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Restoration of endodontic teeth: An engineering perspective

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Fall is here, and
it’s time to go
back to school

For me, autumn always brings memories of going back to school. It’s always exciting to learn new things — which is why the magazine you are holding is so valuable.

In this issue of roots, you can find many helpful articles.

Dr. Gregory Kurtzman offers his opinion on restoration from an engineering perspective. Dr. Eric Herbranson presents an article on what he calls finding the “sweet spot” between effective instrumentation and maximal tooth strength. Dr. Reid Pullen describes using laser technology in a retreatment case. There’s also an article about a three-day course available at the Las Vegas Institute for Advanced Dental Studies.

By reading the article by Dr. Kurtzman, and then taking a short online quiz about his article at www.DTStudyClub.com, you will gain one ADA CERP-certified C.E. credit. Keep in mind that because roots is a quarterly magazine, you can actually chisel four C.E. credits per year out of your already busy life without the lost revenue and time away from your practice.

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I know that taking time away from your practice to pursue C.E. credits is costly in terms of lost revenue and time, and that is another reason roots is such a valuable publication. I hope you will enjoy this issue and that you will take advantage of the C.E. opportunity.

For those of you attending the ADA meeting this fall in San Antonio, be sure to say hello in person. I’ll also be at the upcoming Greater New York Dental Meeting this November.

As always, I welcome your comments and feedback.

Sincerely,

Fred Weinstein, DMD, MRCD(C), FICD, FACD
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Restoration of endodontic teeth: An engineering perspective

**Author** Gregori M. Kurtzman, DDS, MAGD, FAAIP, FPFA, FADC, FADI, DICOI, DADIA

### Introduction

Identifying the canals and negotiating them to be able to instrument and obturate the tooth is necessary to clinical success. But restoration of the endodontically treated tooth is critical to long-term success. It does not matter if we can complete the endodontic portion of treatment if the tooth cannot be restored. With this in mind, we need to look at the restoration phase from an engineering perspective. What is needed to reinforce the remaining tooth so that it can manage the repetitive loading that occurs during mastication? This article will discuss the importance of ferrule in adhesive dentistry as well as when to use posts and what materials are best.

### Ferrule: How important is it today?

Ferrule has long been an important concept in dentistry but has been de-emphasized with the bonding evolution. Yet this concept is as important today as it was prior to dental bonding. But what is a ferrule? A ferrule is a band that encircles the external dimension of residual tooth structure, not unlike the metal bands that exist around a barrel to hold the slats together.

Sufficient vertical height of tooth structure that will be grasped by the future crown is necessary to allow for a ferrule effect of the future prosthetic crown; it has been shown to significantly reduce the incidence of fracture in the endodontically treated tooth. 1,2

Important to this concept is the margin design of the crown preparation, which may include a chamfer or a shoulder preparation. Because a chamfer margin has a beveled area that is not parallel to the vertical axis of the tooth, it does not properly contribute to ferrule height. Therefore, when a chamfer is utilized it would require an additional 1 mm of height between the edge of the margin and the top aspect of the coronal portion of remaining tooth structure.

Thus, use of a chamfer may not be the best margin design when restoring endodontically treated teeth or those teeth with significant portions of missing tooth structure. With today’s movement toward scanning and milling for fixed prosthetics, whether done in the practitioner’s office or at the laboratory, it should be noted that it is difficult to scan the internal aspect of a shoulder preparation, and it has been uniformly recommended that a rounded shoulder be used. The rounded shoulder preparation provides the maximum vertical wall at the margin, with the internal aspect being slightly rounded versus at a 90-degree angle. This ensures better replication of the margins when scanned and milled.

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**Fig. 1** Strain analysis of a posterior tooth demonstrating concentration of strain on loading at the cervical.
(Image/Provided by Dr. Gene McCoy)
Some studies suggest that while ferrule is certainly desirable, it should not be provided at the expense of the remaining tooth/root structure. Alternatively, it has also been shown that the difference between an effective, long-term restoration and restorative failure can be as small as 1.0 mm of additional tooth structure that, when encased by a ferrule, provides greater protection.

