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REVIEW ARTICLE

Microleakage: Apical Seal *vs* Coronal Seal

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ABSTRACT

Microorganisms can reach the dental pulp through the open cavity, dentinal tubules, gingival sulcus, periodontal ligament through a broken occlusal seal or faulty restoration of tooth previously treated by endodontic therapy or extension of a periapical infection from adjacent infected teeth. During operative procedures, these possible paths must be considered to prevent ingress. While endodontic therapy is being performed, these paths must be blocked to avoid contamination during and after the treatment. Well treated tooth might also fail if microorganisms reach the periradicular tissues. After root canal obliteration, care must be taken to ensure maintenance of the coronal as well as apical seal from contaminants.

Keywords: Apical seal, Coronal seal, Coronal restoration, Bacterial irritants, Microleakage, Obturation.

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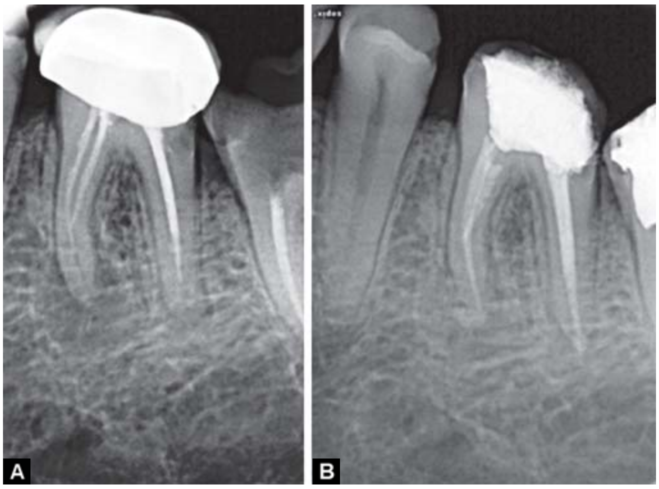
INTRODUCTION

The primary aim in root canal treatment is to obtain 'hermetic seal'. However in endodontics, this term has been wrongly used. The tooth is surrounded by oral fluids and oral microflora, hence the term 'fluid tight seal' is commonly the referred term.[1] The success of root canal depends on three-dimensional obturation of the canal space. For many years lack of adequate obturation of the root canal space was considered as the cause of 'endodontic reinfection'. However recently, focus has been gained on the importance of coronal restoration and its outcome.

APICAL SEAL

The key success in endodontics is the triad of root canal preparation, disinfection and complete canal obturation. The importance of canal filling stage is attributed to the 'hollow tube theory' given by Rickert and Dixon (1931), which remained accepted theory for 30 years.[2] In order to explain the presence of periapical lesions in badly sealed teeth, Rickert and Dixon, implanted small tubes of hypodermic needles in rabbits' back. The tissue reaction was examined after an indefinite postoperative period. The tissues showed significant inflammation, particularly around the lumen of the tubes, leading the authors to conclude that the fluids circulating within lumen of the tubes were not well tolerated by the tissues. Following the same protocol, another study was carried out by Rickert and Dixon by placing sterile teeth instead of hypodermic needles in the skin or muscles of rabbits. The results concluded that the apical fluids, from the blood serum diffuse into the empty canal spaces, stagnate, undergo degradation and then act as a physiochemical irritant when they diffuse back into the periapical tissues.[2] Ingle and Dow (1955), supporting this theory of stagnation, showed that incompletely obturated root canals and root fillings leak. Microleakage, in the root canal, is the movement of periradicular tissue fluids, microorganisms and their associated toxins along the interface of the dentinal walls and the root filling material.[2] As a result, numerous studies have been carried out till date, assessing various techniques and obturation materials.

Lateral compaction of gutta-percha has been proven to be very popular and easy filling technique. Schielder (1967) reported that final filling by lateral compaction resulted in a nonhomogenous mass of many separate gutta-percha cones pressed together and joined only by friction and the cementing substance. He indigenously advocated heat softened techniques to fill the root canal system in three dimensions. A variety of root canal obturation techniques utilizing thermoplasticized gutta-percha or heat-induced compaction of gutta-percha has been evaluated. These techniques have been designed to produce a more homogenous canal seal, but conflicting conclusions were reported. A method for carrying thermoplasticized gutta-percha into the canal space was described by Johnson in 1978 (Figs 1A and B).[3] Johnson claimed that the technique was effective in filling all canal spaces and isthmuses. This system uses a central carrier (stainless steel, titanium or plastic), sized and tapered to match standard endodontic file, coated with a layer of alpha phase gutta-percha. When heated, the alpha phase gutta-percha thermoplasticizes and becomes suitable for canal obturation. The shaft of the file notched with a disk is forced to its working length and while apical pressure is applied, it is twisted or bend back and forth until it breaks at the notch.[3,4] Recently, this method of obturation is commercialized under the name of 'Thermafil Endodontic Obturators' (Tulsa, Dentsply). Manufacturers claim this technique to fill root canal space completely including lateral fissures. Evaluating the long-term sealability of the canal space using Thermafil technique over lateral compaction technique showed significant leakage in the long-term. Thermafil technique shows possible mass shrinkage of gutta-percha after it cools down which creates



