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Inside baseball

We endodontists are a curious bunch. We are constantly honing our craft. We are always looking for ways to treat cases better and more predictably for our patients. But to stay on top of our game, we must always keep up to date on the latest technology and treatment options.

Much of this knowledge is esoteric — call it “inside baseball,” if you will.

In this issue of roots, you can find many articles designed to enhance your specialized skill set. Dr. Asgeir Sigurdsson offers an article on the treatment of traumatic dental injuries. Dr. L. Stephen Buchanan presents a number of cases treated with smaller-than-average access cavities. Dr. Reid Pullen describes using laser technology in a retreatment case, and Dr. Tyler F. Baker shares his experience using new sound wave technology for endodontic disinfection.

The article by Dr. Sigurdsson, which originally appeared in ENDODONTICS: Colleagues for Excellence, the newsletter published by the American Association of Endodontists, is being made available in this issue of roots with the permission of the AAE. By reading this article, and then taking a short online quiz 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.

To learn more about how you can take advantage of this C.E. opportunity, visit www.DTStudyClub.com. You need only register at the Dental Tribune Study Club website to access these C.E. materials free of charge. You may take the C.E. quiz after registering on the DT Study Club website.

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.

As always, I welcome your comments and feedback.

Sincerely,

Fred Weinstein, DMD, MRCD(C), FICD, FACD
Editor in Chief
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The Tango-Endo reciprocating handpiece, available from Essential Dental Systems (EDS), allows for two-instrument shaping, shown with before-and-after images of an endodontic case treated with Tango-Endo. (Photos/Provided by EDS)
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The treatment of traumatic dental injuries

Author_Asgeir Sigurdsson, DDS, MS

When treating dental trauma, the timeliness of care is key to saving the tooth in many cases. It is, therefore, important for all dentists to have an understanding of how to diagnose and treat the most common dental injuries. This is especially critical in the emergency phase of treatment.

Proper management of dental trauma is most often a team effort with general dentists, pediatric dentists or oral surgeons on the front line of the emergency service, and endodontic specialists joining the effort to preserve the tooth with respect to the pulp, pulpal space and root. An informed and coordinated effort from all team members ensures that the patient receives the most efficient and effective care.

Recently, a panel of expert members of the American Association of Endodontists prepared an updated version of Guidelines for the Treatment of Traumatic Dental Injuries. These guidelines were based, in part, on the current recommendations of the International Association of Dental Traumatology (see www.iadt-dentaltrauma.org for more information). This article provides an overview of the AAE guidelines; the complete guidelines are available for free download at www.aae.org/clinical-resources/trauma-resources.aspx.

The benefit of adhering to guidelines for treatment of dental trauma was recently shown in a study by Bucher et al. The study found that, compared with cases treated without compliance to guidelines, cases that adhered to guidelines produced more favorable outcomes, including significantly lower complication rates. The study also found that early follow-up visits were essential to ensure prompt treatment of complications when they arose.

Emergency care

Prior to any treatment, one must evaluate the injury thoroughly by careful clinical and radiographic investigation. It is recommended to follow a checklist to ensure that all necessary information regarding the patient and the injury is gathered, including:

1) Patient’s name, age, sex, address and contact numbers (include weight for young patients).  
2) Central nervous system symptoms exhibited after the injury.  
3) Patient’s general health.  
4) When, where and how the injury occurred.  
5) Treatment the patient received elsewhere.  
6) History of previous dental injuries.  
7) Disturbances in the bite.  
8) Tooth reactions to thermal changes or sensitivity to sweet/sour.  
9) If the teeth are sore to touch or during eating.  
10) If the patient is experiencing spontaneous pain in the teeth.

Once all of this information is gathered, a diagnosis can be made and appropriate treatment rendered. If the injured individual is not a patient of record, all necessary demographic information should be gathered as soon as the patient arrives and prior to any assessment. In the case of avulsion and the tooth being out of its socket, one should immediately place the tooth in a physiological solution of specialized media (such as Hank’s Balanced Salt Solution™ or milk, or saline if those are not available. Only after the tooth is secured in solution should one obtain the patient’s information. Once the patient is seated in the dental chair, it is necessary to do a quick central nervous system (CNS) evaluation before proceeding with further assessments.

Often, the dentist is the first health-care provider to see the patient after a head injury (any dental trauma is, by definition, a head injury) and must assess the risk...