When such a long-lasting, functional restoration cannot be predictably created, osseous crown lengthening should be considered to increase what tooth structure is available to achieve a ferrule, but this is also dependent on the periodontal status of the tooth, and when ferrule cannot be achieved then extraction should be considered. Ichim, et al, stated succinctly, “The study confirms that a ferrule increases the mechanical resistance of a post/core/crown restoration.”

How much ferrule is required?

When rebuilding an endodontically treated tooth, it is best to maintain all dentin that is available, even thin slivers. These thin slivers of dentin provide a strong connecting link between the core and tooth’s root and between the crown and root.

It is important to attempt to retain as much tooth structure as possible, and this aids in achieving ferrule as well as maintaining cervical strength of the tooth where loading concentrates. Under masticatory loading, strain concentrates at the cervical portion of teeth; thus it is important to avoid over-preparation of this portion of the tooth during endodontic treatment and preserve this area during restoration of the tooth (Fig. 1).

Multiple studies discussing how much ferrule is required have found that teeth with at least 2.0 mm of ferrule have significantly greater long-term prognosis from a restorative standpoint than those with less or no ferrule. Libman, et al, reported, “Fatigue loading of cast post and cores with complete crowns of different ferrule designs provide evidence to support the need for at least a 1.5- to 2.0-mm ferrule length of a crown preparation. Crown preparation with a 0.5-mm and 1.0-mm ferrule failed at a significantly lower number of cycles than the 1.5-mm and 2.0-mm ferrules and control teeth.”

Libman further demonstrated when loading at an off-axis direction, which occurs in the maxillary anterior, at the restoration’s margin, the side where the load is originating is under tension, whereas the opposing side is under compression (Fig. 2). This repetitive loading and micro strain due to tension at the lingual margin leads to the margin opening, which may lead to recurrent decay and/or failure of the endodontic seal or restoration.

Additionally, if we look at strain studies by Libman and others comparing ferrule of different heights, we observe that in a ferrule of 0.5 mm there is greater strain at the margin under tension and concentrates at mid tooth where the core or post is situated. Teeth with 2.0 mm of ferrule demonstrated significantly less strain loading at the margins or center of the cervical aspect of the tooth. The lower the strain at the cervical...
midpoint, the less chance of overload and failure restoratively (Fig. 4).

_Detecting failure at the coronal seal_

It is not unusual to have a patient present for a routine recall appointment and the clinician or hygienist note recurrent decay at a crown margin with the patient unaware of the issue. This becomes more complicated with teeth that have previously undergone endodontic treatment, as there is no pulp present that could warn the patient an issue is present until often extensive decay occurs or the crown dislodges from the remaining tooth.

Freeman, _et al_, in their published study, stated, “Fatigue loading of three different post and core designs with the presence of a full cast crown leads to preliminary failure of leakage between the restoration and tooth that is clinically undetectable.”

The literature supports that coronal leakage may be a major factor in failure of endodontic treatment. As previously discussed, when loaded during mastication, margins with inadequate ferrule may demonstrate micro opening on the tension side, leading to leakage over time.

This initially may be observed as recurrent decay, but as it deepens and exposure of the obturation material results, failure of the endodontics may result due to apical migration of oral bacteria. This is minimized when a bonded core or post/core is present, but given sufficient time when a ferrule of sufficient height is not present the endodontics or the restoration will fail.

_Do all posts function the same?_

Teeth function differently, depending on the material that the post is fabricated from, with loads distributed within the root relative to the modulus of elasticity of the post compared to the dentin of the root (Fig. 5).

When a tooth restored with a fiber post does fail due to overload, the mode of failure is coronal, protecting remaining root and tooth structure. This mode of failure with fiber-post-restored teeth typically allows the tooth to be restored, as vertical root fracture is a rare occurrence.

Bitter reported, “Compared to metal posts, FRC posts revealed reduced fracture resistance _in vitro_, along with a usually restorable failure mode” (Fig. 6). Whereas, with metal posts either prefabricated or cast, failure was at a higher value for cast post and core: 91 percent of the specimens had fractured roots (none of the specimens with a fiber post demonstrated root fracture); and the post and core usually fractured at the tooth composite core interface.

As stress concentrates at the apical tip of the metal post due to its higher modulus of elasticity than the surrounding root, vertical root fracture is a frequent occurrence (Fig. 7). This may result also from breakdown of the cement luting the post to the root, allowing slippage microscopically of the post in the tooth under load, leading to torque at the cervical area and the resulting vertical root fracture.

