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When you think about endodontic treatment, it might sound so simple: access cavity, some files, a bit of irrigation, a cone with a sealer, and that’s it. Unfortunately, this is not the reality. The armamentarium that we use is almost as sophisticated as the one used during the brain surgeries. Ironically, we bring in so much heavy equipment to deal with a bit of pulp tissue and some microorganisms. The equipment that, if used on other tissues, can cause irreversible damage. The question is, do we really need it?

Is there a more ecological and tissue-friendly way to accomplish the endodontic treatment? Cryotherapy studies have demonstrated that a simple technique using cold water can solve such a major issue in endodontics as postoperative pain. Our sequence of irrigation is proving that with appropriate timing and alternation of solutions, as well as with the use water between the two main chemicals we can almost disinfect the root canal system—and also more efficiently than any other heavy equipment. The question, thus, is if we really have to bring a one-ton hammer to break open a pumpkin seed?

Learning from history, when mummification was performed in Ancient Egypt, the use of simple materials and procedures in a very strict order was consistently giving an effect lasting for several thousands of years.

Is it possible to modify our thinking to incorporate a similar approach? Thinking out of the box and using the modern technology to more ecological and bio-friendly materials may be the way of the future for our profession. Providing body’s defense cells an environment and conditions to fight infections and limiting the use of antibiotics, using cold water to reduce inflammation and therefore pain, limiting the use of pain killers and so on—I think this is how we could remain biological in the world of ever more complicated technology.
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The final goal of endodontic therapy is to provide the patient with an appropriate biological environment that can host a symptom free and long-term functional tooth with healthy periapical tissues. To achieve this objective, taking care of the valuable dental structure, and preserving peri-cervical dentine and proximal margins, are important factors to have in mind. Minimally invasive procedures are quite popular nowadays, applying them with the objective to preserve sound natural structure is a noble action that has the patient’s best interests, but, on some occasions, the decision of proceeding with a conservative way relies more on the desire of the clinician for showing their clinical ability without being aware of the inherent risks of what a conservative approach entails during endodontic therapy.

The conservative approach to the pulp chamber is not in concordance with the traditional philosophy of straight-line access, in which the main objective is to reduce the stress points to the files as much as possible, eliminating dentinal interferences located at the entrance of the root canal from the beginning of the treatment (Fig. 1). Working in a conservative way applies for mono and multi-radicular roots.

**Fig. 1**: Green arrow is showing a straight-line access to the mesiobuccal canal, dentinal interferences were eliminated during the preflaring protocol.

**Fig. 2**: Root canal treatment with conservative access in a lower premolar that went necrotic due to a dens evaginatus. At some point, this coronal anatomic variation allowed bacteria migration inside of the pulp space; after 18 months, a complete periapical healing can be seen. GL153 instrumentation system was used to preserve the cervical structure.
teeth, it is advisable to use this method on intact teeth when, for any particular reason, a root canal treatment is necessary. One of the most common group of teeth that become necrotic with intact crowns are lower premolars as a result of anatomical variations and incisors with pulp pathology provoked by traumatisms in the area. A good example of conservative access in premolars is presented in Figure 2.

Some of the aspects related to contracted or ninja endodontic access openings that can jeopardise the outcome of a root canal treatment include: missed anatomy, inappropriate delivering of irrigant solutions, increased flexural stress to the files, poor visibility and/or illumination, remaining pulp tissue at the pulp chamber, perforations at the coronal level, inefficient instrumentation. The endodontist’s experience and expertise play a critical role during a conservative root canal treatment due to these possible risk factors.\(^2\,^3\,^5\,^6\)

One of the bigger risks when working through conservative access is the increased flexural stress the files undergo during the procedure, being higher at the entrance of the root canal due to the lack of straight-line access. Cyclic fatigue might also increase at curvature levels, triggering greater transportation and changing the original root canal anatomy.\(^7\) If cyclic fatigue is one of the major risks related to conservative endodontic openings, using files with enhanced cyclic fatigue resistance is advisable.

Controlled memory files have demonstrated better distribution of stress at bending points, have much more flexibility and increased cyclic fatigue resistance when compared with stainless steel and super elastic NiTi files.\(^10\,^11\) The behaviour of controlled memory files can be explained by the presence of stable martensite stage in their microstructure. Stable martensite alloy provides the instruments with the shape memory effect\(^12\,^13\) and the characteristics that have been already mentioned.