Fig. 1a, Clinical case of two uncomplicated crown fractures in which the two broken pieces were located and reattached. (Photos/Provided by American Association of Endodontists)

Figs. 1b, c, After the two pieces had been attached, a chamfer was cut along the fracture line and additional composite cured in place. This will both increase the strength of the attachment and better hide the fracture line.
of concussion or hemorrhage. It has been estimated by a meta-analysis that the prevalence of intracranial hemorrhage after a mild head injury is 8 percent, and the onset of symptoms can be delayed for minutes to hours. The most common signs of serious cerebral concussion or hemorrhage are loss of consciousness or post-traumatic amnesia. Nausea/vomiting, fluids from the ear/nose, situational confusion, blurred vision or uneven pupils, and difficulty of speech and/or slurred speech may also indicate serious injury.5

Once the patient has been cleared of any CNS issues, the dental trauma should be assessed. The key is to obtain comprehensive information about the injury and, to do so, one must conduct thorough extraoral and intraoral clinical exams as well as appropriate radiographic evaluations.

The new AAE guidelines recommend taking one occlusal and two periapical radiographs with different lateral angulations for all dental injuries, including crown fractures. If cone-beam computed tomography is available, it should be considered for more serious injuries, such as crown/root, root and alveolar fractures, as well as all luxation injuries.

Additionally, sensibility tests should be conducted on all teeth involved as well as opposing teeth. Cold testing is recommended over electric pulp testing in young individuals.6 Both testing methods should be considered, however, especially when there is no response to one of the two. The pulp might be non-responsive for several weeks after a traumatic injury, so a pulp test should be done at every follow-up appointment until a normal response is obtained.7

Once the diagnosis is confirmed and more serious complications such as CNS and jaw or other facial bone fractures have been ruled out, the emergency phase of the treatment needs to be initiated. The aim of treating dental trauma should be to either maintain or regain pulpal vitality in traumatized teeth. This is because dental trauma most frequently occurs in pre-teens or young teens in whom the teeth have not yet fully developed, and root development will cease without a vital pulp.

_Clinical examples_

Dental trauma can be roughly divided into two groups: fractures and luxation injuries. The fractures are then further divided by type: crown, crown-root and root fractures. If the pulp is exposed to the oral environment, it is called a complicated fracture; if not exposed, it is called an uncomplicated fracture.

_Crown fractures:_ The first thing to do in any crown or crown-root fracture is to look for the broken-off tooth fragment. With modern bonding technology it is possible to rebond the fragment to the tooth, which is esthetically the best solution. Prior to reattaching the tooth fragment, the remaining dental thickness immediately covering the pulp

<p>| Table 1. Follow-Up Procedures for Fractured Permanent Teeth and Alveolar Fractures |
|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|</p>
<table>
<thead>
<tr>
<th>TIME</th>
<th>Crown Fracture</th>
<th>Crown-Root Fracture</th>
<th>Root Fracture</th>
<th>Alveolar Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Weeks</td>
<td>Uncomplicated</td>
<td>Complicated</td>
<td>Uncomplicated</td>
<td>Complicated</td>
</tr>
<tr>
<td>6-8 Weeks</td>
<td>Clinical and radiographic control</td>
<td>Clinical and radiographic control</td>
<td>Clinical and radiographic control</td>
<td>Clinical and radiographic control</td>
</tr>
<tr>
<td>4 Months</td>
<td></td>
<td></td>
<td>Clinical and radiographic control</td>
<td></td>
</tr>
<tr>
<td>6 Months</td>
<td></td>
<td></td>
<td></td>
<td>Clinical and radiographic control</td>
</tr>
<tr>
<td>1 Year</td>
<td></td>
<td></td>
<td></td>
<td>Clinical and radiographic control</td>
</tr>
<tr>
<td>Yearly for 5 Years</td>
<td></td>
<td></td>
<td></td>
<td>Clinical and radiographic control</td>
</tr>
</tbody>
</table>

*Splint removal in apical third and mid-root fractures; **Splint removal with a root fracture near the cervical area

Fig. 2a. Schematic diagram of minimal pulpotomy, where an approximately 2-mm reservoir is cut with a high-speed diamond bur and copious water cooling and calcium hydroxide mixed with sterile water placed. (Schematic drawings/Provided by Dr. Sigurds) Fig. 2b. Glass ionomer or a protective liner is placed over the pulp capping agent to ensure it stays in place during etching and bonding. Fig. 2c. Clinical pictures of the minimal pulpotomy.

