

# roots

international magazine of endodontology

2<sup>2014</sup>



| **CE article**

Passive micro-volume management of sodium hypochlorite in endodontic treatment

| **review**

Instrument fracture removal revisited

| **industry report**

BT-Race: Biological and conservative root canal instrumentation with the final restoration in mind



# Dear Reader,

**Mahatma Gandhi** once said, "Live as if you were to die tomorrow; learn as if you were to live forever." Learning, thus, is a never-ending process, more so in dentistry and particularly in endodontics. In this present era, knowledge is just a click away; however, the authenticity of such information is not always reliable. Literature plays a vital role in the shaping of a dentist into a concept-driven clinician. Apart from textbooks and journals, various educational forums where knowledge and clinical skills are shared without barriers contribute to the field of dentistry. One such online forum is Roots, which has been passionately educating and motivating young general dentists and endodontists. It has welcomed all those who have a passion for endodontics into its fold.

The majority of the advancements in endodontics are technology driven. Complete dependence on gadgets, however, without application of basic concepts makes us technicians, not endodontists. These tools can only be useful adjuncts to good theoretical knowledge and clinical skills. What better place to obtain the best of both, the latest in technological advancements and the training to use them to enhance your concept-driven clinical acumen, than dental meetings? Roots Summits have been held in various parts of the world. The last one was held at Foz do Iguaçu in Brazil in 2012. This year's Roots Summit will be held in Asia for the first time, in Mahabalipuram, a peaceful beach town near the southern city of Chennai in India. The organising committee has been working tirelessly to make this summit a memorable one. An array of national and international speakers are working on presentations, including the complexities of the root canal, the management of separated instruments, and regenerative endodontics, which are critical areas in today's clinical scenario in endodontics. To add to this, there are more than a dozen pre-summit workshops to choose from for those who wish to gain first-hand experience. This will be a golden opportunity for all dentists from Asian countries and from far to meet in India to further enhance their knowledge and skills in a positive way. To learn more about the technological advancements, there is no better place than the summit, where there will be a plethora of dental companies showcasing the latest in the field of endodontics.

**roots** magazine has always been known for its superior quality, in its articles, illustrations and print. This issue too covers topics that will offer insights on instrument retrieval, pre-endodontic restorations, conservative root canal instrumentation and phototherapy, among others.

I wish to sign off with an invitation to every reader and member of the Roots community to attend Roots Summit 2014 and contribute to its success.

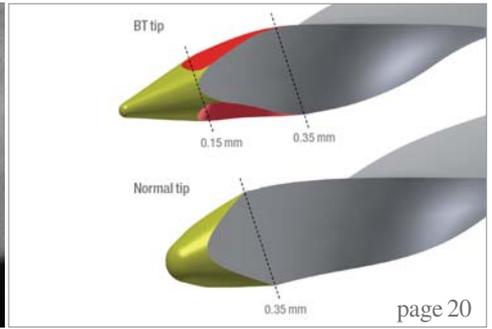
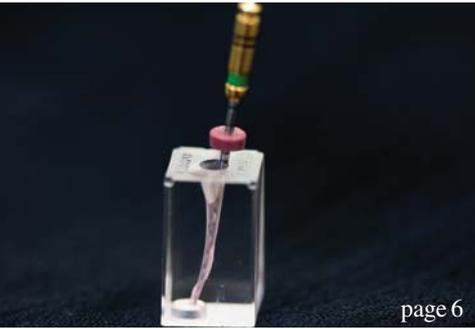
Yours faithfully,

*Sekar Mahalaxmi*

Dr Sekar Mahalaxmi  
Head of the Department of Conservative Dentistry and Endodontics  
SRM University, College of Dentistry, Chennai, India



Dr Sekar Mahalaxmi



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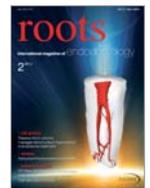
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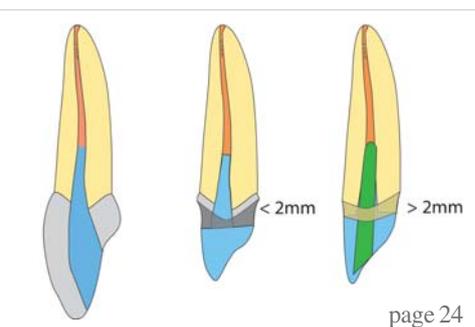
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Cover image: first mandibular premolar anatomical variation by Ronald Ordinola Zapata



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# Passive micro-volume management of sodium hypochlorite in endodontic treatment

Author\_ Dr Les Kalman, USA

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	<p>This article qualifies for CE credit. To take the CE quiz, log on to <a href="http://www.dtstudyclub.com">www.dtstudyclub.com</a>. Click on 'CE articles' and search for this edition of the magazine. If you are not registered with the site, you will be asked to do so before taking the quiz. You may also access the quiz by using the QR code.</p>

## \_Introduction

Endodontic treatment addresses the removal of the tooth's internal pulp and micro-organisms,<sup>1</sup> primarily due to infection and necrosis. Once proper diagnosis and prognosis has been established, the patient has the option of maintaining the tooth's form and function while the vitality becomes lost. Current endodontic treatment consists of utilizing rotary files to remove the pulpal tissue and shape the internal dentin chamber of the tooth. Chemicals, in the form of gels and liquids, are then implemented to disinfect the canal(s) and eliminate bacteria.<sup>2</sup> The chemicals are then dried and the canal space filled with either gutta-percha or resin to create a hermetic seal.

The chemicals employed to clean and disinfect the intracanal space are vast and include file lubricants such as Prolube (DENTSPLY) and irrigants such as QMix (DENTSPLY). During clinical endodontics, the canal is filled with a cocktail of chemicals, as file lubricants and irrigants become a mixture.

## \_Abstract

The passive utilization and micro-volume management of sodium hypochlorite as an endodontic irrigant has been illustrated with a laboratory demonstration and several clinical cases. By limiting the volume and pressure of sodium hypochlorite, the injurious effects can be minimized while still benefiting from the ideal disinfecting characteristics. Further studies are required to understand the behaviour of fluids, especially sodium hypochlorite, within the context of permeability, fluid mechanics and multi-phase fluid flow through porous media.

Fig. 1\_ DENTSPLY Vortex rotary file with sodium hypochlorite.

Fig. 2\_ DENTSPLY Profile rotary file with dyed sodium hypochlorite.



Fig. 1

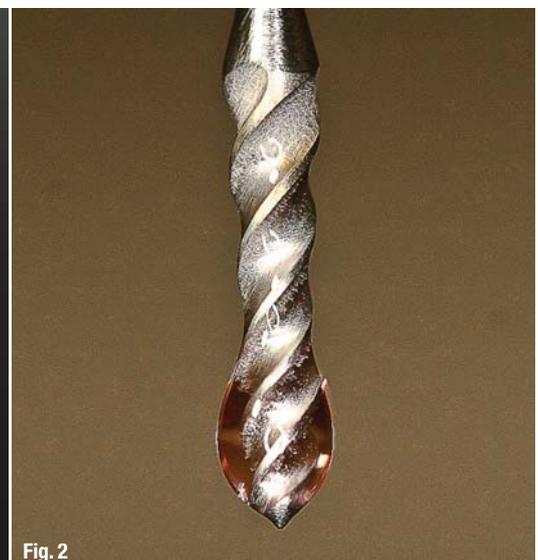


Fig. 2



Fig. 3



Fig. 4

**Fig. 3** Micro-volume delivery of sodium hypochlorite with rotary file.  
**Fig. 4** Sodium hypochlorite in block with rotary file.

Chlorhexidine gluconate (CHX) is an uncommonly used irrigant<sup>3</sup> with several desirable properties. It provides antimicrobial activity against certain aerobic and anaerobic bacteria, exhibits no significant changes in bacterial resistance in the oral microbial environment and has no injurious effect to the skin or mucosa<sup>4</sup>. In fact, CHX has a role as an oral rinse at the 0.12 per cent concentration.<sup>4</sup>

Sodium hypochlorite (NaOCl) still remains the most commonly used chemical,<sup>2,3</sup> due to its availability, cost and effectiveness.<sup>2,5</sup> Sodium hypochlorite is effective against broad-spectrum bacteria and has the ability to dissolve both vital and necrotic tissue.<sup>6</sup> However, this irrigant is equally damaging to the patient and has a history of injurious effects.<sup>5</sup> Typically the NaOCl is delivered into the canal space with a syringe dose of 2–10 ml that is expelled under pressure. The ability of NaOCl to escape either through poorly sealed isolation or other means can cause serious injury to the patient.<sup>5</sup>

Injury from NaOCl is well established in the literature<sup>3,5,6</sup> and has been attributed to three main errors: poor handling, injection beyond the apical foramen and allergy.<sup>6</sup> Poor handling injury can result in operator and/or patient injury to the eye and/or skin.<sup>6</sup> Injection beyond the apical foramen can result in the following:<sup>6</sup>

- \_ immediate and severe pain,
- \_ edema to adjacent tissue edema,
- \_ edema to the lip, infraorbital region, and side of face,
- \_ intense bleeding from within the canal space,
- \_ skin and mucosa bleeding,
- \_ intestinal bleeding,
- \_ paraesthesia,
- \_ secondary infection.

Allergy from NaOCl is rare but has been reported and may result in severe pain, a burning sensation, edema and transient paraesthesia.<sup>6</sup>

### Methodology

Although there is no universally accepted irrigation protocol regarding endodontic treatment,<sup>3</sup> it is the duty of the clinician to apply evidence-based dentistry within clinical parameters to provide their patients with the highest standard of care with minimal morbidity. The use of NaOCl has numerous beneficial factors that maximize treatment success; however, it is the application of the liquid that can cause injury.

Micro-volume management of NaOCl has been proposed. The concept is based on the premise that endodontic instruments have irregular surfaces, crucial for dentinal preparation, and that liquids exhibit surface tension characteristics.<sup>7</sup> By placing an instrument into a suitable container, the NaOCl will be carried within the surface texture of the instrument (Figs. 1 & 2). As the operator inserts the instrument into the canal (Fig. 3), the NaOCl is carried with it. Upon instrument movement, the NaOCl is released into the canal space (Fig. 4). Surface tension and permeability of porous media (dentin) will also increase the ability of the liquid to percolate into the canal.<sup>7</sup> This approach is radically different than current philosophies, as the NaOCl is introduced into the canal space in a micro-volume amount without any pressure. The operator has control of the minimized liquid while benefitting from its effectiveness.

The micro-volume management of sodium hypochlorite has been applied to numerous clinical cases. Post-operative obturation radiographs of completed clinical cases have been presented (Figs. 5–9).

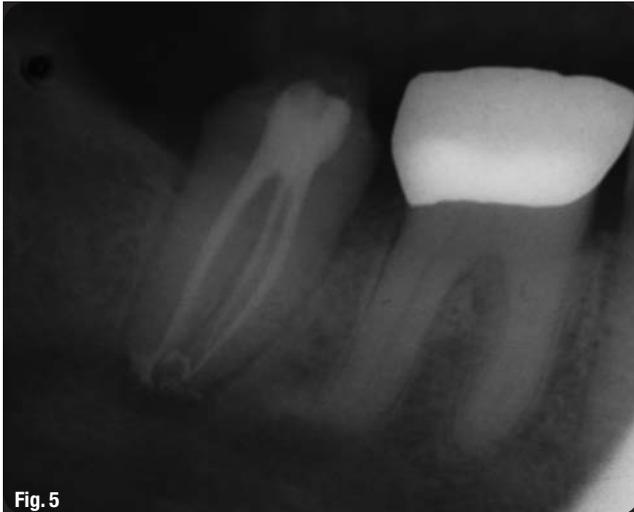


Fig. 5

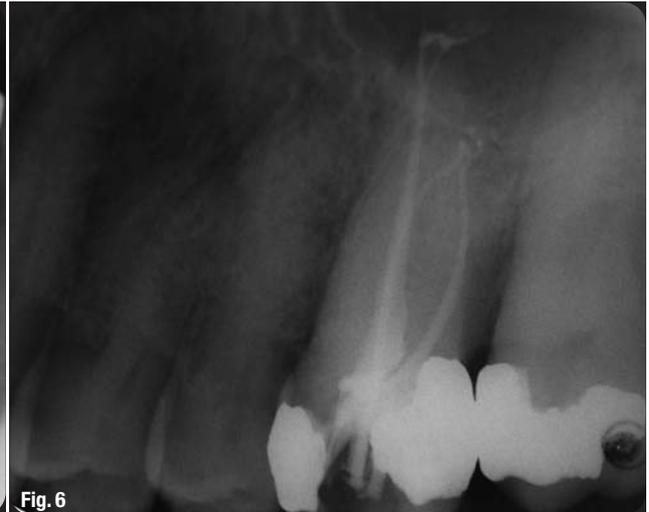


Fig. 6

**Fig. 5\_** Radiograph of endodontic treatment on tooth #47.

**Fig. 6\_** Radiograph of endodontic treatment on tooth #26.

### \_Discussion

The canal system inside a tooth is very complex. Although there is the presence of one or more canals, there also exist numerous micro tunnels, ribbons and sheets throughout the canal network.<sup>8</sup> The canals are also housed within a porous dentinal structure, for which the permeability has been distinguished.<sup>9</sup> Although the elimination of the pulp is a relatively predictable clinical procedure, the introduction of liquids into this complex micro-network porous development further complicates matters. If the clinician introduces liquids, then the successful removal of those liquids is key to clinical success. Concepts of multiphase fluid flow through porous media and capillaries,<sup>10</sup> permeability of porous media<sup>11</sup> and surface tension fluid mechanics<sup>7</sup> must be recognized to validate and further advance canal irrigation.

**Fig. 7\_** Radiograph of endodontic treatment on tooth #16.

**Fig. 8\_** Radiograph of endodontic treatment on tooth #36.

Micro-volume management of NaOCl has been suggested as a delivery modality to maximize its bactericidal effects yet minimizing its injurious effects.

Surface tension fluid mechanics and permeability<sup>7,10,11</sup> suggest that the NaOCl can be carried within the surface irregularities of endodontic instrumentation and deposited into the canal space and percolate within the complex network of the canal. The passive management of the irrigant in micro-volume would greatly reduce complications due to poor handling. CHX has been suggested as the larger volume, positive pressure irrigant that may be delivered into the canal space. CHX has favourable antibacterial characteristics but minimal injurious effects, if mismanagement of the irrigant has occurred. If positive pressure delivery of CHX is required, the operator should regulate the pressure and avoid the risk of injection beyond the apex. The use of EDTA (ethylenediaminetetraacetic acid) could be employed after NaOCl, to minimize the formation of precipitates.<sup>2</sup>

The application of micro-volume management of NaOCl suggests that the canal space can be effectively cleaned in a conservative manner. Application of this principle has been applied to clinical cases with little



Fig. 7



Fig. 8

to no post-endodontic sensitivity. Obturation has been completed with ThermaSeal and Thermafil (DENTSPLY). Even though there is evidence of sealer extrusion, the absence of post-operative symptoms and pathology suggests adequate volume for sufficient disinfection.

Further laboratory studies are required to understand permeability, fluid mechanics and multiphase fluid flow through porous media and their relation to the micro-management of NaOCl. Additional clinical investigations should be implemented to assess and validate the efficiency and efficacy of micro-volume management of sodium hypochlorite on endodontic therapy.

## Conclusions

Introduction of lubricants and irrigants into the canal complex is crucial for endodontic success. The action of fluids in the canal complex must be understood within the context of permeability, fluid mechanics and multiphase fluid flow through porous media.

NaOCl has several advantages for its role as an endodontic irrigant, but its use must be exercised with caution in order to prevent injury. Application of NaOCl as a passive, micro-volume liquid has been illustrated.

Further consideration is required to validate the theory. The potential to minimize morbidity while maximizing clinical endodontic success seems promising for both clinician and patient.

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**Fig. 9** Radiograph of endodontic treatment on tooth #16.

