materials should be roughened and cleaned, and etched if possible. Ceramic materials should be etched with hydrofluoric acid or other suitable etchant. In teeth with thin dentin walls, a bonded restorative material should be

extended apical to the crestal bone if possible, in an attempt to lend strength and support to the remaining tooth structure (Katebzadeh N, Dalton BC, Trope M, 1998) (Figure 9).

Post placement and removal

The topic of posts has been hotly debated for years and is a lengthy, complex issue. For the purposes of this article the discussion will be limited to the endodontic perspective. It is generally agreed that the primary purpose of a post is to retain a core (Robbins JW, 1990). If the core can be retained by coronal tooth structure or by anatomic features in the pulp chamber or canals, there is no need for a post. Placement of a post adds risk to a restorative procedure. In most cases, the canal is enlarged to accommodate the post, and with many post systems, a parallel channel is created in a tapered root. This creates the risk of perforation at the apical extent of the post or a 'strip' perforation in the root concavities. Sound dentin is also removed, which weakens the root. For these reasons, posts should only be used when necessary to retain the core.

From an endodontic standpoint, the most important question about posts is 'do they allow the root canal to be retreated if necessary?' Posts made of ceramic materials, for example, should be avoided because they are often impossible to retrieve. Most metal and fiber posts can be removed.

The best time to prepare a post space is at the time the root canal procedure is performed. The person who performed the root canal treatment is intimately familiar with the anatomy of the root canal space, and one study (Kane JJ, Burgess JO, Summitt JB, 1990) showed more leakage occurs around gutta percha if post space preparation is delayed.

Conclusions

Endodontics and restorative dentistry are a continuum. Root canal treatment cannot be consistently successful without proper planning and follow-up care by the restorative dentist. Success is achieved through effective endodontic procedures, effective temporization and isolation, and timely restorative treatment. With existing endodontic materials, contamination of the root canal space may result in failure of endodontic treatment and the need for retreatment, surgery or extraction.

The future

New materials with improved sealing properties are entering the market that may replace traditional gutta percha and sealers in the next few years. Several hydrophilic resin sealers are currently available, and others are in development. Some of these sealers provide adhesion to dentin, something that is not possible with traditional sealers. None of the new sealers will provide a perfect, leak proof system, but they may prove to be better than traditional zinc oxide and eugenol or calcium hydroxide sealers. Resin based obturating materials allow at least some adhesion between the dentin, sealer and obturating material. Resin based obturating materials need to be soft or dissolvable in solvents to allow retreatment. Even with improved materials and better sealing properties, however, adequate preparation and disinfection of the root canal system will still be necessary, and prevention of coronal leakage will still be important.

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