(Tables/Provided by American Association of Endodontists)
needs to be assessed radiographically and clinically. If there is at least 0.5 mm of the dentin remaining, there is no need to cover it with a protective liner. If it is estimated that the remaining dentin is less than 0.5 mm, it is advisable to cover the deepest part, closest to the pulp, with a cavity liner, and then dimple the fragment accordingly. If the tooth fragment was kept dry, it should be rehydrated in distilled water or saline for 30 minutes prior to reattachment. This process will increase its bonding strength.

In a complicated fracture, the goal is to create a bacteria-tight seal to protect the pulp, after ensuring that the pulpal wound is clean and all inflamed tissue removed. The two best capping materials available today are calcium hydroxide and mineral trioxide aggregate (MTA), but newer bioceramic materials are showing promise for this application. It is advisable to create a 1-2 mm reservoir into the pulp tissue removed. The two best capping materials are calcium hydroxide and mineral trioxide aggregate (MTA), but newer bioceramic materials are showing promise for this application. It is advisable to create a 1-2 mm reservoir into the pulp.

Crown-root fractures: One of the more challenging types of fracture to treat is the crown-root fracture because the fracture margin has to be exposed around the tooth/crown to properly restore the tooth. This can be accomplished by gingivectomy if the fracture line is in the sulcus. In more extreme cases, the tooth will have to be extruded with orthodontic forces or surgically repositioned. In the emergency session, if the pulp is exposed, it needs to be protected in the same fashion as complicated crown fractures. If the pulp is not exposed, all accessible exposed dentin areas should be covered for the patient’s comfort.

Pulpal survival for all these fracture types is generally good; however, endodontic treatment may be indicated later. Therefore, it is of utmost importance that a recall schedule is followed and that the teeth involved in the trauma are tested every time. Tables 1 and 2 outline the recommended recall rates for the most common dental injuries. It is not uncommon for there to be no response to vitality tests for up to three months, and a lack of response to vitality tests does not always indicate that root canal treatment is needed — especially in young and immature teeth. Rather, it is advisable to look for at least one other sign of pulpal necrosis, like vestibule swelling, periapical lesions and/or dramatic color change of the crown. If no signs exist, continue to monitor the patient at regular appointments every three months, for up to one year.

**Root fractures:** The pulp is affected in all root fractures. However, if the fragments are approximated soon after the fracture, there is a good chance that no endodontic treatment is necessary, just observation. With good approximation, it is likely that the pulp will revascularize across the fracture regardless of the age of the patient (Figs. 3a-f). A recent retrospective study included assessment of splinting type and time of root fracture. The study determined that, if the cervical portion of the tooth is stable once the two pieces have been approximated, no splint or a flexible splint for two weeks produces the best treatment outcome. Longer splinting time is recommended only when the fracture is close to the cervical area.

Table 2: Follow-Up Procedures for Luxated Permanent Teeth

<table>
<thead>
<tr>
<th>TIME</th>
<th>Concussion/Subluxation</th>
<th>Extrusion</th>
<th>Lateral Luxation</th>
<th>Intrusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Weeks</td>
<td>Splint removal (if applied for subluxation) Clinical and radiographic examination</td>
<td>Splint removal Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
</tr>
<tr>
<td>4 Weeks</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Splint removal Clinical and radiographic examination</td>
<td>Splint removal Clinical and radiographic examination</td>
</tr>
<tr>
<td>6-8 Weeks</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
</tr>
<tr>
<td>6 Months</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
</tr>
<tr>
<td>1 Year</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
<td>Clinical and radiographic examination</td>
</tr>
<tr>
<td>2-5 Years</td>
<td>Yearly up to 5 years</td>
<td>Yearly up to 5 years</td>
<td>Yearly up to 5 years</td>
<td>Yearly up to 5 years</td>
</tr>
</tbody>
</table>

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**Fig. 3a:** Schematic drawing of a common portion after root fracture: The crown portion is displaced inward toward the palate and the fractured piece is stuck to the facial cortical plate.

**Figs. 3b, c:** It is impossible to move the coronal portion back to its original location without releasing it from the cortical plate. This is accomplished by pulling the coronal portion down and then repositioning it.

**Fig. 3d:** A periapical radiograph of a root fracture a few hours after the injury. It was established that both fragments were in good approximation of each other. Splinting was done for two weeks.

**Fig. 3e:** At the nine-month recall, internal root resorption was noted, but no defect in the PDL or adjacent bone, indicating a ‘normal’ healing process.

