Improving Endodontic Success through Coronal Leakage Prevention

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Introduction
Endodontic failure has been associated with coronal leakage within the canal system following obturation. The literature suggests that coronal leakage is far more likely a determinant of clinical success or failure than apical leakage. Recent advances in resin obturation materials have been shown to provide superior sealing of the canal system but without addressing the coronal aspect of the tooth. Failure endodontically may occur. Studies confirm that a sound coronal seal is of paramount importance to the overall success of root canal treatment. Regardless of the obturation method the best rule is: a properly cleaned, shaped, and obturated tooth should be permanently restored assosialtable.1

No other procedure has as many treatment intentions are following obturation of the canal system, patients may delay restoration or complete treatment if that has been treated. Financial and time constraints often influence when treatment is terminated, and time is completed. Additionally, between visits an adhesive material will prevent leakage and contamination of the canal.

Coronal leakage
Coronal leakage has been indicated in the literature as the major determinant of endodontic success or failure. Matters that take place in the canal, if the coronal portion of the tooth is not sealed with material that bonds to tooth structure and are resistant to leakage by oral fluids, then, over time endodontic failure may be inevitable.

It has been recognized that if we have a patient present with decay at the margin of a crown of a tooth that had prior endodontic therapy, because the tooth was treated endodontically, sensitivity that may indicate a problem may not be clearly recognized. It will not alert the patient to seek dental care. Coronal leakage for even a minimal amount of time may lead to apical migration of bacteria. When the patient does present coronal leakage has been ongoing for an extended period of time complicating treatment or rendering the tooth non-restorable necessitating extraction.

The literature indicates significant coronal dye and bacterial leakage following exposure of sealed root canals to artificial and natural saliva leading to complete bacterial leakage may occur within 2 days.2 Supported in an invitro study, found that dye leakage can occur over different time frames quickly lead to apical migration of bacteria. When the patient does present coronal leakage has been ongoing for an extended period of time complicating treatment or rendering the tooth non-restorable necessitating extraction.

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Post-Endodontic Therapy Buildups (Canal Projection)
Coronal leakages a major contributor to Endodontic failure.3 A buildup core placed prior to disinfection and obturation of the canal system the tooth can greatly diminish the leakage potential both during and after Endodontic therapy.

Isolation of the pulp chamber can be a challenging task when preparing the tooth for Endodontic therapy.4 It is essential to keep the pulp chamber isolated and Endodontic therapy is required as part of the oral rehabilitation (Fig. 3). Contra-reinforcement has traditionally been addressed following the Endodontic phase. But a coronal bonded buildup can simplify the Endodontic phase and strengthen the tooth, decreasing the possibility of further damage to the tooth due to the dam clamp or mastication before a full coverage restoration can be placed. The Canal Projector core allows isolation of the individual canals to be completed with resin buildup (Fig. 2). Sealing the pulpal floor and area surrounding the canal orifices also will decrease coronal leakage potential during and following Endodontic treatment.

Following identification of the canal orifices and caries removed (Fig 3). Coronal seal has been maintained allowing apical healing of periodontal tissue. (Courtesy of Dr. Martin Tropia).

Fig. 3: Temporary restoration using the glass ionomer Fuji Triage Fill (GC America, Alsip, IL) to seal endodontic access. (Courtesy of Dr. Mark Grubosky).

Fig. 4: Placement of an immediate coronal restoration with Fuji IX (GC America, Alsip, IL) glass ionomer cement due to its adhesive nature will prevent leakage of microorganisms.26 It has been suggested that gutta percha does not offer an effective barrier to crown-down leakage when exposed to the oral environment.4 Additional studies using gutta percha and various sealers, indicate that gutta percha will allow bacterial leakage. But use of an adhesive sealer can significantly slow or stop coronal-apical bacterial migration.5

The predominant bacteria found in the root filled teeth with coronal leakage and persistent apical periodontitis is the Gram-positive facultative anaerobe Staphylococcus aureus. This is followed by the groups Streptococcus and Enterococcus; all normal salivary flora.4 Coronal leakage provides a constant source of microorganisms that initiate and maintain periapical lesions.7 Additional studies using the capacitance technique. The coronal restoration with Fugi IX™ (GC America, Alsip, IL) glass ionomer pastes placed in contact with Staphylococcus epidermidis and Proteus vulgaris for 13.5 days in the cusp. This is followed by the groups Streptococcus and Enterococcus; all normal salivary flora.9 Coronal leakage for even a minimal amount of time complicating treatment or rendering the tooth non-restorable necessitating extraction.

