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| CE article

Diagnosis 2013:
The things you need to know for successful endodontic treatment

| technique

Bioactive endodontic obturation:
Combining the new with the tried and true

| special

Laser versus conventional therapies

oemus

Lasers are mainstream in endodontics

Dr George Freedman

_One of the most innovative technologies widely used in medicine, kind to tissue and excellent for healing, has only recently begun to make a significant dental impact. Dental lasers have been commercially available for several decades, but the profession has been slow to incorporate this technology into the practice. Lasers, extensively documented in the academic and clinical dental literature, have long been perceived by practitioners as too limited in intra-oral applications, too complicated and too expensive. In recent years, ease of use, scientific research and documentation, and greater affordability have converged to make lasers essential for every dental practice.

Lasers were first indicated for soft-tissue treatment and management. Diode technology has reduced the initial financial investment and made lasers largely affordable for most practices. More recently, laser technologies have been successfully incorporated into endodontic procedures.

The success of intra-radicular endodontic treatment is dependent upon the cleaning and shaping of the root-canal space, disinfection of the root-canal space and 3-D obturation of the root-canal system. Many technologies have been utilised to accomplish these tasks: instrumentation systems, irrigants, intra-canal medications, and a host of obturation materials. Unfortunately, conventional endodontic therapy is still observed to fail on occasion owing to incomplete disinfection and subsequent reinfection. Bacteria may also be found outside the tooth's root-canal system at the apex and elsewhere on the root surface. These extra-radicular bacteria cannot be eliminated with conventional therapies, and the residual contamination maintains the active infectious process.

Laser-assisted endodontic therapy, undertaken after access and mechanical preparation, overcomes the inherent difficulties of existing treatment. Lasers must be considered additions to the existing endodontic armamentarium rather than as stand-alone instruments. The benefits of the variously documented endodontic laser therapies include patient comfort, effective debridement, and penetrating disinfection. Laser therapy avoids vibration, facilitating anaesthesia and eliminating microfractures. The energy of the laser and its associated hydro-photonic activity efficiently remove pulpal tissue, the smear layer and bacteria from the canal walls three-dimensionally, typically without physical contact and without the risk of over-instrumentation beyond the apex.

While the future mainstream laser tools and techniques are still in the process of development and definition, the mounting scientific and clinical evidence indicates that photoactivated debridement and disinfection instruments cannot be dismissed. Dentists who perform endodontic therapy must consider integrating endodontic lasers into their practices. Lasers have arrived in endodontics!

Dr George Freedman (DDS, BSc, Fellow of the American Academy of Cosmetic Dentistry, American College of Dentists, and International Academy for Dental-Facial Esthetics)


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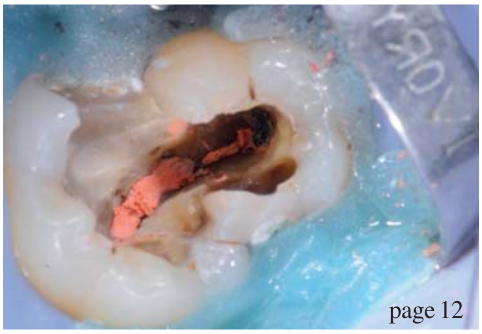
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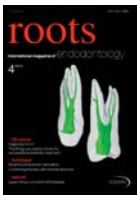

Frontal and lateral views of a 3-D reconstruction of a maxillary first premolar showing a three-rooted canal system. This micro-CT image was developed as part of the Root Canal Anatomy Project http://rootcanalanatomy.blogspot.com in the Laboratory of Endodontics of the University of Sao Paulo in Ribeirao Preto, Brazil by Prof. Marco Versiani, Prof. Jesus Pécora & Prof. Manoel Sousa-Neto.


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Diagnosis 2013: The things you need to know for successful endodontic treatment

Author_ Dr Thomas Jovicich, USA

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_The goal of endodontic treatment is for the clinician to achieve an effective cleaning and debridement of the root canal system, including the smear layer and all of its mechanical and bacterial byproducts. Traditionally this is accomplished via mechanical instrumentation in conjunction with chemical irrigants together and actively engaged to completely debride and sterilize the root canal system.

The root canal system is a vast and complex three-dimensional structure comprising deltas and lateral canals, along with multiple branches off of the main root canal system (Figs. 1, 2, 9).

Before the clinician can begin to treat a patient in need of endodontic treatment, he or she first must come up with the proper diagnosis. Once the diagnosis has been made, it then must be integrated with the treatment plan. Taking that treatment plan and presenting it to the patient creates the next challenge: creating value for the patient. One of my most difficult challenges as a working endodontist is creating value for the patient in my chair who has no pain and is here because his or her dentist "saw something" on the radiograph. Pain is the greatest patient motivator we have in dentistry today.

The focus of this article is on diagnosis, and it is my goal to provide the reader with a good grasp of diagnosis as it relates to endodontic treatment.

Endodontics is all about vision. You have it. I have it. The dentist down the street has it. Doing root canals today is all about having the confidence to make the proper diagnosis. This is achieved through repetition. The more you do it, the easier it becomes. In addition, you need consistency that is achieved through positive reinforcement. Once you believe you can do it and the results support that, you then develop competence. This allows you to retain the skills you have worked hard to hone. The most important trait to utilize in clinical practice today is common sense. This is what separates the true artisans from tooth mechanics.

The key component to endodontic treatment is diagnosis. It is based upon using a multifocal approach that involves:

_patient report,
_medical and dental history,
_clinical signs and symptoms,
_diagnostic testing,
_radiographic findings,
_restorability.

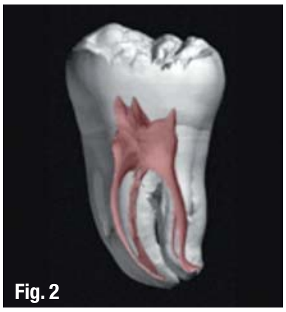


Fig. 1_Maxillary molar. Note the complex anatomy and multiple portals of exit. *(Photos/Provided by Thomas Jovicich, MS, DMD)*
Fig. 2_Mandibular molar. Note the curvature along with the multiple portals of exit.
Fig. 3a_Maxillary central incisor with a periapical lesion. This is a markedly calcified canal.
Fig. 3b_Maxillary central incisor with completed root canal using Sybron TFA rotary nickel titanium instruments, Sealapex sealer. Note the multiple portals of exit in the apical region.

Taking and collating all of this information will allow the clinician to arrive at a proper and thorough diagnosis. Let's break these down and delve into what needs to be done.

_Patient report

This is the first opportunity to create a road map to a diagnosis. The goal is to ascertain the nature of the problem. Step one: Ask the patient the where the pain is located. Once you've localized the area, it's imperative to ask a few more questions. The next question should involve determining pulpal vitality through the use of an ice pencil.

Other times the patient will volunteer this information with a statement like: "The minute I put anything cold on this tooth, the pain is present and quite intense." This information suggests that the pain may be pulpal in origin. Because the trigeminal nerve is involved in endodontics, it is important to determine any type of radiating pain. It is not uncommon for maxillary pain to radiate from the mandibular area and vice versa. A final area of feedback I want from patients relates to biting and chewing.

The patient's report is the foundation upon which we begin the diagnostic procedure. Asking probing and leading questions in "plain English" will allow the patient to give you critical diagnostic information.

_Medical and dental history

Once you have the patient's report, probing his or her medical and dental history gives clarity to the background. What are the patient's medical allergies? What recent dental treatment has the patient had? Was there any mention of restorations placed that were near or at the pulp?

Many times a patient will mention having heard the dentist tell his assistant that they were close to the pulp during the excavation of decay. Asking detailed questions enables you to enrich the diagnostic canvas as to why the patient is sitting in your chair.

_Clinical signs and symptoms

By this point, you have listened to the patient's chief complaint and you have taken radiographs or digital images. It's time to "test" the patient. The "bite test" involves having the patient attempt to reproduce the pain through biting on an orangewood stick or a cotton swab or a wet cotton roll. If there is pain to bite, you are dealing with some degree of pulpal inflammation with secondary involvement of the periodontal ligament. Once you have this information, the next step is to look at your digital imaging and analyze the relationship of the periodontal ligament (pdl) to the root. Is there a thickening? Is there a widening?

If the patient reports pain to bite upon release, this infers that there may be some structural root damage (Figs. 5a & b). At that point is it essential to look at the occlusal surface of the tooth, account for the type and age of any restoration and inquire if any recent dentistry has been done. In addition, it is imperative to probe the suspected tooth.

Probing from buccal to lingual with at least four measurements per side is the best barometer to assess periodontal health. If you find an isolated defect in any single probing, you are most likely dealing with a fracture of the root. Endodontic treatment to confirm or rule out a fracture is indicated in these clinical situations.

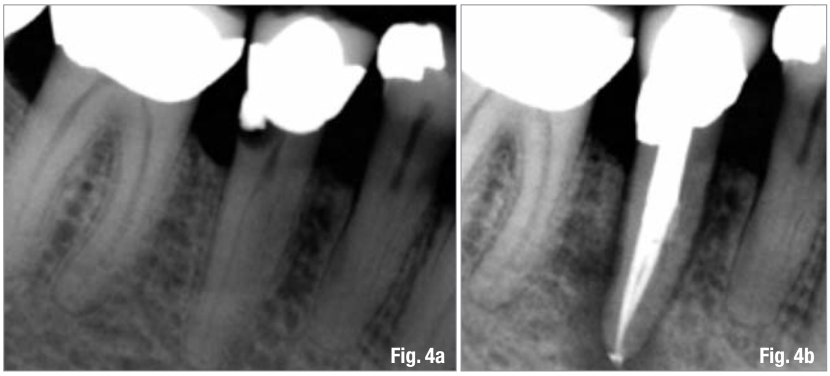


Fig. 4a_The presence of caries under the margin of a restoration. The caries extend to the pulp and will need endodontic treatment.
Fig. 4b_The endodontic treatment is completed. In this case, the patient was lost to the practice for three years and came back when his face was swollen because of incomplete treatment.

_Diagnostic testing

The percussion test involves using the blunt end of a mouth mirror or periodontal probe to assess for periodontal inflammation. It is imperative that the clinician gets a frame of reference. This is accomplished by testing the same tooth on the opposite side of the arch. In addition, it is prudent to test the suspected tooth as well as the teeth on either side. Testing should involve both the occlusal and facial surfaces.

Thermal tests utilizing hot or cold are the definitive modality to assess pulpal vitality. There are a myriad of ways to test with cold, including CO_2 systems, refrigerant sprays and ice cubes (pellets). I believe ice pellets are the best way to test for cold symptoms. In our practice, we use anesthetic carpules that are filled up with water and frozen.

This method is cheap, efficient and plentiful. The goal is to reproduce the patient's symptoms. Many patients who report pulpal hyperemia have managed this symptom by utilizing the opposite side of their mouth. Temperature symptoms are a major motivator for patients to seek dental care.

Fig. 5a_Cracked tooth syndrome. Pre-treatment radiograph.
Fig. 5b_What can happen in a cracked tooth when you obturate with warm, vertical condensation of gutta-percha.


Fig. 5a


Fig. 5b

Testing with ice involves establishing a baseline to cold. Typically, I chose to test the same tooth on the opposite side or the maxillary central incisor. I ask patients to tell me when they feel an "electrical shock or jolt" to the tooth. As soon as they do that, I remove the ice from the tooth. This is easily accomplished on the buccal surface of the tooth at the margin of the gingiva. When porcelain restorations are present, I strive to put the ice right at the margin on or above any metal margins.

Sometimes it is necessary to apply the ice on the lingual aspect of the tooth. As unresponsive as porcelain restorations can be, the clinician needs to be aware that pulp testing gold restorations can have the opposite effect. This is because of the metallurgical properties of gold. It is an amazing conductor of temperature. Always forewarn the patient when testing gold-restored teeth.

Ask the patient if the cold on the tooth reproduced his or her pain. Also, ask if the pain lingered after you removed the ice from the test site. If the pain it is lingering, it is a sign of irreversible pulpitis.

In some cases the pain can and does radiate along the pathway of the trigeminal nerve. Sometimes, especially in the maxilla, referred pain can be related to sinus issues, such as sinusitis, allergic rhinitis and rhinovirus.

If the patient does not respond to any thermal tests, both hot and cold, it is a sign that the pulp is necrotic, dying or infected. In this instance, studying the digital imaging may aid the diagnosis. One caveat: It is possible to have a necrotic pulp without being able to quantify it via digital images In many incipient pathology issues, it takes approximately 90 to 120 days for breakdown to manifest itself on imaging. Today's cone-beam imaging technology can shorten that process to 30 days. It is not uncommon to have a patient in the chair with symptoms that you cannot quantify radiographically.

Fig. 6_Well-done endodontic treatment of tooth #6. Notice the multiple portals of exit as they relate to the presence of lesions.
Fig. 7_Know when to say when. This dentist attempted to do an endodontic procedure that should not have been done.


Fig. 6


Fig. 7

_Radiographic findings

Radiographic findings (Figs. 8a & b) are the road map for endodontics. Thorough study and evaluation of imaging allows the clinician to determine a multitude of facts about the tooth in question. What does the image reveal? Can you see if there is a widening of the pdl? If there is a widening of the pdl, it is essential to have the patient bite down on a bite stick.

Once he or she does that, you must ask if the pain, if present, is worse upon bite or upon release of bite. The latter is highly correlated with root fracture. Once that is confirmed, the next step is to prepare the patient for a root canal.

The dentist must convincingly explain the procedure's value as well as caution the patient about the possibility of losing the tooth due to the fracture extending apical from the cementoenamel junction (CEJ). Is there a lesion (Figs. 3a & b) present? This information allows me to frame my diagnostic questions to the patient. These include: Is the tooth sensitive to cold? I know from the lesion that the answer to that should be no. If, however, the answer is yes, it automatically triggers my mind to look for another tooth.

Generally, speaking teeth with lesions of endodontic origin (LEOs) test non-vital to thermal or electric pulp testing. In sequencing, I first ask for the patient's report, followed by radiographic findings, which I then augment with clinical testing to tie it all together and arrive at a diagnosis. Lastly, are caries present? The location of caries is a determining factor as to whether a root canal is needed (Figs. 4a & b).

_Restorability

Restorability is an issue that has been a hot topic in dentistry for years. Its meaning has evolved as technology has become the backbone of modern dentistry. Prior to the incorporation of implant dentistry, restorability had a very different meaning. Dentists were much more motivated to save teeth. Options and creativity were necessary for clinical success, both in endodontics as well as in restorative dentistry.

Technology has taken away one form of resourcefulness and replaced it with the promise of a panacea. It has become far too easy for general dentists to recommend removal of a tooth to a patient with the promise that an implant will save the day.

> 'In modern endodontics, as technology advances and we bring on file systems that shape more efficiently and safely—and we develop a greater understanding of the role of irrigation in endodontics—we can offer higher success rates than at any time in history.'

Historically speaking, the diagnosis of a tooth being non-restorable came after a myriad of attempts to save the tooth. Every aspect of dentistry came into play. Periodontists did osseous surgery and root amputations. Endodontists performed conventional endodontics and, if necessary, surgical intervention to do everything possible to save the tooth. Decisions involving the long-term prognosis of the tooth were relevant. Decisions about the type of restoration were discussed. Decisions about the osseous health of the roots and surrounding bone structures were relevant.

The goal of every specialist is to be an extension of the general dentist's practice. To that end, deciding whether a tooth was restorable or not was, at a minimum, a conversation to be had between the specialist and the general dentist.