**Fig. 3f:** Five-year recall, no endodontic treatment was needed.
Luxation injuries: All luxation injuries will cause some damage to the periodontal ligament and, in some cases, the pulp as well. The immediate treatment is to limit further damage to the PDL and allow for the best possible healing. As with all dental injuries, follow-up is essential. Late complications, such as internal or external root resorptions, are relatively frequent and require endodontic treatment, especially in more severe injuries. In many of these cases, referral to an endodontist is advisable.

Luxation injuries are divided into subcategories, mainly by degree of severity. The two mildest are termed “concussion” and “subluxation.” In those cases, the tooth is still in its original location, but is tender to percussion and/or, in the case of subluxation, has increased mobility. While no immediate treatment is needed for these injuries, follow-up is critical because the pulp may become necrotic, making endodontic intervention paramount.

When trauma has moved the tooth out of its normal position, it needs to be replaced gently as soon as possible. The only exceptions are cases of intrusion when it might not be possible or advisable to manipulate the tooth immediately. When an immature tooth is intruded up to 7 mm, it is recommended to wait three weeks and watch for signs of re-eruption. If no signs exist, one can initiate orthodontic repositioning. For intrusion of more than 7 mm, surgical or orthodontic repositioning should be performed within three weeks. In the case of an intruded, closed apex tooth, there is a possibility of re-eruption if the tooth is intruded less than 3 mm and the patient is younger than 17 years old. If the tooth is not moving after two to three weeks, however, orthodontic extrusion or extraction and reimplantation is recommended. If a tooth with a closed apex is intruded more than 3 mm, orthodontic or surgical repositioning should be performed within three weeks. The risk with all intrusions is that the intruded tooth may ankylose in the infraposition. Once that happens, the tooth may not be movable except possibly surgically. It is best to advise the patient and the parents/guardians that the long-term prognosis of an intruded tooth is unpredictable, as it is likely to eventually be lost due to ankylosis.

Splinting of a luxated tooth is recommended only for teeth that are still mobile after repositioning. In all types of trauma cases, a splint must allow for physiological movement. (See Figs. 4a–c and 5, and Table 3, regarding splinting time.)

When assessing luxation trauma, it is important to consider the maturity of the apex. If it is still open, there is a chance that the pulp will survive the trauma or revascularize, allowing the growth of the tooth to continue (Figs. 6a–c).

If the apex is closed, endodontic treatment is likely needed. It is advisable to follow the patient closely (Table 1) or refer him or her to an endodontist for further evaluation. Because of the injury to the PDL, rapid inflammatory root resorption can occur (within days or a few weeks) if the necrotic pulpal tissue becomes infected. For mature teeth diagnosed with necrotic pulps, placing calcium hydroxide for two to four weeks prior to obturation is recommended; however, one should allow the PDL to heal for two weeks before placement (see treatment for avulsion, below). Apexitization or revascularization is recommended for teeth with open apices.

It is important to remember that dental injuries do not always fall into one group or category, but often a combination of several categories. Injuries in multiple categories will impact the outcome. For example, it was recently demonstrated that the existence of a concurrent luxation injury with an uncomplicated crown fracture and complete root development are significant risk factors of pulp necrosis.

Avulsion: The time outside of the socket for an avulsed tooth is the most critical of its survival. If the tooth is replanted within 30 minutes, or alternatively kept in a physiological solution of specialized media or milk for a few hours, it has a fairly good prognosis. If the tooth has been dry for more than one hour, the periodontal ligament cannot be expected to survive and the tooth will likely become ankylosed (Fig. 7).

<table>
<thead>
<tr>
<th>Type of Injury</th>
<th>Splinting Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subluxation</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Extrusive luxation</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Avulsion</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Lateral luxation</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Intrusion</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Root fracture (middle 1/3)</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Alveolar fracture</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Root fracture (cervical 1/3)</td>
<td>4 months</td>
</tr>
</tbody>
</table>
recall the pulp chamber is completely calcified; however, the tooth responds normally to EPT and there is no apical pathology.

Fig. 6c. At the six-month recall there is good evidence that the apex is maturing and the pulp responds normally to cold. At the three-year recall the pulp chamber is completely calcified; however, the tooth responds normally to EPT and there is no apical pathology.

Fig. 7. Ankylosis or replacement root resorption, in which the root structure is lost and replaced by bone. Note that no apparent PDL space is seen.

Once reimplanted, most teeth need to be stabilized with a physiological splint for two weeks. The avulsed tooth has an open apex and was reimplanted within the hour, there is a possibility that the pulp will revascularize. In this case, delaying endodontic treatment at the emergency stage is recommended. Endodontic treatment should be performed later only if signs of pulpal necrosis, root resorption and/or arrested root development are confirmed.

