Root Canal Complexity and the Challenge it Presents for Irrigation

Executive Summary

The root canal system extends far beyond the path of rotary and reciprocating instruments. It is extraordinarily complex with numerous intricacies, including accessory canals, isthmuses and dentinal tubules. These variations in canal morphology create countless spaces which are not reached by files during instrumentation. Additionally, a layer of necrotic pulp tissue, bacteria and their toxic byproducts are left behind following instrumentation and can inhibit the penetration of antibacterial irrigants into these canal intricacies. As such, even the advanced rotary and reciprocation techniques used by expert endodontists today are not sufficient to clean the canal.

Rotary files conveniently create access for contemporary irrigants and irrigation techniques to complete the cleaning of the canals and the complex root anatomy. Proper irrigation protocol should use activated irrigants to reach areas of the canal space that bleach alone cannot. Better irrigation supports root canal therapy through cleaner canals, more complete obturation and better long term outcomes.

Introduction

Science and technology have allowed researchers over the past two decades to gain a much better understanding about the complexity of the root canal system. Even single-rooted teeth may contain multiple points of exit, including: isthmuses, tissue webs, fins, accessory canals, canal anastomosis and the splitting of the root canal at any point along its presumed straight path to the apical foramen.

As a result of these canal intricacies, research has shown that up to 35% of the canal walls remain untouched by instruments[1], regardless of the file system being used. As such, the root canal system must be thoroughly disinfected with irrigating solutions in order to remove all bacteria. It is extremely important that all irrigating solutions reach as close to 100% of the root canal system as possible to remove bacteria and debris which could prevent a complete obturation of the canal.

The impact of not properly addressing the irrigation step can undoubtedly have a negative effect on the likelihood of required retreatment and the overall success of root canal therapy, increasing the likelihood of required retreatment and decreasing patient satisfaction.

A CT scan reveals the true complexity of the root canal system. Image courtesy of Dr. Sergio Kuttler.

Just as the technology has advanced that allows clinicians to see this more complex anatomy, fortunately, the technology to disinfect and reach this intricate anatomy has progressed as well. By incorporating some easy changes in your irrigation protocol it will allow you to achieve more complete disinfections

1 Peters OA, Schonenberger K, Laib A. Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro-computed tomography. International Endodontic Journal 2001;34(3):221-30.

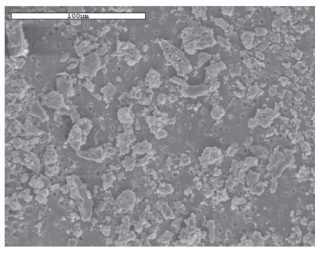
which in turn may lead to less retreatments and better outcomes for your patients.

A 2010 study published in the Journal of Endodontics[2] showed that activation of full strength sodium hypochlorite (NaOCl) using irrigation activating technology killed more bacteria and dissolved more tissues than non-activated irrigation. Because successful obturation first requires removing the barriers to a three-dimensional fill, it is essential that clinicians' irrigation protocol include activated irrigants for successful long term outcomes in root canal therapy.

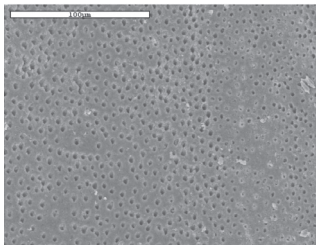
This whitepaper will further examine the necessity of irrigation and activated irrigation. The paper will also present a thorough irrigation protocol by exploring several recent innovative products that are essential to achieving a complete cleaning of the root canal system.

Smear Layer: Traps Bacteria In and Keeps Gutta-Percha Out

The role of instrumentation during root canal therapy is to remove the vital tissue and non-vital tissue contributing to the infection and to facilitate irrigation and obturation of these complex anatomies. However, in the process of instrumentation, when instruments contact the dentinal walls, biological material and debris is pushed into the walls, leaving behind what is known as the "smear layer." The smear layer is composed of organic material such as necrotic pulp tissues, embedded bacteria and bacterial fragments and predentin as well as inorganic material such as remnant dentinal fragments.[3]



SEM Dirty



SEM Clean

The entire canal system is affected by the smear layer due to the forces generated by rotary and reciprocation instruments. In those areas of the canal which are contacted by instruments (approximately 65%), smear layer lines the walls, harboring bacteria and obscuring dentinal tubules. In the remaining 35% of the canal spaces, instruments can push smear layer and contaminated debris into dentinal tubules, accessory canals, fins and other areas. These tubule smear "plugs" and smear layer effectively block the path to these areas of the anatomy. Thus, without a thorough cleaning of the canal space, including smear layer removal, obturation materials cannot fill areas beyond the path of the file such as fins, accessory canals and isthmuses. In short, the smear layer can trap bacteria in and keep gutta-percha out, preventing a successful long term outcome.

