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The Importance of Irrigation in Endodontics

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Infection of the root canals with bacteria causes pulpitis, microabscess formation, degradation of the pulpal tissue, and then, ultimately, leads to the initiation and progression of periapical periodontitis. The obvious objective of endodontic treatment is to prevent or eliminate infection within the root canal. Over the years, research and clinical practice have concentrated on instrumentation, irrigation, and medication of the root canal system, followed by obturation and placement of a coronal seal.

The initial bacterial infection of root canals is dominated by gram-negative species, but Enterococcus faecalis is often the only species recovered from teeth with failed endodontic treatment. E. Faecalis has been shown to be resistant to both sodium hypochlorite (NaOCl) and calcium hydroxide ($Ca(OH)_2$). In addition to the identification of bacterial strains, fungi have also been isolated from root canal infections, with the most common isolate being Candida albicans.

There are a number of obstacles to overcome during the shaping and cleaning phases of root canal therapy. Among the obstacles are vital or necrotic pulp tissue, microorganisms, the creation of a smear layer over the dentinal tubules, the buffering effect of dentin, and of course, complex anatomical variations often found, including additional canals, anastomoses, and lateral canals – all potential portals of exit and "safe harbours" for microorganisms. A further complication arises in retreatment procedures that have been unsuccessful, namely the removal of the obturation material, management of potentially more resistant bacterial species and, perhaps the most difficult, dealing with previous procedural errors such as ledges, zips and perforations.

Instrumentation

Bystrom and Sundqvist, taking clinical samples before and after instrumentation with only saline as the irrigant, demonstrated that the use of instrumentation alone resulted in 100 to 1000 fold reduction in bacterial counts. Recently, Card et al showed the effectiveness of increased apical enlargement combined with the use of 1% NaOCl. The investigators were unable to recover bacteria from 100% of mandibular cuspids and bicuspid canals and between 81.5% and 93% of mandibular mesial canals.

Irrigation

Sjogren et al reported that in root canals that still gave positive cultures before obturation, the overall success rates dropped significantly. If however, the canal could be effectively disinfected with instrumentation and irrigation alone, then the need for medication would be removed, thereby allowing reliable single visit endodontics with high success rates. Ideally, an irrigant should be a tissue or debris solvent, have a low toxicity level, have a low surface tension (in order to flow into inaccessible areas), be an effective lubricant, be able to effectively sterilize the root canals (or at least disinfect them), and be able to remove the smear layer. Other desirable properties of the ideal irrigant include availability, cost, ease of use, convenience, adequate shelf life, and

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ease of storage. Without irrigation, instruments become quickly ineffective due to debris accumulation. Currently, there is no one single irrigant that can fulfill all of these criteria and at best, we need to rely on a combination. The main irrigants at our disposal include NaOCl, chlorhexidine (CHX), and ethylenediaminotetraacetic acid (EDTA). Unfortunately, there does not seem to be one clear regimen that we should follow to maximize the benefits of each of these materials, and the best that can be hoped for is to base clinical decisions on the studies available.

Sodium Hypochlorite

Whereas Bystrom and Sundqvist rendered 8 of 15 canals bacteria free with instrumentation and saline alone, they were unable to recover bacteria in 12 to 15 teeth when NaOCl was used as an irrigant. NaOCl is an effective antimicrobial agent that is able to dissolve vital and nonvital tissue, but it does not remove the smear layer. The concentration that should be used has been the subject of many studies. It seems that it is an effective antimicrobial at low concentrations (0.5% to 1%), especially if large volumes are used with regular exchange. However, with regard to dissolution of necrotic tissue, higher concentrations, such as 5% may be better.

NaOCl has been tested with other irrigants with favourable results. By combining 5% NaOCl with EDTA, the bacterial effect was considerably enhanced, which is most likely due to the removal of the contaminated smear layer. Kuruvilla and Kamath alternated irrigation with NaOCl and CHX and concluded that the antibacterial effect of both agents seemed to be augmented when used together.

Chlorhexidine

With the knowledge that the traditional regimen of NaOCl and $Ca(OH)_2$ can be ineffective against microorganisms such as E. Faecalis, there has been a renewed interest in the use of CHX. As an irrigant, CHX has be shown to be either as effective an antimicrobial agent as 5.25% NaOCl, or possibly even better. Used alone, however, CHX doe not have the tissue-dissolving ability of NaOCl, nor the ability to remove the smear layer.

CHX is a broad-spectrum antimicrobial agent. The antimicrobial mechanism of CHX is related to cationic bisbiquanide molecular structure. The cationic molecule is absorbed to the negatively charged inner cell membrane and causes leakage of the intracellular components. At low concentrations, CHX is bacteriostatic. At higher concentrations, CHX will cause coagulation and precipitation of cytoplasm, and therefore, is bactericidal. In addition, CHX has the property of substantivity (residual effect). Both 2% and .12% CHX cause residual antimicrobial activity for 72 hours when used as an endodontic irrigant, even as longs as 168 hours.