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bacteria and the apical area will heal (Fig. 4 and 5).

Mineral Trioxide Aggregate (MTA) has since its introduction a few years ago been advocated as a sealing material especially when perforation has occurred. But an investigation found mild inflammation was observed in 27% and 39% of the roots with and without an orifice plug, respectively, without development of severe inflammation, the sealing efficacy of MTA orifice plugs could not be determined.27-30

Should amalgam be the material of choice for the dentist, a bonded amalgam produced significantly less leakage than did the non-bonded amalgams. To prevent the reinfection of the endodontically treated molar, it may be preferable to restore the tooth immediately after obturation by employing a bonded amalgam coronal-radicular technique.27 Whereas, core buildup or access closure, with adhesive materials has shown good long term leakage resistance. The "sandwich" technique (GI base with overlaying composite) and the composite resin restorations allowed significantly less coronal leakage than glass ionomer cement restorations. This may be because the composite resin prevents salivary dissolution of the glass ionomer long-term.27

Results indicated that the sealing ability of adhesive and flowable materials can decrease coronal leakage potential.27 Because of the risk of coronal microleakage, endodontically treated teeth should be restored as quickly as possible.28

It is more prudent to use a permanent restorative material for provisional restorations to prevent inadequate canal sealing and the resulting risk of fluid penetration.29 To minimize the potential of perforation when rendering the tooth to place either a post or to retreat endodontically, placement of a contrasting colored resin over each orifice may be beneficial. This is followed by covering the entire pulpal floor with a tooth colored flowable resin (Figs. 6, 7 and 8). These are available in a multitude of easily identifiable colored flowable composites. Available in pink (PermaFill® Pink) or purple (PermaFill® Purple) from Ultradent (South) ordan, UT, dark red (Flow-it dark gingival) from Pentagon Clinical Technologies (Wallingford, CT) or dark blue from DenMat (SantaMaria, CA).

Coronal microleakage has received considerable attention as a factor related to failure of endodontic treatment and much emphasis is placed on the quality of the final restoration. Intracanal posts are frequently used for the retention of coronal restorations. Many authors have examined coronal microleakage with respect to gutta-percha root fillings and coronal restorations, but few have investigated the coronal seal afforded by various post systems. The seal provided by a cemented post depends on the seal of the cement used. It appears that the dentine-bonding cements (adhesive resins and glass ionomers) have less microleakage than the traditional, non-dentine-bonding cements (i.e. zinc phosphates and poly(carboxylates)).31-32

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Fig. 6: The pulp chamber has been etched and an adhesive resin applied to all surfaces.

Fig. 7: To assist in locating the orifice later, a contrasting color light is used and a probe is inserted, and it is covered by a flowable composite and a funnel.

Fig. 8: The entire pulpal floor is covered by a flowable composite and a funnel.
Resin-supported polyethylene fiber dowels permitted the lowest coronal leakage when compared with stainless steel and zirconia dowels. This finding suggests that better adhesion of the luting agent to these resin impregnated posts than metal or ceramic posts which do not support the fiber dowel allows polyether ether ketone fiber and glass fiber dowels at any time period. The initial leakage measurement were similar and stainless steel dowels were similar but became significantly different at 12 months. Supporting polyethylene fiber dowels and glass fiber dowels tested exhibited leakage comparable to zirconia dowels systems.

Cleansing the Canal (Smear Layers)

Coronal sealing ability is the only factor to influence the seal of the canal and prevent apical leakage. How well the sealer adheres to the canal walls is also important. Smaller smear layers in the coronal portion may prevent sealer penetration into the dentinal tubules. The frequency of irrigation and gentleness on teeth obturated with in fact smear layer (70%) was significantly lower than smear layer from which the smear layer had been removed (30%). Removal of the smear layer is necessary because its presence will allow leakage through the canal walls. The incidence of apical leakage was reduced in the absence of smear and the adaptation of gutta percha to the dentinal walls. Moreover, studies on smear layer and what obturation method was used later. However, regardless of the obturation technique, leakage compared with zirconia dowels systems.

The machining of the canal walls with NiTi rotary instruments provides smoother canal walls and shapes that are easier to obturate than those can be achieved with stainless steel files. The better the adaptation of the obturation material to the irregularities of the canal walls, the less leakage is to be expected along the entire root length. The better the axial walls are prepared, the more smear layer and organic debris is removed which is beneficial to coronal leakage.