Leap forward to the new millennium, and dentists no longer fight to save teeth. Dentists realize the financial windfall that implants offer their practices. Dentists can attend a myriad of continuing education courses over a weekend and on Monday become nascent implantologists. This fact makes diagnosis and saving a tooth the most important facet of restorative dentistry moving forward.

Treatment planning and restorability are integral to success both for the patient and the dentist. A patient in pain presents a unique opportunity for the dentist. Many questions need to be asked and answered. Among them: What can the dentist do to manage the pain? What is the cause of the pain? How long has the patient been in pain? Once the initial triage phase is complete, other factors must be addressed. These include: Is the tooth restorable? If endodontic treatment is indicated, what further treatment will be needed? Is there a need for periodontal intervention? If so, what type of treatment is it? Osseous surgery? Does the tooth need crownlengthening surgery? How will these procedures affect the adjacent teeth?

The above paragraph speaks volumes as to the complexities of treatment planning in dentistry today. Every day in offices around the world, a patient visits his or her dentist in pain. How the dentist responds to this will go a long way in determining the patient's dental well-being. A well rounded practice with high moral fiber will enable the dentist and patient to work synergistically to develop a realistic treatment plan.

The last essential ingredient to success is that the dentist knows "when to say when" (Fig. 7). As a specialist and lecturer, I believe that if a general dentist does roughly 80 per cent of the endodontic cases that walk in the door of his practice and refers out the remaining 20 per cent, he or she will have a very busy endodontic practice. In the past five years, especially since the decline in the economy and busyness of practices, more than 50 per cent of my practice consists of retreatment. The general dentist should have never attempted more than half of those cases. I can only speculate how much more there would be if dentists didn't have implants to fall back upon.

_Implants vs. endodontic treatment

The next aspect of the diagnostic conundrum is the increasing role implants play in treatment planning. When I first began practicing endodontics in 1988, implants were in their nascent stages. If a patient had a root canal and continued to experience pain or discomfort, both the dentist and the endodontist had a myriad of choices, from retreatment to surgical correction. In 2013, the knee-jerk reaction to placing implants has never been greater. More and more general dentists go to weekend "seminars/courses," and on Monday morning they are placing implants. Much of this is based on the financially lucrative aspect of implant dentistry.

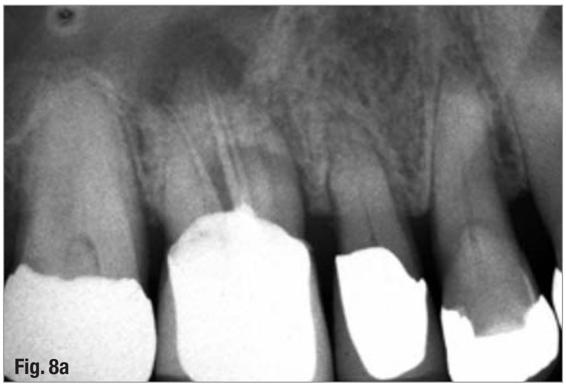


Fig. 8a_Initial digital image with a patient whose chief complaint was mild pain to bite and chew.
Fig. 8b_Digital photo of the tooth after I extracted it, showing a gross negligence. The tooth was perforated through the furcation, and gutta-percha was placed in what the dentist thought was the root canal system.
Fig. 9_The complexities of maxillary molar endodontics and multiple portals of exit. Of note, I was never able to shape the MB2 canal.

This has created polarizing arguments: save the tooth via endodontic treatment, or extract the tooth and place an implant. Too soon today, dentists will opt to extract a tooth that has a questionable prognosis in favour of placing an implant. It is my opinion that dentists should exhaust all possible options before opting to place an implant. Recently, I treated two of my colleagues with cracked teeth who wanted to exhaust every option (both were treated surgically). Ironically, they are two dentists who are heavy into implant dentistry. There has never been a better time to employ the "Golden Rule" for treatment planning.

What are the factors involved in the decision? Is there enough bone to support an implant? Will you have to augment or condition the site? If you elect to do endodontic treatment and it fails, are you willing to surgically try to save the tooth? If so, and it still fails because of a fracture, by doing surgery have you destroyed the bone? Can the patient afford to place an implant? And are they prepared for the amount of time they may be edentulous in that spot? All of these situations merit a thorough and honest discussion with the patient. In addition, the dentist needs to take into consideration the patient's motivation to go through these procedures. Many times I speak to patients about implants, and they are surprised by the cost and shocked by the time it will take before they have an implant crown functioning in their mouths.

In modern endodontics, as technology advances and we bring on file systems that shape more efficiently and safely—and we develop a greater understanding of the role of irrigation in endodontics – we can offer higher success rates than at any time in history. This paradigm starts with understanding the patient's symptoms and medical contraindications, correlating them with the proper diagnosis and then having the ability to honestly look in the mirror and decide that you can perform this treatment successfully.

These are the core decisions that need to occur on every level of dentistry. Successful implementation of these values and diagnostic procedures will lead to a profitable and stress-free practice.

_Summary

Does the dentist have all of the salient dental facts? By asking for the patient's symptoms, you begin the diagnostic process. From there the journey begins. Next, does the dentist understand the patient's chief complaint and symptoms? Once I understand what the patient is in my chair for, I calculate a path that will get me the most diagnostic information. I will need to use imaging, thermal sensitivity tests and bite tests. Imaging gives me the direction. Once I determine the vitality and take the periodontal health into consideration, it's time to discuss the diagnosis and treatment options with the patient.

I always present treatment in sequences. The first option for the patient would be to take my findings "under advisement." Those are patients who typically do not present with pain and at that moment in time do not appreciate the need for a root canal. I never worry about those people, because nine times out of 10 they will be back in my chair sooner rather than later. The second choice revolves around the need for endodontic treatment.

With this option, I create value for the need for treatment. Couple that with the patient being in pain and wanting relief, and the decision and diagnosis is easy for this patient type. The third option I give each and every patient involves letting him or her know that extraction is a viable option for his or her tooth. With that, I explain if the site is a good candidate to receive an implant and give him or her information on the time, cost and procedure involved in placing an implant. It is legally very important that your consultation and diagnosis involve every possible option.

In sum, the goal of diagnosis is to be able to collate the patient's chief complaint with his or her clinical symptoms. Once that is done, the dentist moves through a logical progression of treatment options, with the goal of providing excellence (Fig. 6). In this paradigm, both the patient and the dentist benefit from superior service and treatment._

_author roots

Dr Thomas Jovicich, MS, DMD, is director of the West Valley Endodontic Group, located in the San Fernando Valley of California. In addition to working in his private practice, Jovicich has been a key opinion leader for Sybron Dental Specialties since 2000. He lectures around the world on current concepts and theories in endodontics. Jovicich also hosts a learning lab in his office for dentists, teaching them endodontics on their patients utilizing the latest state-of-the-art technology and materials through the surgical microscope.
He may be contacted at thomasjovicich@mac.com

CBCT in endodontic treatment of fused second and third mandibular molars

Authors_ Dr Andreas Krokidis, Greece, & Dr Riccardo Tonini, Italy

Fig. 1_Initial clinical situation. Observe the plaque in the lingual side in the fusion area and discoloration due to caries.

Fig. 2_Initial X-ray situation.

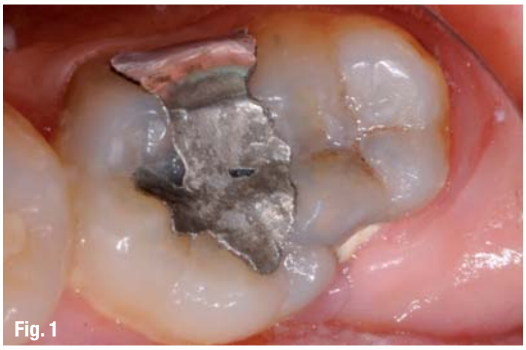


Fig. 1

Fig. 2

_Abstract

The aim of this article is to report a rare anatomic case and the contribution of new technologies in best resolving it. Fusion is defined as the union of two separate tooth germs at any stage of tooth development. Planning treatment for this condition can be difficult and requires all diagnostic means available. A 45-year-old female patient presenting with a fused second and third molar underwent endodontic treatment and direct restoration after CBCT imaging revealed a direct relationship between the two germs. The treatment was successful once the correct diagnosis had been made.

Fig. 3_Reconstruction.

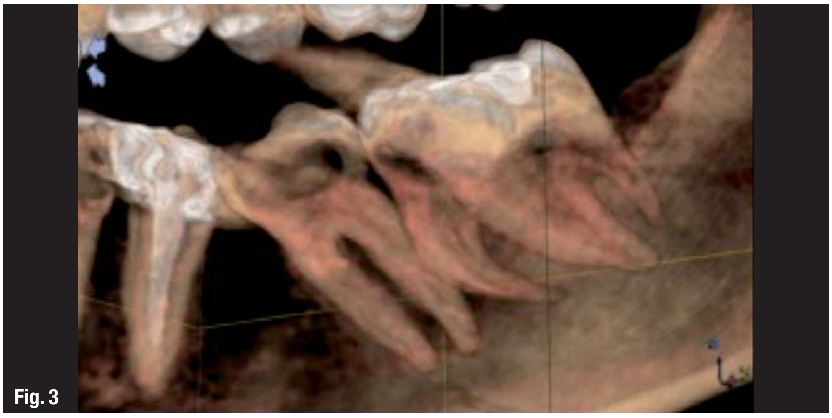


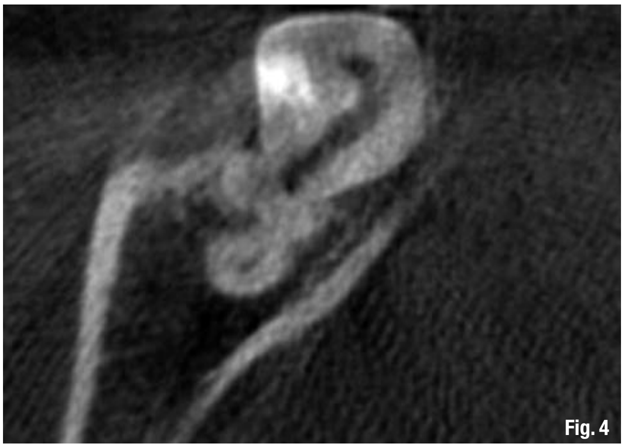
Fig. 3

_Introduction

Fusion is defined as the union of two separate tooth germs at any stage of tooth development. Fused elements may be attached at the dentine or enamel. This process involves the epithelial and mesenchymal germ layers, and results in irregular tooth morphology.[1] Depending on the stage of development in which the fusion occurs, pulp chambers and canals may be linked or separated.

The reason for this phenomenon is unknown, but genetic factors, physical forces, pressure, and trauma may be influencing factors.[2] The prevalence of dental fusion is higher in primary dentition (0.5–2.5 %) than in permanent dentition (0.1 %); in both cases, the anterior region has the highest prevalence.[3] The incidence is the same between males and females.

Cases of affected posterior teeth are rare in the literature. Most posterior teeth are fused with fourth molars (supernumerary). Fusion between premolars and molars or second and third molars has also been reported, but is less common. In some reported cases, teeth are bilaterally fused with supernumerary molars.[4–9] In these cases, the number of teeth in the dental arch is also normal and differentiation from gemination is clinically difficult or impossible. A di-



agnostic consideration, but not a set rule, is that supernumerary teeth are often slightly aberrant and have a cone-shaped clinical appearance. Thus, fusion between a supernumerary and a normal tooth will generally involve differences in the two halves of the joined crown. However, in gemination cases, the two halves of the joined crown are commonly mirror images.[9]

Periodontic problems occur as a part of the pathology in these cases.[5–8] A high prevalence of caries also occurs due to anatomically abnormal plaque retention. In the anterior region, an anti-aesthetic effect occurs owing to the abnormal anatomy. In contrast, crowding and occlusal dysfunction may occur in the posterior region, especially in cases with supernumerary teeth, which often leads to tooth extraction.[5,10,11]

Fused teeth are usually asymptomatic. The collaboration of practitioners with expertise in multiple areas of dentistry is important to create or achieve functional and aesthetic success in these cases. Several treatment methods have been described in the literature with respect to the different types and morphological variations of fused teeth, including endodontic, restorative, surgical, periodontal, and orthodontic treatment.[3–6,10–12]

In cases in which endodontic therapy is indicated, clinicians must be very careful during access because anatomy is not predetermined and canals may be displaced from their normal position, depending on the position of the two germs and whether the teeth involved are part of the normal dentition or supernumerary. For this reason, clinicians should examine the element meticulously, both clinically and radiographically. This case report demonstrates the usefulness of a CBCT scan in addition to conventional intra-oral X-rays from different projections in diagnosing and designing appropriate treatment for this rare case.[13,14]

_Case presentation

A 45-year-old woman was referred by an oral surgeon who had proposed an extraction of the last mandibular molar because of pain and abnormal anatomy. The patient complained of pulsing pain in the right side of the oral cavity, which extended to the ear region and worsened at night.

After a comprehensive extra-oral and intra-oral examination, the pain was found to be localised to the region of teeth 47 and 48 (Fig. 1). Both cold and hot stimuli consistently caused pain in those teeth. An obvious anatomic abnormality noted during the clinical examination was confirmed with intra-oral X-rays

Fig. 4_Axial images where fusion is obvious.

Fig. 5_Access cavity. Non-conventional shape due to abnormal anatomy.

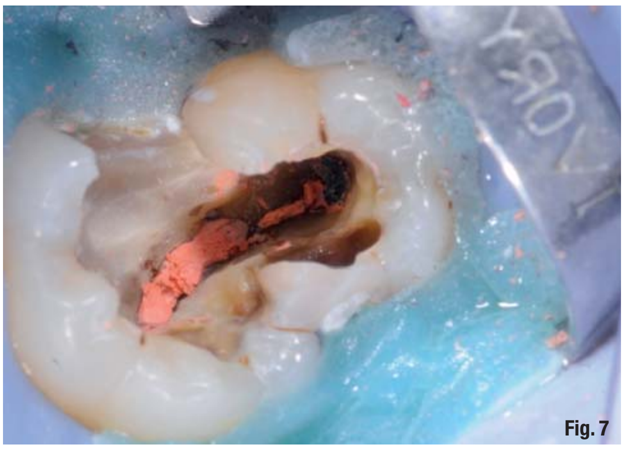


Fig. 6_Working length X-ray.

Fig. 7_Finished case.


Fig. 8

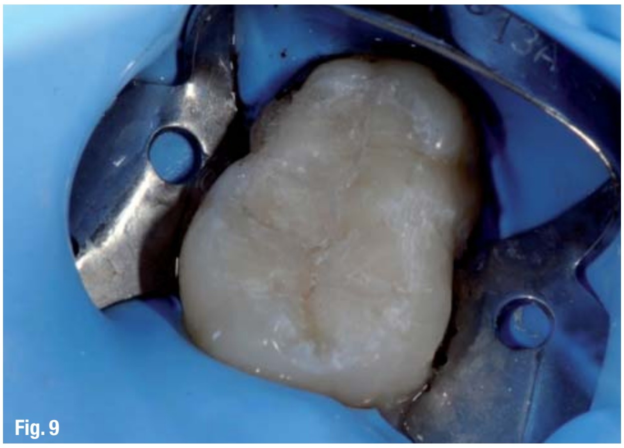


Fig. 9

Fig. 8_X-rays of the finished case.
Fig. 9_After restoration.

using a parallel-cone technique and various projections. The X-ray (Fig. 2) also revealed a deep amalgam restoration extending into the pulp chamber, which had been infiltrated, and distal caries in the fused tooth. A deep carious lesion was also observed on tooth 46, but a simple filling was scheduled because the tooth responded normally to cold and hot stimuli.