Figs 1A and B: (A) Inadequate obturation, lack of apical seal and faulty coronal restoration leads to endodontic failure, (B) completed root canal, healing of periapical region is evident

a gap between gutta-percha and canal wall leading to microleakage. In comparison to other warm gutta-percha techniques, Thermafil is the only technique that does not employ compaction, while gutta-percha is cooling down. In addition to this, the gutta-percha strips from the core carrier.[4]

A sealer associated with gutta-percha is generally used to achieve an impervious apical sealing. The sealer serves as a lubricant when inserting the gutta-percha point as a filling material to fill the irregularities of the preparation and is necessary because gutta-percha does not bond spontaneously to the dentinal walls of the prepared canal.[5] Four types of sealers have been introduced into the market:

1. Zinc oxide based sealers (e.g. pulp canal sealer)
2. Resin-based sealers (e.g. AH plus)
3. Calcium hydroxide–based sealers (e.g. Sealapex)
4. Glass ionomer–based sealers (e.g. Ketac Endo).

Studies have been carried out to compare the sealing ability of the sealers to dentin and to gutta-percha, but no correlation was found between the bond strength of the endodontic sealers either to gutta-percha or dentine.[5,6] One of the recent studies have shown that Sealapex provide better apical sealing in the interface between gutta-percha and the dentinal wall,[5] whereas other authors have shown more leakage with Sealapex.[6] Zinc oxide-based sealers exhibit shrinkage on the setting and solubility. Such shrinkage could be an important cause of the greater leakage.[6] Orstavik et al (1983) showed that resin-based sealers provided better sealing ability compared to other sealers. However, De Gee et al (1994), found that after an initial volumetric expansion, some shrinkage occurred when AH26 was tested at longer time intervals.[6] The new epoxy resin-based material, AH plus, leaks more than AH26 due to more pronounced shrinkage,[7] whereas resin-based RC Seal also exhibits more leakage than AH26 and AH plus.[8] Root canal sealers, though, fills the space between dentinal walls and obturating core, however root canal sealers leak to some extent and produce some amount of microleakage in the interface. The reason for discrepancy between the findings of the studies may be related to the fact that different methods are used in them or the relative difference between the materials change over time.

Guttman et al (1993), proposed the smear layer that is present following canal cleaning and shaping prevents the penetration and adaptation of the softened root canal filling material into the dentinal tubules. The smear layer is a friable amorphous layer consisting of organic and inorganic components loosely adherent to the dentinal tubules.[9] McComb and Smith (1975), showed that smear layer can serve as an avenue for the leakage of microorganisms and as a source for growth of viable bacteria that remain entrapped in dentinal tubules. When the pulp is necrosed, smear layer may be contaminated with bacteria and their by-products. Presence of smear layer may delay the action of endodontic disinfectant.[10] Furthermore the smear layer itself may be infected and may protect the bacteria within the dentinal tubules and also acts as a barrier between obturating material and canal wall.[10] Smear layer, if not removed, disintegrates and dissolves around the obturating material by the bacteria and their by-products such as acids and enzymes. This layer interferes with adhesion and penetration of sealers into the dentinal tubules.[10] Removal of smear layer encourages the creation of a good apical plug to prevent microleakage, overfilling and post restorative sensitivity and enhances the bond strength of resin-based sealers. The most effective method of removing the smear layer is shown to be irrigating the root canal with 2 ml of 17% EDTA followed by sodium hypochlorite.[10]

CORONAL SEAL

Though apical percolation has been considered as a main factor in failure of the endodontic treatment, contamination of the canal system via the coronal route has gained focus over the last decade. Saunders and Saunders (1994), first showed that coronal leakage is an important cause of failure in root canal treatment.[11,12] Ray and Trope (1995), found that for apical periodontal health, the technical quality of the coronal restoration was significantly more important than the technical quality of the endodontic treatment.[12] This disturbed the endodontic community as it openly flaunted the rationale of endodontics that underscores the importance of canal obturation in creating a barrier against bacteria. The same experiments were repeated by undertaking similar clinical studies to confirm the validity of results concluded

