A Predictable Protocol for the Biochemical Cleansing of the Root Canal System

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The triad of biomechanical preparation, chemotherapeutic sterilization and three-dimensional obturation is the hallmark of endodontic success. The purpose of this article is to provide the reader with a review of the variables that are fundamental to the most sophisticated irrigation protocol available in order to achieve the highest standards of success and excellence now possible in endodontics.

APICAL PATENCY

A study performed by Dr. Gary Carr (personal communication) of the PERF Institute (San Diego, CA) assessed the level of penetration of commonly used irrigants when optimized by the introduction of overproof/absolute (96% by volume) ethyl alcohol into root canals. Teeth were shaved sagittally leaving a thin layer of dentin over the root canal space that appeared transparent when wet. It was possible to view the manner by which the motion of the file impacted on the flow of the irrigant along the length of the root canal. In this model, it was observed that the irrigant did flow into the apical area after the file was removed. However, it was noted with even more significance that as sodium hypochlorite (NaOCl) was alternated with absolute alcohol, the irrigant would flow into the apical area as if a file were being used, provided apical patency had been established.

Absolute ethyl alcohol reduces the dentinal surface tension and enables the irrigant to flow unimpeded through the entire length of the root canal and into the vaguaries and intricacies that exist in the root canal system. The conclusion reached by this experiment was that the failure to get irrigant into the apical third of the root canal when patency files were not used was more of a surface tension issue than a mechanical one.

A recent study by Gamberini1 demonstrated that the use of 1% Triton X-100 (Sigma Corp., St. Louis, MO), a tensioactive agent, would enhance debridement when used in combination with NaOCl and 17% EDTA. It would appear that surfactants of one form or another will play a increasingly important role in the endodontic irrigation protocol.

At this juncture however, the authors' conclusion is that it is reasonable to include overproof ethyl alcohol during the irrigation protocol to enhance the penetrability of other irrigants throughout the root canal system and dentinal tubules.

IRRIGANT DELIVERY

It has been shown clearly that the deeper penetration afforded by side irrigation needles such as the Maxi-i-Probe (MPLTechnologies, Franklin Park, IL, Monoject - BD, Franklin Lakes, NJ,

Endo-Eze, Ultradent Products, South Jordan, Utah) with diameter sizes as small as .032 inches leads to more effective irrigation.2 Indeed, there are studies that suggest that effective irrigation may not occur unless the canals are enlarged to at least the diameter of a No. 40 instrument. Other studies have shown that no apical flushing will occur until proper flaring of the canal and an apical diameter of a #25 instrument has been achieved.3,4 The use of apical patency files must be used to allow penetration of the root canal irrigants to working length.

Numerous case reports describing extreme pain, edema, and hematoma formation following the inadvertent extrusion of sodium hypochlorite into the soft tissues. This occurs when end vented irrigating needles are used by injecting the irrigating solutions under pressure. This adverse affect is easily avoided by introducing side vented irrigating needles into the root canal and delivering the solutions in a passive manner avoiding any binding of the needle in the canal whatsoever. When delivered in this manner the incidence of reported cases of so called "irrigating accidents" will decrease dramatically.

SODIUM HYPOCHLORITE

Three percent hydrogen peroxide solution has long been out of favour in the endodontic irrigation protocol; its inclusion did not increase the solvent action of NaOCl.5 Furthermore, It has been well documented for more than 100 years that sodium hypochlorite (hypochlorous acid) alone will remove pulpal remnants, organic debris and predentin from instrumented and uninstrumented surfaces of the root canal space. Only recently have researchers determined theoretically how chlorine derivatives disinfect by their action on gram-negative bacteria. They act by attacking the bacterial cell wall, altering it physically, chemically and bio-chemically thereby terminating the cells vital functions and killing the microorganism.

A possible sequence of events during chlorination would be:

1) disruption of the cell wall barrier by reactions of chlorine with target sites on the cell surface

2) release of vital cellular constituents from the cell

3) termination of membrane-associated functions

4) termination of cellular functions within the cell

During the course of these events, the microorganism dies, meaning it is no longer capable of growing and causing disease. Shuping et al6 have recently shown that when using 1.25% NaOCl, the apical portion of the root canal must be enlarged to at least a diameter 0.279mm for it to be more effective in eliminating microorganisms than saline. The question of concentration has been addressed by Baumgartner and Cuenin.7 While varying dilutions were still effective in removing organic debris, a full strength solution (5.25%) of NaOCl delivered with either an endodontic irrigation needle or an ultrasonic device proved most effective with no perceptible injury of the peripheral attachment apparatus.