Smear layer removal is best achieved by irrigating the canals with between 30% (0.05% hypochlo- rate) followed by 17% EDTA solution.44 Whereas, the NaOCl solution is effective in removing the smear layer exposing the dentinal tubules lining the canal walls. EDTA solution prevents the inorganic portion of the dentin opening the dentinal tubules. Altering between the irrigants as the instrumentation is being performed will permit removal of more organic debris further into the tubules, increasing resistance to bacterial penetration once the canal is obturated.44,45

Obturation

The purpose of the obturation phase of an endodontic therapy is two-fold: to prevent microorganisms from re-entering the root canal system and to eliminate any microorganisms that may remain within the tooth from the nutrients in tissuefluid in which epoxy resin polymerize well we seal the canal, the coronal portion of the root is not thoroughly sealed in most clinical situations. Leakage may be a matter of time. Accessory canals maybe present in the pulpal chamber that are not sealed in the cervical area. This may be an additional source of leakage that often goes unaddressed elsewhere. Leakage through the apical foramen of the canals or during the restorative phase. Placement of a layer of resin-modified glass ionomer cement or adhesive resin to seal this area immediately following obturation can prevent leakage prior to final restoration of the tooth. But, it must always be remembered that success will only be achieved if the root canal system has been as thoroughly debridged as possible of infected material. Irrigation is key, to remove any smear layer lining the canal walls.

The obturation material is a two-pronged approach. The material that sealer is used is as important as which core material is placed within the canal. Gutta percha and AH-26 epoxy sealer have resistance to bacterial contamination which have been overcome with the newer resins.46-48 Although sealers can form close adhesion to the root canal walls, none is able to bond to the dentinal tubules core material. Upon setting, shrinkage of the sealer allows the sealer to pull away from the gutta percha core, creating a microgap through which bacteria may pass.49 Several alternatives are available for core material selection. Resilon™, a resin gutta percha alternative that is bondable with methacrylate-based sealers such as Epiphany® (Pentron Clinical Technologies, Wallingford, CT) or SybronEndo (Orange, CA) was introduced three years ago after extensive studies. The core material Resilon™, is available in .02, .04 or .06 taper ISO sized cones from Pentron Clinical Technologies (Wallingford, CT) or SybronEndo (Orange, CA) and as sized apical plugs (Lightspeed Technologies, San Antonio, TX).15,16 Resi-ilon showed significantly less leakage than gutta percha. In studies performed at University of North Carolina at Chapel Hill, 80% of the samples showing leakage. Furthermore, the gutta percha was determined to be statistically significant difference in penetration of bacteria and fungi between the two versions of the sealer. Comparative studies looking at apical penetration in the literature (Fig. 11). Alternatively, the bond reported between the methacrylic sealer (Epiphany or Real- silon) and Resilon is sufficient to prevent microorganism formation as the sealer polymerizes.42 Electro microscopic leakage stud- ies recently completed at Universi- ty of Michigan showed that the gutta percha with AH-26 sealer and Real- silon™ with Epiphany™ sealer found significantly different in leakage resistance. The gutta percha/AH-26 group demonstrated an average resistance of 404.5 micro amps with one hundred (100) percent of the samples leaking compared to an average resistance of 27.7 micro amps with 27.7 percent showing some leakage. The lower the value of resistance in micro amps, the more resistant the sealer was to leakage.50 These results support other studies indi- cating that gutta percha and AH-26 when challenged do not offer re- sistance to coronal leakage. Should the practitioner wish to continue using these materials, a permanent restoration needs to be placed at the appointment when endodontic therapy is completed.

Conclusion

Of 44 articles published between 1969 and 1999 (the majority from the 1990s) the literature sug- gests that the prognosis of root canals treated teeth can be improved when 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.9 Endodontic success is a multi- factorial issue. Like a jigsaw puzzle, the full picture can only be seen when all the pieces are fit together. How the canals are instrumented is as important as what is used to obturate the canal system. This is also influenced by what is placed coronally and when the coronal aspect is sealed. NiTi rotary instruments and an irrigation protocol that in- cludes NaOCl and EDTA will max- imize the sealing ability of glass ionomer or the newer methacrylic resin sealers. The last piece of the puzzle, sealing coronally should be performed with adhesive perma- nent restorative materials immedi- ately at the conclusion of the first endodontic appointment to prevent apical migration of bacteria and assure sealability of the canals.

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