Aurum Blue and GL153 (Meta Biomed Inc.) are endodontic files with stable martensite; because of this physical characteristic, both instrumentation systems offer outstanding cyclic fatigue resistance, pre-bending ability and high flexibility.

GL153 is a system composed by six files with cross sections with rounded angles, a 10 mm active part and 23 degrees helical angle (Fig. 3). The cross section with rounded
angles provides high resistance to torsional failure and the ability to maintain the original anatomy of the root canal system while enlarging it. The 10 mm active part was designed with the objective of preserving cervical radicular dentinal structure (Fig. 4), which is important for the resistance of the endodontically treated tooth, while the 23 degrees helical angle will prevent the screw-in effect. GL153 files are recommended to use at 500 rpm with 2.5 Ncm torque.

In Figure 5, it is possible to observe a root canal treatment performed on an upper molar with GL153, the endodontic opening was a caries driven one for preserving dentinal structure; it is possible to notice in the radiographs that there was not a straight-line access to the distal canal. Despite the double curvature at the middle and apical third, it was possible to work safely, shaping to the complete working length, maintaining the original anatomy and a conservative enlargement at cervical radicular third at the same time.

Aurum Blue (Meta Biomed Inc.) is a four file root canal instrumentation system (Fig. 6) in stable martensitic stage, the cross section, taper, NiTi alloy and electropolish surface treatment were designed and combined together to provide a good balance between cyclic and torsional fatigue resistance and high flexibility. All files below and 25.04 are square cross section and higher sizes are convex triangular. These files are recommended to use at 500 rpm with 2.0 Ncm torque.

Figures 7 and 8 are examples of root canal treatments performed with Aurum Blue files. In both cases, contracted access was made to preserve the healthy dentinal structure. It is possible to notice that in both cases there was not a straight-line access to the canals. Despite the double curvature on the mesial root of tooth #17, it was possible to work safely all along the complex anatomy. In tooth #19, it was possible to manage the apical abrupt curvature in the distal canal successfully.

Current technology advances in terms of endodontic materials, digital imaging and adhesive protocols have made minimally invasive dentistry possible. The endodontic cavity access is one of the most important first
steps in the final outcome of the treatment; an inappropriate endodontic opening can make locating, negotiating, cleaning and filling the root canal system time consuming and extremely difficult to handle; however, the extension for prevention concept in endodontics is not advisable to be followed in this era, in which, diagnostic modern tools allow the clinician to have a better understanding of the anatomy, for an enhanced treatment planning.

Among the different developments in dentistry that make conservative approaches in the endodontic practice possible include flexible endodontic files with controlled memory, alloy, and enhanced cyclic fatigue resistance, visual magnification and improved illumination and cone beam computer tomography. The development of this technology was crucial in making conservative endodontics possible, prioritising the preservation of dentine, especially in the cervical region.

Despite all the benefits that an operative microscope can offer during dentistry treatments regarding high quality procedures, and for the operator’s posture and general comfort, it is surprising how long it took to become popular and be implemented in daily clinical practice. The main advantage of the operative microscope is the ability to provide visual feedback through magnification and enhanced illumination, both of which are key factors for analysing the dental coronal anatomy to establish an adequate design of the access cavity.

Root canal treatments are performed with the purpose of keeping teeth functioning and healthy; however, coronal fracture is a risk factor after the treatment because almost all dental pieces undergoing a root canal treatment have significantly lost dental structure. This is why maintaining as much of the dental tissue as possible during the endodontic procedure is fundamental. Although the benefits of conservative access opening have not been clearly demonstrated, there are reports indicating that contracted endodontic cavities improve fracture strength in unrestored teeth with root canal treatment, but it can also compromise other important factors such as instrumentation efficiency and increasing the risk of file separation due to cyclic fatigue.

If the clinician decides to go for a conservative approach, it is important to consider the fact that the absence of a straight-line access will increase the stress of the file at the most coronal point, the area in which the instruments are weaker when facing cyclic fatigue because of the large size of the core at that level. The selection of high cyclic fatigue resistance files could be advisable to decrease the risk of file separation. Heat treated files in stable martensitic stage have demonstrated higher cyclic fatigue resistance when compared to super elastic nickel-titanium and stainless-steel instruments. Adequate selection of the endodontic instrumentation system to be used is an important factor to consider when performing a conservative endodontic access opening.