Traditional irrigation methods have primarily used NaOCl to debride and disinfect the canal following instrumentation. However, removing the smear layer and subsequent smear plugs cannot be achieved by NaOCl alone. While NaOCl acts as a solvent of organic material and serves as a powerful antimicrobial agent, smear layer removal also requires the use of an inorganic solvent or chelating agent. Many clinicians use 17% EDTA following NaOCl to accomplish smear layer removal; this protocol does however present a drawback. While EDTA is somewhat successful in removing the smear layer, following its use, areas of the canal are now opened that were not previously reached by NaOCl. Given that EDTA does not serve as an antimicrobial agent, these areas now require an additional rinse with NaOCl to achieve disinfection. This problem is further exacerbated by NaOCl's effect on dentin. Research has shown that a second rinse and soak with NaOCl can erode the collagen matrix of the underlying dentin, which negatively impacts the ability of root filling materials to adhere to it.[4] Thus, clinicians are faced with the challenge of removing the smear layer, while also disinfecting the entire canal and keeping dentin intact.

2 JOE Source. Assessment of irrigant activation efficiency in the apical third of curved canals; A scanning electron microscope study (Paris 7 – Denis Diderot University, France: Caron G, J Endod 36:8, pp. 1361-1366, 2010)

3 Sen BH, Wesselink PR, Turkun M. The smear layer: A phenomenon in root canal therapy. Int Endod J 1995;28:141-8.

4 Tay FR, Gutmann JL, Pashley DH. Microporous, demineralized collagen matrices in intact radicular dentin created by commonly used calcium-depending endodontic irrigants. J Endod 2007;33:1086-90.

QMix® 2in1 Irrigating Solution

The inability of either NaOCl or EDTA to simultaneously remove the smear layer and disinfect the canal while still preserving dentin presents a challenge for root canal therapy. It is this challenge which DENTSPLY Tulsa Dental Specialties sought to address with the development of QMix 2in1 Irrigating Solution. It is a final rinse to be used after NaOCl that simultaneously removes the smear layer and acts as a powerful antimicrobial agent. It is premixed and ready to use in a 60-90 second rinse after NaOCl.

QMiX 2in1
IRRIGATING SOLUTION

The ability of QMix to remove the smear layer and kill bacteria has been evaluated in a combination of research. Two studies by academic researchers have found it to be superior to 17% EDTA in removing the smear layer and also concluded it is gentler on dentin[5,6]. Additionally, a study by an independent laboratory demonstrated that QMix kills 99.99% of planktonic bacteria on contact – including the resistant species Enterococcus faecalis, which occurs in the vast majority of secondary root canal infections[7].

Activating Irrigants

Successful root canal therapy happens when one measures the elimination of the disease clinically and the elimination can be seen radiographically. Through active and thorough irrigation, the diseased pulpal remnants of tissue and smear layer are dissolved in areas of the canal that are non-negotiable by instruments alone. Even in two-dimensional radiographs, the anatomy is visibly opened in ways a clinician may have never seen before. Each radiograph reveals filled accessory canals, points of exits and the true complexity of the root canal system. A successful clinical outcome is the result of applying personal experience, proven peer-reviewed research and refining our technique with the latest tools and technologies.