## about the author

roots



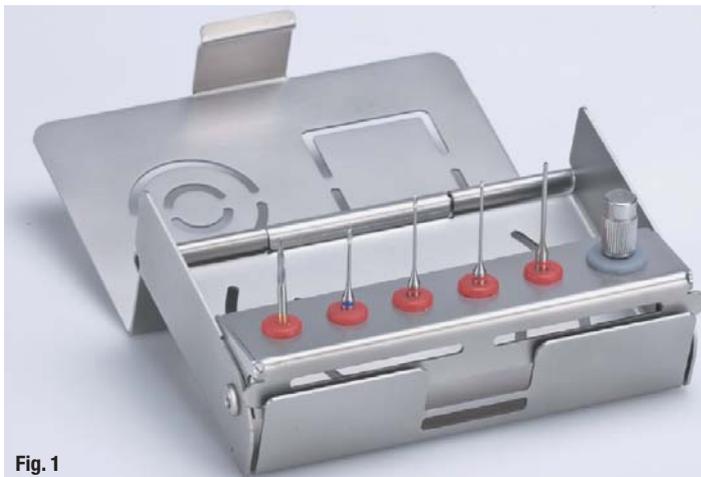
**Dr Les Kalman, B.Sc. (Hon), DDS**, graduated from the University of Western Ontario with a doctor of dental surgery degree in 1999. He then completed a GPR at the London Health Sciences Centre. He has been involved in general dentistry within private practice since 2000. He has served as the chief of dentistry at the Strathroy-Middlesex General hospital. In 2011, he transitioned to full-time academics as an assistant professor at the Schulich School of Medicine and Dentistry. Kalman's research focuses on clinical innovations, including the Virtual Facebow app. Kalman is also the director of the Dental Outreach Community Services (DOCS) program, which provides free dentistry within the community. Kalman has authored articles ranging from paediatric impression to immediate implant surgery in both Canadian and American journals. He has been a product evaluator for several companies, including GC America and Clinician's Choice. Kalman is the co-owner of Research Driven, a company that deals with intellectual property development. Kalman is a member of the American Society for Forensic Odontology, International Team for Implantology, Academy of Osseointegration, American Academy of Implant Dentistry and the International Congress of Oral Implantology. He has been recognized as an Academic Associate Fellow (AAID) and Diplomate (ICOI). In his spare time, Kalman enjoys photography as an accredited MotoGP photojournalist. He can be contacted at [lkalman@uwo.ca](mailto:lkalman@uwo.ca)

# Instrument fracture removal revisited

**Authors\_** Drs Dominique Martin & Pierre Machtou, France

## Introduction

The fracture of a root canal instrument during endodontic treatment is quite a common occurrence. The estimated risk of instrument fracture is between 0.5 and 5 per cent.<sup>1-6</sup> It has been shown that the number of instrument fractures has notably increased with the growing use of rotary instruments made of nickel titanium (NiTi).<sup>2,4</sup>



**Fig. 1**

**Fig. 1\_**The Endo Rescue Kit (Komet).

Procedures to remove instrument fragments have been used for many years, but the introduction of operatory microscopes to clinical practice has led to a completely new approach. The possibility of actually seeing the instrument allows a far more effective procedure, which is further helped by the development of instruments specially designed for this purpose. These techniques are now well documented, and studies evaluating the possibilities of removing instrument fragments have shown encouraging results.<sup>7-10</sup> The most common technique entails preparing straight-line access to the coronal part of the fragment using Gates Glidden drills, creating a staging platform with a modified Gates Glidden drill, and then using thin ultrasonic tips to retrieve the fragment from the canal walls through ultrasonic vibration.<sup>11</sup>

Although this technique is very effective, it has some disadvantages:

It requires great skill from the operator, since the procedure is done under high magnification. In addition, it is difficult to trough around the fragment without touching it. Especially in the case of an NiTi broken instrument, the fragment may fracture during the course of treatment if the ultrasonic tip contacts the instrument too early or if not enough space is available around it.<sup>12</sup>

Often, too much radicular dentine structure is removed, which is likely to weaken the root.<sup>13</sup>

In order to improve visual control, the treatment is carried out without irrigation, potentially leading to an increase in temperature of the periodontal tissue.<sup>14,15</sup> Work therefore must be interrupted regularly to control heating and provide cooling.

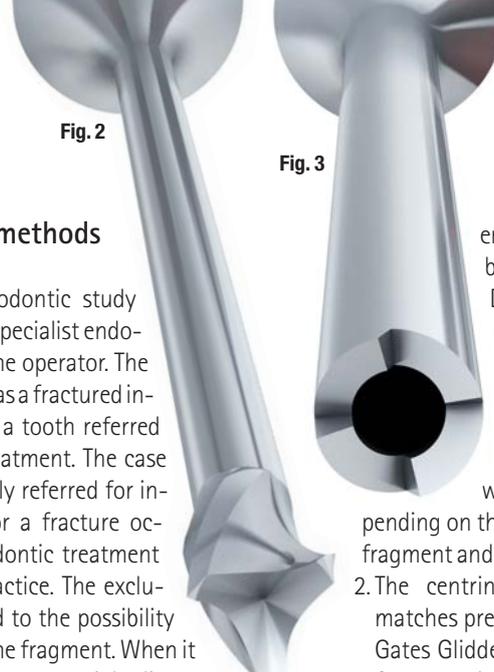
The procedure is fairly time consuming. The estimated time required for the treatment was shown to be between 40 and 55 minutes.<sup>16</sup>

An alternative method is to remove the fragment with the micro-tube technique. Several variations of this technique have been described, including the Masserann Micro Kit (MICRO-MEGA),<sup>17</sup> the IRS (DENTSPLY Maillefer),<sup>18</sup> and a micro-tube coupled with a Hedstroem file.<sup>9</sup> The use of tubes and cyanoacrylate glue (Cancellier Kit, SybronEndo) or composite self-curing resin<sup>19</sup> are other methods to retrieve the fragment.

The present technique is a combination of the trephine drill technique using a new device, the Endo Rescue Kit (Komet Dental), and the micro-tube technique using dedicated needles and composite self-curing resin. The main goal of this technique is to be the least destructive as possible for the tooth structure. The aim of the present study was to assess the success rate of this micro-endodontic removal technique and compare the results with those of published studies.

Fig. 2

Fig. 3



**Materials and methods**

This clinical endodontic study was conducted in a specialist endodontic practice by one operator. The inclusion criterion was a fractured instrument located in a tooth referred for endodontic retreatment. The case was either specifically referred for instrument removal or a fracture occurred during endodontic treatment in the operator's practice. The exclusion criterion related to the possibility of safely accessing the fragment. When it was not possible to create straight-line access to the coronal part of the fragment or when such access would have been too destructive to the tooth structure, the case was excluded from the study and removal of the fragment not attempted. All cases were treated according to the same procedure using the Endo Rescue Kit following the Masserann's basic approach, which involves removal of dentine around the fragment with trephine drills. However, this new kit differs from the Masserann Micro Kit.<sup>20</sup> The first instrument is a special centring drill featuring a concave active surface (Fig. 1) whose diameter matches precisely the size of the corresponding trephine (Fig. 2). The centring drill prepares the site for the subsequent use of the trephine. Three trephine sizes are available. The smallest trephine has an external diameter of 0.7 mm (corresponding to a #2 Gates Glidden drill), the size of the next one is 0.9 mm (corresponding to a #3 Gates Glidden drill) and the last one is 1.1 mm (corresponding to a #4 Gates Glidden drill).

The following steps were followed in a strict sequence:

1. Similar to the currently used techniques, straight-line access to the coronal portion of the fractured instrument has to be created. The goal of this step is to visualise the fractured instrument under the op-

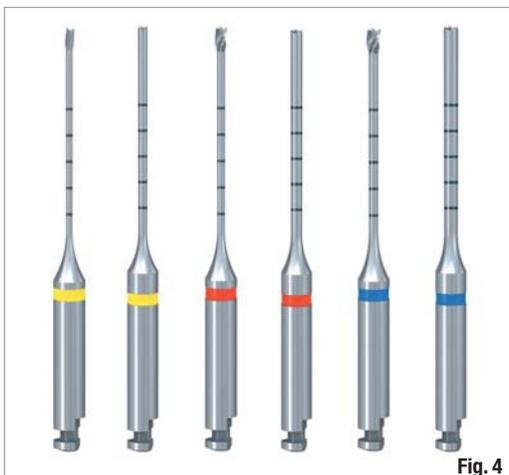


Fig. 4

erating microscope. A cylindro-conical bur with a non-cutting tip (Komet Dental) was used to refine the access cavity walls, followed by the use of a short #4 Gates Glidden drill (Komet Dental) to relocate the canal orifice away from the furcation. Direct access to the fragment was then created with a #2, 3 or 4 Gates Glidden drill, depending on the diameter of the coronal part of the fragment and its location within the canal.

2. The centring drill, whose external diameter matches precisely the size of the previously used Gates Glidden drill, removes dentine around the fragment. Its concave active surface, when coming into contact with the fragment, allowed good centring of the preparation around the coronal part of the fragment.

Teeth	n	Removed	Not removed	Success (%)
Incisors	1	1	0	100
Upper premolar	6	6	0	100
Lower premolar	0	0	0	0
Upper molar buccal root	8	7	3	70
Upper molar palatal root	1	1	0	100
Lower molar mesial root	13	11	4	73
Lower molar distal root	3	3	0	100

3. The corresponding trephine was placed in the area previously prepared with the centring drill to free the fragment by removing the surrounding dentine. The trephine was used in a handpiece at a low speed (300 rpm) in an anti-clockwise rotation or by hand (Figs. 1 & 3).

4. When the fragment could not be removed with the trephine alone, the Endo Rescue Kit was used in combination with a needle filled with a self-curing composite. A needle (Ultradent) with the same external diameter as the trephine was filled with a self-curing composite core material and placed on to the free portion of the fragment. Once the composite had set, the needle was removed with an anti-clockwise motion (Fig. 2). A radiograph was taken to confirm that the instrument had been successfully removed. Complete removal of the fragment without creating a perforation was defined as a success.

The distribution of fractured instruments among different root types (i.e. anterior teeth, premolars, buccal roots of maxillary molars, mesial roots of mandibular molars, distal roots of mandibular molars, and palatal roots of maxillary molars) was recorded, as well as the anatomical location of the fractured instruments (i.e. coronal part of the fragment in the coronal third, middle third or apical third).

Fig. 2\_Centring drill.

Fig. 3\_Trephine.

Table 1\_Success rate depending on the type of tooth.

Fig. 4\_Different sizes of centring drill and trephine: the smallest has an external diameter of 0.7 mm (corresponding to a #2 Gates Glidden drill), the size of the next one is 0.9 mm (corresponding to a #3 Gates Glidden drill) and the last one is 1.1 mm (corresponding to a #4 Gates Glidden drill).

Position	n	Removed	Not removed	Success (%)
Coronal third	5	5	0	100
Middle third	18	16	2	89
Apical third	8	8	5	61

**Table 2**\_Success rate depending on the level of the fragment.

**\_Results**

*Success or failure rate*

According to the inclusion criterion, 36 fragments were recorded within the 18-month period, involving 32 teeth in 30 patients. Five instruments were excluded because straight-line access to the fragment was deemed impossible. Therefore, no attempt was made to use the described technique. Thus, the technique was used for 31 instruments, 29 of which were removed successfully. Of those, 19 were removed with the trephine alone and ten with a needle filled with composite resin (Table 1). This resulted in a success rate of 93.5%. Two instruments (6.5%) further fractured on attempted removal, leaving the most apical part in the canal. No perforation of the root walls was noted.

**Case 1: Fragment removal with the ø 90 Endo Rescue Kit.**

**Fig. 5a**\_Pre-operative X-ray of tooth #26 showing a fractured instrument located in the middle part of a MB curved root canal.

**Fig. 5b**\_Trephine size 90 surrounding the fragment.

**Figs. 5c-d**\_Fragment locked inside the trephine and removed from the canal.

**Fig. 5e**\_Final X-ray.

*Type of tooth and root*

There were 24 instrument fragments found in 21 molar teeth (75% of the sample). There were six premolars with six fragments (accounting for 21.4% of the teeth) and one incisor with one fragment (accounting for 3.6% of the teeth).

The two failures occurred in a mesial root of a molar, one in a mesial root of a mandibular molar and one in a mesiobuccal root of a maxillary molar (Table 2).

*Location of fragments in root canal*

It is important to note that it was the location of the coronal part of the fragment that was recorded. All instruments that had fractured in the coronal third ( $n = 5$ ) were removed from the root canal. All removal failures ( $n = 2$ ) occurred in situations in which only the head of the fragment was visible but the main portion of the fragment was located beyond a sharp curvature. In these two cases, the instrument fractured again, leaving the most apical part in the canal.



Fig. 5a



Fig. 5b

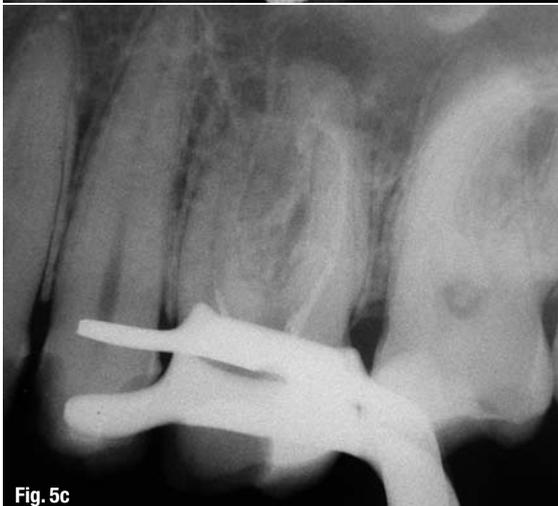


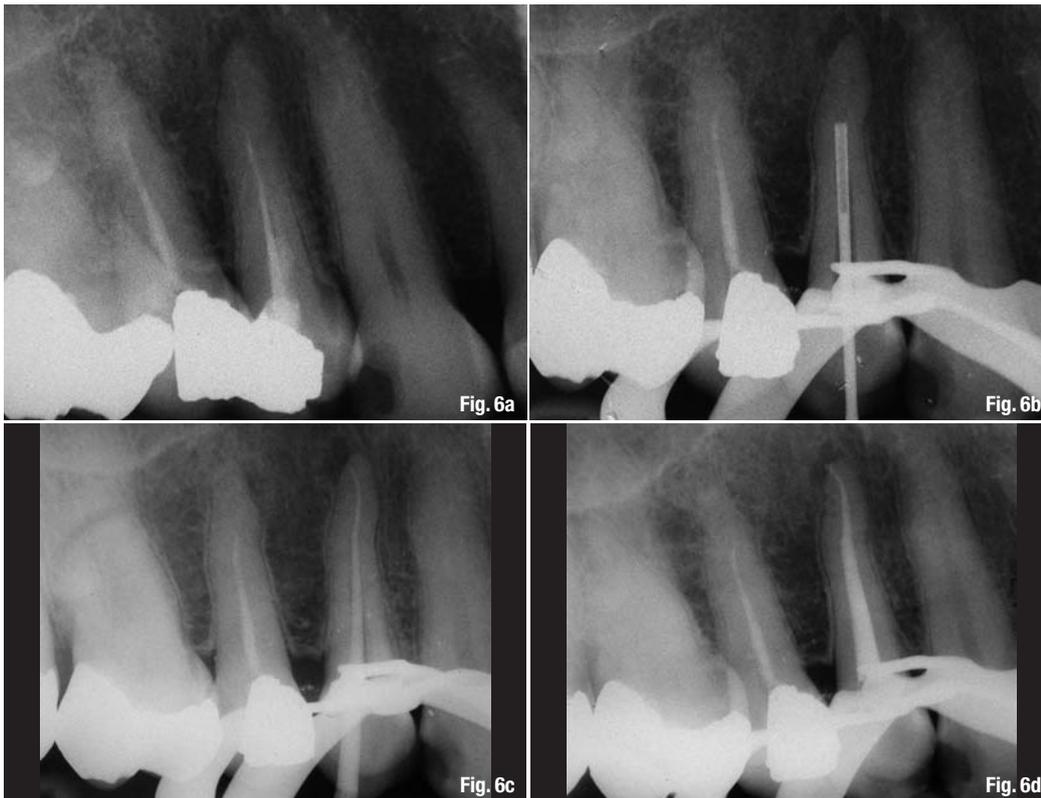
Fig. 5c



Fig. 5d



Fig. 5e



**Case 2: Fragment removal with the ø 70 Endo Rescue Kit trephine.**

**Fig. 6a**\_Pre-operative X-ray of tooth #25, featuring a long and narrow root with a very thin fragment fractured at the junction between the middle and the apical third of the root.

