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Endodontic/Implant Algorithm

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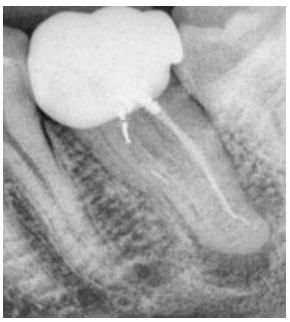
SPECIAL POINTS OF INTEREST

- Foundational Dentistry
- Irrigation Modalities
- Chemistry of Irrigation
- BioPure MTAD™
- Endodontic Monobloc
- When to restore; when to remove

Foundational Dentistry

Anecdote, empiricism, science and skill are the "DNA" of all dental procedures. Technical innovations abound; in the case of endodontics, microscopes, nickel-titanium rotary instrumentation, a new generation of root filling materials and the means to redress unsuccessful treatment outcomes are at the forefront of therapy. One would therefore expect dramatic increases in the rate of procedural success; yet based on selected follow-up studies that offer the best evidence, the chance of teeth without apical periodontitis to remain free of disease after initial treatment or orthograde retreatment is 92 percent to 98 percent. The chance of teeth with apical periodontitis to completely heal after initial treatment or retreatment is 74 percent to 86 percent, and their chance to be functional over time is 91 percent to 97 percent (Friedman S, Mor C 2005). There are those who conclude that the choice between implant and endodontic therapies should be based on outcomes measurement evidence. Endodontic and implant therapies profoundly differ in many ways and although rigorous and clearly defined outcome measures have been proposed for use in endodontic and implant outcomes studies, broad outcomes data may not be sufficiently specific to directly impact clinical decision making (White SN 2006). This first newsletter in a series dedicated to foundational dentistry, will address areas in endodontics that need to be revisited as they are not the primary focus of "market driven therapies" and yet, they may ultimately prove to be what matters most in order to achieve predictable clinical success.



Irrigation Modalities...chchanges

With the endodontic procedures at our disposal, it is impossible to shape and clean the root canal completely. This is mainly due to the complex anatomy of the root canal system [RCS] (Ricucci & Bergenholtz 2003, Peters 2004, Nair et al. 2005). Irregularities of the root canal wall in particular are a major concern, including oval extensions, isthmuses and apical deltas (Wu & Wesselink 2001, Ricucci & Bergenholtz 2003, Peters 2004, Nair et al. 2005). Therefore, irrigation is an essential part of a root canal treatment as it allows for cleaning beyond the reach of root canal instruments. Ideally, root canal irrigants should flush out debris, dissolve organic tissue, kill microbes, destroy microbial byproducts, and remove the smear layer. High volume usage of sodium hypochlorite (NaOCl*) will disinfect the RCS effectively because it can dissolve organic tissue, can kill microorganisms, act as a lubricant and is nontoxic (Haapasalo et al. 2005). Until recently, clinicians had been slow to adopt ultrasonic or sonic instrumentation as an ancillary adjunct for irrigation in canal debridement **.

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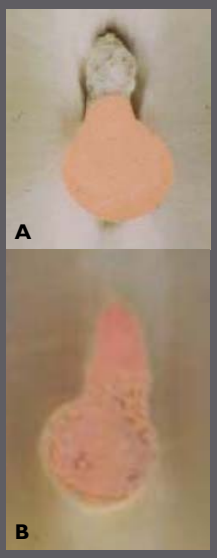
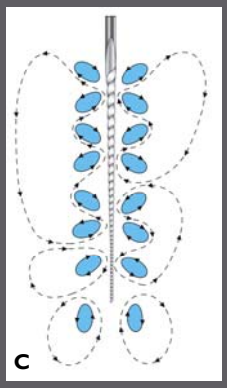
Irrigation Modalities....chchanges



A. Syringe irrigation leaves dentin debris in ovoid area of canal
B. PUI for 3 min.



C. The acoustic streaming pattern corresponds to nodes and antinodes of energy released along the length of the oscillating file. Shear flow produced by energy release removes debris and bacteria from the walls of the root canal space. PUI is adjunctive—it is used after shaping as the objective is not to contact the walls. Precurving the file to emulate canal shape produces a greater active streaming pattern in curved canals.