In this case, the treatment plan was determined to be root-canal therapy for the pulpitis in the fused tooth and a direct restoration for the same tooth. In addition, dental hygiene sessions were scheduled for the patient because of generalised plaque and to avoid worsening of periodontal conditions in the area of the fused tooth. Direct restorations were also arranged with the general practitioner to avoid any other pulp implications in other teeth with marked infiltrated restorations.

Initially, the treatment plan was targeted at the root-canal therapy of the fused tooth, which was urgent. In order to clarify the anatomy of this element, a CBCT examination was also performed; it revealed two independent mesial roots (lingual and buccal) and a single distal root. The fused root in the middle involved two independent canals ending in the same area (Figs. 3 & 4).

After anaesthetic with 1:100,000 lidocaine had been administered, the tooth was isolated with a rubber dam (KKD, Sympatic Dam). Because of the abnormal anatomy, the use of a liquid photopolymerising dam (DAM COOL, Danville Materials) was necessary to seal gaps completely and to avoid leakage of saliva into the treated tooth and sodium hypochlorite into the patient's mouth. An extended access cavity using a 1.2 mm cylindrical bur and a #2 Start-X ultrasonic tip (DENTSPLY Maillefer) was created to visualise all five orifices (Fig. 5).

Once the surface was clean and canals were visible, negotiation with hand files (K-files) and PathFiles (DENTSPLY Maillefer) was performed to ensure patency of the canals. First #10 and #08 K-files (if needed) were alternated along the canals with copious irrigation with sodium hypochlorite and using 17 % EDTA gel (B&L Biotech) until the #10 file was at the apex. Working length was measured with an apex locator (Root ZX, Morita). Afterwards #1–3 PathFiles were used until the #3 file reached working length in all five canals. Once patency had been confirmed, working length was also confirmed radiographically (Fig. 6).

The next step was to shape the canals using reciprocating files (WaveOne, DENTSPLY Tulsa Dental

Fig. 10_After restoration.
Fig. 11_One-year recall X-ray.


Fig. 10


Fig. 11

Fig. 12

Fig. 13

Fig. 12_One-year recall.
Fig. 13_Four-year recall.

Specialties) with a single-file reciprocating technique. Since the anatomy was slightly different, the shaping technique was changed. After the primary file (25.08, red code), apical gauging was performed with manual NiTi K-files (ISO) to measure the apical restriction diameter. For the distal canal, the large file was also needed. Throughout the procedure, irrigation with preheated 5.25% sodium hypochlorite was performed with 30 g irrigating needles (NaviTip, Ultradent) and the irrigant was activated with IrriSafe files (ACTEON).[15–17] Once the shaping had been completed, apical diameter was confirmed through apical gauging, and cones were fitted. Irrigation with preheated and activated 17% EDTA solution (Vista Dental Products) was used to remove inorganic debris from the canals. Canals were then dried with paper cones and the roots were sealed with vertical condensation of hot gutta-percha (Endo-α2 B&L Biotech) with standardised gutta-percha cones and Pulp Canal Sealer. Back-filling was performed with warm liquid gutta-percha (SuperEndo-β B&L Biotech; Figs. 7 & 8). The treatment was completed with a direct composite restoration (Figs. 9 & 10). All treatment was performed under clinical microscope (OMNI pico, Zeiss).

The patient kept to her treatment plan and attended several recall appointments after the root-canal therapy. She also attended six-monthly oral hygiene appointments with the dental hygienist (Figs. 11–13).

_Discussion

Treatment planning for rare conditions such as fused teeth is fundamental to the success of each case. For this reason, clinicians must consider every parameter before starting treatment. In this case, a tooth extraction would have been the likely outcome without a CBCT examination. Because the fused teeth complex did not involve any occlusal or periodontal problems, the extraction would have caused significant biological damage and held significant financial implications.

Once a treatment plan was in place, a CBCT scan was very helpful in determining the exact position of the canals and in designing the access cavity according to the exact anatomy, which was different from that of a normal single tooth. The single-file reciprocating technique chosen for this case was adapted to the need of the tooth. Since the anatomy was complex, the direct use of a large file in the distal root might have failed. Had different diameters been established during apical gauging, the shaping technique would have been changed and more files would have been introduced. For this reason the shaping technique was modified using more files for this particular root.

_Conclusion

In conclusion, this case demonstrates the importance of treatment planning. In designing a treatment plan, all diagnostic methods should be considered. In this case, a CBCT examination resulted in a successful and predictable treatment._

Editorial note: A complete list of references is available from the publisher.

_contact roots

Andreas Krokidis, DDS, MSc, is a research associate at the National and Kapodistrian University of Athens in Greece. He can be contacted at andreaskrokidis@hotmail.com

Riccardo Tonini, DDS, MSc, is in private practice in Brescia in Italy.

Bioactive endodontic obturation: Combining the new with the tried and true

MTA Fillapex and Continuous Wave of Condensation

Author_ Dr Gary Glassman, Canada


Fig. 1a

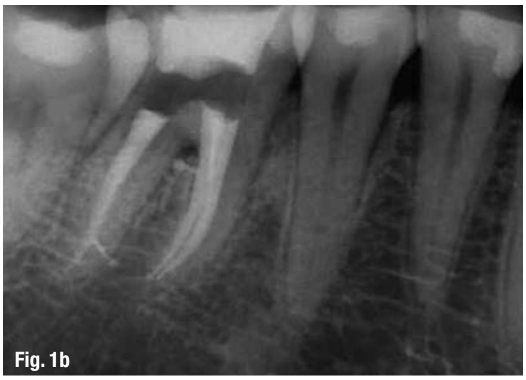


Fig. 1b

Fig. 1a_A post-treatment image of a maxillary first molar, which illustrates the complex anatomy that exists in the apical one-third of the palatal root. *(Images courtesy of Dr Gary Glassman, unless otherwise noted)*
Fig. 1b_A post-treatment film of a mandibular first molar demonstrates the importance of shaping canals and cleaning and filling root-canal systems. *(Image courtesy of Dr Clifford J. Ruddle, Santa Barbara, CA, USA)*

_**The triad of biomechanical** preparation, chemotherapeutic sterilization and three-dimensional obturation is the hallmark of endodontic success.[1,2]

The obturation of root-canal systems represents the culmination and successful fulfillment of a series of highly integrated procedural steps (Figs. 1a & b). Although the excitement associated with capturing complicated root-canal anatomy is understandable, scientific evidence should support this enthusiasm. Moving heat-softened obturation materials into all aspects of the anatomy is dependent on eliminating pulpal tissue, the smear layer and related debris and bacteria and their by products, when present. To maximize obturation potential, clinicians would be wise to direct treatment efforts toward shaping canals and cleaning root-canal systems.[2–4]

Shaping facilitates three-dimensional cleaning by removing restrictive dentin, allowing a more effective volume of irrigant to penetrate, circulate and potentially clean into all aspects of the Root-canal system (Fig. 2). Well-shaped canals result in a tapered preparation that serves to control and limit the movement of warm gutta-percha during obturation procedures. Importantly, shaping also facilitates 3-D obturation by allowing pre-fit pluggers to work deep and unrestricted by dentinal walls and move thermo-softened obturation materials into all aspects of the root-canal system. Improvement in obturation potential is largely attributable to the extraordinary technological advancements in shaping canals and cleaning and filling root-canal systems.[4–6]

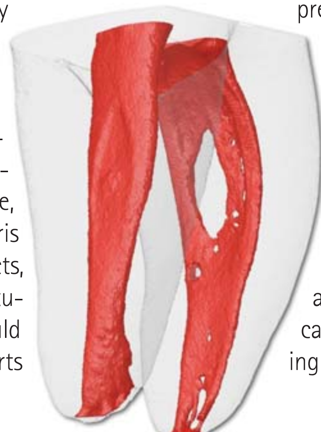


Fig. 2

Fig. 2_Microcomputed tomography 3-D reconstruction of the mesial root-canal of mandibular molar; the presence of an isthmus between the root-canals and multiple foramina are evident. These areas must be cleaned of their organic debris and bacterial contaminants by thorough irrigation protocols in preparation of being three-dimensionally sealed with thermo-softened gutta-percha. *(Image courtesy of Dr Ronald Ordinola Zapata, Brazil)*

In the article "Filling Root-canals in Three Dimensions,"[7] Dr Herb Schilder stated that while there was merit in all obturation techniques available at that time, "when used well … vertical condensation of warm gutta-percha produces consistently dense, dimensionally stable, three-dimensional root-canal fillings." This landmark article gave birth to a paradigm shift in not only a variety of warm gutta-percha techniques, but in a new approach to cleaning and shaping canals, as well as irrigation protocols.[8]

In addition to the classic "Schilder technique" of obturation, there is Steve Buchanan's "Continuous Wave of Condensation" technique[9] and variations thereof. Vertical condensation of gutta-percha is now one of the most-trusted obturation methods of our time. It is taught in most of the graduate endodontic programs in North America and in a growing number of undergrad programs as well. Its success rate is well documented.[8, 10]

This article will feature the Elements Obturation Unit (Axis | SybronEndo, USA) that may be used to fill root-canals systems (Fig. 3a) using the Continuous Wave of Condensation technique and a new mineral trioxide aggregate-based endodontic sealer that is biocompatible and bioactive, called MTA Fillapex (MTA-F; Angelus, Londrina, Brazil) (Fig. 3b). Mineral trioxide aggregate was developed at Loma Linda university and in 1998 received approval from the FDA for human use.[11, 12]

Since then, MTA has shown excellent biological properties in several *in vivo* and *in vitro* studies.[13–18]

In cell culture systems, for example, MTA has been shown to enhance proliferation of periodontal ligament fibroblasts,[15] to induce differentiation of osteoblasts[16, 17] and to stimulate mineralization of dental pulp.

In an effort to expand its applicability in endodontics, MTA-based root-canal sealers have been proposed, such as MTA Fillapex.[19–22]

MTA Fillapex is an endodontic sealer that combines the proven advantage of MTA with a superior canal obturation product. Its formulation in the paste/paste system allows a complete filling of the entire root-canal, including accessory and lateral canals. MTA, present in the composition of MTA Fillapex, is more stable than calcium hydroxide, providing constant release of calcium ions for the tissues and maintaining a pH that elicits antibacterial effects. The tissue recovery and the lack of inflammatory response are optimized by the use of MTA and disalicylate resin. The product is eugenol-free and will not interfere with adhesive procedures inside the root-canal.

The two-paste system contains tricalcium silicate, dicalcium silicate, calcium oxide and tricalcium aluminate, a salicylate resin, a natural resin and bismuth oxide as a radiopacifing agent. The combination of these components has been shown to have bioactive potential in its ability to stimulate nucleation sites for the formation of apatite crystals in human osteoblast-like cell culture.[22]

The two pastes of MTA Fillapex are mixed in equal volumes and dispensed on a glass slab. Its average working time is 35 minutes, with an average setting time of 130 minutes.

The chemical reaction that promotes setting in MTA Fillapex is not a polymerization reaction between pastes but a com-

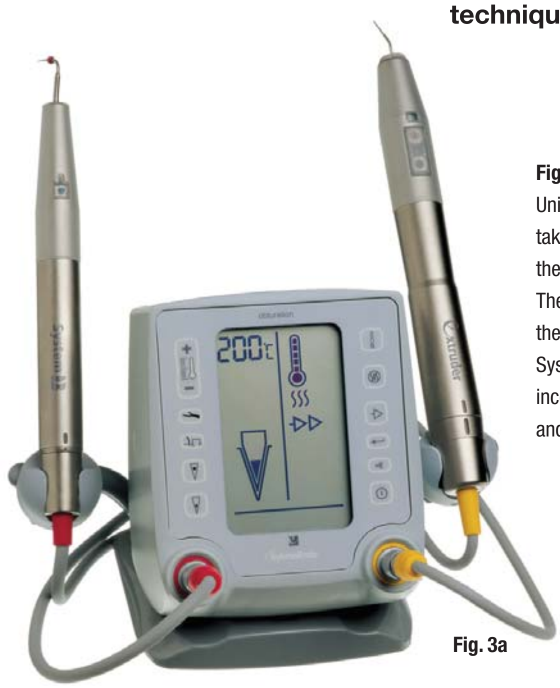


Fig. 3a

Fig. 3a_The Elements Obturation Unit replaces multiple devices while taking up approximately one-third the space of separate machines. The left side of the unit incorporates the controls and handpiece from System-B, while the right side incorporates the extruder system and its controls.

Fig. 3b

Fig. 3b_MTA Fillapex is available as a two-paste system, which must be mixed into a homogeneous consistency, or as a double syringe with self-mixing tips.

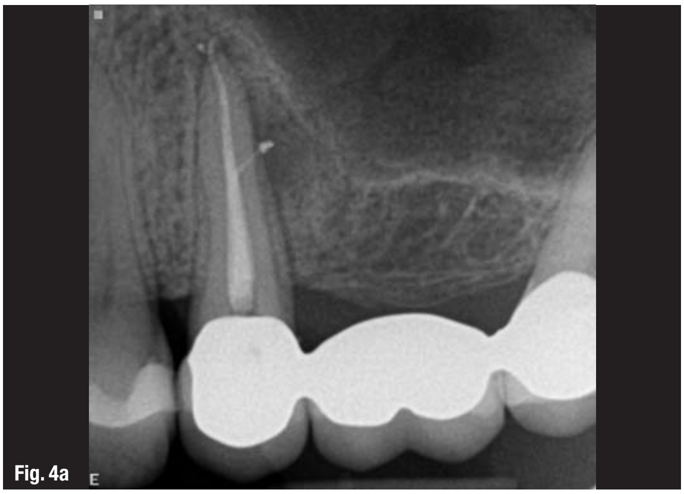


Fig. 4a

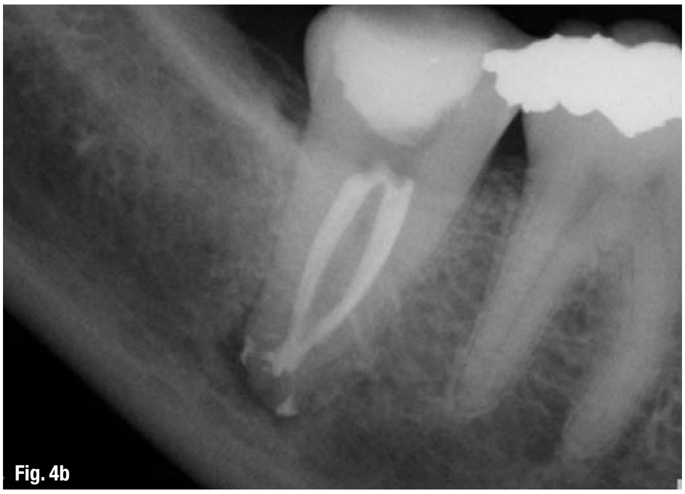


Fig. 4b

Figs. 4a & b_Gutta-percha and sealer can move into extremely small canal ramifications by virtue of the vertical and lateral forces created during the simultaneous warming and condensation of the gutta-percha.

plexation reaction. The complexation reaction is an autocatalytic process. A chain reaction is initiated by water molecules in the external medium that has an intrinsic process of self-acceleration. The complexation reaction is also a chelation reaction where $Ca(OH)_2$ contacts thedisalicylate resin, resulting in the entrapment of calcium ions in the compound. In addition to salicylate, $Ca(OH)_2$ is fundamental. The major source of $Ca(OH)_2$ responsible for the MTA Fillapex reaction is from the hydration of free CaO, which is in high concentration in the formula. It is therefore concluded that the moisture present in the dentin tubules hydrates free CaO, forming $Ca(OH)_2$, which will react with the salicylate and promote the setting.[23]

_The Continuous Wave of Condensation technique

This technique allows a single-tapered electric heat plugger to capture a wave of condensation at the orifice of a canal and ride it, without release, to the apical extent of down packing in a single, continuous movement. Because the tip moves through a viscosity-controlled material into a tapered-like canal form, the velocity of the thermo-softened gutta-percha and sealer moving into the root-canal system actually accelerates as the downpacking progresses, moving softened gutta-percha into extremely small ramifications (Figs. 4a, b).