In the case of a closed apex, revascularization is not expected. Therefore, endodontic treatment must be initiated two weeks after the tooth is reimplanted, and prior to removal of the splint. Treatment should not be initiated earlier because any further manipulation of the tooth prior to or immediately after reimplantation can cause further damage to the PDL. In addition, it has been shown that placing calcium hydroxide as an intracanal medicament immediately after reimplantation will promote inflammation that can lead to PDL damage. If the tooth had been kept dry longer than 60 minutes, performing root canal treatment prior to replantation is indicated.

After the emergency situation has been managed and the tooth/teeth stabilized, the second phase begins, in which the pulpal condition and likelihood of root resorption have to be carefully evaluated and the patient followed over a period of months, if not years. A follow-up timeline is essential to allow for intervention if signs of complications appear. In such cases, the expertise and training of endodontists become important. Diagnosing, preventing and treating any pulpal complications are an integral part of endodontic training as are performing pulp regenerative procedures and treating inflammatory root resorption (Figs. 6a,b).

Conclusion

Traumatic dental injuries present difficult challenges for both patients and their dentists. Current evidence allows the dental health care provider to manage situations that, in the past, often resulted in crippled dentition and unsightly appearance. Appropriate treatment can turn what at first glance looks like a hopeless situation into a very satisfactory outcome for patients. The endodontic specialist can play an important role in the team approach to treating patients with traumatic dental injuries.

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Errors accumulate during procedures. That’s the reason botching the access at the start of an RCT is so much more devastating than say, problems that come from misfitting a gutta-percha cone just before finishing the case. Miss a canal and the case is going down, regardless of how brilliant the remaining procedure is carried out. Perforate the tooth, and suddenly titanium starts looking better. Cut huge access cavities, and expect to see relatively huge numbers of root-fractured teeth within five years of treatment. Simply cheat the access procedure by beginning the instrumentation of canals before a straight, perfectly smooth path has been cut to each canal orifice, and be punished every time a file, an irrigating needle, an explorer, a gutta-percha point, a paper point or a plugger is taken into each of the canals scores of times.

This is not a critique so much as an admission of the ways that teeth and their root canal systems have taught me, usually the hard way, to spend whatever time is needed to create perfect entry paths into canals, before I attempt to work in them. So why do I have to have a talk with myself before beginning every access cavity — even after doing this for 35 years — to be certain to hit the mark I know must be met before it is safe to venture further?

Zen and the art of endo access

Robert Persig, in his book “Zen and the Art of Motorcycle Maintenance,” described being deeply frustrated when a bolt stripped as he was attempting to remove the side covers to the engine of his motorcycle, before rebuilding it. The rebuild could not continue until he was able to circumvent this problem. He had expected to spend several days completing the mission, yet he was amazed at the fury he experienced when faced with this conundrum.

The more he thought about it, the more mystified he became about his instinctual response, until he realized that he was tweaked because he had grossly undervalued this part of the long rebuild procedure, thinking mostly about the more dramatic routines to follow, such as cracking the cylinder case, honing the cylinder, replacing the piston and putting it all back...
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together afterward. When he realized that nothing was going to progress until he had successfully removed the side cover, he made removing that side cover a separate and important mission, an accomplishment that would deliver satisfaction in and of itself, if it could be completed during the next several hours spent.

So it is with endodontics. When we realize how critical the quality of our access preparations is to the remainder of the case, it feels like fingernails on a chalkboard to head into a canal before securing an ideal path into it. Aristotle got it right — excellence is a habit, not a character trait. So what do the habits of access excellence look like in this 21st century?

_Failing to plan is planning to fail_

Atul Gawande, in his book “The Checklist Manifesto,” describes the importance of planning not just which procedure to do, but how every single aspect of that procedure must be planned in detail, from start to finish, if consistently ideal results are the goal. Does the preoperative imaging accurately describe the anatomical challenges? Does the clinician have adequate magnification and light? Are the cutting tools adequate and well chosen? Are the locations, angles and depths of entry determined before beginning the procedure? Have maximal safe cutting lengths been marked on access burs? Are there procedures in place to deal with calcified canals that defy location? And so on.

In other words, the Alfred E. Neumann attitude of “What, me worry?” is not appropriate during this critical event. Conversely, when each of these critical elements is included in the treatment planning and execution of an ideal access cavity preparation, the rest of the procedure becomes progressively simpler as the finish is approached.