Because metal posts are stiffer (higher modulus of elasticity) than the dentin of the root, stress concentrates at the post’s apical tip, leading to vertical root fracture and catastrophic loss of the tooth. Ansari reported, “The risk of failure was greater with metal–cast posts (nine out of 98 metal posts failed) than with carbon fiber posts (using which, none out of 97 failed) risk ratio.” But with fiber posts having a flexibility equal to or greater than the root (lower modulus of elasticity), stress concentrated at the cervical region, leading to horizontal fracture of the post and core; and typically the tooth can be salvaged.

The elastic modulus refers to the relative rigidity of the material. The stiffer the material, the higher its relative modulus. When two different materials are placed together, such as when a post is placed into a tooth’s root, the elastic modulus is influenced by whichever of the materials is stiffest. Dentin averages a modulus of elasticity of 17.5 (+/- 3.8) GPa, with glass fiber posts at 24.4 (+/- 3.4) GPa, titanium prefabricated posts at 66.1 (+/- 9.6) GPa, prefabricated stainless steel at 108.6 (+/- 10.7) GPa and cast high noble gold posts at 53.4 (+/- 4.5) GPa.

Cast posts fabricated from noble or base metals have higher modulus then high noble alloys and approach stainless-steel prefabricated posts in their relative stiffness. Fiber posts have an elastic modulus that more closely approaches that of dentin (Fig. 8). The flexural strength of fiber and metal posts was respectively four and seven times higher than root dentin, and there is still debate on whether a post
strengthens the tooth.\textsuperscript{16,17} The basic purpose of a post is to aid in retention of the core.

The absence of a cervical ferrule has been found to be a determining negative factor, giving rise to considerably higher stress levels within the root. When no ferrule was present, the prefabricated metal post/composite combination generated greater cervical stress than cast post and cores. Yet, the ferrule seemed to cancel the mechanical effect of the reconstruction material on the intensity of the stresses. With a ferrule, the choice of reconstruction material had no impact on the level of cervical stress. The root canal post, the purpose of which is to protect the cervical region, was also shown to be beneficial even with sufficient residual coronal dentin. In the presence of a root canal post, cervical stress levels were lower than when no root canal post was present. Pierrisnard concluded that the higher the elasticity modulus, the lower the stress levels.\textsuperscript{18}

The material the post is fabricated from should have the same modulus of elasticity as the root dentin to distribute the applied forces along the length of the post and the root and not concentrate them at the apical tip of the post. Studies have shown that when components of different rigidity are loaded, the more rigid component is capable of resisting forces without distortion. This stress is concentrated when the post is the stiffer material at the post’s apical tip. The less-rigid component fails invariably when a post is used that is stiffer than the root’s dentin.\textsuperscript{19}

Posts with modulus of elasticity significantly greater than that of dentin create stresses at the tooth/cement/post interface, with the possibility of post separation and failure. As repetitive loading occurs on the endodontically restored tooth, the cement eventually fails at the interface between the metal post and root dentin, allowing microslippage of the post. This allows higher stresses to be exerted on the root, leading to vertical root fracture and catastrophic loss of the tooth. The higher modulus (rigidity) of the metallic posts makes it stiff and unable to absorb stresses. In addition, transmission of occlusal and lateral forces through a metallic core and post can concentrate stresses, resulting in the possibility of unfavorable fracture of the root.\textsuperscript{20} Dentin’s modulus of elasticity is approximately 14 to 18 GPa. Fiber posts have modulus that is approximately 9 to 50 GPa, depending on the manufacturer of the post.

This provides a similarity in elasticity between the fiber post and dentin of the root, allowing post flexion to mimic tooth flexion. The fiber post absorbs and distributes the stresses and thus shows reduced stress transmission to the root.\textsuperscript{21} The longitudinal arrangement of fibers in the fiber post and the modulus of elasticity of a post that is less than or equal to that of the dentin may redistribute the stress into the tooth and away from the chamfered shoulder to increase the likelihood of failure of the post core/root interface instead of root fractures.