Of note; one of the primary disadvantages of NaOCl (Chlorox) has been its smell. The introduction of "fresh scent" sodium hypochlorite (Clorox) has eliminated that problem. Harrison et al.8 demonstrated that formulary changes involved in the manufacture of the "fresh scent" sodium hypochlorite had no apparent effect on its antimicrobial properties.

THERMO-ACCELERATION

A study by Cunningham et al.9 demonstrated that while the in vitro bactericidal action of sodium hypochlorite solution was comparable at room temperature (22°C) and at body temperature (37°C), sterility was achieved in significantly less time at 37°C. A study by Berutti et al (10) compared the effect of 5% sodium hypochlorite solution at 21°C and at 50°C. The findings demonstrated that in the middle third of the root canal space, where NaOCl had been used at 50°C, the smear layer was thinner and made of finer, less well-organized particles than where it had been used at 21°C. In the apical third, the smear layer was of almost the same thickness in the two groups of specimens, although the particles were finer where the NaOCl had been used at 50°C.

Irrigation syringe warmers are now commercially available (Vista Dental, Racine WI). Thermo-acceleration of an irrigation solution would logically speed up the dissolution of organic debris in much the same way that sugar dissolves in hot water quicker than in cold water. Alternatively, the solution can be microwaved before the procedure and coffee cup warmers can be used to hold the solution container during the procedure.

ANTIMICROBIAL EFFECT OF IRRIGANT COMBINATIONS WITHIN DENTINAL TUBULES

The most effective irrigation sequence for removing the smear layer and other debris is the alternating sequence of sodium hypochlorite (NaOC1) and ethylenediaminetetraacetic acid (EDTA). NaOC1 will dissolve and aid in the removal of the organic component and EDTA will aid in the removal of the inorganic calcific component of the smear layer (the combined organic and inorganic layer that is produced during canal instrumentation left behind on the root canal walls, which may occlude accessory canals and dentinal tubules). The inclusion of absolute ethyl alcohol in the sequence will increase the penetrability of both irrigants. The inclusion of CHX (chlorhexidine) in this sequence has been demonstrated to further synergize its effectiveness. Many studies have noted a significant decrease in cleaning efficiency as the apical end of the canal was approached. This was corrected in a study by wherein it was demonstrated that 30 second ultrasonic pulses of the irrigant between file sizes particularly as the apical terminus was approached would effect almost total smear layer removal.11

EFFICACY OF THE CROWN DOWN APPROACH IN RESERVOIR CREATION

It is generally appreciated that various techniques for root canal instrumentation may have different effects in cleaning curved root canals, especially their apical portions.12 The consensus indicates that the balanced-force technique produced a cleaner apical portion of the canal than did the other techniques studied. The Balanced Force or Crown Down technique first advocated by Roane13 creates a reservoir of increasing diametral size that facilitates the ionic exchange

demonstrated by EDTA to work and enhances the reactivity of the constantly replenished and heated NaOCl. This same effect can be achieved by practicing a crown-down shaping approach using variable tapered Ni-Ti instruments.

CHLORHEXIDINE

A study by Leonardo et al14 suggests that 2% chlorhexidine prevents microbial activity in vivo with residual effects in the root canal system up to 48 h. In a study by Vahdaty15 solutions of 0.2% and 2% chlorhexidine, 0.2% and 2% sodium hypochlorite (NaOCl) and normal saline were tested for their efficacy in disinfecting dentinal tubules following root canal irrigation in vitro. The results indicated that chlorhexidine and NaOCl were equally effective antibacterial agents at similar concentrations against the test microorganism. They significantly reduced the bacterial counts in the first 100 microns of dentinal tubules.

Studies16,17,18 have demonstrated that the 2% CHX concentration instilled greater and longer lasting antimicrobial activity then the 0.12% CHX concentration.