**Fig. 6b**\_Trephine size 70 surrounding the fragment.

**Fig. 6c**\_The fragment is removed with the trephine, shaping and filling are achieved.

**Fig. 6d**\_Final X-ray showing a minimally invasive procedure.

## \_Discussion

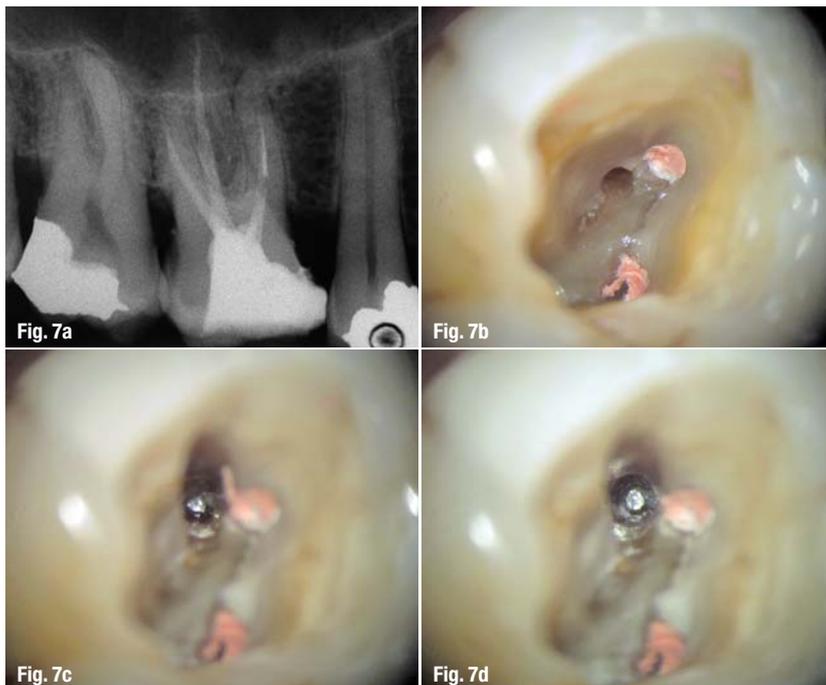
### Success rate

The present study is a prospective evaluation of cases referred to a specialist practice and treated under a dental operating microscope. The success rate of removal of the fractured instruments with the described technique was 93.5%.

A variety of different techniques and devices for removal of fractured instruments have been described in the endodontic literature.<sup>15</sup> The majority of these publications involve descriptions of techniques and case reports. To date, there have been only two detailed investigations on the influence of different factors regarding success or failure of removal attempts using micro-endodontic techniques and a dental operating microscope. In these two studies, the success rate for the removal of fractured instruments was reported to be 87%<sup>9</sup> and 95%,<sup>10</sup> respectively. In Suter's study, various techniques were used to remove the fragments. In Cujé's study, the same procedure was applied using ultrasonic files in all cases. The loss of dentine was not mentioned in either study. In the present study, taking into account the cases for which no attempt at removal was made, the overall success rate was 80.5% and compared favourably with Suter's study. For the 31 cases treated, the success rate was similar to Cujé's study. In the current protocol, the focus was on the preservation of the tooth structure.

### Decision-making

The general principle for removing a fractured instrument is based on the fundamental principles and objectives of root canal treatment. A fractured instrument may be an obstacle to mechanical and chemical treatment of an infected root canal system. Bacteria and pulp tissue remaining in the root canal because of insufficient cleaning may have a negative impact on the treatment outcome.<sup>21</sup> Moreover, the prognosis is likely to depend on the stage and degree of canal preparation and disinfection at the time of instrument fracture and, therefore, on the extent to which microbial control has been achieved.<sup>1,2</sup> The risk factors associated with the presence of a fragment are not clear. Recently, a systematic review and meta-analysis were performed to determine the outcome difference between retained fractured instrument cases and matched conventionally treated cases. Two case-control studies were identified, covering 199 cases. The risk difference of the combined data indicated that a retained fragment did not significantly influence healing.<sup>22</sup> The presence or absence of a pre-operative periradicular disease has been reported to be the main predictive factor for outcome in such cases.<sup>2,23</sup> The risk-benefit ratio of the two therapeutic options, that is, either leaving the fragment *in situ* and completing the treatment by filling the accessible parts of the canal, or trying to remove the fragment so that the entire canal can be treated, should be carefully assessed for each case.



**Case 3: Fragment removal with a needle and composite resin.**

**Fig. 7a** Pre-operative X-ray of tooth #16. A fractured instrument is located in the middle part of the MB2 canal.

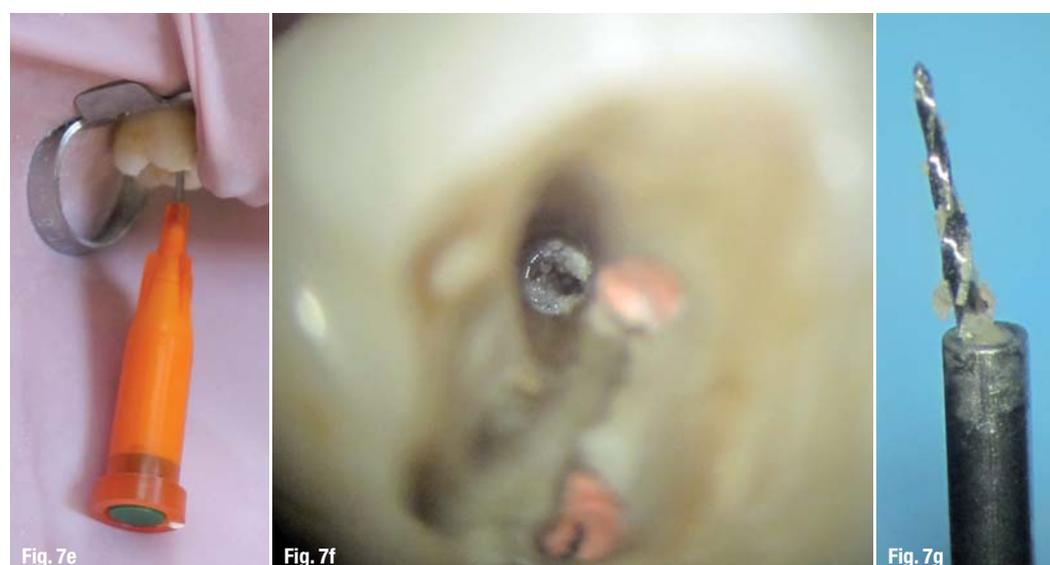
**Figs. 7b & c** Relocation of the canal orifice and centring of the preparation after the pointer drill use.

**Fig. 7d** The coronal portion of the fragment is freed after the work of the trephine.

Instrument removal itself represents a risk and the decision to remove, or not to remove, a fragment is a difficult one. Depending on the technique used, perforation of the root, ledge formation and transportation of the original canal may occur, as well as weakening of the affected root in case of excessive removal of dentine<sup>13</sup> or fracture of an additional instrument.<sup>8,9,23-25</sup> Therefore, when no lesion is present, current knowledge leads us not to attempt a risky procedure to remove the fragment. In this study, five fragments were deeply fractured and not accessible with straight-line access. According to the previous rationale, no attempt was made to remove these fragments, since no apical lesion was present (Fig. 4). Two of these fragments were bypassed and the endodontic treatment completed.

**Figs. 7e-h** The needle technique with composite resin inside the lumen is used to remove the fragment.

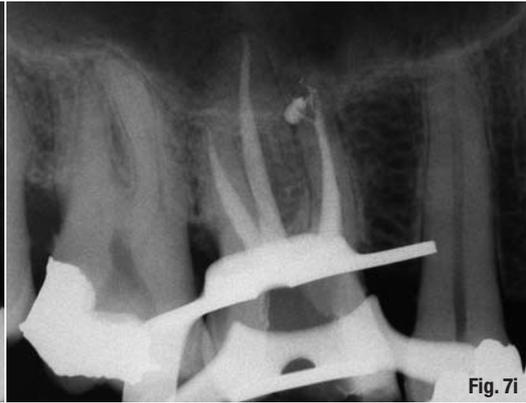
**Figs. 7i** Final view of the completed case.



*NiTi fractured instruments*

The fracture of rotary NiTi instruments is characterised by certain distinctive features. The first characteristic is that, owing to the rotary movement of the instrument and penetration of the flutes into the walls, the fragment is most frequently blocked in the dentine.<sup>23</sup> The second characteristic of these fractures is related to the instrument design. Most rotary NiTi instruments have a taper greater than 2%. Owing to this increased taper, the coronal part of the fragment is likely to be blocked in the canal, whereas the apical portion remains free. This particular feature of NiTi instruments complicates the primary procedure of removing the fragment, which normally entails passing an endodontic hand instrument between the fragment and the canal walls, and guiding it along the fragment to regain patency of the canal. In this case, a more invasive solution is required. This involves straightening the coronal curve to gain access to the fragment at the expense of the dentinal walls. Such techniques are still very controversial.

A frequent counter-argument is the fact that the root canal is weakened by the removal of dentine during the procedure.<sup>26,27</sup> This loss of tissue reduces the fracture resistance of the root<sup>13,28,29</sup> and may lead to complications, such as inadvertent perforation of the root.<sup>8</sup> Ideally, the dentine should be preserved as much as possible and the extent of the root canal preparation after the removal of the fragment should not exceed that of a conventional preparation. The tested technique is intended to overcome this limitation. Although the use of the Endo Rescue Kit involves the removal of an additional amount of dentine, the small diameter of the instruments keeps the damage to the root structure to a minimum, while creating access to the fragment.



*Access to the fragment*

As with all the techniques described, the decisive factor for success was to gain direct access to the fragment. Given that the fragment is usually located beyond the curve of the canal, it is essential to straighten the coronal curve in order to create direct access to the fragment and ensure an unobstructed view of it through the operative microscope. It is equally necessary to expose at least 1.5 mm of the fragment with a trephine in order to be able to catch the fragment with a needle filled with composite

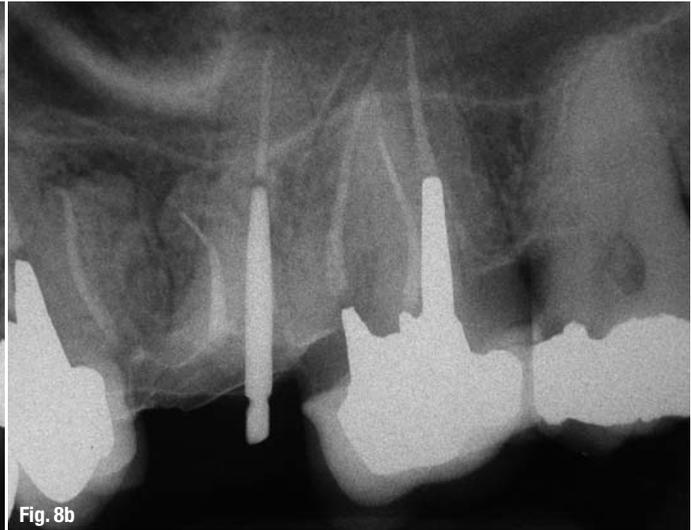
resin. A dilemma exists in such situations because it has not been clearly shown that a retained fragment has any impact on the prognosis,<sup>2</sup> but there is some evidence that removing tooth structure weakens the tooth. It must be carefully evaluated and critically analysed to determine whether a removal attempt is necessary or indicated in each clinical case.<sup>23</sup> In this study, after the preparation of the coronal access and when no periapical lesion was present, it was decided not to attempt to remove the fragment, as it was not visible under the operating microscope.

AD



Biological & Conservative





**Case 4: No removal attempt.**  
**Figs. 8a & b** \_Fragment located apically beyond the canal curvature of tooth # 26 without radiographic signs.

The second step was to prepare a staging platform around the fragment. By investigating different techniques for preparation of a staging platform, Iqbal et al. found it was increasingly difficult to prepare a platform with a centred fragment owing to the increasing distance between the fractured instrument and the maximum curvature of the root canal.<sup>4</sup> The modified Gates Glidden drill described in Ruddle's technique is a helpful instrument for preparing the staging platform but it does not allow centring of the fragment.

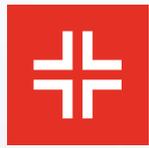
The design of the centring drill in the Endo Rescue Kit follows the same concept but was modified to have a tapered concave active portion. The outer blades cut into the dentine surrounding the fragment, and the concave tapered area that encounters the coronal part of the fragment allows centring of the preparation by advancing the drill apically. This can be carried out by removing a minimum amount of dentine according to the size of the drill, while working in the centre of the canal (Fig. 8).

#### *The micro-tube technique*

The first device to use micro-tubes was the Masserann Micro Kit. This well-known kit is designed to remove all metallic objects from the root canal and consists of a variety of trephines of different sizes and an extractor to grasp the fragment and remove it.<sup>17</sup> The extraction method is easier to use than the ultrasonic technique, but it has some disadvantages as well. The trephines are too large compared with the size of the fragments that are usually found in the root canal. The smallest available diameter is 1.1 mm, whereas the diameter of the extractor is 1.2 mm, which means that it has to be used with a trephine of the same diameter. Depending on the position of the fragment in the root, a large quantity of dentine might have to be removed, which is likely to weaken the root.

Some improvement to the Masserann's extractor was made with the introduction of the IRS. However, in the described technique,<sup>18</sup> access to the fragment was accomplished with ultrasonic tips. The use of ultrasonic tips to disengage the fragment results in an over-enlarged access compared with the size of the IRS extractor. This reduces the interest to use smaller extractors, which are fragile and may deform.

Compared with the Masserann Micro Kit, the Endo Rescue Kit has a number of special features. The first feature is a centring drill with the same diameter as the trephine. Owing to its active concave tip, the outer blades trough around the fragment, and allow centring of the preparation. The second feature is the miniaturisation of the trephines. Three trephines are available: the smallest trephine has an external diameter of 0.7 mm (internal diameter of 0.4 mm), the size of the next one is 0.9 mm (internal diameter of 0.5 mm), and the last one is 1.1 mm (internal diameter of 0.7 mm). Compared with the Masserann's trephines, the sizes are considerably smaller. The largest size trephine drill in the Endo Rescue Kit corresponds to the smallest size in the Masserann Micro Kit. The trephines are designed to be used with an anti-clockwise motion in order to have an unscrewing effect on the fragment. This feature is particularly useful for NiTi rotary fragments, which are usually screwed into the dentine. When the fragment is short (less than 3 mm), it is often pulled out of the canal with the trephine drill. In this instance, it is trapped by the dentinal chips inside the lumen of the trephine. When the fragment is longer than 3 mm or when the tip is located beyond the curvature, the action of the trephine should be stopped before grinding the fragment with the active part of the trephine. The direction of rotation must be considered too, depending on the type of fractured instrument. Rotary instruments used for obturation, such as Lentulo spirals or McSpadden compactors,



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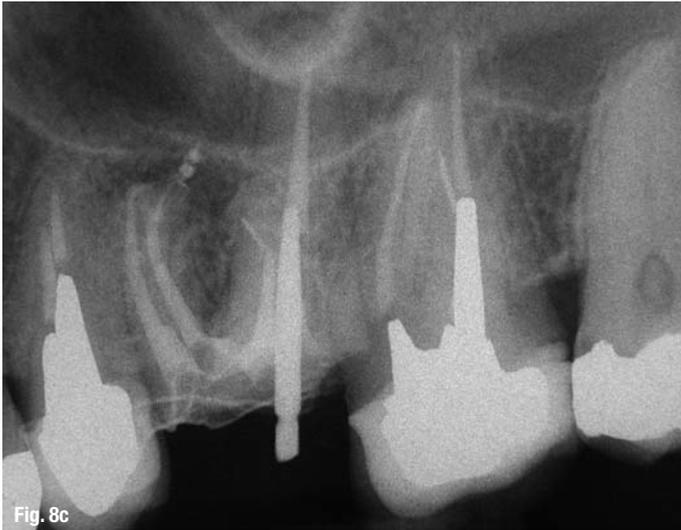


Fig. 8c



Fig. 8d

**Fig. 8c\_**Cleaning, shaping and filling of the root canal system.

**Fig. 8d\_**One year recall: tooth is symptomless.

or shaping instruments that work in a reciprocating motion, should be disengaged with a clockwise motion because their helix angle is reversed.