_Radiographic imaging_

We wouldn’t even attempt RCT without Roentgen’s invention of the dental radiograph, so it is not much of a stretch to claim the critical necessity of ideal preoperative radiography. Ideal preoperative X-ray imaging must include a straight-on angle that splits the mesial and distal contacts perfectly — taken either as a periapical or as a bitewing X-ray image, then at least one ideal off-angle view in order to capture data from the Z-plane (buccolingual) of the tooth in question.

In my practice, a mesial off-angle view of anteriors and premolars works well, because it is much easier to capture than a distal angle, and in anteriors and premolars the mesial view reveals as much radicular anatomy as a distal view. In molars it is different. In molars a distal view is far preferable to a mesial off-angle view, as the mesial view superimposes the body of the root over the distally curved root structure, while the distal view casts the apical root end sideways, where it can be more easily seen on the radiographic image.
Of course, cone-beam CT (CBCT) imaging is the unfair endodontic imaging advantage. If told I could have either a microscope or a CT machine, but not both, I would choose 3-D imaging every time. Only CBCT imaging can capture the mesial view of root structure — the view in which we see “The Secret Life of Root Canals” — the bucco-lingual plane containing the greatest degree of anatomic complexity. One of the greatest joys of having a CT machine in practice is knowing, for sure, before the access procedure is begun, that there is only a single canal in the mesiobuccal root of an upper molar. Conversely, one of the few negative experiences to be had with this technology is when the reconstructed volume shows two or three canals, in a root that has given up only one to the clinician’s exhaustive search.

The first gift of CBCT imaging to the field of endodontics has been the gift of finding all canals in a given tooth. Its second gift is the great diminution of access size possible, because the access cavity is no longer the primary viewing port into the pulp chamber and beyond. In fact, CT imaging is the only view needed into the anatomic verities of root canal spaces, allowing access cavities to be used exclusively as treatment, rather than as exploratory portals. Ultimately, RCT access procedures will be done with CT-generated drill guides, allowing molars to be treated as treatment, rather than as exploratory portals. Ultimately, RCT access procedures will be done with CT-generated drill guides, allowing molars to be treated with minimal structural weakening when the mesio-distal dimension is kept to a 1 to 1.5 mm width (Fig. 1).

In anterior teeth, convenience form is harder won as the incisal edge is to be avoided, out of respect for postendodontic esthetic objectives, thus requiring a deeper cut under the cingulum, to allow a more straight-line entry path, while minding the “no-fly zone” of the incisal edge. The most dangerous anterior access cavity error is not cutting adequately through what Dr. Schilder called the “lingual dentinal triangle” under the cingulum, and this can be accomplished with minimal structural weakening when the mesio-distal dimension is kept to a 1 to 1.5 mm width (Fig. 1).

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In posterior teeth, premolars and molars, it is important to remember that their occlusal surfaces are not centered over the root structure, but are skewed toward the idling cusp side of the root structure. As pulp chambers are centered in the root structure, not centered under the occlusal surface, access in posterior teeth is best accomplished by cutting near working cusps, while staying 1-2 mm away from idling cusps (Fig. 2).

In posterior teeth, premolars and molars, it is important to remember that their occlusal surfaces are not centered over the root structure, but are skewed toward the idling cusp side of the root structure. As pulp chambers are centered in the root structure, not centered under the occlusal surface, access in posterior teeth is best accomplished by cutting near working cusps, while staying 1-2 mm away from idling cusps (Fig. 2).

In molars, conservation form is held by avoiding the distal half of the occlusal plane, as ideal file paths from the distal canals of upper and lower molars are canted severely to the mesial, so much so that distal canals of lower molars are best referenced to the MB or ML cusp tips, and distobuccal canals of upper molars are best referenced to the palatal cusp tips. Convenience form is achieved by cutting the mesial wall of molar access cavities parallel to the mesial surface of the tooth (Fig. 3).
Back from the abyss

I was taught Schilder technique at University of the Pacific by Dr. Michael Scianamblo and after grad school by Dr. Cliff Ruddle. I understood the clinical imperative Dr. Schilder had placed on cutting an access adequate to treat the entire root canal system in a predictable manner, and I enjoyed working through the large access cavities and the generous coronal canal shapes he recommended until I was brought up short by Dr. Carl Reider, a well-known prosthodontic lecturer from Southern California.

When I asked what he most wanted from the endodontists he referred his patients to, he said he wished we could “just suck the pulp out, without cutting any tooth structure.” As we talked, I came to better understand the structural imperative of saving teeth in the long term, setting me on a quest for tools and methods that would allow us to achieve the same consistently ideal endodontic outcomes, through smaller access openings and coronal canal shapes.