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

about

Dr Jenner Argueta completed his DDS at the Universidad de San Carlos de Guatemala’s dental school in Guatemala in 2011. He also earned a master’s degree in endodontics from the same university in 2014. Dr Argueta is a researcher of the Guatemalan National Council for Science and Technology. He is President of the Academia de Endodoncia de Guatemala [Guatemalan academy of endodontics]. He has run a private clinical practice focusing on micro-endodontics and micro- restorative dentistry since 2011.
Cleaning and shaping a three-dimensional root canal system is often very challenging. In modern endodontics, CBCT (cone beam computed tomography) imaging techniques might facilitate the diagnosis and analysis of complicated canal systems and the clinical techniques. Pre-bendable NiTi files can take advantage of the three-dimensional imaging information and facilitate the negotiation of the complicated canal anatomy. The aim of this case report is to describe a clinical technique with pre-bendable NiTi files that takes advantage of the tactile perception provided by these files to tackle complicated anatomies.

The biggest challenge in endodontics is still in exploring the natural three-dimensional structures in the human root canal. Imaging techniques, such as CBCT, now allow endodontic experts to provide a detailed picture of individual root canal outline and special structural features. Good knowledge of anatomic structures also helps in anatomic-congruent preparation of individual canals. Despite the most modern technical aids, the use of highly flexible nickel-titanium files in instrumentation allows practitioners to also assure themselves with their trained tactile perception. How “Tactile Controlled Activation” (TCA) works is shown with a recent treatment case, which started in emergency duty as an acute pain case.

Irreversible pulpitis in tooth #17

Just before Christmas, a 55-year-old male patient presented in our dental office with acute pain symptoms in the right maxilla. After an in-depth examination, his complaint was found to be in correlation to tooth #17 (Fig. 1). The findings of the examination and the X-ray diagnostics carried out indicated irreversible pulpitis. Therefore,
root canal treatment was initiated during emergency duty to achieve immediate pain relief. The small canal diameters shown on the radiograph indicated a more difficult preparation (Fig. 2).

In each endodontic treatment, you have to anticipate special anatomical features and deviations from textbook anatomies. In the presented case, the mesiobuccal canal (MB1) was far to the centre. In addition, there was the suspicion of a second mesiobuccal canal (MB2) right next to MB1. The negotiation of all canals was very challenging (Fig. 3). For this reason, we opted for CBCT imaging to have a better understanding of the exact anatomical conditions. The three-dimensional representation provided a clear impression of the positions of the three rather than four main canals that joined apically to form just two canals so that we could plan the necessary intervention (Figs. 4a–c). After placing the rubber dam to isolate the working area and opening the canal, the actual preparation followed using special, pre-bendable NiTi files, which have proven themselves many times over, especially in cases of narrow canals.

Changing files on the fly

Thorough preparation and cleaning of the root canal should always respect the anatomical conditions of the respective case as far as possible. Specifically, this means, in the first step, creating straight line access and dentine removal (preflaring) that is gentle to the tooth substance and preserves the natural contour of the canal. Furthermore, the original position of the apical foramen should not be displaced. With a restricted field of view in the region of the rear molars, the dentist therefore also benefits from particularly flexible NiTi files that move with assurance in the canal centre.

The modular NiTi file system from the Swiss dental specialist COLTENE excels first and foremost with its high fracture resistance. Depending on the indication and the shape of the root canal, you simply select the suitable file sizes with the required taper from the HyFlex series based on the modular principle. The great advantage lies in the characteristics of the alloy. Rotary files with the “Controlled Memory” effect can be effortlessly pre-bent in a similar way to classical stainless steel files, which also facilitates the tactile exploration of the canal. At the same time, and in contrast to conventional NiTi files, they show almost no shape memory effect. This effectively prevents blockage in the canal, and with the use of “CM”-treated files, straightening or transportation of the canal is virtually impossible (Fig. 5).
In the case described here, the following file sequence was used: first HyFlex CM 25/08 was used for coronal flaring and straight line access. We then created the suitable glide path with the HyFlex EDM 10/05. Here the abbreviation “EDM” stands for “Electrical Discharge Machining”. Spark erosion in the production of the files generates a hardened surface which imparts special cutting performance (Fig. 6). Negotiation to the apical terminus was facilitated by the TCA instrumentation technique. In the subsequent sequence, shaping was carried out using ascending sizes with initially constant taper: HyFlex CM 15/04, 20/04 and 25/04. For a change on the fly, the files were alternately used in two different cordless contra-angle handpieces. This saves valuable treatment time for the dentist and patient and ensures a smooth procedure. The final shaping was done with file sizes 20/06, 30/04 and a 40/04 file (Fig. 7). The ascending standardised sequence is easy to remember, and enables the efficient, and reliable preparation. Even in highly curved canals, shape-congruent preparation through to the apical tip is effortless thanks to “Controlled Memory” files.