Fig. 5

Fig. 5_The Tip Snip can be used to customize the apical size of the master gutta-percha cone.

The continuously tapered root-canal preparation facilitates the fit of a suitably sized gutta-percha cone, preferably fine-medium or medium. A clever tool to assist with the cone fit, especially if you choose not to use pre-sized cones or prefer nonstandardized cones, is a gutta-percha gauge such as the Tip Snip (Axis | SybronEndo, USA) (Fig. 5). This allows you to customize a non-standardized or tapered cone to a precise apical diameter. The master cone is fit in a fluid-filled canal to more closely simulate the lubrication effect that sealer will provide when sliding the buttered master cone into the prepared canal.

Further, the master cone should be able to be inserted to the full working length and exhibit apical tugback upon removal. It is simple to fit a master cone into a patent, smoothly tapered and well-prepared canal.[4]

The intimacy of diametrical fit between the cone and the canal space is confirmed radiographically (Fig. 6). The cone is then trimmed about 0.5 to 1 mm from radiographic terminus, so that its most apical end is just short of the working length to accommodate vertical movement of the vertically condensed gutta-percha cone.

The System-B 0.06 or 0.08 taper, 0.5 mm plugger should fit to within 4 to 6 mm from most canal termini and is pre-fit to its binding point in the canal, and the rubber stop is adjusted adjacent to a reference point (Fig. 7).

Difficulties in achieving adequate plugger depth are because of deficient deep shape in the canal preparation (inadequate enlargement 3 to 4 mm shy of the terminus).

Stainless-steel Buchanan pluggers (Axis | SybronEndo, USA) are pre-fit into the canals to their binding point. Rubber stoppers are adjusted on these pluggers to the occlusal reference point, corresponding to 2 mm short of the apical binding point. These pluggers are placed aside to be used later in the backfill phase of canal obturation (Fig. 8).

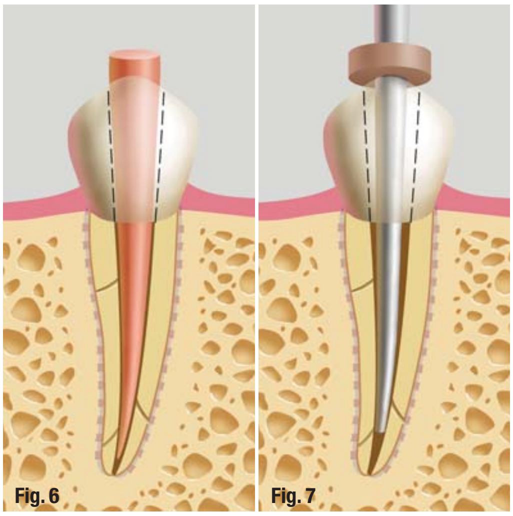


Fig. 6_A non-standardized (finemedium or medium) gutta-percha cone is fit into the tapered root-canal preparation, making sure that "apical tugback" has been achieved 0.5 to 1 mm short of the working length (distance from apical reference point will vary with canal curvature and size).
Fig. 7_It is essential that appropriate System-B plugger is pre-fit into each canal to its binding point. A rubber stop must be placed and adjusted to the appropriate coronal reference point for each canal.

_Sealer and master cone placement

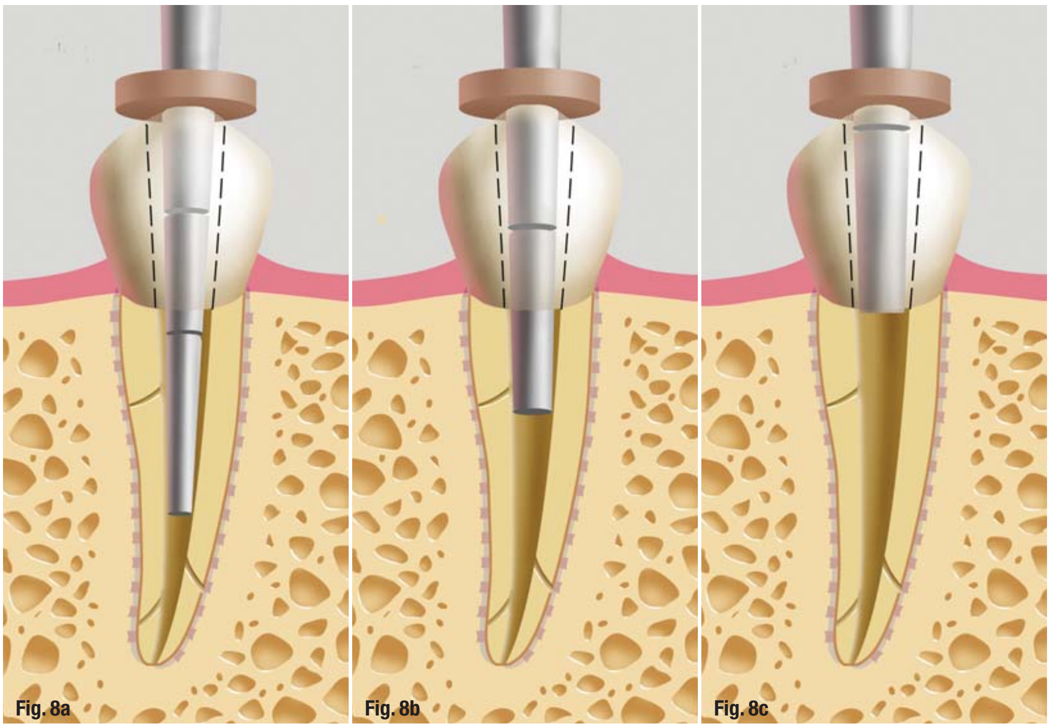
MTA Fillapex can be used for the warm gutta-percha with vertical condensation technique and affords several advantages.[23]

The presence of MTA in the formula along with its calcium ion release allows the formation of new tissue, including root cementum without causing an inflammatory reaction. Perfect radiographic visualization is possible because of its high radiopacity, and its excellent flow properties make MTA Fillapex suitable to penetrate and fill lateral and accessory canals. Upon setting, MTA Fillapex expands, thereby providing an excellent seal of the root-canal, avoiding the penetration of tissue fluids and/or bacterial recontamination. It is available in a two-paste system, which allows easy handling, insertion and adequate working time to be used by both specialists and/or general practitioners. If retreatment is necessary it is easily removed particularly when used with GP points.

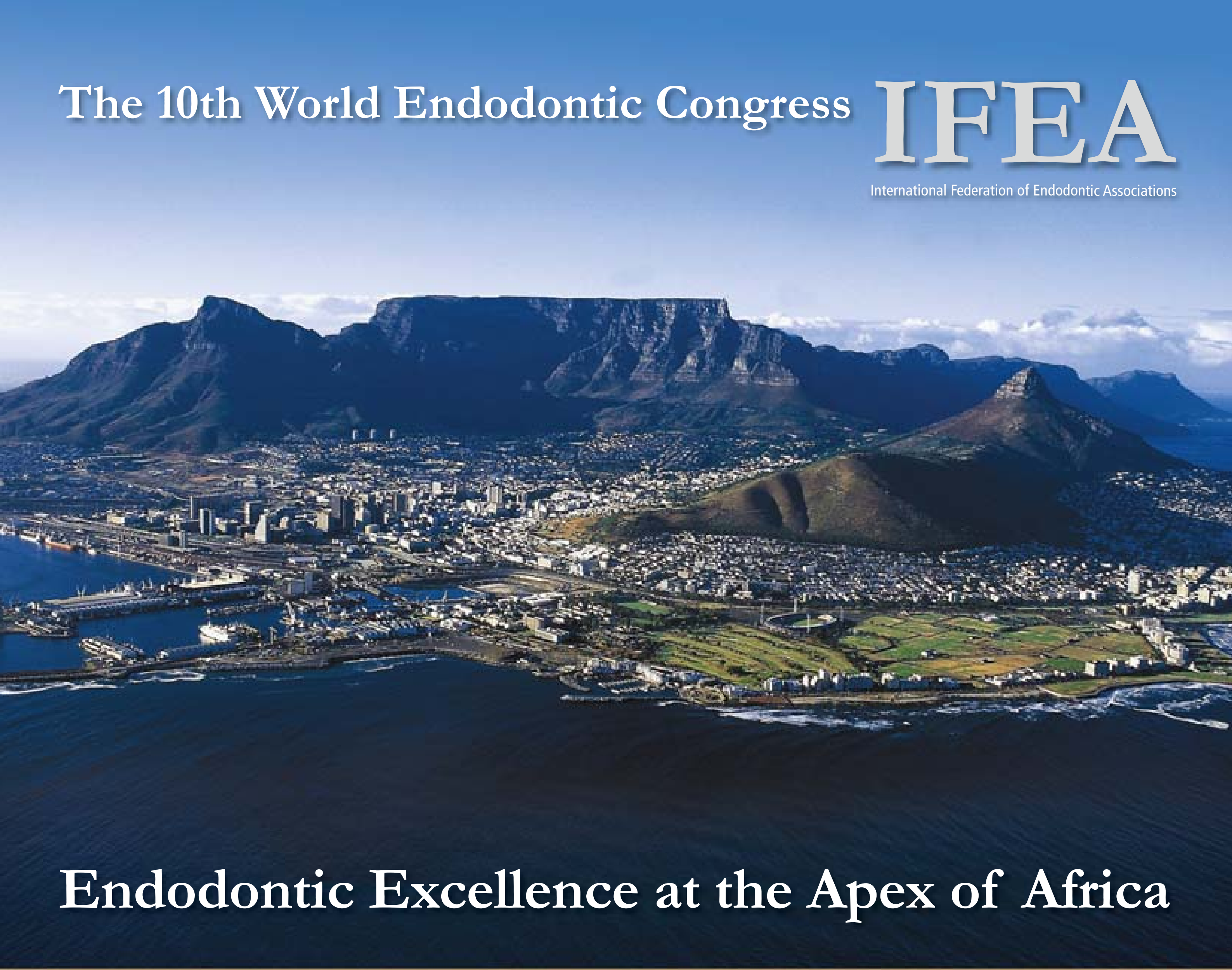
The amount of sealer used in this obturation technique should be minimal.

The radicular portion of the master cone is lightly buttered with sealer and gently swirled as it is slowly slid to length. Placing the master cone in this manner will serve to more evenly distribute sealer along the walls of the preparation and, importantly, allow surplus sealer to harmlessly vent coronally. To be confident that there is sufficient sealer, the master cone is removed and its radicular surfaces inspected to ensure it is evenly coated with sealer. If the master cone is devoid of sealer, then simply re-butter and re-insert this cone to ensure there is sufficient sealer present. When the master cone is evenly coated with sealer and fully seated, obturation can commence.[4] The canal is dried and the master cone is cemented in the canal with sealer (Fig. 9).

The System-B handpiece is activated by depressing the button with a gloved finger. The tip will heat instantly, and the LED indicator on the handpiece will illuminate. The tip will remain heated only as long as the button is depressed. A "time-out" feature assists the clinician by shutting off the energy to the tip after four seconds. This will aid in avoiding overheating of the tooth and/or tissue. The handpiece will need to be reactivated to resume heating beyond the preset duration.



Figs. 8a–c_Buchanan pluggers may be pre-fit into the canals to their binding point. Rubber stoppers are adjusted on these pluggers to the occlusal reference point corresponding to 2 mm short of the apical binding point.



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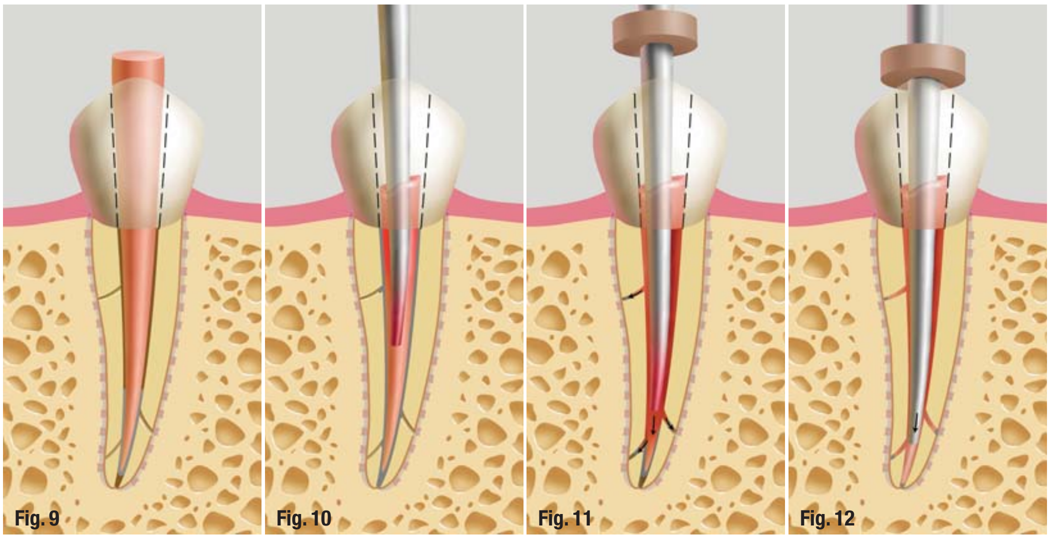
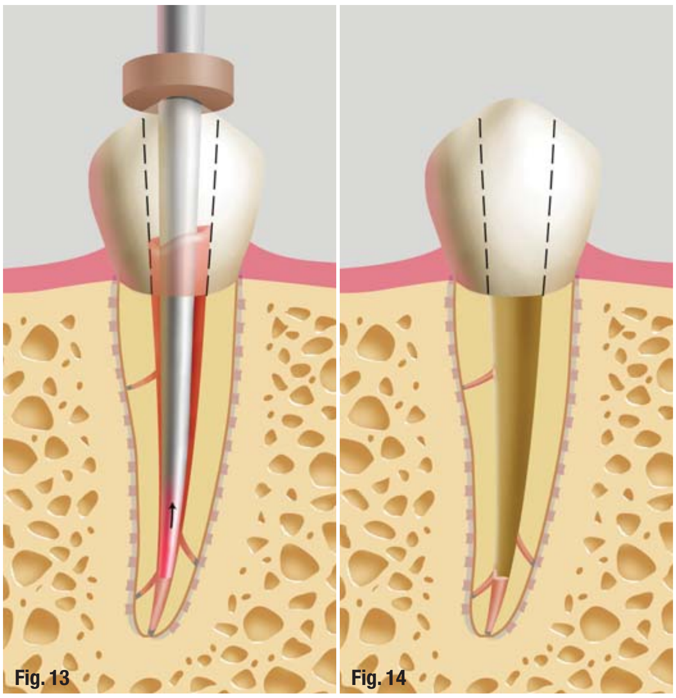


Fig. 9_The master cone is cemented in the canal with sealer. **Figs. 10 & 11**_With the activation button depressed on the System-B handpiece, the pre-fit, preheated plugger is smoothly driven through the mass of gutta-percha to within 4 to 6 mm of the binding point. **Fig. 12**_The activation button should be released once within 3 to 4 mm of the apical binding point. The plugger should slow and stop within 2 mm short of the binding point. Apical pressure is maintained for a full 10-second 'sustained' push to prevent the cooling gutta-percha mass from shrinking.