Ultimately, it was the inspiration for my invention of the Maximum Flute Diameter (MFD) limitations on GT and GTX rotary files (DENTSPLY Tulsa Dental Specialties), the LAX (line angle extension) Guided Access Diamond Burs by SybronEndo, as well as obturation methods using flexible condensation devices, such as System-B Continuous Wave electric heat pluggers (SybronEndo) and GT/GTX Obturators (DENTSPLY Tulsa Dental Specialties).

The Itty Bitty Access Committee

Since that initial awakening in the ’80s, it has felt like being a lone voice in the wilderness until the past 10 years, when a new generation of dentists and endodontists, steeped in the new reality of implant dentistry as an alternative to RCT, have taken up the cry for longer-term outcomes through improved structural preservation, ultimately becoming what I jokingly call The Itty Bitty Access Committee (IABC).

As so often happens, somebody outside of our specialty, a general dentist named Dr. David Clark, started lecturing on the access elephant in the endodontic living room. He got my buddy Dr. John Khademi turned on to the possibilities that more conservative access cavities could offer the specialty, and one by one a group of young endodontists joined the game of who can do a perfect RCT through the smallest access cavity. This ad hoc group of talent began the IABC club.

The cases shown in Figures 4 through 10 — mostly done by IBAC members — make me very happy and afraid at the same time. What the heck are they doing? Little, tiny entries, leaving pulp chamber roofs intact, lateral pulp horns unroofed as well, or just total RCT through previously cut restorative cavities!

After getting over my initial shock at what they were accomplishing, I came to understand that the future of endo is very good in these extremely talented hands, and I saw that the procedure I was developing for endodontic surgery — CT-guided endodontic surgery (CT-GES) — could be applied to conventional treatment as well (Figs. 11a-12d).

And morning breaks over the field of endodontics._

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About the author

L. Stephen Buchanan, DDS, FACP, FACD, FICD, is a diplomate of the American Board of Endodontics, a fellow of the American and International Colleges of Dentists and serves as part-time faculty to the UCLA and USC graduate endodontic programs. He holds patents on the Endo Bender Plier (SybronEndo), System-B and Continuous Wave obturation tools and methods (SybronEndo), GT and GTX file systems (DENTSPLY Tulsa Dental Specialties), LA Axxess Burs (SybronEndo), and Buc ultrasonic tips (Spartan/ Obtura). Buchanan lives in Santa Barbara, Calif., where he enjoys a practice limited to conventional and microsurgical endodontics and dental implant surgery. He is the founder of Dental Education Laboratories, a hands-on training facility in Santa Barbara that he has directed for 28 years.
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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 periodontium 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 a 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
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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” more than 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.
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Conventional endodontic therapy has suffered from the inability to consistently clean and disinfect the entire root canal system. While incremental improvements and modifications have been made, conventional techniques are largely unchanged from original endodontic ideology. We know that files do not clean canals. Yet, dental companies continue to market their new files with the idea that changes in flexibility and file shape will make outcomes more successful. There has also been a push to use multiple different types of irrigants to more effectively clean the canals. However, current irrigation devices have proven to leave much of the bacteria, biofilm and smear layer behind. The theory being that certain bacteria are more resistant than others to differing forms of cleaning solutions. Studies have consistently shown that the classic combination of 5.25 percent NaOCl and 15 percent EDTA are highly effective cleaning agents, and alternative agents have yet to show a significant antimicrobial improvement.

In an attempt to more effectively eliminate bacteria, pulpal tissue and debris from the canal system, clinicians instrument the canals to a large enough size to ideally debride and irrigate all the walls of the canal system. Unfortunately, these techniques are not completely effective and may pose risks to the long-term survival of the tooth. Clinicians will never be able to instrument all the walls of the canal system. Attempts to do so generally lead to excessive weakening of the tooth and possible iatrogenic complications. Likewise, it is not our cleaning solutions that require improvement. It is our inability to effectively work the cleaning agents into the difficult-to-reach anatomy that is the problem. This combination of inadequate disinfection and excessive removal of tooth structure continues to lead to root canal failure.

Sonendo® has departed from conventional thought to develop new technology that dramatically improves cleaning of the root canal system and breaks past the barriers that have limited endodontic success. The company’s patented GentleWave™ handpiece generates and delivers sound energy with a broad spectrum of frequencies to detach tissue and biofilm from the entire root canal system. The mechanism of action is so effective that file instrumentation of the canals can be kept to a minimum to preserve dentin and overall tooth strength. This is one of the very few endodontic technologies designed specifically for our specialty and is not an adaptation of an existing one.