When failure does occur due to overloading, failure typically is in the coronal portion, frequently demonstrating fracture of the core at the tooth in-
C.E. article

Restoration of endodontically treated teeth needs to take an engineering view of how best to reconstruct the remaining tooth for the best long-term survival. With this in mind, the practitioner needs to categorize the tooth based on how much native tooth structure is present following endodontic treatment and how much existing restorative material is currently present in the tooth.

Decision making for restoration of teeth treated endodontically

Restoration of endodontically treated teeth needs to take an engineering view of how best to reconstruct the remaining tooth for the best long-term survival. With this in mind, the practitioner needs to categorize the tooth based on how much native tooth structure is present following endodontic treatment and how much existing restorative material is currently present in the tooth.

Fig. 9 Minimal tooth missing or previously restored following endodontic treatment.

Fig. 10 Moderate tooth missing or previously restored following endodontic treatment.

Minimal tooth missing or previously restored

Posterior teeth gain strength when the marginal ridge area and proximal surface is natural tooth structure and has not been restored. Teeth that have undergone endodontic treatment — when either occlusal decay was present in the pits and fissures leading to pulpal involvement, or a small- to moderate-sized previously placed amalgam or composite restoration is present — require conservative restoration (Fig. 9).

These teeth can be restored with removal of the existing restorative material and cleaning the pulp chamber of obturation material, including 2.0 to 3.0 mm of the canal.

Placement of a conventional composite bonded within the tooth provides a good long-term restorative solution to these teeth, and a crown typically is not needed. The access or existing restoration should leave most of the cuspal width present. When the preparation following removal of decay and existing restorative materials invades the width of the cusp leaving half of this tooth structure missing, more extensive restoration is indicated.

Moderate tooth structure missing or previously restored

When the tooth to be restored is missing one or both marginal ridges and these areas have been previously restored or will be restored, placement of a bonded composite will not suffice as the final restoration (Fig. 10). The marginal ridges provide resistance to cuspal flexure of the tooth, improving its strength.

When these are missing, functional loading of the tooth will allow greater cuspal flexure and consequentially a higher chance of fracture under masticatory function. Restoration of these teeth will require a core buildup with optional pins or other retentive elements for the core followed by a full coverage crown. Posts are often not needed, as the remaining tooth structure at the cusps after crown...
preparation is sufficient to retain the core, and a ferrule can be achieved.

A post may be considered in those patients who are bruxers or clenchers or whose occlusion may place higher forces on the restored tooth due to the tooth’s position relative to the occlusal plane. When a ferrule cannot be achieved, the practitioner should consider osseous crown lengthening or forced eruption to improve the ferrule.

Inlay restorations should be avoided in endodontically treated teeth because the access created to perform the endodontic treatment weakens the tooth from a cuspal flexure standpoint and the inlay even when bonded may act as a wedge forcing the cusps apart and leading to fracture of the tooth. An onlay restoration may be utilized, and its design should include shoeing of the cusps to limit cuspal flexure.

Significant tooth structure missing or previously restored

These teeth are a challenge to restore when removal of the old restorative material and decay leaves significant portions of the tooth needing replacement (Fig. 11). These teeth will require placement of posts to retain the core of the remaining tooth structure.

Because the purpose of posts is to retain the core, it is recommended that in multi-canal teeth a post be placed into each canal to cross-pin the core to the remaining tooth structure (Fig. 12). Projection of the posts in posterior teeth due to the angulation of the canals leads to convergence of the posts in the coronal portion of the tooth. This locks the core in place and assists in preventing fracture of the post or dislodgement under function that is observed when only a single post is placed.

Use of pins may also be considered to assist in retaining the core portion when cusps are missing and as an augment to posts being placed. These teeth require a full coverage crown to limit cuspal flexure under load. As with teeth with moderate missing tooth structure, use of inlays should be avoided because they do not restrict cuspal flexure. An onlay may be used if desired in some cases but should include shoeing the cusps as part of the preparation design to limit cuspal flexure. Again, when ferrule is not achievable, consider osseous crown lengthening or forced eruption to improve the ferrule.

Conclusion

For restoration of endodontically treated teeth, an engineering view is needed to ensure long-term survival. Ferrule is often overlooked in today’s age of adhesive dentistry, but it is as critical today as it was in the past. Lack of ferrule has been shown to affect survival of the tooth, and the literature supports use of 2.0 mm of ferrule, which is more critical in maxillary anterior teeth due to the direction of loading during mastication.