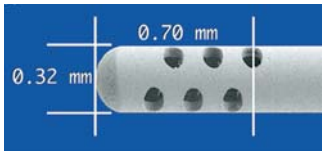
Acoustic streaming is the creation of intense circular fluid movement or flow patterns around files known as eddies (C). When files are activated with ultrasonic energy in a passive manner, the acoustic streaming enhances the cleaning effect of the irrigant in the pulp space through hydrodynamic shear stress. Passive activation implies that no attempt is made to instrument, plane, or contact the canal walls with the file (Jensen SA et al. 1999). **Studies have shown superior debris removal, biofilm removal, bacterial reduction and enhanced isthmus clearing along the length of the entire canal space after 3 minutes of passive ultrasonic irrigation [PUI] (Munley and Goodell 2007, Weber et al. 2003) in comparison to traditional side-vented syringe irrigation.**

Gutarts R, Reader A et al. 2005 demonstrated that **ultrasonic activation of an irrigating needle would produce significantly cleaner canals and isthmuses in the mesial roots of mandibular molars** (traditionally the most difficult to clean effectively—Nair et al. 2005). The device continually introduced fresh irrigant into the canal space and this may well have created higher cleanliness values. The problem remains the use of metal which on contact with dentin will produce a smear layer no matter how deep the canal or how emulated the curvature.

The EndoActivator™ System, by Drs. Ruddle, Sharp and Machtou, recently launched has a cordless handpiece with flexible, noncutting polymer tips to facilitate the debridement and the disruption of the smear layer and biofilm. Studies are currently underway to evaluate its efficacy in the reduction of CFU's at a number of postdoctoral programs.

The EndoVac™ system (Discus Dental, Culver City, CA) consists of a delivery/evacuation tip attached to a syringe of irrigant and the high

speed suction of the dental unit. A small tube attaches either a macro- or micro-cannula to the suction. The delivery/evacuation tip places irrigant in the chamber and siphons off the excess to prevent overflow. The macro-cannula is plastic with an open end that measures size 55 with a .02 taper. The micro-cannula is stainless steel and has 12 small, laterally positioned, offset holes in 4 rows of 3,



with a closed end measuring ISO size 32. As these cannulas are placed in the canal, negative pressure pulls irrigant from a fresh supply in the chamber, down the canal to the tip of the cannula, into the cannula, and out through the suction hose. The micro-cannula can be used at working length in a canal enlarged to ISO size 35 or larger. The first published study (Nielsen BA, Baumgartner JC 2006) **showed significantly better debridement1mm from working length for the EndoVac system compared with needle irrigation**. Future studies should look at the effect of taper, apical size, safety, and effect on apical seal when the EndoVac is used for irrigation.

Photodynamic therapy is the latest iteration of laser usage for RCS disinfection. In a study by Soukos NS et al. 2006, strains of microorganisms were sensitized with methylene blue (25 µg/ml) for 5 minutes followed by exposure to red light of 665 nm with an energy fluence of 30 J/cm2. Methylene blue fully eliminated all bacterial species with the exception of E. faecalis (53% killing). The same concentration of methylene blue in combination with red light (222 J/cm2) was able to eliminate 97% of E. faecalis biofilm bacteria in root canals using an optical fiber with multiple cylindrical diffusers that uniformly distribut light at 360 degrees. With further study, photodynamic therapy may prove to be an effective adjunctive procedure for killing residual bacteria in the RCS.