The micro-tube coupled with the Hedstroem file technique<sup>9</sup> is another way to create an extractor that is more adaptable to the clinical situation using different size tubes and files.

Using tubes and glue is also advocated to grasp the fragment with cyanoacrylate glue (Cancellier Kit) or composite self-curing resin.<sup>19</sup> Needles of different diameters may be used to match the size of the broken instrument. This can only occur if the coronal part of the fragment has been freed from the dentinal walls. This technique is predictable but three problems have been reported. The first is that, to ensure that the cavity is clean and dry, the cavity must be rinsed with pure alcohol and be perfectly dry before using the needle filled with composite resin. The second is that the operator must ensure that the needle is filled with resin in order to surround the fragment. The third is that the operator must ensure that the resin does not overflow from the needle and remains inside the root canal. These problems can be easily overcome however. The composite resin was injected into the needle. The hub of the needle was then plugged with wax until the resin emerged from the tip. The tip was wiped with gauze to ensure that there was no resin on the outer walls of the needle. In this way, the resin can surround the fragment without any overflow. In the study, this technique was performed using a needle of the same diameter as the trephine for 12 of the 29 fragments. Ten of the 12 fragments were removed without leaving any composite resin to potentially block the root canal. Two failures occurred because the fragments were further fractured, leaving the most apical part in the canal and the coronal part embedded in the resin.

## \_Conclusion

Several techniques for removing fractured instruments have been described. Any procedure for removing fractured instruments should seek to avoid damage to the root structure, and should be predictable. The removal technique investigated in the present study, based on the use of a micro-tube and preparation of a staging platform by means of new centring drills, was shown to be effective for the removal of fractured instruments. Although no technique can claim to be universal, the technique described in the study proposes a removal solution well suited to fractured NiTi rotary instruments and offers an alternative to the ultrasonic tips technique. Like any endodontic technique, the Endo Rescue Kit is a technique-sensitive approach and requires clinical experience to be used successfully. However, this preliminary study reported few cases and therefore further studies must be conducted to corroborate these results. The location of the instrument within the root canal, the angle of curvature of the affected root and the location of the broken instrument in relation to the root curvature appear to be decisive factors for the outcome of the removal technique.

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

## \_contact

roots

**Dr Dominique Martin**

21 rue Fabre d'Églantine  
75012 Paris  
France

endomartin@wanadoo.fr

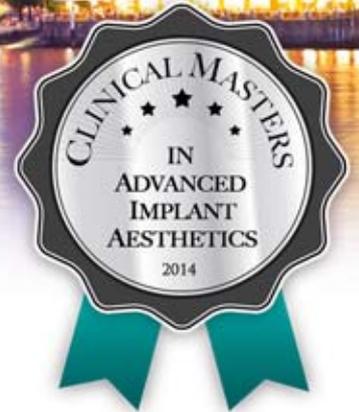


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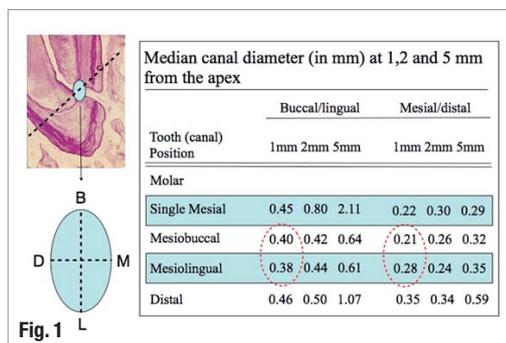
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# BT-Race: Biological and conservative root canal instrumentation with the final restoration in mind

Authors\_ Dr Gilberto Debelian, Norway, & Dr Martin Trope, USA

Fig. 1\_Median canal diameters.



Intra-canal microbes are the cause of endodontic disease.<sup>1-3</sup> The removal of microbes from the root canal system during treatment and the prevention of microbes entering the canals determines whether treatment will be successful.<sup>4,5</sup>

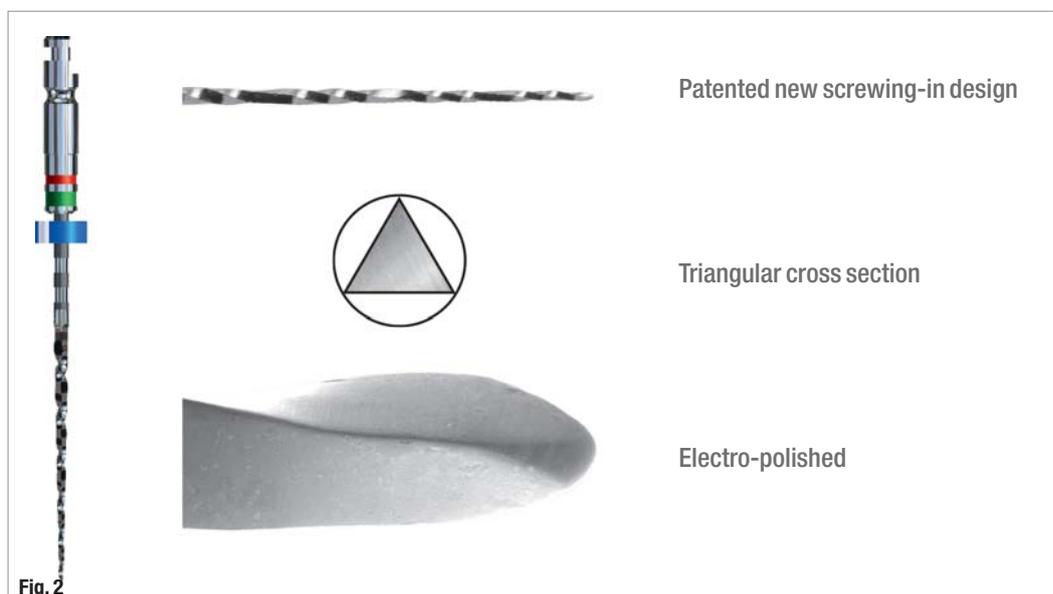
Root canal instrumentation is one of the major tools with which to ensure the long-term success of root canal therapy.<sup>6,7</sup> The aim is to mechanically disrupt as much biofilm as possible so that, with the addition of irrigants and/or intra-canal medicaments,

a very low microbial count can consistently be achieved before root canal filling. Furthermore, the aim of root canal instrumentation is to achieve the microbial reduction goals mentioned above without unnecessarily weakening the root by over-instrumentation, that is, the reduction of the dentinal wall thickness. Preservation of native tooth structure, especially in the cervical region of the tooth, has been demonstrated to correspond to better long-term survivability from a loading and restorative standpoint. It is well established that the root decreases in its resistance to fracture as the remaining dentine thickness decreases.<sup>8</sup>

## What is the ideal root canal instrumentation size?

The file alone does not remove the maximum amount of biofilm but works in synergy with irrigation. What then is the ideal instrumentation size to achieve the desired goal of biofilm elimination? In order to answer this question, we need to analyse anatomical studies, and evaluate whether and how it is possible to remove biofilm from these canals.

Fig. 2\_Benefits of BT-Race files.



A review of anatomical studies demonstrates striking consistency regarding instrumentation size. Figure 1 summarises the anatomical aims for a mandibular molar. Consider the mesiobuccal and mesiolingual canals at the 1 mm measurement from the apical foramen, which corresponds most closely to the dentinocemental junction. In the mesiodistal direction, the diameters are 0.21 mm and 0.28 mm, respectively. Thus, finishing at a #25 file would appear to be sufficient when viewed on a periapical radiograph, since the mesiodistal direction is what we see on the radiograph. However, if we look in the buccolingual direction, the correct sizes are between #35 and #40 files. For the distal canal, a #35 file would appear adequate on the radiograph (mesiodistal view) but the correct size would be a #50 file. Thus, if we want to clean in three dimensions, we need to instrument in the buccolingual dimension also.

Furthermore, if we look at the measurements at 2 and 5 mm from the end of the root, it is apparent that a 0.04 taper is all that is needed to contact the walls in these areas further from the apex if we do, in fact, instrument to the apical sizes required (a #35 or 40 file mesially and a #50 file distally). Using tapers larger than 0.04 is not required to remove microbes and unnecessarily weakens the root. Anatomical studies on all roots follow this basic biological rule, that is, size 35 or 40 for the smaller canals and size 50 for the larger canals.<sup>9-11</sup>

**What is the ideal shape of an instrumented canal?**

Adequate biological sizes with minimal taper with the least number of files will ensure the ideal shape. Thus, in order to achieve the aims stated above, that is, maximal biofilm disruption with minimal weakening of the root, we should aim for apical sizes 35, 40 or 50 with no more than a 0.04 taper.<sup>9-11</sup> These biological sizes with an adequate irrigation protocol will ensure a consistently low microbial count for maximal success.

**The BT-Race system, biological and conservative**

BT-Race files (FKG Dentaire; Fig. 2) are sterilised in individual blisters so that sterility is ensured for every file. The biological sizes mentioned above can be achieved every time with three files once a glide path has been achieved. The system is designed such that these sizes can be attained with minimal removal of coronal dentine to maintain the strength of the root. The files have a non-screw-in design and triangular cross-section to increase flexibility and cutting efficiency, and are electropolished to decrease the effects of torsional and cyclic fatigue.

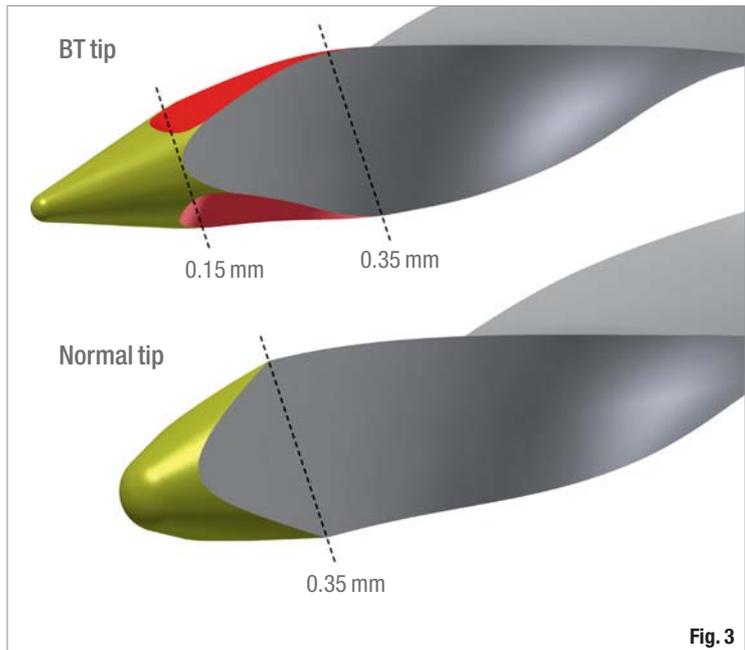


Fig. 3

**Booster Tip**

The Booster Tip (BT) is the key feature of these files and allows them to follow curvatures in canals without undue stress on the file or the root. The tip starts as a non-cutting tip from the 0.0-0.15 mm file diameter, and the cutting edges start from the 0.15 mm file diameter and upwards. This allows these files to follow a canal safely, even one with a very narrow diameter. Thus, the BT2 file (Figs. 3 & 4a-c), for example, which is a non-tapered file with a cutting size of 0.35 mm, can still easily advance into the canal prepared by the glide path file, which is 0.15 mm in diameter.

Fig. 3 Localisation of the cutting point in the BT and normal tips.

Figs. 4a-c Efficiency of the normal tip and the BT in the canal (a & b). Path of the tip with guide (c).

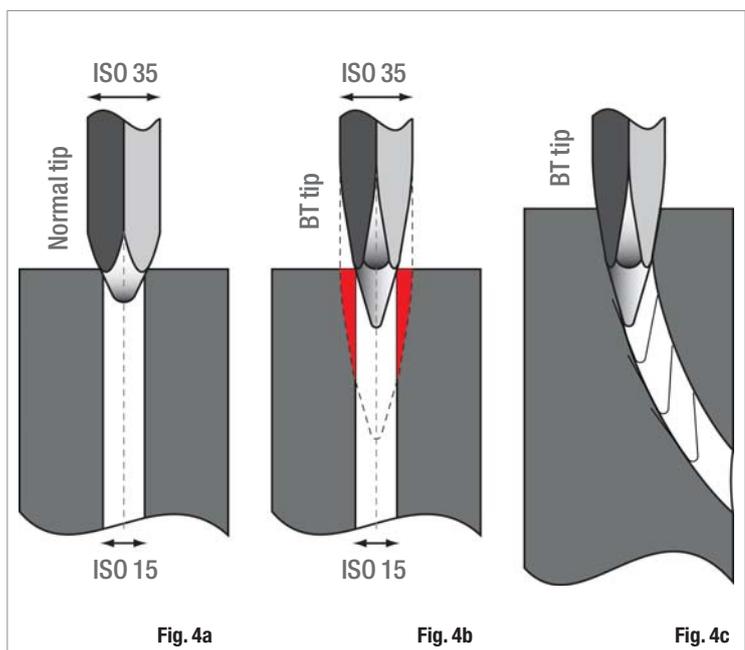
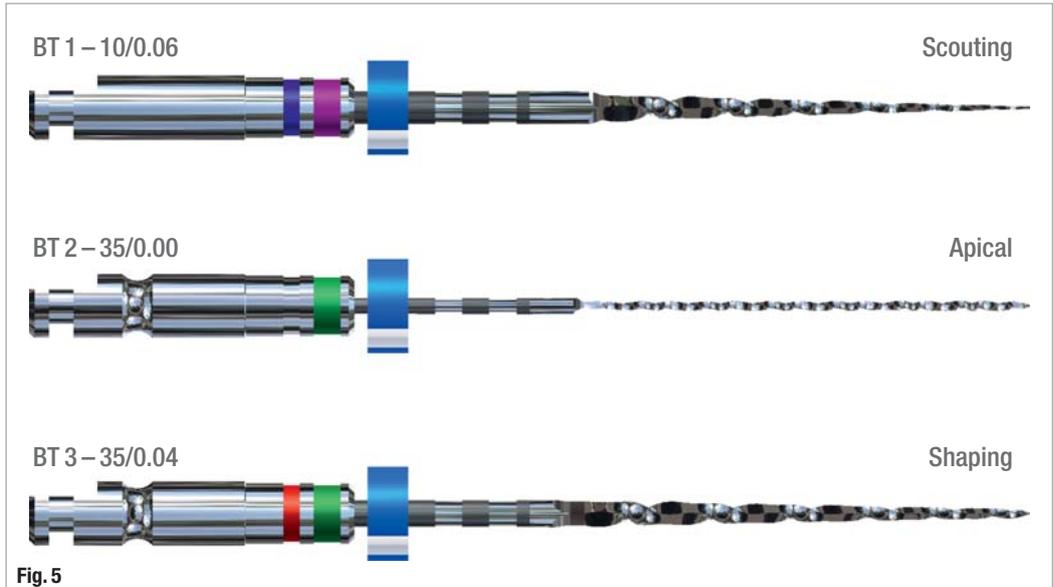


Fig. 4a

Fig. 4b

Fig. 4c

Fig. 5\_BT-Race sequence.



The BT allows a file of any diameter to follow the shape of a canal that has been prepared with a #15 glide path stainless-steel file. However, the sequence of three files (Fig. 5) is designed to relieve undue stress on the root and files, while instrumenting the canal to the correct biological sizes.

cyclic fatigue is also reduced. Thus, by using a high speed and limiting file use to one patient, we can limit the risk of file breakage.

**Essential aspects for the successful application of the BT-Race sequence**

**BT-Race sequence**

*1. Glide path*

*BT1 (a 10.06 file)*

In order to guarantee minimal file breakage, a 15.02 glide path is essential. Hand files can usually achieve this aim. However, if a #6 or #10 file is extremely difficult to take to working length, then ScoutRace files allow one to achieve a glide path more quickly.