Additionally, how we restore the remaining tooth plays a role in potential issues in the long term. Metal posts are being used less frequently due to vertical root fractures that can occur when the tooth is overloaded, and the direction has increasingly moved to the use of fiber posts, which mimic the roots modulus of elasticity. When teeth restored with a fiber post are overloaded,

‘Teeth rarely fail when they are over-engineered, but many fail due to under-engineering.’
fracture typically occurs in the coronal (supragingival) portion, leaving sufficient tooth remaining to re-re-
store the tooth. Teeth rarely fail when they are over-
engineered, but many fail due to under-engineering.

References

I don't like the term "microendodontics." I like the term "minimally invasive endodontics" better, but they both imply an objective that is not the reality of the changing concepts of what access and shaping results should ideally look like. It's not about how small you can make an access but about designing treatment protocols that maximize dentin conservation while balancing the need for meeting treatment objectives. It's about dentin conservation and root form appropriate shaping, not the smallest possible accesses.

There is a growing awareness that the legacy access concepts and principles have resulted in unnecessary removal of critical dentin that is structurally compromising teeth. Dr. David Clark and Dr. John Khademi deserve the credit for identifying and defining the critical importance of pericervical dentin. Pericervical dentin is the dentin from the top of the pulp chamber to the upper canal area (Fig 2).

This is considered to be the dentin critical for tooth strength and should be conserved as much as possible. Strength equates to longer lasting restorations — our ultimate goal. Two features of the legacy designs are a problem for dentin conservation. The first is the recommendation to completely de-roof the pulp chamber. The second is developing "convince form" in the coronal part of the canal by removing the internal triangle of dentin. Both are unnecessary and remove dentin that should be retained for strength.

Defenders of these legacy concepts point to the five mechanical objectives for shaping presented in 1974 by Dr. Herbert Schilder. Even though he was a giant in endodontics who dramatically influenced the specialty, the almost religious defense of his ideas gets in the way of conceptual progress. His objectives need a fresh look in the light of our better understanding of dental anatomy and newer file designs and materials.

_Dental anatomy_

Work with high-resolution micro-CT scanners starting in the 1990s provides us a much more profound understanding of tooth anatomy. In addition to the obvious canal complexity shown by these scans, the presences of concavities were shown to

_Fig. 1_ This case by Dr. Jeff Pafford has all the features of a well-designed conservation approach, including respect for the natural dimensions of the pulp chamber, an orifice-directed occlusal outline and root-form-appropriate canal shaping with adequate deep shape and conservative upper shape. It shows the typical hourglass profile of this style prep. (Images/Provided by Dr. Eric Herbranson)
be ubiquitous, and they reduce the amount of dentin we have to work with. An example is the lower molar mesial root. Virtually all of them have significant concavities in the furcation side of the root that starts at the furcation (Fig 3).

There is simply much less dentin than most clinicians realize at this point, and over-enlargement of the canal must be guarded against to maintain strength and prevent strip perforations.

_Pulp chamber outline_

The legacy recommendation for pulp chamber outline is to un-roof the pulp chamber and, once identified, flare the opening from the canal orifice to the occlusal. This excessively large access is justified by the need for irrigation, visualization and canal access. All can be accomplished through a smaller, more conservative access design that does not destroy tooth strength.

_Convenience form — triangle removal_

The recommendation to remove the dentin triangle from the upper canal is based on the need for straight-line access to the coronal part of the canal system. This feature was dictated by the historical use of stiff stainless-steel instruments and later by the excess stiffness of overly large NiTi instruments.

Today’s newest generation heat-treated NiTi instruments are much more flexible, have a smaller upper flute diameter and do not require this feature.

_Instrument design_

Multitaper instruments were introduced to solve some inherent problems of straight taper instruments. They automatically created more deep shape for better irrigation and steeper apical tapers for better obturation control. Good ideas — however, the first-generation multitaper instruments and their newer derivative all have a design defect, in my estimation.

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The mean flute diameter (MFD) at the upper end of these instruments is too large for most teeth. It is certainly too large for most molar canal systems and results in unnecessary removal of critical dentin, especially in teeth with longer roots. The newest instrument designs have profiles that better match the actual root anatomy and thus conserve valuable pericervical dentin — all while creating shapes that allow us to meet quality treatment objectives.