Clinicians should use the GentleWave system in a clinical setting to fully appreciate and believe the power of this new technology. A clinician has no idea what a fully cleaned tooth looks like until after the GentleWave system has been used. In the case below (Figs. 1-2b), separate apical radiolucencies were present at the apex of the palatal root as seen on the CBCT scan. Predictably cleaning an apical bifurcation like the one shown can be very difficult, if not impossible. After using the GentleWave system, the dentin gives off a clean luster due to the system’s ability to clean deep into dentinal tubules to remove stains and debris. The system’s enhanced ability to clean lateral canals and fins shows up as more...
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obturated accessory anatomy on post-op radiographs. Obturation is more predictable, as can be seen in the post-op image. A clean and smooth flowing canal system allows obturation material to flow into eccentricities without micro debris blocking the flow of material. An ideal apical cleaning and preservation of the constriction allows obturation material to more effectively fill apical ramifications. Overall tooth strength was also kept to a maximum without the need to over-enlarge the canals. Most importantly, my excitement factor is off the charts in knowing I can predictably clean and obturate complex anatomy.

The patient can also tell the difference. The mechanism of action is very unassuming to the patient without any scary sounds or aggressive movements during treatment. Treatments can be compressed to shorter treatment times or single-visit appointments due to less instrumentation along with thorough disinfection of the canal system. Patients also notice less post-op pain due to a gentle mechanism of action and minimal remaining bacteria that can cause post-procedure pain. It has become common in my practice for patients to comment on the minimal level of post-op discomfort the day following the procedure. It is nice to have the peace of mind that when I treat the patients, they will feel better in a shorter period of time.

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Sonendo has grown from a concept in 2006 to its selective commercial release today. The device is FDA cleared.

References


about the author

Tyler F. Baker, DDS, MS, received his DDS degree from Loma Linda University. He received an AEGD certificate and other awards while serving as a dentist in the United States Air Force. He returned to Loma Linda University, where he received a certificate in endodontics and a master’s degree. He has been published in the Journal of Endodontics. He currently practices endodontics in San Marcos, Calif., where he was voted one of San Diego Magazine’s Top Dentists.
This year marks the first time FKG Dentaire will be a Bronze Sponsor of ESE congress, which takes place Sept. 16–19 at the International Conference Centre of Barcelona.

“The ESE congress is incredibly important for us, as it brings together over 2,000 specialists in endodontics,” says Thierry Rouiller, CEO of FKG Dentaire. "It's a unique opportunity in Europe to present our different products and demonstrate how they work. It also gives us a chance to share and exchange ideas with a group of passionate individuals coming from different perspectives."

To mark the occasion, FKG Dentaire is focusing on the big picture. It has invited three distinguished endodontic experts who will present in detail a hand-picked selection of FKG instruments, including the company’s flagship product this year, the XP-endo Finisher.

Kicking off proceedings on Wednesday, Sept. 16, will be Dr. Martin Trope from the United States.

“We are honored to have Dr. Trope animate two pre-congress sessions organized by FKG on the theme of ‘Biologic and conservative endodontics: 3-D disinfection of the root canal system using memory shape technology,’” explains Patricia Borloz, marketing director at FKG Dentaire. "From shaping to obturation, participants at this hands-on lecture will be able to follow a step-by-step demonstration at the microscope.

“On Thursday, Dr. Gilberto Debelian from Norway will lead a lecture on the challenges of cleaning the root canal and present the characteristics and advantages associated with the XP-endo Finisher. This latest FKG innovation is a revolutionary instrument that allows practitioners to treat highly complex root canal systems and clean hard-to-reach areas with minimal impact on the dentin.

“Finally, on Friday, Sept. 18, we have the pleasure of welcoming Dr. Bertrand Khayat from France,” Borloz adds. "He will showcase from start to finish a short sequence of exclusively rotary instruments developed by FKG to maximize the quality and efficiency of root canal preparation. We are really looking forward to these sessions and to hearing participants’ comments and suggestions."

Advance online registration for pre-congress sessions, together with the full schedule of congress lectures, is now available on the ESE website: www.e-s-e.eu. For more information, please visit the FKG Dentaire stand in area 49/36 of the exhibition hall or get in touch using the contact details below._
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Author: Vista Dental Products staff

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