This file establishes the final glide path and determines the coronal diameter. In any canal in which a 15.02 glide path has been achieved, the file will contact mainly the coronal third of the canal. At 12 mm from the working length, the diameter will be 0.82 mm. These files have no BT, since the tip diameter is already 0.10 mm and smaller than the glide path established with a 15.02 K-file.

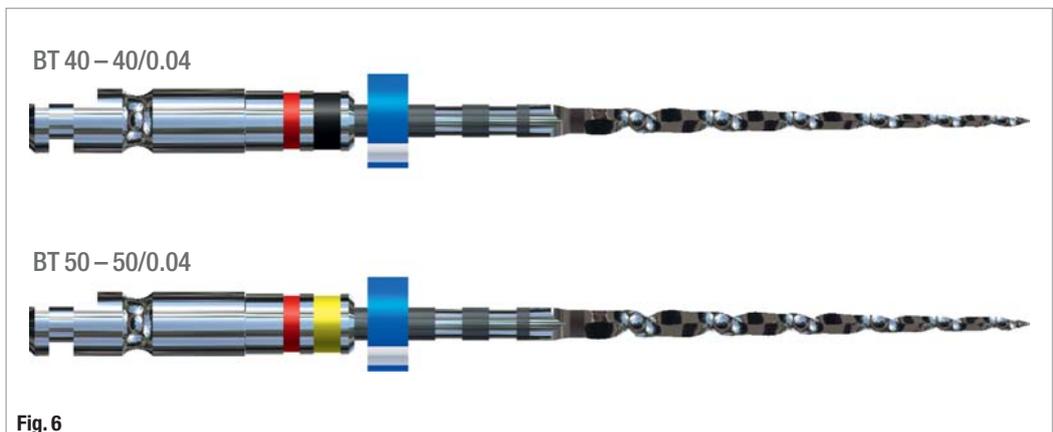
*2. Speed of 800-1,000 rpm*

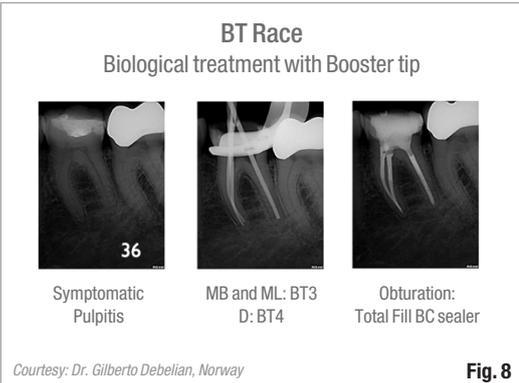
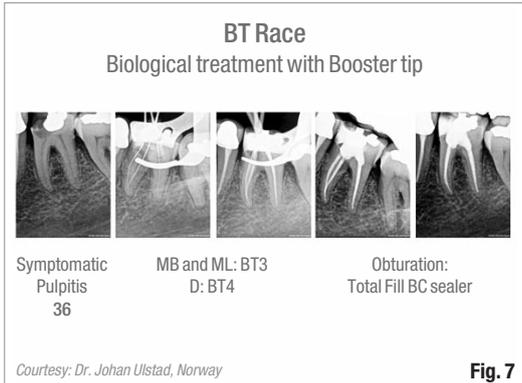
*BT2 (a parallel #35 file with a BT)*

A high speed reduces the risk of breakage due to torsional fatigue. Since these files are for use with individual patients only, the risk of breakage due to

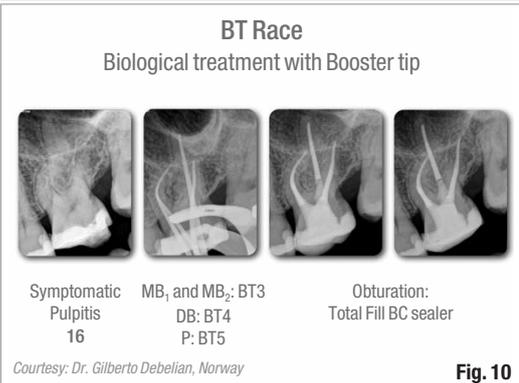
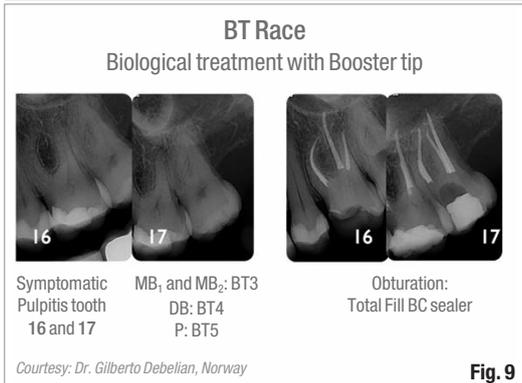
The BT2 file is used to prepare the apical third of the canal. The file is extremely flexible owing to its non-tapered design, yet penetrates into the narrow canal easily and efficiently owing to the BT.

Fig. 6\_BT-Race XL for finishes at sizes 40 and 50.





**Figs. 7–10** Example cases. Note that these cases fulfil the objective of biological apical sizes with conservative removal of coronal dentine. Thus, they have a high probability of endodontic success and survivability.



**BT3 (a 35.04 file with a BT)**

This file is used to join the coronal and apical thirds prepared with the BT1 and BT2 files, thus creating a 35.04 final shape that allows maximal irrigation and a tight cone fit. The file is able to go to working length with minimal stress, since the coronal third has been cleared with the BT1 file and the apical third with the BT2 file.

Importantly, the maximum diameter at the 12 mm level in the canal is 0.83 mm. Thus, the removal of coronal dentine is minimal, allowing for the strongest root possible after restoration.

*BT-Race XL: BT 40 (a 40.04 file) and BT 50 (a 50.04 file), 600–800 rpm*

These two instruments (Fig. 6) enable finishes at ISO #40 and 50 when larger adequate apical sizes are required. If apical preparations even larger than size 50 are required, the Race range of instruments is recommended in the required sizes, preferably with a small taper of 0.02.

**Conclusion**

With this unique file system, all canals can be conservatively instrumented to the correct biological sizes, while maintaining maximum cervical tooth structure. The BT ensures that the original canal shape is maintained, thus keeping even the larger files cen-

tered in the canal. With this centring, in addition to the minimal taper required to achieve these biological sizes, the canal is maximally cleaned without weakening or stressing the root.

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

**\_about the authors**

**roots**



**Dr Gilberto Debelian (Oslo, Norway)**

Dr Debelian received his DMD degree from the University of São Paulo, Brazil, in 1987. He completed his specialisation in Endodontics at the University of Pennsylvania, Philadelphia, USA, in 1991. He completed his PhD studies at the University of Oslo in 1997. He is an adjunct visiting professor in the postgraduate programmes in Endodontics at the University of North Carolina at Chapel Hill and the University of Pennsylvania. Dr Debelian maintains a private specialist endodontics practice in Bekkestua, Norway.



**Dr Martin Trope (Philadelphia, USA)**

Dr Trope received his BDS degree in dentistry from University in Johannesburg, South Africa, in 1976. In 1980 he moved to Philadelphia to specialize in Endodontics at the University of Pennsylvania. After graduating as an Endodontist he continued at the University of Pennsylvania as a faculty member until 1989 when he became Chair of Endodontology at Temple University, School of Dentistry. Dr Trope is now Clinical Professor, Department of Endodontics, School of Dental Medicine, University of Pennsylvania. He is also in private practice in Philadelphia, USA.

# Managing coronal destruction

## A clinical case demonstrating the pre-endodontic reconstruction of a tooth

Author \_ Dr Andreas Schult, Germany

\_For many years, post systems have been an important component of post-endodontic core build-ups. Post crowns or posts and cores used to be manufactured in a dental laboratory with the primary goals of repairing the restoration on significantly destroyed teeth and stabilising the tooth structure. With the development of adhesive systems, mechanical anchoring of the denture to the remaining tooth structure became increasingly less important, to such an extent that clinicians now debate whether a post is even needed.

Whether a tooth requires stabilisation must be critically questioned as well, particularly in view of the risk of fracture and its causes. In this regard, root fractures, vertical root fractures and crown fractures have to be assessed differently. The risk of a fracture of the crown increases with the size and depth of the cavity being prepared in the tooth (Fig. 1).

A tooth with a mesial-occlusal-distal cavity (MOD) and an endodontic trepanation has a much higher risk of fracture than an undamaged tooth does.<sup>1</sup> The

Fig. 1\_Various preparations in a maxillary molar.

Fig. 2\_A restoration covering the cusps with complete replacement of the occlusal surface.

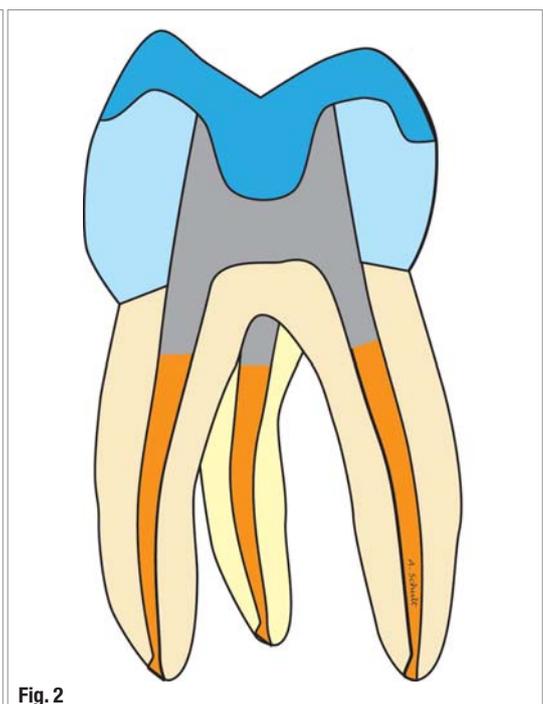
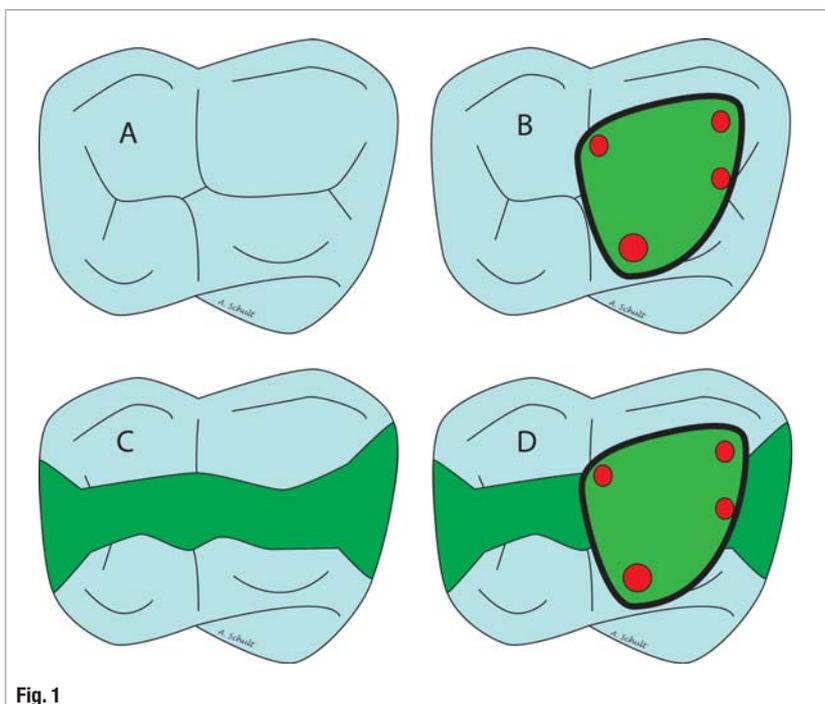
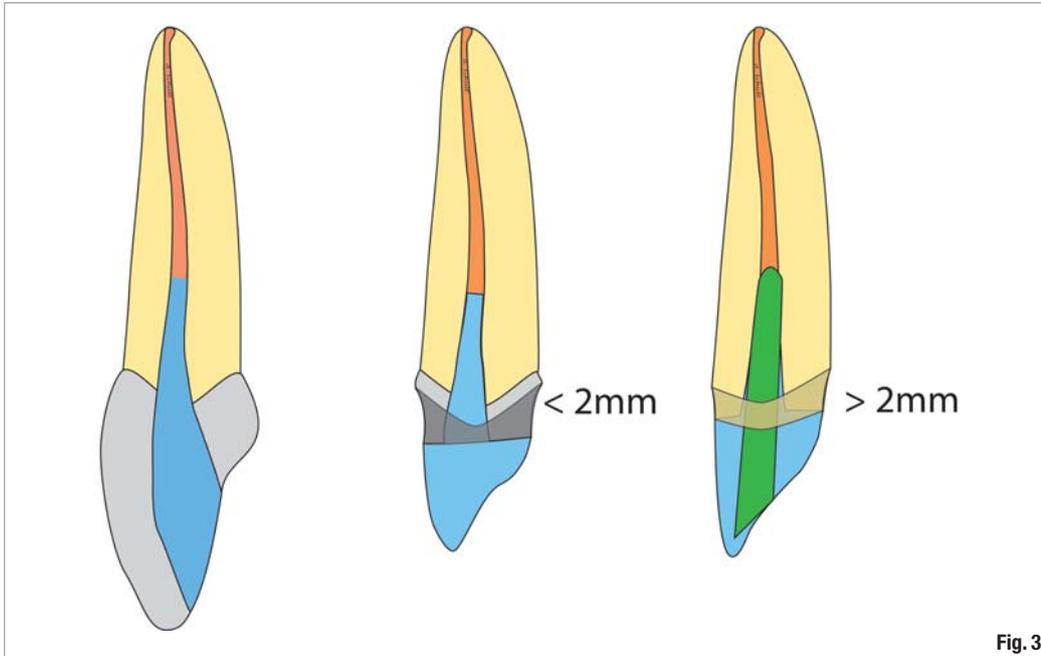


Fig. 1

Fig. 2



**Fig. 3** Various degrees of destruction of a root-filled anterior tooth.

risk of a cuspal fracture can be significantly reduced through a preparation covering the cusps for endodontically treated teeth with an MOD cavity (Fig. 2).<sup>2,3</sup>

Vertical root fractures differ from fractures in the area of the crown. Lost endodontically treated teeth owing to a vertical fracture are often treated with a post. The difference in the elastic modulus between the hard tooth structure and post material has been suggested as a cause of a vertical fracture. It can thus be concluded that post treatment and root canal treatment are the primary reasons for a vertical fracture.<sup>4</sup>

Preparation that preserves hard tooth substance is considered to be a superior solution for preventing fractures. In addition, the fracture resistance in the coronal area is stabilised through adhesive build-up materials and restorations that cover the cusps. The post and the dentine should have a similar elastic modulus in order to reduce the risk of a vertical root fracture. The decision whether to use a post in the case of an endodontic build-up critically depends on the degree of destruction of the tooth: the more hard tooth tissue present, the less the need for a post.

The diagram in Figure 3 shows three different degrees of destruction of an anterior tooth. In the case of a coronally intact but root-filled anterior root, an adhesive restoration is sufficient. When treating teeth with damage to the hard tissue and for which a crown is planned, the remaining core height and width to be enclosed by the crown play a decisive role (ferrule effect). If the ferrule is more than 2 mm wide, a build-up secured with an adhesive is sufficient. If it is narrower than 2 mm, the use of a glass fibre post is indicated.