They have significantly smaller MFD at D16 than the older designs while creating similar deep shape for irrigation and obturation (Fig 4). This smaller MFD combined with newer heat-treating protocols has created a much more flexible instrument that eliminates the need for the “convenience form” design.

_Dentist conservation needs to be designed into our access and shaping. It involves reducing the excessive widening of the pulp chamber, eliminating the convenience form and using instruments with a smaller MFD at the upper end. The occlusal opening is outlined by projecting the canal center line to the occlusal surface to avoid impinging the file into an “S” bend (Fig 5). The result is, each tooth has a different geometry, depending on its specific needs (Fig 1)._

_Does it matter?_

Yes, it does. A recent project conducted at the University of Toronto and published by Dr. Rajesh Krishan, et al, specifically set out to answer this question. It showed that the greater the amount of dentin conserved, the greater the increase in strength.

The more-conservative access prepped molars had strengths that approached the un-accessed control group and were 2.5 times stronger than the traditional access design. Coronal fracture is responsible for a significant percentage of endodontic failures and a more conservative approach to access and shaping has the potential to lower that percentage. It is time we integrate these concepts and instruments into our clinical practice.

Let’s just not call it “microendodontics.” Let’s call it “conservative endodontics,” with respect for the anatomy. “Root form appropriate shaping,” if you will!

_A complete list of references is available on request._

_SSHWhite vTaper instrument is significantly smaller and creates a more appropriate root form shape than the ProTaper F2._

_Legacy access concept on the left; modern conservative access concept on the right with its orifice-directed occlusal outline form, minimal chamber enlargement and root form appropriate shaping. Note the significant difference in the amount of critical cervical dentin saved with this approach. More dentin — more strength and fracture resistance._

_Eric Herbranson, DDS, MS, FICO, is a co-founder and chairman of the board of Brown & Herbranson Imaging, a company that develops dental and human anatomy education software under the eHuman moniker. He is also the developer of the XMount series of microscope camera mounts. With close to 40 years in practice, Herbranson is a dedicated clinical endodontist. His study of physics and 40 years of experience in film and digital imaging provide him with an educated understanding of macro and microphotography and affords him a unique vision of endodontic education and image production. With his innovative approach and advanced imaging skills, Herbranson developed the unique processes and methodology for capturing images of human and dental anatomy now used as the basis for eHuman’s 3D Tooth Atlas, TMJ Occlusion Atlas and other products. Herbranson was the co-author of the chapter on tooth anatomy in “Pathways of the Pulp,” editions 7 and 8. He is a frequent speaker and educator at universities and conferences on the subjects of integration of new technology into dentistry, the use of software and computers in presentations, surgical microscope photography and endodontic technique. Herbranson earned a bachelor of science from La Sierra College, a doctoral of dental surgery from Loma Linda University and a master’s of science in endodontics from Loma Linda University. He was awarded Distinguished Alumnus from Loma Linda University in 2007 and Master of Innovation from the Academy of Microscope Enhanced Dentistry in 2008. He can be contacted at eherbranson@yahoo.com._
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Retreatment can be difficult and time-consuming. The first order of business is to figure out why the primary root canal treatment is failing. Sometimes the answer will be evident after the patient interview, clinical exam and radiographic analysis, but other times the root canal failure is a mystery. Some of the questions I recommend thinking about are: Was a rubber dam used? Is there a root fracture? Is there a missed canal? Did the practitioner use sodium hypochlorite and use proper irrigation methods? Is the root canal underfilled and/or undercondensed? Is there periodontal involvement? If the supporting periodontum appears healthy and the root does not appear to be fractured, than typically the root canal failure is originating from inside the canal system. With all of these factors in play, it is not surprising that the retreatment success in endodontics is lower than primary root canal success by 10 to 20 percent. While retreatment success can vary from 70 to 90 percent, non-surgical root canal treatment success hovers around 90 percent. This article will review the Photon Induced Photoacoustic Streaming (PIPS) (Lightwalker Laser from Fotona) literature and discuss a retreatment case where the PIPS irrigation technique was instituted in hopes of increasing the success rate.