The master cone is seared at the orifice of the canals with the activated System-B plugger and then gently "seated" with a larger stainless-steel Buchanan plugger. The plugger is driven through the center of the gutta-percha in a single motion (about one to two seconds), to a point about 3 to 4 mm shy of its apical binding point (Figs. 10 & 11).

While maintaining pressure on the plugger, the activation button on the System-B is released and the plugger slows its apical movement as the plugger tip cools (about one second) to within 2 mm from its apical binding point. After the plugger stops short of its binding point, apical pressure on the plugger is sustained until the apical mass of gutta-percha has set (5 to 10 seconds), to prevent any shrinkage that occurs upon cooling (Fig. 12).



Figs. 13 & 14_The System-B activation button is depressed for one second then released. The plugger is held in position for one second after the button is released, and the plugger is removed with the down pack surplus of gutta-percha, leaving the apical seal intact. All portals of exit may be sealed, primarily with gutta-percha or a combination of gutta-percha and sealer, and the canal is ready for backfilling

_Separation burst

After the apical mass has set, the activation button on the System-B is depressed again, for a one-second surge of heat. Pause for one second after this separation burst, and then remove the heated plugger and the middle and coronal gutta-percha, leaving behind the 4 to 6 mm apical plug of gutta-percha (Figs. 13 & 14). Because these pluggers heat from their tips, this separation burst of heat allows for quick, sure severance of the plugger from the already condensed and set apical mass of gutta-percha, minimizing the possibility of pulling the master cone out. Be certain to limit the length of this heat burst, as the goal is separation from the apical mass of gutta-percha without reheating.

Clinicians must be very alert during the first second of the downpack that the binding point is not reached before completion of the downpack. If heat is held for too long, the plugger drops to its binding point in the canal and then cannot maintain condensation pressure on the apical mass of gutta-percha during cooling, possibly allowing it to pull away from the canal walls. If binding length is reached by mistake, the heat plugger should be removed immediately, and the small end of the nickel-titanium end of a Buchanan hand plugger (Sybron Endo, USA) should be used to condense the apical mass of gutta-percha until set.

_Backfilling

The Elements Obturation Unit (Fig. 3a) has an extruder handpiece that accommodates disposable preloaded cartridges of gutta-percha of varying densities and is use to back fill the root-canal space. They are available in easy-flow, normal-flow and heavy-body-flow viscosities. The applicator tips are available in 20-, 23- and 25-gauge diameters. There is enough gutta-percha in the disposable cartridges to fill an average four-canal molar. The author prefers to use

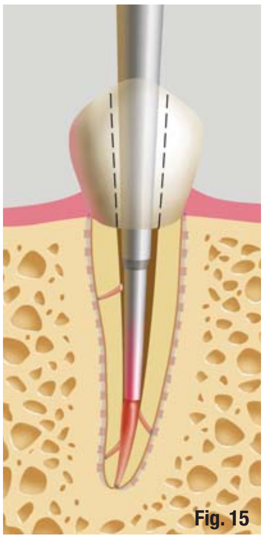


Fig. 15

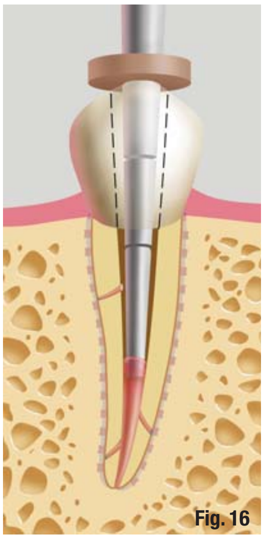


Fig. 16

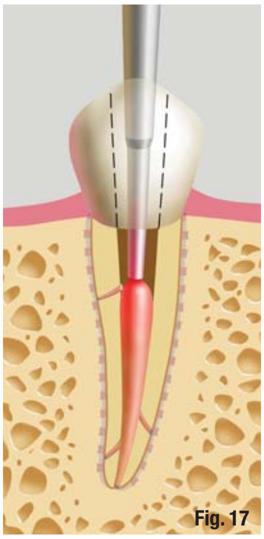


Fig. 17

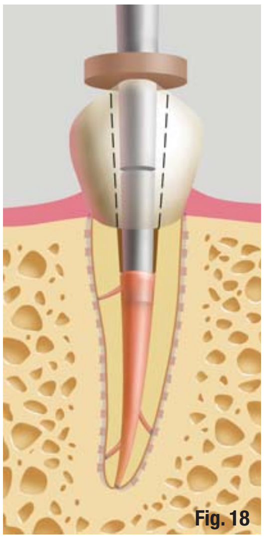


Fig. 18

the heavy-body gutta-percha and a 23-gauge applicator tip, as they are suitable for most canals treated.

The applicator tip is placed into the root-canal space until it penetrates the coronal aspect of the apical plug of gutta-percha for five seconds to re-thermo-soften its most coronal extent. This procedural nuance promotes cohesion between each injected segment of warm gutta-percha.[4] Segments of 5 to 6 mm of gutta-percha are then deposited. Injecting or dispensing too much gutta-percha leads to shrinkage and/or voids that result in poorly obturated canals.[4] As gutta-percha is extruded from the applicator tip, the viscosity gradient of the back pressure produced will push the tip coronally from the root-canal space.

The technique sensitivity requires that when this sensation occurs, the operator must sustain pressure on the trigger mechanism as the applicator tip moves from the canal. The Buchanan pluggers are then used in sequence to maximize the density and homogeneity of the compressed gutta-percha mass. This sequence of thermo-softened gutta-percha injection and progressive compaction is continued until the obturation of the entire root-canal space is achieved (Figs. 15-21).

_Restoration of the endodontically treated tooth

To ensure a seamless link between the root-canal procedure and the permanent restoration of the tooth, immediate restoration is the very best policy to protect the hard work you have just accomplished with the previous steps. Where temporization is necessary, ensuring a coronal seal is crucial to long-term success. Taking a few minutes to lay down an effective coronal seal protects your three-dimensionally obturated root-canal from coronal leakage.[8]

_The future

With each improvement and modification of the technical limitations of the technique, the thermo-softened millennium will continue to expand the horizons of endodontic success and elevate the standard of care and pursuit of excellence in clinical treatment materials.[1,2]

As the health of the attachment apparatus associated with endodontically treated teeth becomes fully understood and completely appreciated, the naturally retained root will be recognized as the "ultimate dental implant." When properly performed, endodontic treatment is the cornerstone of restorative and reconstructive dentistry.[3]_

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Figs. 15–21_Applicator tips for the EOU System are available in sizes #20, #23 and #25 gauges. Additional root-canal sealer may be placed in the coronal aspect of the root-canal with a hand file prior to back filling. Fourto 6-mm increments of gutta-percha are injected into the canal space then immediately condensed with the pre-fitted Buchanan pluggers in sequence using the sequentially larger pluggers as the coronal aspect of the canal is approached. As thermosoftened gutta-percha is deposited in the canal, backpressure is produced and the applicator is forcibly extruded from the canal space. It is essential that the operator continue injecting as the applicator tip is retrieved from the canal in order to avoid inadvertent removal of the newly deposited gutta-percha, mass prior to condensation.

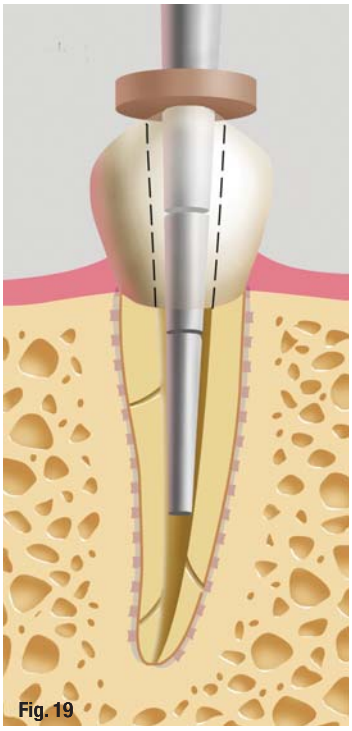
Fig. 19

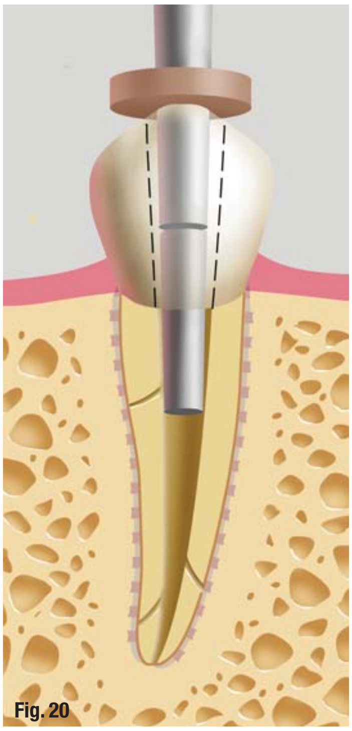
Fig. 20

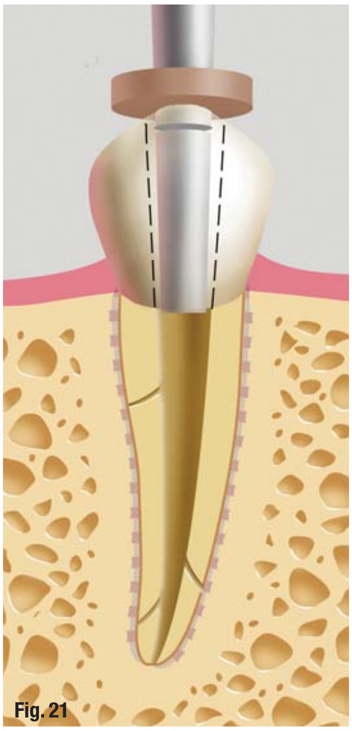
Fig. 21

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_about the author

roots

Gary D. Glassman, DDS, FRCD(C) graduated from the University of Toronto, Faculty of Dentistry in 1984 and was awarded the James B. Willmott Scholarship, the Mosby Scholarship and the George Hare Endodontic Scholarship for proficiency in Endodontics.
A graduate of the Endodontology Program at Temple University in 1987, he received the Louis I. Grossman Study Club Award for academic and clinical proficiency in Endodontics.
The author of numerous publications, Gary is on staff at the University of Toronto, Faculty of Dentistry in the graduate department of endodontics aand Adjunct professor of dentistry and director of endodontic programming at UTech in KIngston, Jamaica.
Dr Gary Glassman maintains a private practice in Toronto.

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SEM analysis of the laser activation of final irrigants for smear layer removal

Authors_Dr Vivek Hegde, Dr Naresh Thukral, Dr Sucheta Sathe, Dr Shachi Goenka & Dr Paresh Jain, India

Fig. 1_Access opening.
Fig. 2_Stainless steel #10. K-file for patency.

_Introduction

The complete restoration of the root canal space with an inert filling material and the creation of a fluid tight seal are the goals of successful endodontic therapy.[1] In order to create a fluid tight seal, it is imperative that the endodontic filling material closely adapts or bonds to the tooth structure. This, however, is impaired by the presence of a smear layer, which invariably forms after endodontic instrumentation.[2,3] The smear layer contains organic material, odontoblastic processes, bacteria and blood cells.

Various materials and techniques have been reported with wide variations in their efficacy regarding the removal of the intra-canal smear layer.[2,4] The most widely used chemical for the purpose is EDTA, used in different formulations.[5] They have been reported to consistently produce canals with patent dentinal tubules.[6] However, it has been found to be less efficient in narrow portions of the canal[7], it requires a long application time for optimum results[8] and can seriously damage the dentin, if used in excess.[9]

Clinically, endodontic procedures use both mechanical instrumentation and chemical irrigants in the attempt to three dimensionally debride, clean and decontaminate the endodontic system.[10,11]

Even after doing this meticulously, we still fall short of successfully removing all of the infective microorganisms and debris. This is because of the complex root canal anatomy and the inability of common irrigants to penetrate into the lateral canals and the apical ramifications. It seems, therefore, appropriate to search for new materials, techniques and technologies that can improve the cleaning and decontamination of these anatomical areas.[12]

Some of these mechanically activated irrigation techniques include manual irrigation with needles, K-file, Master cone GP points, Irrisafe, ultrasonics, Endo-activator, Rotobrush, Roekobrush, etc. The newest of the lot is PIPS, i.e Photon-Induced Photoacoustic Streaming via laser. Hence it was chosen for the study.

_Material and methods

Forty single-rooted, extracted human teeth were used in the study. Teeth with fractures, cracks or any other defects were excluded. Subsequently, they were scaled with ultrasonics for the removal of calculus or any soft-tissue debris, washed with distilled water and then stored in normal saline. Standard endodontic access cavity preparations were performed and then a stainless-steel #10

K-file (Mani K-File) was inserted into the canal until the tip was just visible at the apical foramen to check for patency. Chemo-mechanical preparation was done up to F3 using rotary protapers (DENTSPLY Maillefer) along with EDTA gel (Glyde – DENTSPLY Maillefer) for all the samples.

Irrigation of all the samples during preparation was accomplished using 5 ml of 5.25 % sodium hypochlorite between each file. Samples were then divided randomly into two groups, depending upon the method of activation of the final irrigant used.

These groups were further divided into two subgroups, depending upon the final irrigant used (Tab. 1):

_Subgroup A: 5.25 % NaOCl (n = 10)
_Subgroup B: 17 % EDTA (n = 10)

Activation of the irrigant for group I was done mechanically by agitating a stainless steel #25 K-file (2 % taper) in the canal when it was filled with the final irrigant solution.

An Er:YAG laser with a wavelength of 2,940 nm (Fotona) was used to irradiate the root canals in Group II with a newly designed 12 mm long, 400 µm quartz tip. The tip was tapered and had 3 mm of the polyamide sheath stripped away from its end. The laser operating parameters used for all the samples (using the free-running emission mode) were as follows: 40 mJ per pulse, 20 Hz, at very short pulse (MSP) mode, which provides the same 400 W of peak pulse power as the parameters recommended by Olivi (20 mJ, 15 Hz, SSP). The coaxial water spray feature of the handpiece was set to 'off' while air settings were kept at 2. The tip was placed into the coronal access opening of the chamber just above the orifice, and was kept stationary. During the laser irradiation cycles, the root canals were continuously irrigated with the final irrigant to maintain hydration levels using a hand syringe with a 25 gauge needle positioned above the laser tip in the coronal aspect of the access opening, according to the above protocol.

GROUPS / SUB-GROUPS	GROUP I (Hand Activation)	GROUP II (Er:YAG with PIPS)
Sub Group A (5.25 % NaOCl)	n = 10	n = 10
Sub Group B (17 % EDTA)	n = 10	n = 10

Table 1_Subgroups depending on the final irrigant used.

After preparation, the root canal walls were dried using paper points. Longitudinal grooves were made on the distal and mesial root surfaces, preserving the inner shelf of the dentin surrounding the canal. Roots were then sectioned with the help of a chisel and mallet. Samples were then subjected to SEM to visualize the surface characteristics.