### Clinical case

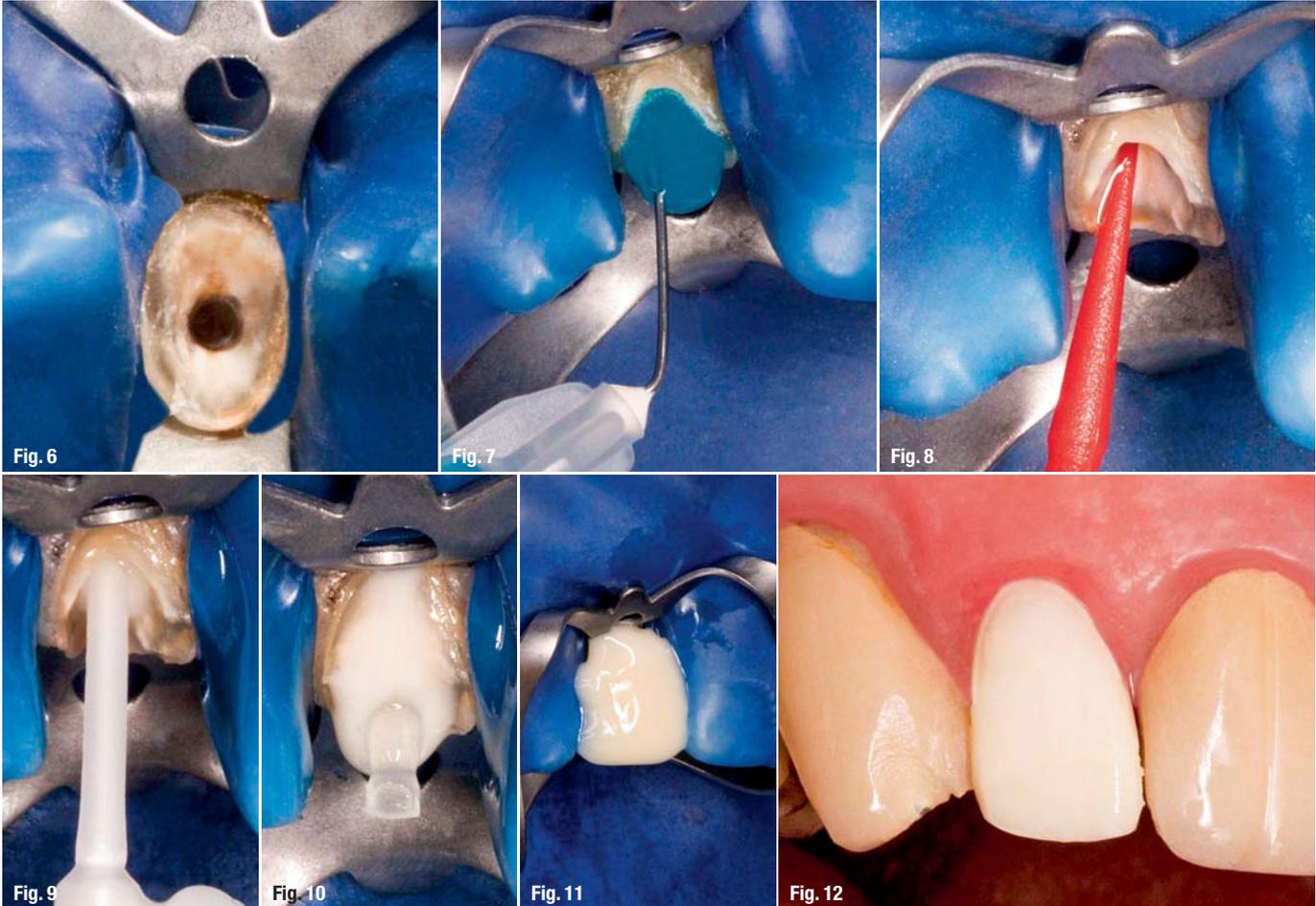
A busy sales representative came to our practice with tooth 12 broken. Owing to time constraints, we only had one hour available for the reconstruction of the crown. The fracture line ran circumferentially at the level of the gingiva (Fig. 4). A root canal treatment had been performed on this tooth by another dentist three months before.

Initially, the patient requested preservation of the tooth but, after discussion, he said that he was not able to invest time in undergoing systematic tooth treatment. The clinical findings showed a retained root. The degree of tooth mobility was Grade 0–I and the probing depth was 1–2 mm around the tooth. X-ray images showed a root filling up to approximately

**Fig. 4** Clinical baseline findings: tooth 12 showed a coronal fracture circumferentially at the level of the gingiva.

**Fig. 5** Radiological baseline findings: intra-radicular radiopacity and apical radiolucency.





**Fig. 6** Isolation of the working field with a rubber dam and preparation of the post bed.  
**Fig. 7** Conditioning of the cavity with 35% phosphoric acid.  
**Fig. 8** Working in the freshly mixed adhesive for 20 seconds.  
**Fig. 9** Filling the post cavity with LuxaCore Z-Dual.  
**Fig. 10** Insertion of the selected root post, which was previously covered with LuxaCore Z-Dual.  
**Fig. 11** Incremental build-up of the crown.  
**Fig. 12** Finished build-up of tooth 12 after contouring and polishing.

3 mm before the radiological apex, as well as apical radiolucency (Fig. 5).

We diagnosed chronic apical periodontitis in tooth 12. The apical radiolucency should be subsequently observed and, if necessary, root canal treatment should be revised prior to placing a crown.

Being able to position a rubber dam clamp is a basic prerequisite for endodontic treatment and for pre-endodontic reconstruction. If a clamp cannot be positioned, surgical crown lengthening is indicated, if applicable (Fig. 6). The retained root was cleared of remaining tissue, caries and plaque. Then the optimal post diameter was determined using a stencil. A size of 1.5 mm was selected.

Since there was only a small amount of remaining tooth substance, the post cavity was prepared to a depth of 6 mm and thoroughly rinsed. The canal and remaining exposed dentine were conditioned with 35% phosphoric acid for 15 seconds and then rinsed with a multifunctional syringe for 15 seconds (Fig. 7).

Excess fluid was suctioned off with a micro-suction device. The pre-bond was applied using an application tip and worked into the surface for 15 seconds.

The micro-suction device was again utilised to remove any excess.

In order to prepare the bonding material, Bond A and B were mixed in equal portions for 5 seconds and massaged into the dentine surface for 20 seconds (Fig. 8). Then they were blown to a thin layer and light cured for 10 seconds. The tooth was built up with the dual-curing core build-up material LuxaCore Z-Dual (DMG Dental; Fig. 9) and the post cavity was filled with LuxaCore Z-Dual. The LuxaPost post (DMG Dental) was positioned and the material was light activated (Fig. 10).

The crown was built up in small increments, activated, and contoured and polished with diamond grinding tools (Figs. 11 & 12).

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

_contact	roots
<p><b>Dr Andreas Schult</b> is a dentist in a joint practice in Bad Bramstedt in Germany. He can be contacted at <a href="mailto:zahnpflegepraxis@t-online.de">zahnpflegepraxis@t-online.de</a></p>	

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# Root canal therapy setting your teeth on edge?

Author\_ Dr Peter Southerden, UK



Figs. 1a & b\_A radiograph showing the root canal.

Every endodontic treatment is different. However, if you as a dentist have only half an hour before risking your life, if your patient weighs about 22 stone (139.71 kg) and if his canines are 14 cm long, you are literally in the lion's den.

Root canals come in all shapes and sizes. There are multiple canals, hidden accessory canals or even horizontal branches. And sometimes root canals are just unusually long. In the case of my most prominent patient so far, the root canal was 9 cm long to be precise. It was a fine male specimen of *Panthera leo persica*, an Asiatic lion. When I received a call from Bristol Zoo to say that they had an adult lion with an apparent tooth problem, I was rather intrigued to say the least.

It turned out that the patient was a 17-year-old Asiatic lion named Kamal. The zoo's veterinary surgeon informed me that the animal was suffering from a fractured canine tooth and was unable to chew on bones. After our first conversation, we needed to come up with a special treatment plan. Leaving the infected tooth untreated would have meant a painful

deterioration in his condition, which would ultimately lead to an infection in his mandible, making life even more difficult for the poor animal.

As a veterinary dentist, I have worked on thousands of cats and dogs during my 28 years in practice. In terms of anatomy, the canine was very similar to that of my regular patients; it was just scaled up in proportion. Radiographic examination (Figs. 1a & b) showed evidence of an infection around the root apex. Root canal therapy was indicated. Before our patient was ready to undergo surgery, we had to order extra-long endodontic files from the US that would fit into a 9 cm-long root canal. The only files fit for the purpose are so-called "Tiger Files". These Hedstrom files are 12 cm long.

## Operating in less than 2 hours

One of the challenges we faced was the time constraints we would be working under; the whole procedure had to be done as efficiently as possible.

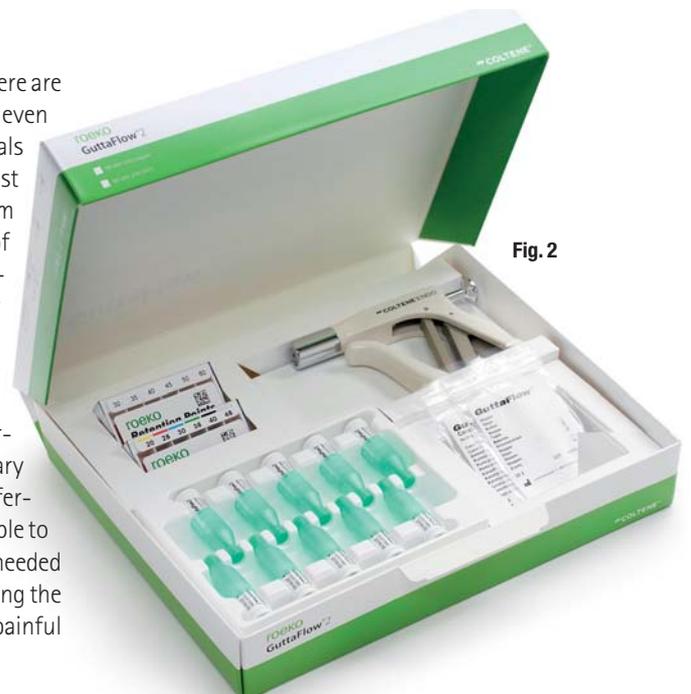


Fig. 2

Fig. 2\_GuttaFlow 2 set.

Owing to his age and the fact that the lion was anaesthetised in field conditions (not in a hospital), we did not want the lion to be anaesthetised for too long. We thus had to come prepared. In advance, my team and I had to obtain the correct equipment for such a special treatment. The Swiss dental specialist Coltène/Whaledent provided us with a fast-flowing filling system (GuttaFlow 2), which helped us tremendously in keeping down the treatment time. In this case, we definitely had to reduce "chair time", if you know what I mean.

The operation was performed on-site at Bristol Zoo. After the lion was anaesthetised and placed on the operating table, we had to perform the treatment quickly. Dispensing with a dental dam owing to the special circumstances, I started to clean and shape the canal with the Hedstrom files. Their effectiveness in terms of swift dentine removal was a great benefit to us. Irrigating the canal did not prove to be easy either. The main cleaning agent was a sodium hypochlorite solution with a concentration of 5%. A feline urinary catheter was used for flushing.

After all necrotic pulp tissue and dentine shavings had been successfully removed, the canal had to be obturated with a reliable permanent filling. It goes without saying that the average masticatory force in lions is considerably larger than it is in human beings. We placed a single master gutta-percha point with the help of a plugger. The master point was 60mm long and covered with GuttaFlow 2. This new filling system combines cold free-flow gutta-percha and a sealer to create a fast-flowing filling material that is easy to handle and provides a reliable barrier against bacteria and liquids re-entering the root canal. Its working time is approximately 10–15 minutes. After placing the gutta-percha in the canal from the syringe, it was carried into the canal using the Hedstrom files. Even in these unusual working conditions, handling was easy and the application of the material really straightforward. The short working and curing times helped us to establish a safe seal for the canal within minutes. After the successful obturation of the canal, the final restoration was created with a layer of glass ionomer and a normal nano-hybrid composite. It took us less than 2 hours to complete the whole procedure.

## Conclusion

The needs of a very large feline patient are not that different to those of a human patient. The key to a successful endodontic treatment is the effective and complete removal of any infected tissue, as well as quick and safe obturation of the canal. New, innovative filling systems have excellent flow properties.



Fig. 3



Fig. 4

They are easy to handle and help to speed up treatment sessions. Two-in-one products, moreover, combine sealer and gutta-percha in powder form to guarantee a tight seal of the root canal for optimum protection against reinfection. And reduced chair time is a big bonus to the dentist, whether treating children, patients with dental fear, or lions.

**Fig. 3** \_ Filling the root canal with GuttaFlow 2.

**Fig. 4** \_ Radiographic control.

## \_about the author

roots



### Dr Peter Southerden

is a recognised European Veterinary Dental Specialist. He is the founder of the Eastcott Veterinary Clinic and Hospital in Swindon in South West England, where he sees referred dentistry, and oral and maxillofacial surgery cases.

He is a regular presenter at both UK and international veterinary conferences.

# Diclofenac, dexamethasone or laser phototherapy?

## Part I

Author\_Jan Tunér, Sweden

[PICTURE: ©ROBERT KNESCHKE]

### Introduction

In the May 2013 edition of *Photomedicine and Laser Surgery*, the editorial written by Prof. Tina Karu is titled "Is it time to consider photobiomodulation as a drug equivalent?" Well, is it? Let us have a look and see what the literature has to say about two very popular drugs:

NSAIDs (non-steroidal anti-inflammatory drugs) are the best sold pharmaceuticals ever. The short-term effects on pain and inflammation are obvious and valuable. The long-term effects, however, have been questioned and this is especially valid considering the many side effects of NSAIDs. Millions of patients are on long-term medication with NSAIDs, and even lifelong. Indeed, many persons die from their medication. So an alternative option is required. I believe it is already available: laser phototherapy! First, let us have a look at the strength of the scientific evidence for NSAIDs as such, and long term use of these in particular:

The meta-analysis by Bjordal<sup>1</sup> on the effect of NSAIDs on knee osteoarthritis pain appears to become important for the recognition and future development of LPT. Let us read the abstract: The research group summarises that non-steroidal anti-inflam-

matory drugs (NSAIDs), including cyclo-oxygenase-2 inhibitors (coxibs), reduce short-term pain associated with knee osteoarthritis only slightly better than placebo, and long-term use of these agents should be avoided. Up for analysis were 23 placebo-controlled trials involving 10,845 patients, 7,767 of whom received NSAID therapy and 3,078 placebo therapy. All in all 21 of the NSAID-studies were funded by the pharmaceutical industry, and the results of 13 of these studies were inflated by patient selection bias as previous NSAID-users were excluded if they had not previously responded favourably to NSAID. Such an exclusion criterion for non-responders has never been seen in any controlled trial of LPT or other non-pharmacological therapies of osteoarthritis. In the remaining ten unbiased NSAID-trials, the difference from placebo was only 5.9 mm on a 100 mm pain scale.

This is far less than established data on differences that are considered minimally perceptible (9 mm) or clinically relevant (12 mm) for knee osteoarthritis patients. In addition, none of the trials found any effects beyond 13 weeks. This bleak support for long term use of NSAIDs is an excellent support for non-pharmaceutical methods, such as LPT. Diclofenac is one of the best-selling NSAIDs. Several investigators have compared the effect of LPT and diclofenac.



Ramos<sup>3</sup> investigated the effects of LPT (810 nm) in rat-induced skeletal muscle strain. Male rats were anaesthetised with halothane prior to the induction of muscle strain. Previous studies have determined that a force equal to 130% of the body weight corresponds to approximately 80% of the ultimate rupture force of the muscle tendon unit. In all animals, the right leg received a controlled strain injury while the left leg served as control. A small weight corresponding to 150% of the total body weight was attached to the right leg in an appropriate apparatus and left to induce muscle strain twice for 20 minutes with three-minute intervals. Walking index, C-reactive protein, creatine kinase, vascular extravasation and histological analysis of the tibial muscle were performed after six, twelve and 24 hours of lesion induction. LPT in an energy-dependent manner markedly or even completely reduced the Walking Index, leading to a better quality of movement. C-reactive protein production

[PICTURE: ©INESBAZDAR]



The aim of a study by Marcos<sup>2</sup> was to evaluate the short-term effects of LPT or sodium diclofenac treatments on biochemical markers and biomechanical properties of inflamed Achilles tendons. Wistar rats Achilles tendons (n = 6/group) were injected with saline (control) or collagenase at peritendinous area of Achilles tendons. After one hour animals were treated with two different doses of LPT (810 nm, 1 and 3 J) at the sites of the injections, or with intramuscular sodium diclofenac. Regarding biochemical analyses, LPT significantly decreased COX-2, TNF-alpha, MMP-3, MMP-9, and MMP-13 gene expression, as well as PGE2 production when compared to collagenase group. Interestingly, diclofenac treatment only decreased PGE2 levels. Biomechanical properties were preserved in the laser-treated groups when compared to collagenase and diclofenac groups.

was completely inhibited by laser treatment, even more than observed with Sodium diclofenac inhibition (positive control). Creative Kinase activity was also significantly reduced by laser irradiations. In conclusion, LPT operating in 810 nm markedly reduced inflammation and muscle damage after experimental muscle strain, leading to a highly significant enhancement of walking activity.