PIPS introduction

PIPS is a technique that uses Erbium:YAG laser energy to agitate the irrigation solution inside a root canal system and cause a strong shockwave effect that can lyse bacteria cells and remove biofilm. By placing the tapered PIPS tip into the access and irrigation solution, subablative laser is used to push a tsunami of irrigation solution into the main root canal, the lateral, secondary and accessory canals, isthmuses and the deep complex apical anatomy of the treated tooth. PIPS creates an irrigant shockwave of bacterial destruction.

PIPS and research

An article in 2011 showed that the PIPS technique was superior in removing bacteria when compared with standard needle aspiration and passive ultrasonic irrigation when using 6 percent sodium hypochlorite in an extracted premolar tooth prepped to a size 20 foramen with an 07 taper. Another article shows 100 percent inhibition of regrowth of Enterococcus faecalis after using the PIPS irrigation technique for 20 seconds with 6 percent sodium hypochlorite in a single rooted tooth. These teeth had soaked in an Enterococcus faecalis broth for four weeks. PIPS also effectively removed biofilm from within the root canal system. In a bovine study model, PIPS outperformed standard needle irrigation, the EndoActivator and passive ultrasonic irrigation in removing biofilm from infected bovine dentin. In an article published this year, PIPS was shown to remove debris and increase canal space 2.6 times more than standard needle irrigation in the isthmuses of lower molars.

PIPS and retreatment

A 62-year-old female patient presents with a chronic, persisting pain in the mandibular left second
molar (#18) with a duration of two weeks. The tooth had been endodontically treated approximately two years prior. The patient was unable to bite on #18 without significant discomfort.

Clinical testing revealed that #18 was percussion- and bite-stick-sensitive, while #19 and #20 tested normal to all tests. Radiographic analysis revealed that #18 had an adequate root canal without a periapical lesion (Fig. 1). Because of the positive clinical tests, it was determined that #18 needed a non-surgical root canal retreatment.

The patient was anesthetized and a rubber dam was placed. The composite core access was removed with a 701 carbide and 557 surgical length carbide bur. Upon inspection of the gutta-percha it appeared an uncontaminated “healthy” pink and did not contain any odor. It did not look or smell like the majority of retreatments where the gutta-percha appeared to be a mixture of black and pink color with a nefarious odor.

Before using chloroform, the ProTaper Retreatment #2 and #3 rotary files (DENTSPLY Tulsa) were used at 500 rpm to carefully remove the majority of the coronal and middle gutta-percha. In two of the three canals the #2 or the #3 retreatment rotary file removed the entire cone from the canal, making it an extremely efficient retreatment and allowing extra treatment time for 6 percent NaOCL to soak inside the canal system.

The technique was as follows: Carefully drill into the gutta-percha with the retreatment rotary file and after a 5- to 10-mm bite stop rotation. Let it cool for a few seconds and then with one hand pull up on the rotary handpiece head while the other hand is protecting the maxillary teeth from any blunt trauma in case the handpiece head pulls out of the canal with high velocity. In some cases if a single cone has been used and/or if the sealer did not set or was inadequately placed, the entire cone will come out in one piece.

In this case, two of the three cones were extracted fully intact while using the rotary technique mentioned above. The third cone was removed intact with a #35 Hedstrom file (Figs. 2, 3). The canals were then “PIPSed” for 30 seconds with 6 percent NaOCL as the irrigation solution and then patency and working length were established using hand files and an electronic apex locator (EAL). The canals were then reshaped with a reciprocating WaveOne Primary file (DENTSPLY Tulsa) and a final PIPS protocol was followed using 6 percent NaOCL, distilled water, 17 percent EDTA and then distilled water (Fig. 4).

Because it appeared that a single cone technique was used and that the resin sealer did not fully set, or was not adequately placed into the canal, the case was completed in one visit. The canals were obturated with bioceramic gutta-percha coated cones and bioceramic sealer (Brasseler USA). A modified warm vertical condensation technique was used to help condense and pack the gutta-percha and sealer. The canals were backfilled with warm gutta-percha (Fig. 5).

Conclusion

PIPS is a ER:YAG laser-enhanced irrigation technique where laser energy is used to strongly agitate canal irrigant. Studies have shown that it is more effective in killing bacteria, removing biofilm, removing canal debris and increasing canal space than standard needle irrigation, sonic irrigation and passive ultrasonic irrigation.