_Results

Group I specimens (hand activation) consistently exhibited a thick smear layer with NaOCl (subgroup A, Figs. 8a–c) while comparatively less smear layer was observed with EDTA (subgroup B, Figs. 9a–c). SEM examination demonstrated that when NaOCl irrigation was applied, a noticeable smear layer and occluded dentinal tubules remained on the treated surface. Debris, defined as dentin chips and pulp remnants loosely attached to the internal surface of the root canals, was present in the specimens in subgroup A (Group I). In the specimens of EDTA, mostly open dentinal tubules were observed in the coronal and the middle third while in the apical third of all specimens occluded tubules were observed.

Figs. 3 and 4_Chemo-mechanical preparation up to F3.
Fig. 5_Group I—Hand activation using stainless steel #25 K-file (n = 20).

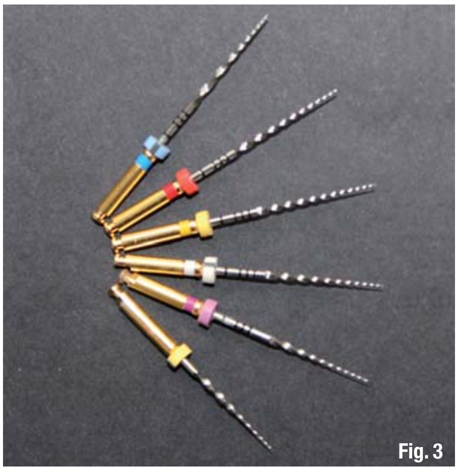
Fig. 3

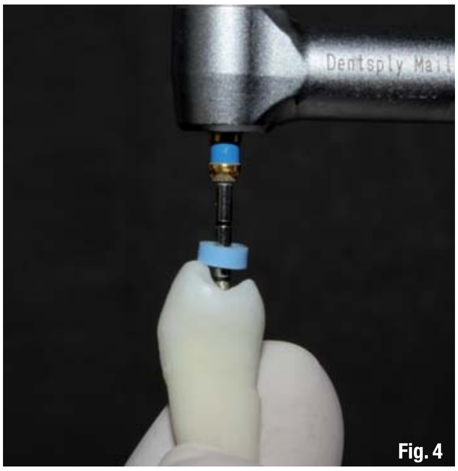

Fig. 4

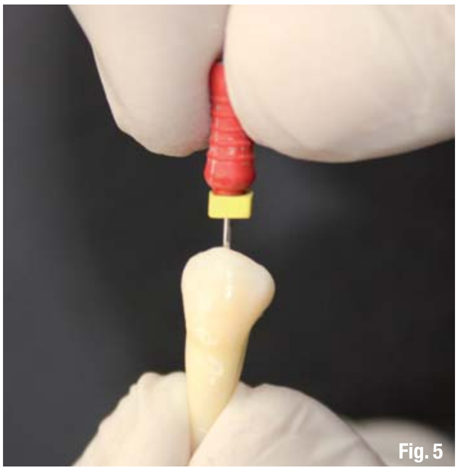
Fig. 5

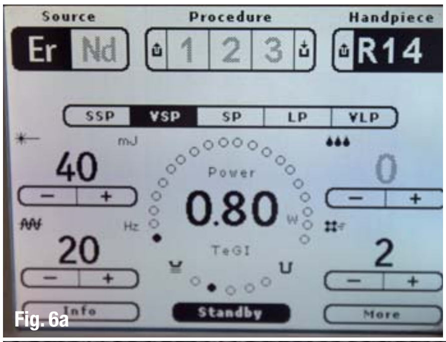

Fig. 6a

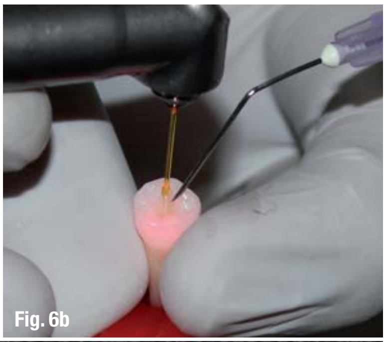

Fig. 6b

Fig. 7

Figs. 6a & b and 7_Group II—Er:YAG activation using Photon-Induced Photoacoustic Streaming tip (n = 20).

Group II specimens treated with the Er:YAG laser with PIPS showed the most effective removal of the smear layer from the root canal walls compared to Group I (hand activation) specimens. At higher magnifications (1,000x–2,000x) subgroup B (17 % EDTA) showed better results with exposed and intact collagen fibers and open dentinal tubules, even in the apical third (Figs. 11a–c), when compared with subgroup A (5.25 % NaOCl), where open dentinal tubules along with scattered dentinal chips were observed (Figs. 10a–c). None of the SEM images indicated signs of dentin melting.

_Discussion

Current instrumentation techniques using rotary instruments and chemical irrigation still fall short of successfully removing the smear layer from inside the root canal system. Mechanical activation of the chemical irrigant plays an important role in removing the smear layer. Fiber-guided lasers have also been used hoping to achieve some degree of success, however, there is limited availability of literature regarding this topic.

The concept of laser-activated irrigation is based on cavitation. Because of the high absorption of water by the mid-infrared wavelength of lasers, the cavitation process generates vapor-containing bubbles, which explode and implode in a liquid environment.[13] This subsequently initiates pressure/shock waves by inducing shear force on the dentinal wall. In a water-filled root canal, the shock waves could potentially detach the smear layer and disrupt bacterial biofilms. To efficiently activate irrigant and generate shock waves in the root canal, lasers with wavelengths from 940–2,940 nm have been used.[14–22]

5.25 % sodium hypochlorite was used in Group I because the majority of practitioners still use only sodium hypochlorite as the irrigant along with hand instruments. Hence sodium hypochlorite was used in Group I. To remove inorganic debris of the smear layer, use of aqueous EDTA had been recommended. But prolonged use of EDTA can cause dentinal erosion of the root canal by decalcifying the peritubular dentin. The recommended time in endodontic literature is only 1–2 minutes. Hence, 17 % aqueous EDTA was used for one minute in Group II to minimise time and damage.

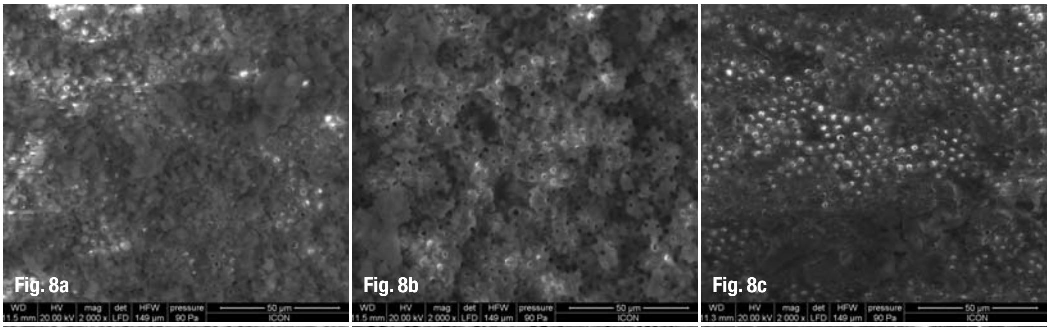

Fig. 8a Fig. 8b Fig. 8c

Fig. 8_Group I—Hand Activation (5.25 % NaOCl—Subgroup A): coronal third **(a)**, middle third **(b)**, apical third **(c)**.

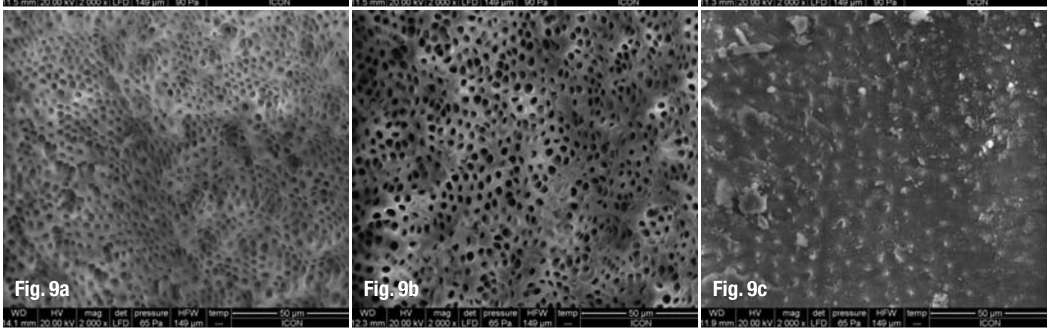

Fig. 9a Fig. 9b Fig. 9c

Fig. 9_Group I—Hand Activation (17 % EDTA—Subgroup B): coronal third **(a)**, middle third **(b)**, apical third **(c)**.

The results of this study indicate that NaOCl subgroups could remove the smear layer in the coronal third; however, it did not remove the smear layer from the middle and apical third of the canal wall. EDTA is efficient in removing the smear layer, which is evident in this study for both groups. The effects of EDTA were limited to the coronal and middle third in Group I (hand activation) while it was effective even in the apical third for Group II (Er:YAG-PIPS). Ciucchi et al. stated that there was a definite decline in the efficiency of irrigating solutions along the apical part of the canals.[23] This can probably be explained by the fact that dentin in the apical third is much more sclerosed and there are fewer dentinal tubules present there.[24] Also apical reach, canal configuration, and smooth transition are a few of the anatomical key factors. Hence root canal success is dependent on apical third anatomy.

The Er:YAG laser used in this investigation proved to be more effective than the conventional technique in removing the smear layer. This finding can be attributed to the photomechanical effect seen when light energy is pulsed in liquid.[25-27] When activated in a limited volume of fluid, the high absorption of the Er:YAG wavelength in water, combined with the high peak power derived from the short pulse duration that was used for five seconds (three cycles), resulted in a photomechanical phenomenon. A profound "shockwave-like" effect is observed when a radial and stripped tip is submerged in a coronal chamber above the orifice. As a result of the very small volume, this effect may remove the smear layer and residual tissue tags and potentially decrease the bacterial load within the tubules and lateral canals.[28-30] By using lower sub-ablative energy (40 mJ) and restricting the placement of the tip to within the coronal portion of the tooth only, the undesired effects of the thermal energy, as previously described in the literature, was avoided.[31-45] In the current study, the smear layer and debris were not removed by thermal vaporisation, but probably by photomechanical streaming of the liquids, which were laser activated in the coronal part of the tooth.

Giovani Olivi and Enrico DiVito have described this light energy phenomenon as photon-induced photoacoustic streaming (PIPS). The effect of irradiation with the Er:YAG laser equipped with a tip of novel design at sub-ablative power settings (20 mJ, 15 Hz, SSP, 400 W peak power) is synergistically enhanced by the presence of EDTA. This leads to a significantly better debridement of the root canal, contributing to an improvement in treatment efficacy. Hence, the PIPS technique resulted in pronounced smear layer removal when used together with EDTA and at the settings outlined.

_Conclusion

Within the limitations of this study, the Er:YAG laser with PIPS showed significantly better smear layer removal than the hand-activation group. At the energy levels and with the operating parameters used, no thermal effects or damage to the dentin surface was observed. With the described settings, the Er:YAG laser produced a photomechanical effect, demonstrating its potential as an improved alternative method for debriding the root canal system in a minimally invasive manner._

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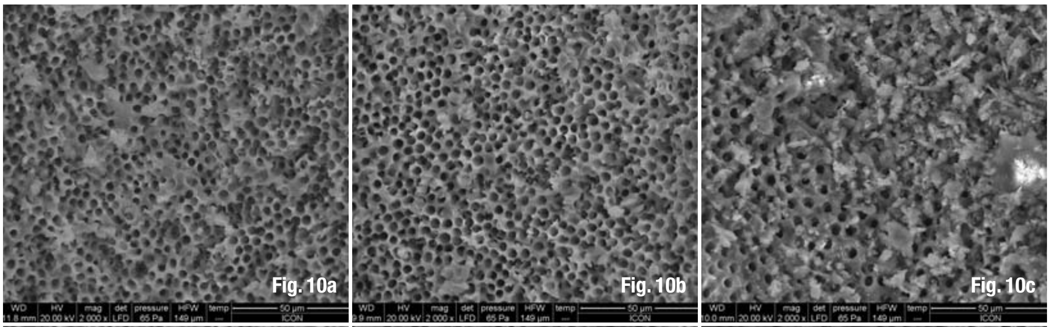

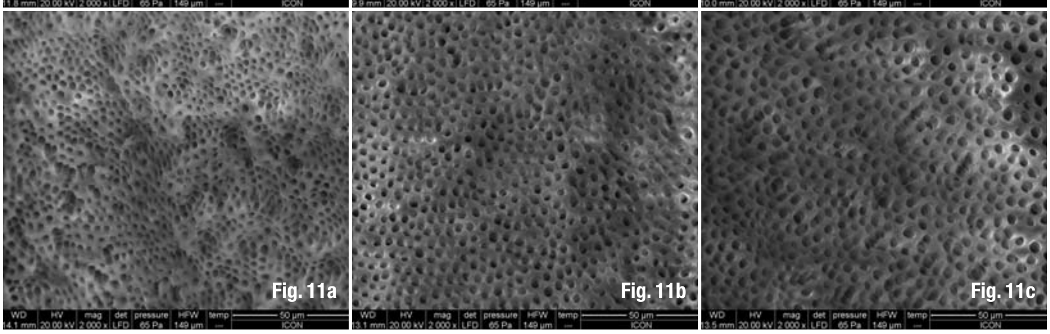

Fig. 10_Group II—Er:YAG with PIPS (5.25 % NaOCl—Subgroup A): coronal third **(a)**, middle third **(b)**, apical third **(c)**.

Fig. 11_Group II—Er:YAG with PIPS (17 % EDTA—Subgroup B): coronal third **(a)**, middle third **(b)**, apical third **(c)**.

_contact roots

Prof. Dr Vivek Hedge
Professor and Head
Department of Conservative Dentistry and Endodontics
M A Rangoonwala Institute of Dental Sciences
Pune, India

Laser versus conventional therapies

Authors_Cristiane Meira Assunção, Joanna Tatith Pereira, Renata Schlesner Oliveira & Dr Jonas de Almeida Rodrigues, Brazil

Fig. 1a_DIAGNOdent 2095.

_Introduction

In recent years, several studies have been conducted on the clinical applications of laser in dentistry. At the same time, there has been a marked emergence of organisations in support of the use of laser in dentistry. In the last decades, laser therapy has been used in dentistry as an adjunct or alternative to conventional approaches. In this paper, the following topics will be reviewed: the application of laser in caries prevention and diagnosis, hard- and soft-tissue treatments, and periodontal and endodontic procedures. There is a large research effort into new indications for laser in dentistry. It is expected that laser will become an essential component of the dentist's armamentarium.