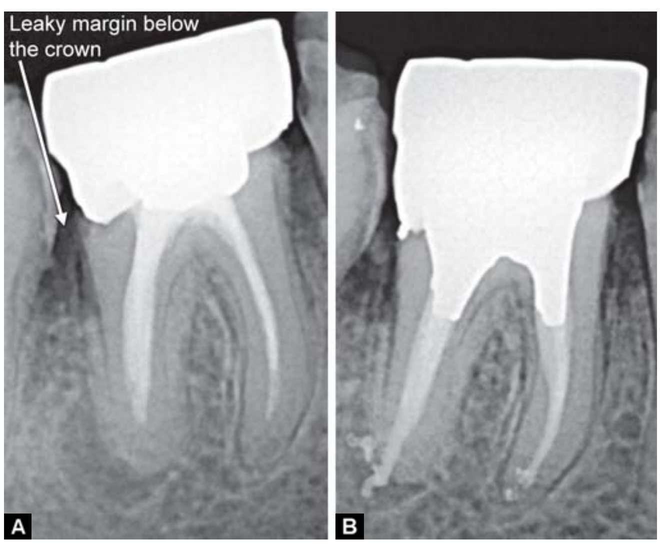
Fig. 2: Decay under the crown leads to coronal leakage. Poor endodontics with poor coronal restoration makes the prognosis unfavorable

by Ray and Trope.[13] Magura et al (1991) had previously reported that presence or absence of temporary restorative material had no effect on coronal leakage. Torabinejad et al (1990) and Khayat et al (1993), found the canals to be contaminated after placing the coronal portion of filling materials in contact with human saliva.[13] Maintaining a coronal seal by placing a definitive restoration should be considered an essential component of successful endodontic treatment. Tronstad et al (2000) duplicated the Ray and Trope study and found the highest success rate in teeth with good endodontics and good restoration (81%) in comparison to the teeth with good endodontics and poor restoration where the success rate dropped to 71% (Fig. 2).[14]

Salivary microleakage is considered a major cause of endodontic failure due to bacteria and endotoxin penetration along the root canal filling. If the pulp chamber becomes contaminated, it may serve as a reservoir of microorganisms and their toxins. This could cause a problem in either of the ways. First, the apical seal may be affected adversely and cause the root canal treatment to fail, second, the movement of microorganisms and toxins may result in periodontal furcation involvement through the accessory canals in the floor of the pulp chamber.[15] Provisional restorations in teeth undergoing root canal treatment must provide an effective barrier against salivary contamination of root canal, therefore the use of temporary restoration is an important factor in preventing contamination of the obturated root canal before placement of the permanent restoration (Figs 3A and B).[15]

A great number of temporary restorative materials have been used to seal access cavities, including gutta-percha, Cavit, zinc oxide eugenol, glass ionomer cement and composite resins. Previous studies (Bergenholtz et al 1982, Saunders and Saunders 1990) have shown extensive leakage when gutta-percha was used as a provisional restoration and is considered to be an appropriate temporary restorative material for access cavities.[16] IRM is used as a provisional restoration because of its high compressive strength, however, Cavit is considered to be superior to IRM in preventing bacterial penetration. Cavit is generally considered to have excellent sealing properties due to its linear hygroscopic expansion.[16]

Dental practitioners often debate whether it is preferable to place a permanent restoration immediately after completion of the endodontic treatment or to wait for the resolution of the periapical pathosis. Safavi et al suggested that an appropriate and prompt restoration after completion of endodontic treatment should be performed.[17] A higher success rate was found in teeth with permanent restoration



Figs 3A and B: (A) Leaky margin (arrow) below the restoration could lead to microleakage. Periapical lesion in relation to distal root is evident, (B) completed retreatment with adequate coronal and apical seal than in teeth with provisional restorations. The sealing usually occurs from the inside of the tooth outward. If the coronal avenue of leakage is not properly sealed on the external surface of the tooth, it may be a source of leakage between appointments.[18] If the quality of root filling is good, a good restoration improves the endodontic success rate.[19] Therefore, the presence of coronal microleakage, even in the presence of temporary restorative material should alert the clinician to the fact that this route is potential etiological factor in root canal treatment failure.

CONCLUSION

A plethora of studies have reported that no canal obturation technique or material can maintain a long-term apical seal. Obtaining an impervious seal may not be feasible because of the porous tubular structure of dentin.[1] Complexity of the root canal system helps us to appreciate the importance of the need to adequately cleanse and obturate the system. Obturation is a barrier to the elimination of bacterial irritants and must be a supplemented outcome of endodontic treatment.

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