Lin et al testing against E. Faecalis, compared the use of CHX as either an irrigant alone, or in the form of a slow-release device. Viable bacteria in each layer of dentin were significantly reduced with 0.2% CHX irrigation solution and were completely eliminated with CHX-impregnated gutta-percha points.

CHX has been reported to cause staining, especially when used in combination with NaOCl, which means it needs to be used judiciously, especially in anterior teeth where cosmetic considerations are greatest. A saline rinse between the NaOCl and the CHX will eliminate the brown pigmentation that develops when these two solutions are mixed in the canal.

EDTA

The smear layer consists of an organic portion (coagulated proteins, necrotic and non-necrotic pulpal tissue, saliva, microorganisms, etc.) and an inorganic portion (minerals from

the dentinal structure), and its presence along with debris may reduce the efficacy of root canal irrigants and medicaments by blocking access to bacteria residing in the dentinal tubules. In addition, at the time of obturation, the smear layer may prevent the contact of obturation materials with the root canal walls, decreasing the sealing potential.

EDTA used in conjunction with NaOCl effectively removes the smear layer. In a recent study by Beltz et al, the authors concluded that EDTA is likely to be capable of removing the organic and inorganic substances in dentin as well as removing some organic components in the pulp.

The effect of EDTA on dentin depends on the concentration of the EDTA solution and the length of time it is in contact with dentin. Serper and Calt observed that EDTA was more effective at a neutral pH than when it is applied at pH 9.0, and that the phosphorous releasing effect of EDTA rapidly rises to a level within 1 minute, and further exposure to EDTA only doubled this effect upon 15 minutes of further administration. They recommended that to reduce the erosive effects of EDTA solutions during prolonged cleaning and shaping of root canals, lower concentrations of EDTA at neutral pH should be used.

Smear Clear (Sybron Endo, Orange CA) is an EDTA solution recently introduced to the market that consists of 17% EDTA, cetrimide, and a special surfactant. The introduction of the surfactant seems to reduce the contact angle of the EDTA solution when placed on the dentin surface and enhances cleaning efficacy. Jantarat et al demonstrated that Smear Clear is superior to removing the smear layer after root canal instrumentation when compared to distilled water, 5.25% NaOCl, 17% EDTA, or 17% REDTA.

Ultrasonics

The use of ultrasonics has been found to eliminate bacteria from the canal more efficiently than hand instrumentation alone. Ultrasonic energy passes through the irrigating solution and exerts its acoustic streaming or scrubbing effect on the canal wall. Weber et al investigated the effect of passive ultrasonic activation of 2% CHX or 5.25% NaOCl irrigant on residual antimicrobial activity in root canals. Residual antimicrobial activity with 2% CHX was statistically superior to 5.25% NaOCl with irrigation alone and even with final passive ultrasonic activation of NaOCl. Using ultrasonics with CHX also increased its efficacy.

Intracanal Medication

Bystrom et al continued their cleaning and shaping investigation by examining the use of Ca(OH)2 as a dressing material for 7 days and found that they wre unable to obtain a bacterial sample from 34 of 35 teeth. Sjogen et al then studied whether the application of $Ca(OH)_2$ would be successful if used for shorter time periods - 10 minutes were compared to 7 days. Unfortunately, the results highlighted the need for a 1 week cleansing of $Ca(OH)_2$ as the most effective way to eliminate most of the bacteria that have survived instrumentation and irrigation phases of treatment.

Conclusion

As often occurs with research, more questions are raised than answered. There are very few research articles that have studied the in vivo effect of irrigation regimens on infected cases because they are difficult, costly, and time consuming. Most research focuses on a small number of bacteria commonly isolated and may or may not use dentin as a research tool. It has been shown that the presence of dentin affects the antibacterial properties of irrigants and medicaments, so this needs to be taken into consideration.

Based on the different properties of the different irrigants we currently have available, it would seem as though we need the tissue

dissolving and antibacterial properties of NaOCl, the widened spectrum of antibacterial activity provided by CHX, and the smear layer removal properties of EDTA, coupled with the advantages of a surfactant, such as Smear Clear, to reduce surface tension and allow for better penetration toward the apex.

The difficult question to answer is, what is the best protocol in which to use these irrigants? There is likely to be no one correct answer, but based on the above findings, a suggested protocol would include the following:

- **Canal preparation with EDTA gel and alternate use of NaOCl and CHX (saline rinses in between).**
- **After instrumentation is complete, flood the canal with Smear Clear and leave it for 1 minute.**
- **The canals should then be flushed with NaOCl with perhaps passive ultrasonic energy, followed by a saline rinse and a final rinse of CHX to penetrate the open tubules.**
- **If intracanal medication is indicated: mix $Ca(OH)_2$ powder with CHX (again, only if there is no cosmetic risk), and deliver the into the canal, leaving it for 1 week.**
- **At the second appointment, Smear Clear/NaOCl should be used again to allow for greater obturation potential.**