Chemistry of Irrigation

In a recent study (Davis JM, Maki J 2007), the antimicrobial action of Dermacyn (Oculus Innovative Sciences, Petaluma, CA), **BioPure MTAD (Dentsply Tulsa Dental, Johnson City, TN)**, 2% chlorhexidine (CHX; Ultradent, West Jordan, UT), and 5.25% sodium hypochlorite (NaOCl) were tested against Enterococcus faecalis the standard marker for failed root canal treatment. **BioPure MTAD** showed significantly ($p<0.05$) **more** zones of microbial inhibition than 5.25% NaOCl, 2% CHX, and Dermacyn. Sodium hypochlorite and CHX showed significantly ($p<0.05$) more zones of microbial inhibition than Dermacyn. The zone of inhibition between NaOCl and CHX was not significant ($p>0.05$). **Of note**, this is in direct contrast to a study (Kho P and Baumgartner JC 2006) that demonstrated no statistical difference between1.3% NaOCl/Biopure vs. 5.25% NaOCl/15% EDTA in the apical 5 mm of canals infected with E. Faecalis. So much of experimental outcome is a function of experimental design—to whit-oxidation of MTAD by NaOCl can result in the partial loss of antimicrobial substantivity similar to the peroxidation of tetracycline by reactive oxygen species (Tay et al. 2006). The zone of inhibition in the Kho study was no greater with BioPure than other combinations; however, the point is not that BioPure was ineffective, **but that its use must NOT be concomitant with the presence of residual NaOCl in the RCS.**

*** ChlorXtra—www.vista-dental.com**
**** Sonofiles –www.tulsadental.com**

Chemistry of Irrigation

Removal of the smear layer is essential for the adherence of sealers. MTAD contains citric acid and a detergent and in comparison studies was shown to produce cleaner canals with less dentinal erosion that 17% EDTA (Torebinejad et al. 2003). It usage is recommended for final soak. The use of citric acid in 10—12.5% solutions throughout the procedure has shown certain benefits in comparison with 17% EDTA, primarily as it relates to its antibacterial effects (Yamaguchi et al. 1996).

The use electrochemically activated water (Sterilox—Optident) to eradicate microflora is under study in several centers. Full strength anolyte and catholyte shows some promise based on studies by Nagayoshi et al. 2004. Ozone or aerotherapy has its advocates as does electric current, however, for now, the size of the apical preparation and exact length control in conjunction with deep shape still provides the most effective means of carrying substantial volume of irrigant through the RCS.

In addition to NaOCl, calcium hydroxide in an inert vehicle for interim appointment usage remain the irrigation standard. The role of Ca(OH)2 becomes more relevant in the realm of necrotic pulps and chronic apical periodontitis. Both Bystrom et al. 1985 and Sjogren et al. 1991 reported microflora elimination within one to four weeks. However, these findings have been challenged and their relevance called into question. What is indisputable is that Ca (OH)2 neutralizes lipopolysaccharides and as such facilitates the solubilizing action of NaOCl in cases where time or complexity factor into the treatment equation. Moreover, it can be speculated that further killing of the microorganisms could occur during multiple appointments due to the unavailability of nutrients, which is particularly harmful to many bacteria, including anaerobes.

Chlorhexidine is emerging as a potential irrigant and interappointment medication. A recent study by Siquiera et al. 2007 concluded that chemomechanical preparation with 0.12% CHX solution as an irrigant significantly reduced the number of intracanal bacteria, but failed to render the canal free of cultivable bacteria in about one half of the cases. Application of a 7-day intracanal dressing with Ca(OH)2/CHX paste further increased significantly the number of cases yielding negative cultures. CHX does not possess the tissue dissolution activity of NaOCl and in combination will produce a precipitate that discolours dentin. **Thus the sequence of relevance for irrigation is idealized as NaOCl, citric acid, interim usage of Ca(OH)2, final rinses with CHX and BioPure MTAD in conjunction with sonic oscillation.**

The Endodontic Monobloc: Is there a Real Seal?