While the technology was regarded as complex and of limited use in clinical dentistry in the past, a growing awareness of the usefulness of laser in the modern dental practice has been observed. Laser can be used as an adjunct or alternative to conventional approaches.[1] When comparing the use of laser with conventional therapies, three important areas must be considered: safety, efficacy and effectiveness. From an ethical standpoint, it is important to use the best available evidence when making clinical decisions.[2]

_Diagnostic laser applications

The most common methods for caries detection are visual and radiographic examination.[3] However, visual examination is a subjective method that depends on the knowledge and clinical experience of the examiner.[3-6] Several studies have demonstrated that radiographic examination demonstrates poor sensitivity to non-cavitated lesions.[3,7-9]

For this reason, fluorescence-based methods have been developed, aiming at the detection of occlusal and approximal carious lesions, for example DIAGNOdent 2095 (KaVo; LF; Figs. 1a-c) and DIAGNOdent 2190 (LF pen; Figs. 2a & b). They rely on the same principle: a laser diode emits red light at 655 nm and a photodetector quantifies the reflected fluorescence from bacterial metabolites (fluorophores) in carious lesions, showing values ranging from 0 to 99.[3,9]

A study that assessed the performance of a visual method, radiographic examination and fluorescence-based methods in detecting occlusal caries in primary teeth found that the visual method and VistaProof fluorescence camera (Dürr Dental; FC) exhibited better accuracy in detecting enamel and dentine carious lesions, whereas the visual method combined with LF, LF pen and FC better detected dentine lesions on occlusal surfaces in primary teeth, with no statistically significant difference among them.[3]

Another study compared the performance of fluorescence-based methods (FC, LF and LF pen), radiographic examination, and another visual method called the International Caries Detection and Assessment System (ICDAS) II on occlusal surfaces. This study demonstrated that the combination of ICDAS and bite-wing radiographs yielded the best performance for detecting caries on occlusal surfaces.[9]

_Caries prevention: Enhancing enamel resistance

In the past, several *in vitro* studies have shown that enhancing enamel demineralisation resistance can be achieved by irradiation with lasers. In a blind *in vitro* study, Ana et al. 2012[1] compared the effect of professional fluoride application with that of laser irradiation with regard to the demineralisation of enamel and fluoride formation and retention. The study found that both methods enhanced enamel resistance, and no side-effects were found. A greater concentration of retained calcium fluoride-like material was found in the laser group. Formation and retention of calcium fluoride were also improved with laser irradiation.

The wavelengths absorbed most strongly by dental enamel are the 9.3 and 9.6 µm carbon dioxide laser wavelengths. The reduction in acid dissolution of enamel is said to be caused by a loss of the carbonate phase of enamel crystals due to the heat of irradiation. Rechmann et al. 2011[10] demonstrated that short-pulsed 9.6 µm carbon dioxide laser irradiation successfully inhibited enamel caries without any harm to the pulpal tissue of the teeth irradiated. The efficacy of carbon $C0_2$ laser irradiation regarding its long-term effect on caries resistances can be verified by further studies.

_Hard-tissue applications: Caries removal

There is limited evidence to support the effectiveness of dental lasers in the removal of caries compared with rotary burs. In order to evaluate this, a systematic review of seven studies with adequate methodologies was performed.[8] Two of the studies found that there was no difference with regard to time taken for caries removal and cavity preparation. Four of the studies found that the laser took up to three times longer to perform these procedures. Four of the studies found that there were no differences between lasers and rotary burs with regard to pulpal effects. One of the studies found that dentists preferred the bur to the laser, and all the studies found that patients favoured the laser with respect to comfort. The studies found that adult patients prefer the laser, although the response from children was inconclusive. The results are not surprising, considering that local anaesthesia is often not needed when using a laser, making the overall dental experience more pleasant for the patient.[10]

_Endodontic laser procedures (disinfection)

The main causes of endodontic treatment failure are the presence of persistent micro-organisms and recontamination of the root canal owing to inadequate sealing.[11] The long-term success rate of conventional endodontic treatment depends on several factors, such as the diverse and complex anatomy of the root-canal system that consists of small canals diverging from the main canal. This complex system does not allow direct access during biomechanical preparation because of the canals' positioning and diameter.[6] New antimicrobial approaches to disinfecting root canals have been proposed; these include the use of high-power lasers and photodynamic therapy, which works by dose-dependent heat generation. However, in addition to killing bacteria, they have the potential to cause collateral damage such as charred dentine, ankylosed roots, melted cementum, root resorption and periradicular necrosis.[2]

In order to compare the effectiveness of antimicrobial photodynamic therapy with standard endodontic treatment and combined treatment to eliminate bacterial biofilms present in infected root canals, a study was conducted on ten single-rooted freshly extracted human teeth inoculated with stable biolu-

Fig. 1b_Tip A for occlusal surfaces.
Fig. 1c_Tip B for smooth surfaces.

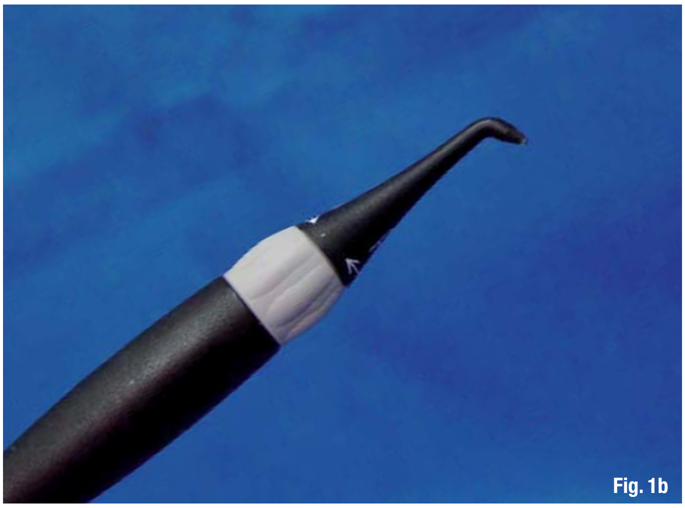
Fig. 1b


Fig. 1c

Fig. 2a

Fig. 2b

Fig. 2a_Cylindrical tip for occlusal surfaces.
Fig. 2b_Wedge-shaped tip for proximal surfaces.

minescent Gram-negative bacteria. It found that endodontic therapy alone reduced bacterial bioluminescence by 90 %, while photodynamic therapy alone reduced bioluminescence by 95 %. The combination reduced bioluminescence by up to 98 %, and, importantly, the bacterial regrowth observed 24 hours after treatment was much less for the combination group than for the treatment groups individually.[12]

Alternatives to conventional therapies to improve the disinfection of root canals are Nd:YAG and Er:YAG lasers. One study evaluated the bactericidal efficacy of Nd:YAG and Er:YAG lasers in experimentally infected curved root canals and concluded that in the straight root canals the Er:YAG laser had a bactericidal effect of 6.4 to 10.8 % higher than that of the Nd:YAG laser. Conversely, the bactericidal effect of the Er:YAG laser in the curved root canals was 1.5 to 3.1 % higher than that of the Nd:YAG laser.[13] These results suggest that further development of the endodontic laser tip and techniques are required to ensure its success.

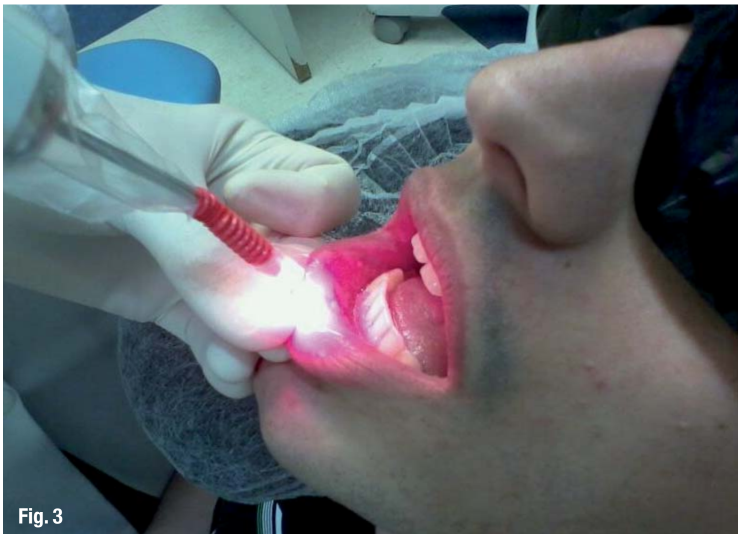

Fig. 3

Fig. 3_Infra-red laser therapy for treatment of a primary herpetic infection in an adolescent patient undergoing chemotherapy (Therapy XT, DMC).

_Periodontal laser procedures (disinfection)

Conventional periodontal therapy procedures include mechanical scaling and root planing, which has some limitations, especially in reducing bacteria inside deep pockets. In order to overcome the limitations of conventional mechanical therapy, several adjunctive protocols have been developed. Among these, laser has been proposed for its bactericidal and detoxification effects and for its ability to reach sites that conventional mechanical instrumentation cannot.[14]

Different lasers could be used in periodontal therapy for calculus removal, periodontal pocket disinfection, photoactivated dye disinfection of pockets and de-epithelialisation to assist regeneration.[15]

Several studies have indicated that the diode laser, with a wavelength of between 655 and 980 nm, can accelerate wound healing through the facilitation of collagen synthesis, promotion of angiogenesis, and augmentation of growth factor release. Furthermore, the diode laser has in vitro bactericidal and detoxification effects and can prevent ablation of the root surface, which theoretically reduces the risk of removal of normal root tissue.[13]

Sgolastra et al. 2012[14] did not observe significant differences for any investigated outcome (clinical attachment level, probing depth, and changes in the plaque and gingival indices) in their systematic review. These findings suggest that the use of the diode laser as an adjunctive therapy to conventional non-surgical periodontal therapy did not provide additional clinical benefit. However, given that few studies were included in the analysis, the results should be interpreted with caution. Important issues that remain to be clarified include the influence of smoking on clinical outcomes, the effectiveness of the adjunctive use of the diode laser on microbiological outcomes, and the effect of adverse events. Future studies are required to assess the effectiveness of the adjunctive use of the diode laser, as well as the appropriate dosimetry and laser settings.

_Soft-tissue applications

There are numerous soft-tissue procedures that can be performed with laser. Two key advantages of this are reduced intra-operative bleeding and less post-operative pain compared with conventional techniques, such as electrosurgery. Certain procedures in patients with bleeding disorders are better suited to lasers with greater haemostatic capabilities.[5]

_Conclusion

Although the results of laser therapy are similar (in safety, efficacy and effectiveness) to those obtained with conventional methods, new techniques and devices have been developed. Laser could thus be an evidence-based and well-supported treatment option for the dentist in daily dental practice._

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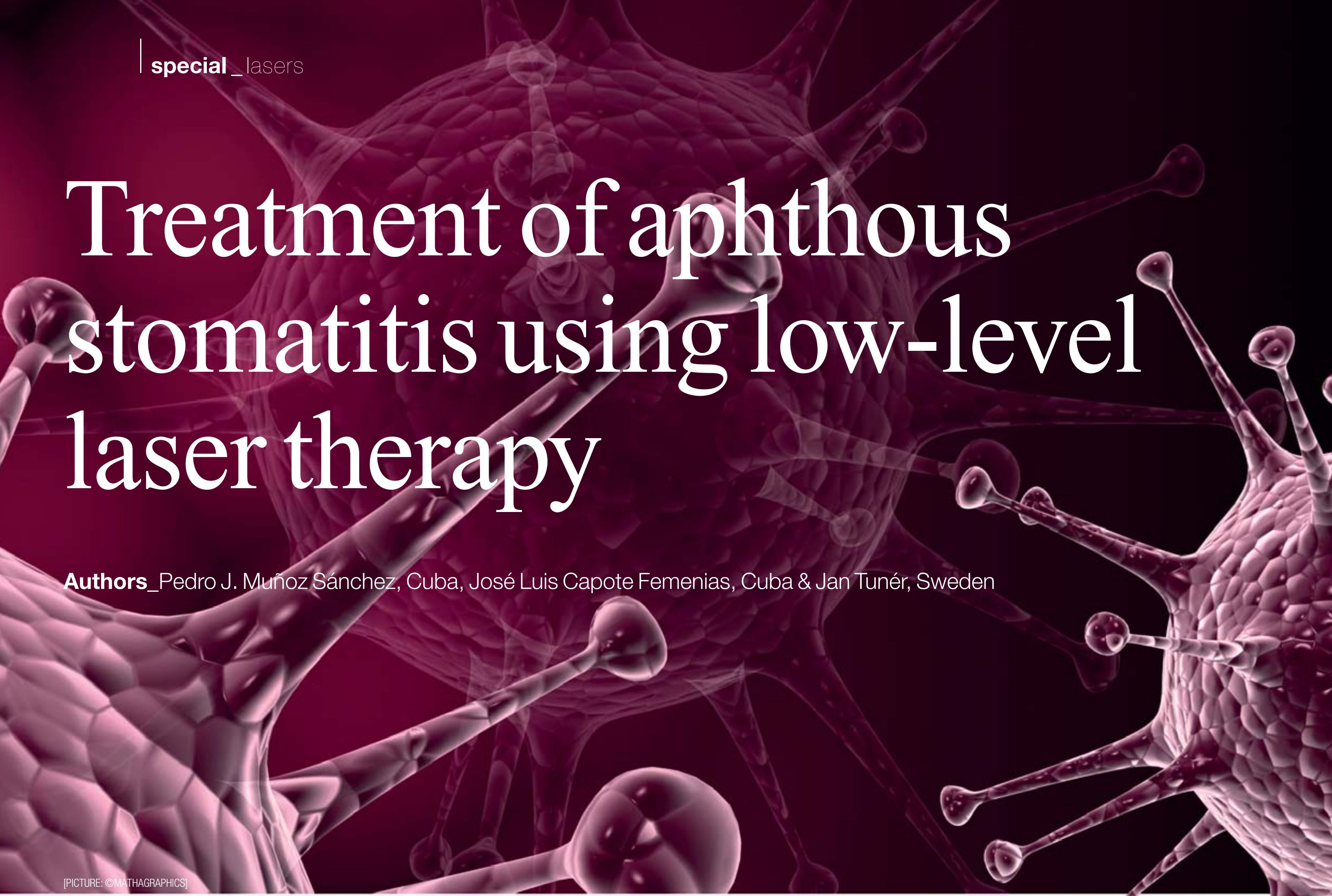
Dr Jonas de Almeida Rodrigues
School of Dentistry
Federal University of Rio Grande do Sul
Av. Paulo Gama, 110
Porto Alegre – RGS
90000-000
Brazil

jorodrigues@hotmail.com



[PICTURE: ©MATHAGRAPHICS]

Treatment of aphthous stomatitis using low-level laser therapy

Authors_Pedro J. Muñoz Sánchez, Cuba, José Luis Capote Femenias, Cuba & Jan Tunér, Sweden

_Introduction

Aphthous stomatitis has been investigated to a great extent; however, the aetiology of these lesions is still to be identified accurately. Recurrent aphthous stomatitis is considered a chronic illness accompanied by painful oral ulcers that reappear with irregular frequency.