Even the most trusted, time tested irrigants must physically contact bacteria in order to kill it. Traditional irrigants cannot flow into tubules, lateral canals or isthmuses if they are plugged by the bacteria harboring smear layer. If your irrigation solution cannot flow into these blocked areas, your filling material will never reach them either and the bacteria will remain. Evidence-based root canal procedures have shown that activation of NaOCl and acoustic streaming improves debridement and disrupts the smear layer. Research shows how sonic irrigation is better at removing the smear layer than simple irrigation methods alone. “The Sonic Activation Group (final rinse 17% EDTA / 3% NaOCl and the EndoActivator® system) showed statistically significantly better smear layer removal ($P<0.05$) in comparison with the No Activation Group and other Test Groups in the apical third.”[8]

One of the easiest, most efficient ways to achieve this is through the use of the EndoActivator. The EndoActivator vigorously energizes the solution and creates a constant

ENDO ACTIVATOR®

5 Tay FR. The effect of 2-year and 3-year accelerated aging on the efficacy of QMix to remove canal wall smear layers (unpublished report), 2010.

6 Eliot C, Hatton JF, Stewart GP, Hildebolt CF, Jane Gillespie M, Gutmann JL. The effect of the irrigant QMix on removal of canal wall smear layer: an ex vivo study. Odontology. 2013 Jan 19. [Epub ahead of print]

7 Nelson Labs, Salt Lake City, STP #0158.1 Time Kill Study Protocol.

8 Assessment of irrigant activation efficiency in the apical third of curved canals; A scanning electron microscope study (Paris 7 – Denis Diderot University, France: Caron G, J Endod 36:8, pp. 1361-1366, 2010)

exchange of irrigants throughout the canal. This hydrodynamic phenomenon of activated fluids promotes deep cleaning and disinfection into lateral canals, fins, webs and anastomosis.

Irrigation Protocol

Prior to using any new equipment or material, clinicians should always prepare for root canal procedures with a thorough review of literature, video demonstrations and whenever possible using practice blocks or extracted teeth to get a feel for the new equipment.

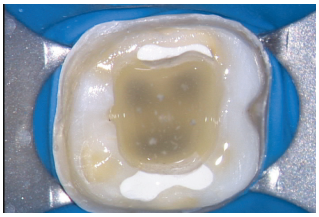
Step One – Bleach during instrumentation

Full strength bleach (8%+) should be used with or between instruments during the procedure to aide in debridement. It dissolves tissue and begins the process of killing bacteria. Use a syringe of bleach with a side vented ProRinse® irrigation needle to express the irrigant laterally into the canal. This will protect against extruding the material apically.

Step Two – Activated bleach

The EndoActivator® is used in conjunction with a final bleach cycle to debride and disinfect both the instrumented and untouched areas of the canal where instruments and inactiviated solutions cannot gain access. Attach the EndoActivator tip based on the size of the canal. Express bleach gently into the canal on the outstroke with the syringe and side vented needle. Place the EndoActivator tip into the canal no closer than 2 mm from working length. Depress the on/off switch to activate the solution. Hydrodynamically agitate the solution using a pumping action to move the activator in short 2 to 3 mm vertical strokes for 30 seconds. Use intra-canal suction to remove loose debris. Repeat another 30 second agitation cycle with fresh bleach. Use sterile water or saline to rinse the canal and remove any remaining bleach.

Before



After

Step 3 – Final rinse

Sodium hypochlorite is very effective in digesting tissue during the root canal procedure but it has been shown to be far less effective in removing the smear layer and for many years endodontists have used additional irrigants to achieve this critical step in root canal therapy.

Because bleach alone cannot remove the smear layer, QMix® 2in1 Irrigating Solution as a final rinse after bleach effectively accomplishes the task, breaking down the smear layer, disinfecting the root canal and opening plugged dentinal tubules. It contains a powerful chelating agent to remove the inorganic smear layer and a potent antimicrobial agent to simultaneously kill bacteria imbedded in and behind the smear layer. Peer-reviews have found that QMix is gentler on dentin than other protocols and leaves the canal clean – the ideal condition for obturation and restorations.

To use QMix, gently shake or agitate the bottle. Avoid creating excessive bubbles or foam inside the container. Fill a syringe with QMix and attach a ProRinse irrigation needle to the syringe. Insert the needle into the canal being treated, no more than 2 mm from the apex. Express QMix into the canal, irrigating for 60-90 seconds.

Using QMix as a final rinse after bleach effectively removes the smear layer, disinfects the root canal system, opens plugged dentinal tubules and prepares the root canal system to receive the obturation material. With a complete clean, the obturation material is now free to flow into dentinal tubules, isthmuses and accessory canals.