The aim of the study by de Almeida<sup>4</sup> was to analyse the effects of sodium diclofenac (topical application), cryotherapy, and LPT on pro-inflammatory cytokine levels after a controlled model of muscle injury. For such, we performed a single trauma in the tibialis anterior muscle of rats. After one hour, animals were treated with sodium diclofenac (11.6 mg/g of solution), cryotherapy (20 min), or LPT (904 nm; superpulsed; 700 Hz; 60 mW mean output power;



[PICTURE: ©RACORN]

1.67 W/cm<sup>2</sup>; 1, 3, 6 or 9 J; 17, 50, 100 or 150 s). Assessment of interleukin-1 and interleukin-6 (IL-1 and IL-6) and tumour necrosis factor- $\alpha$  levels was performed at six hours after trauma employing enzyme-linked immunosorbent assay method. LPT with 1 J dose significantly decreased IL-1, IL-6, and TNF- $\alpha$  levels compared to non-treated injured group as well as diclofenac and cryotherapy groups. On the other hand, treatment with diclofenac and cryotherapy does not decrease pro-inflammatory cytokine levels compared to the non-treated injured group. Therefore, the authors conclude that 904 nm LPT with 1 J dose has better effects than topical application of diclofenac or cryotherapy in acute inflammatory phase after muscle trauma.

The purpose of a study by Albertini<sup>5</sup> was to investigate the effect of LPT on the acute inflammatory process. Male rats were used. Paw oedema was induced by a sub-plantar injection of carrageenan, the paw volume was measured before and one, two, three and four hours after the injection, using a hydroplethysmometer. To investigate the action mechanism of the GaAlAs laser on inflammatory oedema, parallel studies were performed using adrenalectomised rats or rats treated with sodium diclofenac. Different laser irradiation protocols were employed for specific energy densities (EDs), exposure times and repetition rates. The rats were irradiated with laser for 80 s each hour. The EDs that produced an anti-inflammatory effect were 1 and 2.5 J/cm<sup>2</sup>, reducing the oedema by 27% and 45.4%, respectively. The ED of 2.5 J/cm<sup>2</sup> produced anti-inflammatory effects similar to those produced by the cyclooxygenase inhibitor sodium diclofenac at a dose of 1 mg/kg. In adrenalectomised animals, the laser irradiation failed to inhibit the oedema. These results suggest that LPT possibly exerts its anti-inflammatory effects by stimulating the release of adrenal corticosteroid hormones.

The aim of a work by Meneguzzo<sup>6</sup> was to investigate the effects of infrared 810 nm on the acute inflammatory process by the irradiation of lymph nodes, using the classical model of carrageenan-induced rat paw oedema. Thirty mice were randomly divided into five groups. The inflammatory induction was performed in all groups by a sub-plantar injection of carrageenan (1 mg/paw). The paw volume was measured before and 1, 2, 3, 4 and 6 hours after the injection using a plethysmometer. Myeloperoxidase (MPO) activity was analysed as a specific marker of neutrophil accumulation at the inflammatory site. The control group did not receive any treatment (GC); GD group received sodium diclofenac (1mg/kg) 30 minutes before the carrageenan injection; GP group received laser irradiation directly on the paw (1 Joule, 100 mW, 10 sec) one and two hours after the carrageenan injection; GLY group received laser irradiation (1 Joule, 100 mW, 10 sec) on the inguinal lymph nodes; GP+LY group received laser irradiation on both paw and lymph nodes one and two hours after the carrageenan injection. MPO activity was similar in the sodium diclofenac as well as in the GP and GLY groups, but significantly lower than the GC and GP + LY groups. Paw oedema was significantly inhibited in GP and GD groups when compared to the other groups. Interestingly, the GP+LY groups presented the biggest oedema, even bigger than in the control group. LPT showed an anti-inflammatory effect when the irradiation was performed on the site of lesion or at the correlated lymph nodes, but showed a pro-inflammatory effect when both paw and lymph nodes were irradiated during the acute inflammatory process.

The aim of a study by Barretto<sup>23</sup> was to investigate the analgesic and anti-inflammatory activity of LPT on the nociceptive behavioural as well as histomorphological aspects induced by injection of formalin and carrageenan into the rat temporomandibular joint. The 2.5% formalin injection (FRG group) induced behavioural responses characterized by rubbing the orofacial region and flinching the head quickly, which were quantified for 45 min. The pretreatment with systemic administration of diclofenac sodium-DFN group (10 mg/kg i.p.) or irradiation with infrared LPT (LST group, 780 nm, 70 mW, 30s, 2.1 J, 52.5 J/cm<sup>2</sup>), significantly reduced the formalin-induced nociceptive responses. The 1% carrageenan injection (CRG group) induced inflammatory responses over the time-course of the study (24 h, three and seven days) characterised by the presence of intense inflammatory infiltrate rich in neutrophils, scanty areas of liquefactive necrosis and intense interstitial oedema, extensive haemorrhagic areas, and enlargement of the joint space on the region. The DFN and LST groups showed an intensity of inflammatory response that was significantly lower than in CRG group over the time-course of the study, especially in

the LST group, which showed exuberant granulation tissue with intense vascularization, and deposition of newly formed collagen fibres (three and seven days).

The aim of a study by de Almeida<sup>7</sup> was to analyse the effects of sodium diclofenac (topical application) and LPT on morphological aspects and gene expression of biochemical inflammatory markers. The researchers performed a single trauma in the tibialis anterior muscle of rats. After one hour, animals were treated with sodium diclofenac (11.6 mg/g of solution) or LPT (810 nm; continuous mode; 100 mW; 1, 3 or 9 J; 10, 30 or 90 s). Histological analysis and quantification of gene expression (real-time polymerase chain reaction-RT-PCR) of cyclooxygenase 1 and 2 (COX-1 and COX-2) and tumour necrosis factor- $\alpha$  (TNF- $\alpha$ ) were performed at six, twelve and 24 h after trauma. LPT with all doses improved morphological aspects of muscle tissue, showing better results than injury and diclofenac groups. All LPT doses also decreased COX-2 compared to injury group and to diclofenac group at 24 h after trauma. In addition, LPT decreased TNF- $\alpha$  compared both to injury and diclofenac groups. LPT mainly with dose of 9 J is better than topical application of diclofenac in acute inflammation after muscle trauma.

Yet another study by Marcos<sup>8</sup> investigated if a safer treatment such as LPT could reduce tendinitis inflammation, and whether a possible pathway could be through inhibition of either of the two-cyclooxygenase (COX) isoforms in inflammation. Wistar rats (six animals per group) were injected with saline (control) or collagenase in their Achilles tendons. Then they were treated with three different doses of IR LPT (810 nm; 100 mW; 10 s, 30 s and 60 s; 3.57 W/cm<sup>2</sup>; 1 J, 3 J, 6 J) at the sites of the injections, or intramuscular diclofenac, a nonselective COX inhibitor/NSAID. It was found that LPT dose of 3 J significantly reduced inflammation through less COX-2-derived gene expression and PGE<sub>2</sub> production, and less oedema formation compared to non-irradiated controls. Diclofenac controls exhibited significantly lower PGE<sub>2</sub> cytokine levels at 6 h than collagenase control, but COX isoform 1-derived gene expression and cytokine PGE<sub>2</sub> levels were not affected by treatments. As LPT seems to act on inflammation through a selective inhibition of the COX-2 isoform in collagenase-induced tendinitis, LPT may have the potential to become a new and safer non-drug alternative to coxibs.

The aim of the study by de Paiva Carvalho<sup>9</sup> was to evaluate the effect of single and combined therapies (LPT, topical application of diclofenac and intramuscular diclofenac) on functional and biochemical aspects in an experimental model of controlled muscle strain in rats. Muscle strain was induced by overloading tibialis anterior muscle of rats. Injured groups re-

ceived either no treatment, or a single treatment with topical or intramuscular diclofenac (TD and ID), or LPT (3 J, 810 nm, 100 mW) 1 h after injury. Walking track analysis was the functional outcome and biochemical analyses included mRNA expression of COX-1 and COX-2 and blood levels of prostaglandin E<sub>2</sub> (PGE<sub>2</sub>). All treatments significantly decreased COX-1 and COX-2 gene expression compared to the injury group. However, LPT showed better effects than TD and ID regarding PGE<sub>2</sub> levels and walking track analysis. The author concludes that LPT has more efficacy than topical and intramuscular diclofenac in treatment of muscle strain injury in acute stage.

Crystalopathies are inflammatory pathologies caused by cellular reactions to the deposition of crystals in the joints. The anti-inflammatory effect of He-Ne laser and that of the non-steroidal anti-inflammatory drugs (NSAIDs) diclofenac, meloxicam, celecoxib, and rofecoxib was studied in acute and chronic arthritis produced by hydroxyapatite and calcium pyrophosphate in rats. The presence of the markers fibrinogen, L-citrulline, nitric oxide, and nitrotyrosine was determined. In the study by Rubio<sup>10</sup>, crystals were injected into the posterior limb joints of the rats. A dose of 8 J/cm<sup>2</sup> of energy from a He-Ne laser was applied for three days in some groups and for five days in other groups. The levels of some of the biomarkers were determined by spectrophotometry, and that of nitrotyrosine was determined by ELISA. In arthritic rats, the fibrinogen, L-citrulline, nitric oxide, and nitrotyrosine levels increased in comparison to controls and to the laser-treated arthritic groups. When comparing fibrinogen from arthritic rats with disease induced by hydroxyapatite to healthy and arthritic rats treated with NSAIDs, the He-Ne laser decreased levels to values similar to those seen in controls. Inflammatory and oxidative stress markers in experimental crystallopathy are positively modified by photobiosimulation.

*Editorial note: To be continued with further studies on the effectiveness of diclofenac and LPT and conclusion in roots 3/2014. An list of references is available from the author.*

## \_contact

roots

**Jan Tunér**

Spjutvagen 11  
772 32 Grängesberg  
Sweden

jan.tuner@swipnet.se

# SIROLaser Factbook: Comprehensive information on diode lasers

Sirona reports on the wide range of applications of diode lasers in a special edition of the English-language "Laser – International Magazine of Laser Dentistry." The "SIROLaser Factbook—Clinical articles about SIROLaser Advance and Xtend applications" includes research by well-known experts as well as informative field reports from experienced users of laser technology.

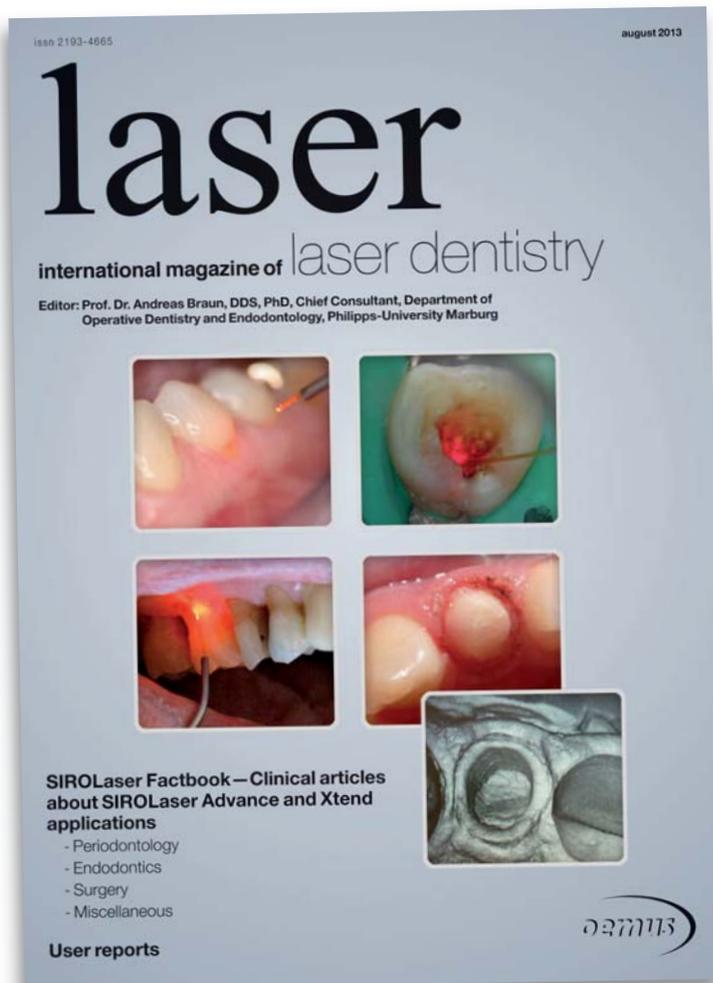
Fig. 1 Compact information on lasers: SIROLaser Factbook.

Compact and informative: Sixty pages full of solid expertise and practical applications await the readers of English texts collected by Sirona in "SIROLaser Factbook—Clinical articles about SIROLaser Advance and Xtend applications." Academic articles and real-life user reports by well-known experts provide information on the many uses and treatment options of diode lasers with a wavelength of 970 nm. Interesting facts and figures, study results, documented case studies with descriptive pictures, and recommendations for further reading complete the compendium.

"Anyone with an interest in laser dentistry should read the SIROLaser Factbook," says Ingo Höver, product manager at Sirona. The book is especially meant for beginners, says the laser specialist. "However, experienced users will also find it worth reading. I am sure that they will be surprised to learn the many possibilities of diode lasers and the range of applications that are open to them with models like the SIROLaser Advance or SIROLaser Xtend."

## Routine and less common aspects of dental treatment

The 970 nm diode laser discussed in the SIROLaser Factbook covers a variety of dental indications, says co-publisher and co-author Prof. Andreas Braun from the Center for Dental and Oral Medicine of the University of Marburg. These include incision/excision associated with gingivectomy, gingivoplasty, implant exposure, and removal of abnormal tissue and reducing bacteria as a supporting measure in periodontal, peri-implant or endodontic procedures as well as adjunctive therapy in the treatment of aphthous ulcers. "The selected articles cover both routine and less common aspects of dental treatment with a particular focus on new treatment strategies combined with conventional techniques," says Prof. Braun.





"There are few instruments that symbolize modernity and innovation in dentistry more than the laser," says Prof. Roland Frankenberger. Laser applications in dentistry are now scientifically established. The President of the German Society for Restorative Dentistry (DGZ) writes in his foreword, "I am especially pleased that a variety of interesting aspects of routine work are examined and laser treatment is conveyed objectively, but with enthusiasm." Prof. Braun hopes, "Perhaps new recommendations for day-to-day practice will result from the treatment procedures described."

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quality, and top design. The SIROLaser Advance and SIROLaser Xtend ensure relaxed dentists and relaxed patients. More information for dentists and the compendium "SIROLaser Factbook – Clinical articles about SIROLaser Advance and Xtend applications" are available for download at [www.sirona.de](http://www.sirona.de).

**Fig. 2** SIROLaser Advance and Xtend – two models for safe, precise, pain-free treatment.

**\_contact**

**roots**

**Sirona Dental GmbH**

Sirona Straße 1  
5071 Wals bei Salzburg  
Austria

[www.sirona.com](http://www.sirona.com)

# Planmeca and the University of Turku found Nordic Institute of Dental Education

**Fig. 1** The objective of the new institute is to export and share Nordic expertise in digital dentistry on the basis of academic knowledge and technologies. (Photo: Planmeca)

**\_Dental technology company** Planmeca and the University of Turku have founded a joint venture company, the Nordic Institute of Dental Education. The institute will offer high-quality continuing education courses to dental professionals.