Interest in utilizing the classical monoblock concept for sealing and reinforcing the root canal space was rekindled in 2004 with the advent of bondable root filling materials that are advocated as alternatives to conventional gutta-percha. To date, there are three bondable root filling materials available commercially. Of these, Resilon (Resilon Research LLC, Madison, CT) is the only bondable root filling material that may be used for either lateral or warm vertical compaction techniques. As Resilon is applied using a methacrylate-based sealer to self etching primer–treated root dentin, it contains two interfaces, one between the sealer and primed dentin and the other between the sealer and Resilon, and hence may be classified as a type of secondary monoblock.

Initial studies on Resilon-filled root canals were highly favorable. Resilon-filled root canals were found to be better than conventionally gutta-percha–filled canals in resisting bacterial leakage and improving the fracture resistance of endodontically treated teeth. Based on these promising properties, Resilon, together with the Epiphany primer and sealer system (Pentron Clinical Technologies, which produces ideal root obturation in terms of coronal sealing and fracture resistance, were initially referred to as the Resilon Monoblock System. Although Resilon-filled root canals do achieve good apical and coronal seals, **it is equivocal from subsequent independent research studies whether such seals are better than those achieved using gutta-percha and conventional root canal sealers.**

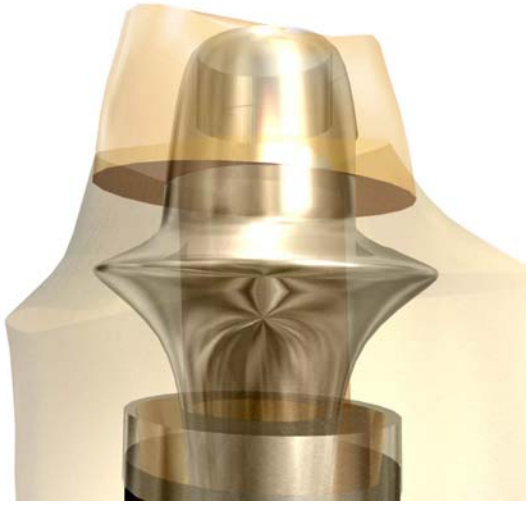
All adhesive restorations create interfacial stresses during polymerization due to the intrinsic volumetric shrinkage associated with converting double bonds to single bonds. Polymerization shrinkage stress can be high enough to debond adhesive interfaces. The stress increases as the volume to surface area ratio increases. Thus, the configuration of the cavity or "C-factor" is very important. In a box-like class I cavity, there are five bonded cavity walls and only one (i.e., occlusal) unbonded "wall" where polymerization stress can be relieved by resin flow. Such a cavity has a C-factor of 5/1, or 5. In root canals, C-factors can be over 1000 (Tay FR, Loushine RJ et al. 2005). Any polymerizing endodontic sealer will be subjected to large polymerization stresses during setting that may cause debonding and gap formation along the periphery of the root filling. The extremely high C-factor in root canals has been cited as a possibility for not achieving perfect seals in Resilon filled root canals.

Although the concept of creating mechanically homogenous units with root dentin is excellent in theory, accomplishing these "ideal monoblocks" in the root canal space is easier said than done. Beginning with dentin adhesive application, removal of thick smear layers or attempts to infiltrate these smear layers with mild self-etching adhesives are not as predictably achieved inside a long narrow channel even with improved vision from a surgical microscope. Evaporating adhesive solvents and hydrogen-bonded water from hydrophilic adhesives is difficult even for crown dentin . To date, there are no data on how this may be performed efficaciously inside root canals without avoiding overthinning of the adhesive.

Both microshear bond testing and push-out test showed that the bonding of Resilon to methacrylate resin–based sealers and root dentin is weak. That is, the reported bond strengths are 1–3 MPa, whereas resin– dentin bonds are 25–30 MPa. As Resilon is used commercially as a fully polymerized material that lacks a free radical– containing oxygen inhibition layer, its bondability to resin-based sealers has further been questioned.