TIME

The duration of irrigation remains the most important variable contributing to an effective and efficient cleansing action of the prepared root canal system.19 The longer the irrigant is in contact with the root canal, the greater the antimicrobial, tissue dissolving and smear layer removal effectiveness will be. The advent of NiTi rotary instruments has proven to be more effective in the tapering design of the root canal space than traditional hand instrumentation. However, the cutting speed of NiTi instrumentation may reduce the time component that under the circumstances may prove to be disadvantageous to a successful end result. The variables of heat, ultrasonic vibration, and variable irrigant combinations must be factored into the equation to compensate for time adjustment that may be decreased by using NiTi instrument systems.

ULTRASONIC INSTRUMENTATION

Perhaps the most dramatic study conducted on the debridement efficacy of the ancillary usage of ultrasonics in canal preparation is the work of Archer et al.20 This study evaluated two groups of mandibular molars. Group I was prepared using a traditional instrumentation technique and intermittent irrigation with 5.25% NaOCl. In Group II, 3 minutes of ultrasonic instrumentation was performed per canal after instrumentation. The results were assessed at mm levels from the apical terminus. At every point of comparison, the cleanliness levels with the ultrasonic usage were as much as 30% higher in Group II. Of particular significance was the dramatic percentage differential in the isthmus areas (the thin areas of communication between principal canals) of Group II.

Ahmad et al reported that the physical mechanisms of ultrasound, namely cavitation and acoustic streaming, in conjunction with 2.5% sodium hypochlorite solution demonstrated powerful bactericidal activity.21 Studies22,23 demonstrated that ultrasonic irrigation with 5.25% NaOCl successfully eradicated bacteria from an artificially created smear layer while the introduction of 5.25% NaOCl irrigation alone with a syringe was insufficient. Ultrasonic irrigation with less

concentrated NaOCl failed to eliminate bacteria completely from reservoir channels in most samples.

OPTIMIZING CLINICAL SUCCESS

The authors recommend that sodium hypochlorite solutions not be stored from use to use. The reservoir, especially if uncovered, should be replenished with new solution for each new procedure. The stability of sodium hypochlorite is adversely affected by exposure to high temperature, light, air, and the presence of organic and inorganic contaminants. The tissue-dissolving ability of 5.25% sodium hypochlorite remains stable for at least 10 weeks. The tissue-dissolving ability of 2.62% and 1.0% sodium hypochlorite remains relatively stable for 1 week after mixing and then exhibits a significant decrease in tissue-dissolving ability at 2 weeks and beyond.24

The authors recommend that sodium hypochlorite should be heated to between 60°C and 70°C to enhance the chemical reactivity of the solution during usage.

RC-Prep (Premier Dental Products, King of Prussia, PA) or any other chelating agent that contains urea peroxide may be used during the initial phase of instrumentation. The urea peroxide allows emulsification of the dental pulp that will help in the prevention of soft tissue compaction. A 2.5 cc NaOCl flush is recommended after each instrument during this phase to remove the accumulated dentin debris. Replenishment of the RC-Prep et al is recommended before the next instrument usage.

Heated 5.25 % NaOCl and room temperature 17% aqueous EDTA may be used. The most effective irrigation sequence for removing the smear layer and other debris is EDTAC/NaOCl/EDTAC etc. This should be performed during the entire shaping protocol of the root canal preparation in combination with absolute ethyl alcohol.

A 2% solution of chlorohexidine may be used to flush each canal at this time to increase bacterial elimination.

After completion of the canal shaping, it is recommended that a 5 cc flush of 17% EDTA be used with ultrasonic vibration in each canal (performed with a file tip in many proprietory ultrasonic devices) for approximately 30 seconds, followed with a 10 cc flush of each canal using 5.25% NaOCl with ultrasonic vibration for 30 seconds.

Absolute alcohol is then used to flush out the root canal to allow drying and dehydration. Minimal paper points will be required to absorb residual moisture. Access to accessory and lateral canals as well as dentinal tubules is maximized prior to obturation by following this protocol.

CONCLUSION

The future holds the possibility that lasers will be used to sterilize the root canal system, heat the irrigants and "weld" the dentinal tubules shut. The ND-Yag laser and experimental procedures

with the Erbium Wavelength laser are being assessed for these purposes.25,26 Other studies are evaluating the use of electrolyzed neutral water which exhibits a bacteriostatic/bactericidal action against isolates obtained from infected root canals.27

As the biochemical cleansing protocol of the root canal system evolves, the science of endodontics is rapidly approaching a time when 100% predictable clinical success will be a reality rather than an objective.

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Oral Health welcomes this original article.

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