In my experience of “PIPSing” over 2,000 cases, I see an increase in the obturation of lateral canals and deep complex apical anatomy. PIPS also aids in removing pulp stones, retreatment canal debris and separated files that have been loosened by ultrasonics. Photon induced photoacoustic streaming gives clinicians confidence that they are doing everything in their power to clean the entire root canal system.

A list of references is available from the publisher.

About the Author

Reid Pullen, DDS, FAGD, graduated from USC dental school in 1999 and served three years in the U.S. Army as a dentist in Landstuhl, Germany. While in the Army, he completed a one-year advanced education in general dentistry residency. After the military, Pullen practiced as a general dentist for two years in southern California, prior to attending the endodontic residency at the Long Beach Veterans Hospital in 2004. He graduated from the endodontic residency in 2006 and has maintained a private practice limited to endodontics in Brea, Calif., since 2007. Pullen obtained his endodontic board certification in 2012.
LVI Core I three-day course is designed for doctors and their teams to learn together

Author: Mark Duncan, DDS, FAGD, LVIF, DICOI, FICCMO, Clinical Director, LVI

As a patient, I expect the best care I can find. As a doctor, I want to deliver the best care possible. That takes us to the power of continuing education, and as doctors we are faced with many choices in continuing education.

As a way to introduce you to the Las Vegas Institute for Advanced Dental Studies, or LVI, I want to outline what LVI is about and what void it fills in your practice. The alumni who have completed programs at LVI were given an independent survey, and unlike the typical surveys, 99.7 percent said they love practicing dentistry, and of those surveyed, 92 percent said they enjoy their profession more since they started their training at LVI. That alone is reason enough to go to LVI and find out more.

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The Dental XR6. (Photo/Provided by Seiler)

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What is the first thing that comes to mind?

Author: Dr. Barry H. Korzen

We are living in the “Information Age,” where Professor Google is more accessible than many, if not all, of the teachers we had in dental school. However, we have been programmed to think “inside the box” — not the way our children and grandchildren will be — and therefore more often than not we tend to focus on the first thing that comes to our mind, especially when there is a subliminal thought that we either follow to see where it leads us or, not being familiar with the name or phrase, we just shut the door on it and move back into our comfort zone.

Here are a few well-known places with what Professor Google feels most people associate with that location. You may have different associations with these places, especially if you have personally visited any or all of them, but what is important is that you really can’t argue with the connection that certain places have with the first thought that goes through our mind when we hear that name.

Canada — Mounties
Paris — Eiffel Tower
Rome — Coliseum
Egypt — Pyramids
New York — Broadway
Switzerland — precision and quality

When an endodontist such as myself sets out to create a company dedicated to bringing to the profession quality and European precision with each product that we deliver, there was only one place to headquarter that company — Switzerland.

But having the best products must also mean having an added attraction to start practitioners thinking about moving outside their “comfort zone,” outside “the box” — and in these economic times the greatest motivator is value. So by selling direct to you, over the Internet, we have been able to bring the price for European-quality products down to a level where you don’t need to be a volume buyer to get a volume discount. For example, nickel titanium files are value priced at $5.99 per file.

You should still associate Canada with the Mounties and Paris with the Eiffel Tower. But when thinking quality endodontic products at the right price, leave those other brand names inside the box; step outside to Zendo Direct, where you will get substantial savings at www.ZendoDirect.com every time.

A graduate of the University of Toronto Faculty of Dentistry and the Harvard University graduate endodontic program, Dr. Barry H. Korzen is the founder of The Endo Academy (www.TheEndoAcademy.com) and Zendo Direct (www.ZendoDirect.com). He was an associate professor, assistant dean and former head of the Discipline of Endodontics at the University of Toronto Faculty of Dentistry. Besides authoring numerous papers, Korzen has spoken to dental societies and organizations around the world and has delivered lectures at more than 20 universities. He has received fellowships from the American College of Stomatologic Surgeons, the International College of Dentists and the Pierre Fauchard Academy. Korzen is a past president of both the Canadian Academy of Endodontics and the Ontario Society of Endodontists and has been a longstanding member of the American Association of Endodontists and the Alpha Omega International Dental Fraternity.
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