The objective is to export and share Nordic expertise in digital dentistry on the basis of the academic knowledge of the University of Turku and the technologies developed by Planmeca, as well as their global dental networks.

The courses will be held at the University of Turku and at Planmeca's headquarters in Helsinki from autumn 2014. The course topics cover rapidly evolving dental technologies and their application in modern dentistry, including 3-D imaging, prosthodontics, endodontics, biomaterials science, orthodontics and CAD/CAM technologies.

The University of Turku awards ECTS credits (a standard for higher education in Europe) and course certificates to the students. The joint venture company complements Planmeca's broad range of training activities and collaboration with universities around the world.

The University of Turku is an active participant in the export of education. "We have now established a partnership with one of the world's leading companies in dental technology. Together with Planmeca we are a strong education provider globally," stated Prof. Kalervo Väänänen, Rector of the University of Turku.



## **\_contact** roots

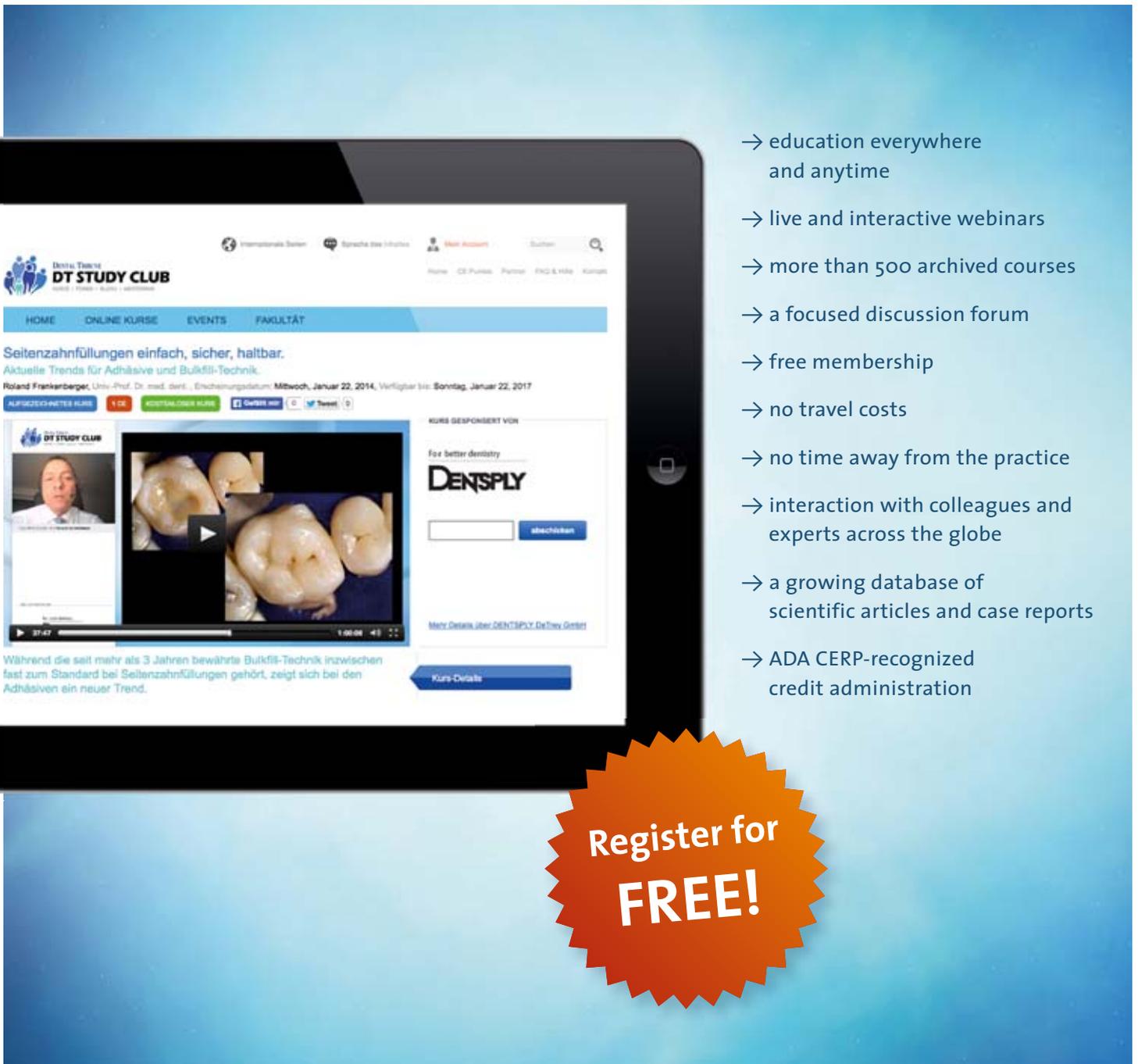
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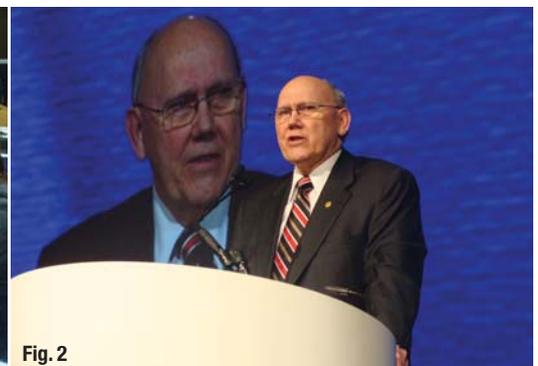
# “Striving for perfection” — AAE holds 2014 Annual Session in Washington

**Author\_** Fred Michmershuizen, DTA

**Fig. 1\_** Meeting participants work with apex locators during a hands-on workshop, „The Rationale and Use of Electronic Apex Locators,” presented by Dr L. Stephen Buchanan.



**Fig. 1**



**Fig. 2**

**Fig. 2\_** AAE President Gary Hartwell welcomes meeting attendees to the 2014 AAE Annual Session.

Endodontists from around the world and across the country gathered at the Gaylord National resort just outside Washington, D.C., for the 2014 AAE Annual Session. From lectures to hands-on workshops to formal and informal social gatherings, the meeting, held from April 30 to May 3, offered a wide range of opportunities for attendees.

photograph of the flag raising at Iwo Jima, offered an inspirational message to those in attendance: Nothing is impossible.

The exhibit hall featured products and services from several hundred companies, as well as various educational opportunities.

**Fig. 3\_** Meeting attendees try new endodontic technology available from Sonendo Inc.

James Bradley, author of the New York Times best-seller “Flags of Our Fathers,” gave the keynote address. Bradley, whose book follows the lives of the five US Marines and one US Navy Corpsman who would eventually be made famous by Joe Rosenthal’s lauded

A “Corporate Workshop and Lecture” series was presented on the show floor. Some of the highlights included “Surgical Applications of Bioceramics,” sponsored by Brasseler USA, presented by Dr Ali Nasseh; “The Rationale and Use of Electronic Apex Locators,” sponsored by J. Morita USA, presented by Dr L. Stephen Buchanan; and “Sound Science: Multisonic Ultracleaning,” sponsored by Sonendo Inc., presented by Dr. Mehrzad Khakpour.

**Fig. 4\_** Dr Manor Haas demonstrates the use of a surgical operating microscope at the Zeiss booth.

A number of companies used the meeting as an occasion to launch new products.

Sonendo unveiled its new GentleWave System utilizing patented Multisonic Ultracleaning technology that is designed to quickly, easily and safely loosen and remove pulp tissue, debris, decay and bacteria within minutes. The system is designed to clean the entire canal system, automatically and simultaneously.



**Fig. 3**



**Fig. 4**

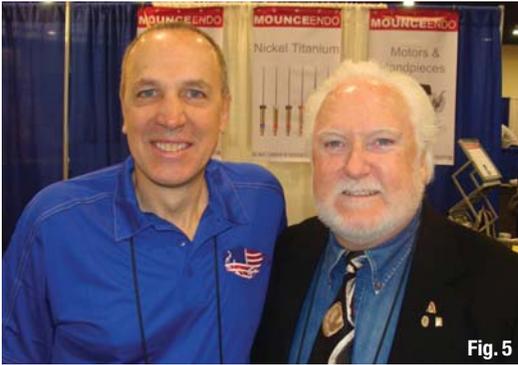


Fig. 5



Fig. 6

**Fig. 5**\_Dr Rich Mounce (left) and Dr C. John Mounce.

**Fig. 6**\_Dr Mehrzad Khakpour presents „Sound Science: Multisonic Ultracleaning,” one of several „To the Point” lectures offered on the exhibit hall floor.

Bjarne Bergheim, president and CEO of Sonendo, has been directly involved in the development of the GentleWave since its early inception. “Very soon, endodontists performing root canal therapy will have the ability to provide an ultraclean environment for their patients in a more comprehensive, efficient and predictable way,” he said. “We remain focused on creating a new standard of care for the patient as well as improving the clinical quality and business performance of doctors performing root canal therapy.”

DENTSPLY Tulsa Dental Specialties launched ProTaper Gold rotary files, featuring what it calls “the same efficient, variable tapered shapes and predictable performance that clinicians have known and trusted from ProTaper Universal, with increased flexibility.”

According to DENTSPLY Tulsa, ProTaper Gold’s proprietary advanced metallurgy creates a difference clinicians can see and feel. ProTaper Gold files have the same geometry as ProTaper Universal, but with an increase in flexibility. This is especially important in the finishing files, which must navigate challenging curves in the apical region of the canal, the company says. The files also feature a shorter, 11-mm handle for improved accessibility to teeth.

Brasseler introduced its ESX Rotary File. Designed with several performance-enhancing patented features, ESX Rotary Files are designed for a powerful yet minimally invasive performance, maximizing the long-term success of the treated tooth, the company says.

J. Morita unveiled its Root ZX II OTR Module, a new, low-speed handpiece for its popular apex locator. According to the company, the new OTR Module safely and efficiently prepares canals while simultaneously taking measurements.

Several companies exhibited at the AAE meeting for the first time. Among them: Edge Endo, whose “biker chicks” and rock ‘n’ roll-themed booth had attendees looking twice; Avalon Biomed, with its new Grey MTA bioactive root and pulp treatment material; and Rapid City, S.D.-based Mounce Endo, offering its own MounceFiles, plus a full range of supplies from Mani, Aseptico, San Diego Swiss Ultrasonics and MetaBiomed.

The 2015 AAE meeting is scheduled for May 6 to 9 in Seattle.

*Photos: Fred Michmershuizen*



Fig. 7



Fig. 8

**Fig. 7**\_James Bradley, author of the New York Times bestseller „Flags of Our Fathers,” offers the keynote address.

**Fig. 8**\_Dr Allen Ali Nasseh offers a presentation on endodontic files in the „To the Point” educational theater on the exhibit hall floor.

# International Events

## 2014

### 18<sup>th</sup> World Congress on Dental Traumatology

19–21 June 2014

Istanbul, Turkey

[www.iadt-dentaltrauma.org/2014conference/index.html](http://www.iadt-dentaltrauma.org/2014conference/index.html)

### 2014 AAE/AAP/ACP Joint Symposium

**Teeth for a life time: Interdisciplinary Evidence for Clinical Success**

19–20 July 2014

Chicago, USA

[www.perio.org/meetings/joint-symposium2014.htm](http://www.perio.org/meetings/joint-symposium2014.htm)

### Scand Endo Reykjavik 2014

21–23 August 2014

Reykjavik, Iceland

### FDI Annual World Dental Congress

17–19 June 2014

Dubai, UAE

[www.apdentalcongress.org](http://www.apdentalcongress.org)

### Italian Academy of Endodontics (AIE)

#### 22<sup>nd</sup> National Congress

2–4 October 2014

Montecatini Terme, Italy

[www.accademiaitalianaendodonzia.it](http://www.accademiaitalianaendodonzia.it)

### 155<sup>th</sup> ADA Annual Session

9–12 October 2014

San Antonio, USA

[www.ada.org](http://www.ada.org)

### Digital Dentistry Show

16–18 October 2014

At the International Expodental Milano, Italy

[www.digitaldentistryshow.com](http://www.digitaldentistryshow.com)

### ROOTS Summit

7–9 November 2014

Chennai, India

[www.rootssummit2014.com](http://www.rootssummit2014.com)

### BES: 2014 Regional Meeting

14–15 November 2014

Manchester, UK

[www.britishendodonticsociety.org.uk](http://www.britishendodonticsociety.org.uk)

### ADF Meeting

25–29 November 2014

Paris, France

[www.adf.asso.fr](http://www.adf.asso.fr)

### Great New York Dental Meeting

28 November–3 December 2014

New York, USA

[www.gnydm.com](http://www.gnydm.com)

### Austrian Society of Endontology Annual Meeting & PENN ENDO Global Symposium

4–6 December 2014

Vienna, Austria

[www.pennglobalvienna2014.at/](http://www.pennglobalvienna2014.at/)



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- \_ all the image (tables, charts, photographs, etc.) captions;
- \_ the complete list of sources consulted; and
- \_ the author or contact information (biographical sketch, mailing address, e-mail address, etc.).

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Article lengths can vary greatly—from 1,500 to 5,500 words—depending on the subject matter. Our approach is that if you need more or less words to do the topic justice, then please make the article as long or as short as necessary.

We can run an unusually long article in multiple parts, but this usually entails a topic for which each part can stand alone because it contains so much information.

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### Questions?

Magda Wojtkiewicz (Managing Editor)  
[m.wojtkiewicz@oemus-media.de](mailto:m.wojtkiewicz@oemus-media.de)

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## Publisher

Torsten R. Oemus  
[oemus@oemus-media.de](mailto:oemus@oemus-media.de)

## CEO

Ingolf Döbbecke  
[doebbecke@oemus-media.de](mailto:doebbecke@oemus-media.de)

## Members of the Board

Jürgen Isbaner  
[isbaner@oemus-media.de](mailto:isbaner@oemus-media.de)

Lutz V. Hiller

[hiller@oemus-media.de](mailto:hiller@oemus-media.de)

## Managing Editor

Magda Wojtkiewicz  
[m.wojtkiewicz@oemus-media.de](mailto:m.wojtkiewicz@oemus-media.de)

## Executive Producer

Gernot Meyer  
[meyer@oemus-media.de](mailto:meyer@oemus-media.de)

## Designer

Josephine Ritter  
[j.ritter@oemus-media.de](mailto:j.ritter@oemus-media.de)

## Copy Editors

Sabrina Raaff  
Hans Motschmann

## Published by

Oemus Media AG  
Holbeinstraße 29  
04229 Leipzig, Germany  
Tel.: +49 341 48474-0  
Fax: +49 341 48474-290  
[kontakt@oemus-media.de](mailto:kontakt@oemus-media.de)  
[www.oemus.com](http://www.oemus.com)

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Am Waldstrauch 1  
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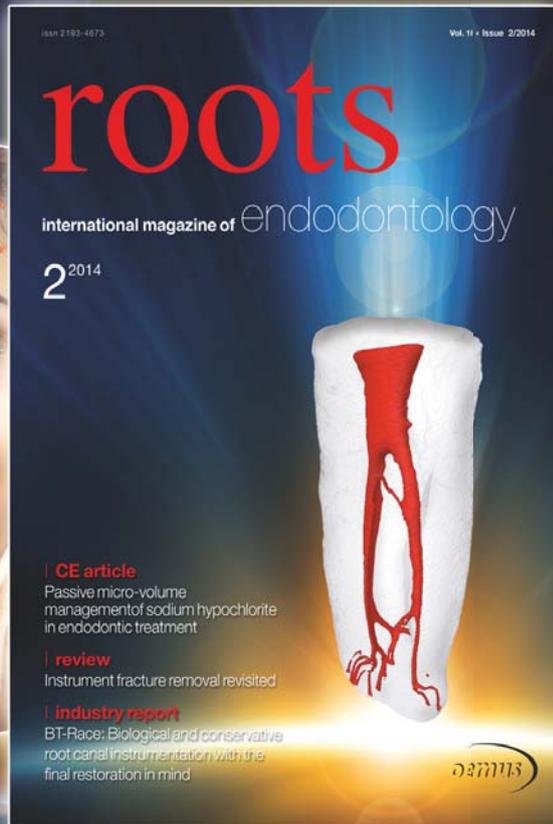
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