The highly unfavorable cavity geometry within the root canal space is detrimental to the relief of shrinkage stresses during the polymerization of the resin cements or sealers. Moreover, the modulus of elasticity of the post, in an anterior or bicuspid tooth, the root filling material, and the accompaning resin cements or sealers have to match that of root dentin so that loading stresses are evenly distributed and borne by all the monoblock components. **Thus, until non-shrinking composites are available the pursuit of an ideal monoblock for reinforcing the root canal may be viewed as an ideal, albeit unattainable goal.**

Accomplishing these "ideal monoblocks" in the root canal space is easier said than done.



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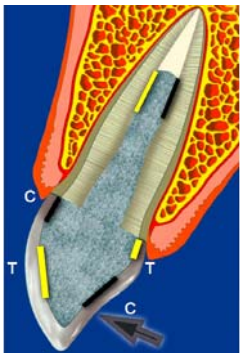
Dental Informatics has entered a new age. On May 18th, Google introduced Universal Search, the harbinger of what will undoubtedly be increasingly sophisticated engines for information retrieval. The true value standard for dental research is the systematic review. Unfortunately, the very nature of the review mandates retrospection over an extended timeline. As such, remaining on the cutting edge of knowledge is fraught with a temporal Catch 22. The intent of this and future newsletters is to alter the traditional format and by scanning the globe for papers on similar topics, a narrative approach can be formatted to emulate systematic reviews and expedite the learning curve of the endodontic/implant algorithm.

When to Restore, When to Remove - Importance of the Ferrule

The ultimate resistance to forces of compression and tension (diagram) will be provided by the combined effort of the foundation and the portion of the root to which the crown is cemented….**the ferrule**. Libman WJ and Nicholls JI 1995 wrote a paper entitled **Load fatigue of teeth restored with cast posts and cores and complete crowns** which remains one of the best in terms of insight into what acceptable ferrule height truly is. Natural teeth were used for all specimens, each tooth was endodontically treated and fitted with a gold post/core. A gold crown was cemented over the preparation of the core and root. The only variable was the ferrule. All post lengths were kept consistent. For the teeth with minimal ferrule, the core made up most of the preparation height; for those with greater ferrule height, the core made up a smaller portion of the preparation. The means by which failure was determined was what makes this study so important. Rather than fracturing specimens by increasing load to failure, a gauge was placed on the crown root interface.

The instant that marginal opening occurred, it was detectable. The load applied was consistent with that of occlusal contact. The goal was to determine the number of cycles to produce marginal opening. Teeth with .5 mm of ferrule height required only 113 cycles to marginal failure; those with 1 mm of ferrule height required 1,140 cycles to failure and those with 1.5 mm of ferrule height required 71,651 cycles to failure. What is proved by an analysis of the force distribution is that the direct area of the crown/root interface under tension is most critical regardless of tooth type. **Ultimately the more area of the tooth with a 1.5 to 2.0 mm ferrule, the more predictable the ferrule will be.** Libman's paper was done in 1995. Factoring in resin cements et al and other bonding advantages, the increased retention to the tooth structure is enhanced, but will not overcome a lack of adequate ferrule (Dietschl D et al. 1997). The second factor of greatest importance is the dentinal thickness. The guesstimation, as there was no study found to validate the position, is that 1.0 mm of residual dentinal wall thickness primarily in the buccal and lingual areas is essential to provide resistance to displacement.



Perhaps one of the most underestimated factors inducing failure is the post length. The old axioms re; post length were never accurate. 3 to 4 mm of residual apical gutta-percha was at best an arbitrary standard and led to gapping between the post and the root filling. A recent study by Moshonov J et al. 2005 showed that a gap between the gutta-percha and the post was related to an increased rate of emerged disease in endodontically treated teeth restored with a post and core. **A ratio of 1:1 is ideal with an adequate ferrule; if the ratio is inadequate, splinting must be considered.**