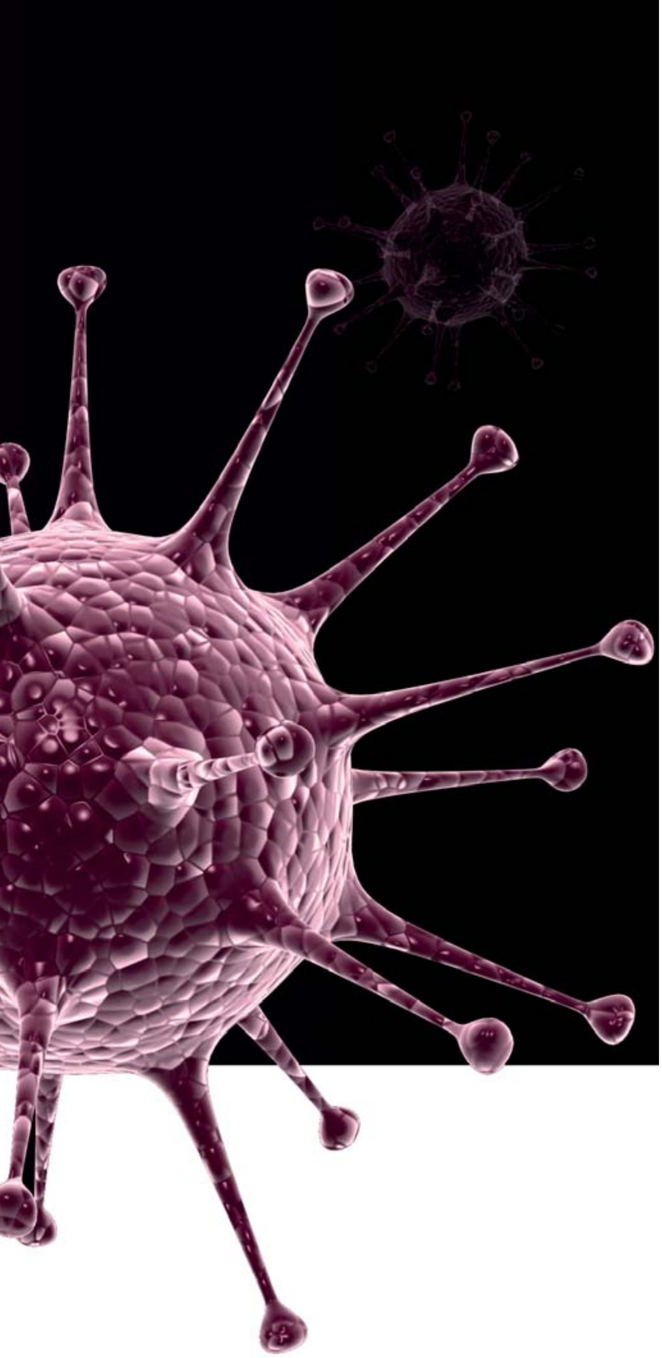
The following categories have been described:
- _smaller aphthous ulcers (80–85 % of cases; of a diameter of 1–10 mm; healing spontaneously in seven to ten days);
- _larger aphthous ulcers (Sutton's disease; 10–15 % of cases; of a diameter larger than 10 mm; healing spontaneously within ten to 30 days or more; may leave a scar); and
- _herpetiform ulcers (5–10 % of cases; multiple clusters of lesions of a diameter of 1–3 mm, which can coalesce into larger erosions; healing in seven to ten days).[1]

The predisposing factors of recurrent aphthous ulcers are speculative; among them are trauma, emotional stress, coeliac disease, hormonal changes, hypersensitivity to certain foods, allergic reactions and intoxications.[1] It is believed that aphthous stomatitis affects 20 % of the US population and studies have demonstrated a worldwide prevalence of 31–66 %.[2] It is important to highlight that the diagnosis of aphthous stomatitis is primarily clinical and should be differentiated from systemic conditions, such as coeliac disease, Crohn's disease, herpes simplex virus Type I, Reiter's syndrome, syphilis, systemic lupus erythematosus, T cell disorders, chicken pox and B6 deficiency.[3–7]

The benefits of local therapies have been demonstrated with anaesthetics and corticosteroids, applied in prodromal stages or in early stages of the lesions. When treating with systemic steroids, it is important to consider the course of the ulcer.[8–21] According to reports from Cuba, treatment with low-level laser therapy (LLLT) is effective, achieving rapid relief of pain, quicker wound healing and lower frequency of recurrence.[22–24] The aim of the present clinical unblinded study was to evaluate the prevalence of aphthous stomatitis in various age groups, as well as the effect of LLLT in the treatment of aphthous stomatitis.

_Material and methods

An experimental study was carried out in patients with a clinical diagnosis of aphthous stom-



atitis attending the Leonardo Fernández Sánchez dental clinic in Cienfuegos in Cuba between September 2010 and March 2011. Among the 252 patients registered, 208 attended the clinic until the lesions had healed completely. The study was approved by the Scientific Council of the University of Medical Sciences, Cienfuegos. All of the patients were informed about the parameters of the study and gave their informed consent.

LLLT was administered to 104 patients (study group) and the remaining 104 (control group) received conventional treatment, such as topical anaesthetics (2 % lidocaine), dietary advice and oral painkillers. Every second patient with the same type of ulcer was allocated to either the study or the control group. The two groups consisted of 56 males and 148 females, with a great variation in age distribution (Table 1).

All of the patients were seen daily and the patients in the study group received LLLT every second day unless their ulcer had already healed. The patients were categorised with regard to age and ulcer type (Tables 1 & 2). Special diagnostic procedures were performed in patients with large ulcers to confirm a safe differential diagnosis. Pain was evaluated, but since pain is subjective, it was decided only to register the time until wound closure (Fig. 1), which can be registered objectively. No patient in the study group reported any negative effects of the laser irradiation.

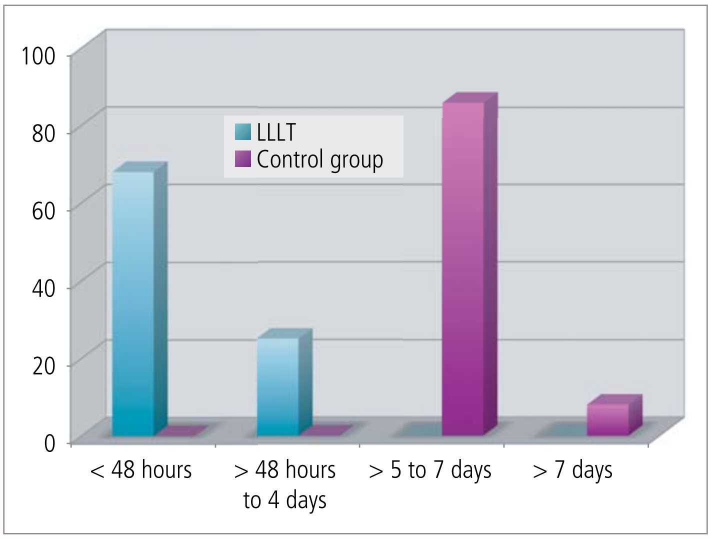
The laser used was the Lasermed 670DL (Cuban manufactured), 670 nm, 40 mW. Each ulcer underwent 40 seconds of irradiation at 1.6 J, 2.04 J/cm^2 and 51 mW/cm^2 from a distance of about 0.5 cm. The parameters used were based upon the successful application of these in a previous study on herpes simplex virus Type I blisters.[32]

The study was unblinded. A 660 nm laser emits clear red light and, although a patient-blinded design is possible, it is not possible to mask a placebo laser for the therapist.

The distribution of the age of the patients, of the types of ulcer according to age, and of the types of ulcer in the study and control groups is shown in Tables 1–3. This data corresponds with the literature, where smaller aphthous ulcers represent 80–85 % of cases, larger ulcers 10–15 % and herpetiform ulcers 5–10 %.[1]

_Results

The main results of the study are presented in Figure 1. The results shown are for small ulcers, which were the dominant type of ulcers treated. As for the large ulcers in the study group, four scarred



Sex	Age group (years)					Total
	0–9	10–19	20–39	40–59	60+	
Male	4	4	16	24	4	52
Female	4	20	48	52	28	152
Total	8	24	64	76	32	204

Clinical type	Age group (years)					Total
	0–9	10–19	20–39	40–59	60+	
Small ulcers	4	24	60	64	28	180
Large ulcers	–	–	8	12	–	20
Hepetiform ulcers	–	–	–	–	4	4
Total	4	24	68	76	32	204

Clinical type	Age group (years)		Total
	Study group	Control group	
Small ulcers	92	92	184
Large ulcers	8	8	16
Hepetiform ulcers	4	–	4
Total	104	100	204

between two and four days, and another four scarred between five and seven days. In the control group, eight large ulcers scarred within seven days. For ethical reasons, and because of the small number of cases, the four herpetiform ulcers were all treated with laser. They healed between two and four days. According to the literature, the normal healing time with no treatment is seven to ten days for small aphthous ulcers, ten to 30 days for large aphthous ulcers, and seven to 14 days for herpetiform ulcers.[1, 3]

_Discussion

The use of LLLT to treat aphthous stomatitis was suggested in 1986 already by Quang-Hua[25] using a helium–neon laser and in 1987 by Von Alften[26] using a gallium arsenide laser. Recent studies, such as the one by De Souza et al.[27] have used a laser similar to ours, 670 nm, 50 mW, 3 J/cm^2. It therefore appears that the wavelength itself is not decisive. Indeed, Zand et al.[28] report good results using a carbon dioxide laser at non-thermal levels in combination with a transparent gel to reduce beam absorption. Surgical lasers have also been reported to be effective, but the mechanism here ought to be different, since it entails superficial tissue evaporation. Tezel et al.[29] report fair results using an Nd:YAG laser, while the erbium laser in addition can be used for surface modification of the lesion and pain relief.[30]

The biological mechanism behind the effect of the various lasers is still unknown. The power setting used in our study was rather low and the effect of higher power settings needs to be investigated. Another aspect is the number of sessions. In our study, the patients were treated every second day until wound closure had been achieved. In the De Souza study,[27] patients were treated daily until an obvious result was observed. Only four patients with a herpetiform ulcer took part in the current study. Although these ulcers responded well to LLLT, no definite conclusions can be drawn, since all four were included in the study group.

Patients typically have an occasional aphthous ulcer. The problem arises in patients with recurrent aphthous ulcers. The frequency of recurrence was not investigated in our study, but no presently available treatment has been able to reduce recurrence.[31] However, such a possibility is suggested in some sources.[22–24] In a recently published study,[32] our clinic found that LLLT reduced the recurrence frequency in herpes simplex virus Type I patients. Although aphthous ulcers are different to herpes simplex virus Type I blisters, LLLT might reduce their frequency of recurrence too.

_Conclusion

LLLT appears to be a safe and effective option for treating aphthous stomatitis. The distribution of aphthous stomatitis in the various age groups was found to be in accordance with previous reports.[33] Further studies are warranted to investigate the optimal laser parameters and frequency of irradiation.

_Statement

The present study was financed by the authors and their clinics. Pedro J. Muñoz Sánchez and José Luis Capote performed the clinical part. Jan Tunér served as scientific advisor and authored the manuscript._

Editorial note: A list of references is available from the publisher.

_contact roots

Jan Tunér
Spjutvagen 11
772 32 Grängesberg
Sweden

jan.tuner@swipnet.se

Navigating canal systems— The 16th ESE biennial congress

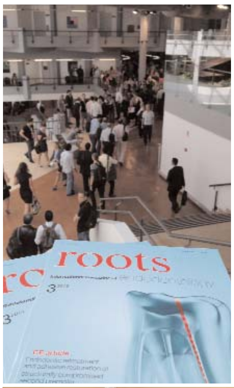
Author_ Magda Wojtkiewicz, DTI

_The 16th European Society of Endodontology (ESE) biennial congress, which covered everything of importance to modern endodontic treatment, finished in a middle of September. The event was hosted by the Portuguese Society of Endodontology from 12 to 14 September and was a fantastic opportunity for endodontic specialists to meet friends and colleagues in the spectacular city of Lisbon. According to the organisers, the congress provided an exceptional scientific programme together with an exciting social programme.

The congress was aimed at the entire dental team, and general practitioners, postgraduate students, academics and hospital-based dentists in particular. The ESE aimed to attract not only specialists from Europe but also those interested in endodontology and the associated biological, biomaterial and clinical sciences from the rest of the world.

Lectures in three halls were complemented by poster sessions and pre-congress courses. Topics covered included just about everything of importance to modern endodontic treatment: pulp regeneration and therapy, irrigation and retreatment, canal anatomy and the use of CBCT; all these practical skills were considered in depth. Further lectures dwelt on pure science and explored future techniques and technologies.

On the first day of the meeting, Prof. Gottfried Schmalz, the new President of the Pan-European Region of the International Association for Dental Research, presented the very interesting concept of pulp regeneration and discussed a cell-based versus cell-free approach to the treatment. During a parallel session, Dr Shanon Patel from King's College London in the UK and Dr Sashi Nallapati from the Nova Southeastern University in Florida in the USA focused



on the advantages and disadvantages of using CBCT in the endodontics practice. In the afternoon, participants had the opportunity to learn more about successful bonding concepts for root-filling materials and new instrumentation.

Friday and Saturday were completely filled with clinical and scientific sessions. Root-canal cleaning and shaping, safe irrigation, and disinfection were discussed. In addition, endodontic surgery was a popular topic, with presentations by Prof. Syngcuk Kim, Chairman of the Department of Endodontics at the University of Pennsylvania's School of Dental Medicine in the USA, Prof. Christine Peters from the University of the Pacific in the USA, and Dr Igor Tsesis, coordinator of graduate endodontics at Tel Aviv University in Israel. A well-known Italian endodontic school was represented by Dr Arnaldo Castellucci, past president of the Italian Endodontic Society, and Prof. Gianluca Gambarini from the Sapienza University of Rome.

The congress was supported by a number of major industry players, including DENTSPLY Maillefer, SybronEndo, VDW, SS White, ACTEON, MICRO-MEGA and Morita. DENTSPLY, SybronEndo and VDW also held sponsored sessions.

The next ESE congress will take place in Barcelona from 16 to 19 September 2015._

International Events

2014

Irish Endodontic Society ASM 2014
30–31 January 2014
Dublin, Ireland
www.irishendodonticsociety.com

BES Spring Scientific Meeting: The Biomechanics of Root Canal Treatment
8 March 2014
London, UK
www.britishendodonticsociety.org.uk

Biannual symposium of AEDE
14–15 March 2014
Madrid, Spain
www.aede.info

AADR Annual Meeting
19–22 March 2014
Charlotte, USA
www.aadronline.org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AAE Annual Session
30 April – 3 May, 2014
Washington, USA
www.aae.org

DGET Spring Meeting
9–10 May, 2014
Witten, Germany
www.dget.de

Asia Pacific Dental Congress (APDC)
Improving quality of life through better dental care
17–19 June 2014
Dubai, UAE
www.apdentalcongress.org

2014 AAE/AAP/ACP Join Symposium
Teeth for a life time: Interdisciplinary Evidence for Clinical Success
19–20 July 2014
Chicago, USA
www.perio.org/meetings/joint-symposium2014.htm

FDI Annual World Dental Congress
11–14 September 2014,
New Delhi, India
www.fdi2014.org.in

Italian Academy of Endodontics (AIE)
22nd National Congress
2–4 October 2014
Montecatini Terme, Italy
www.accademiaitalianaendodonzia.it

155th ADA Annual Session
9–12 October 2014
San Antonio, USA
www.ada.org

BES: 2014 Regional Meeting
14–15 November 2014
Manchester, UK
www.britishendodonticsociety.org.uk

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Questions?

Magda Wojtkiewicz (Managing Editor)
m.wojtkiewicz@oemus-media.de

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Publisher
Torsten R. Oemus
oemus@oemus-media.de

CEO
Ingolf Döbbecke
doebbecke@oemus-media.de

Members of the Board
Jürgen Isbaner
isbaner@oemus-media.de

Lutz V. Hiller
hiller@oemus-media.de

Managing Editor
Magda Wojtkiewicz
m.wojtkiewicz@oemus-media.de

Executive Producer
Gernot Meyer
meyer@oemus-media.de

Designer
Josephine Ritter
j.ritter@oemus-media.de

Copy Editors
Sabrina Raaff
Hans Motschmann

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