Sensitive instrumentation by means of TCA

The so-called TCA technique was applied in the case described for safe and predictable instrumentation of the canals. In literature, the practical method is described in detail by Chaniotis et al. In principle, the tactile approach means that the rotating NiTi file is activated inside the canal in a single stroke until the file reaches final working length.

The idea is very simple: after opening the pulp chamber and sighting the canal entries, the reproducible glide
path is established (Fig. 8). The first pre-bent “CM” file is now passively inserted into the canal up to the point at which the maximum resistance is sensed. The endo handpiece is only now switched on once noticeable friction of the file gives the dentist an indication of the anatomical structure of the canal. The activated, rotating file is moved down in a single stroke until resistance at which it can no longer be advanced towards the apex. At this point, the file is removed from the canal, cleaned and checked for any deformations. The canal is rinsed and re-capitulated to ensure patency before the next TCA stroke that will bring the file closer to the apex.

On repeated insertion of the same file, passively and without rotation, the pre-bent NiTi file now reaches that second point which, in the first advance, had been initially “worked towards”. After activation of the file in situ, it is further advanced towards the apex and approaches closer to the required working length. The use of this file size is concluded as soon as the non-rotating file can be inserted in the canal to the full working length without it having to be activated. With the aid of tactile activation, even challenging canal anatomies can be prepared over the entire working length. In case of highly curved or constricted root canals, with pre-bent NiTi files the exact contour of the canal can be investigated behind the curve, even passively. With the “out-stroke” of the technique, the file is also activated at the point of maximum jamming of the blades. Rather than actively pushing forward, this time the file is immediately pulled back, however. On repeated insertion of the file, you soon sense how the blades only respond far lower down. In this way, using the normal tactile feedback the apical third can be probed safely. The given geometry is felt little by little, which in turn leads to optimal cleaning of the affected canal with minimal, if any, debris extrusion.

Besides the smart “tactile” approach, the thorough cleaning of the canal with each change of instrument, played a crucial role in the therapy described. Sodium hypochlorite (NaOCl) was used to remove any remaining debris and inflamed tissue, followed by EDTA. After drying the canals, they are classically obturated with warm gutta-percha using the warm vertical compaction technique (Fig. 9). The subsequent radiograph clearly shows the successful root canal filling and the anatomically natural contour of the three slender main canals (Fig. 10). In the follow-up, the tooth continued to be clinically inconspicuous and the patient has remained pain-free to this very day.

Summary

The clever use of ultra-modern, technical aids such as imaging techniques and extra-flexible nickel-titanium instruments clearly simplifies the work of the endodontic specialist in daily practice. Yet, tactile probing of the natural, three-dimensional canal anatomy is imperative and supports safe and reliable preparation, even in highly curved and constricted root canals. Unbreakable files with the “Controlled Memory” effect can be pre-bent for this purpose and adapt effortlessly to all imaginable canal anatomies – for the right “feel” in almost all treatment situations.

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

Figs. 1–4, 8–10: Courtesy of Dr Andreas Habash.
Figs. 5–7: Courtesy of COLTENE.

contact

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Introduction

Pulp canal obliteration (PCO), or calcific metamorphosis, is considered by some authors as the pulp response to trauma and is characterised by the deposition of hard tissue within the root canal space and a yellow discolouration of the clinical crown.\(^1,2\) The exact mechanism of canal obliteration is still unknown, but damage to the neurovascular supply of the pulp at the time of the injury is the most accepted explanation. Different factors, such as dental trauma (concussion or subluxation), caries, coronal restorations, vital pulp therapy, orthodontic treatment, occlusal pathology, abfraction, abrasion, harmful oral habits and individual aging, can trigger PCO.\(^1-4\)

PCO usually affects the anterior teeth of young adults and can cause total or partial obliteration of the canal space radiographically.\(^3\) Generally, the obliteration of the pulp canal space starts in the crown, with the narrowing of the pulp chamber, and then extends apically, followed by a gradual decrease of the root canal space.\(^5,6\) Complete radiographic obliteration of the pulp space does not necessarily mean the absence of the pulp canal space. In fact, in most of these cases, pulp tissue is present, but the sensitivity of radiographic examinations is too low to allow visualisation of the root canal path.\(^1\)

Normally, PCO has no symptoms and may be noted by tooth discoloration, yellow or grey, during routine ex-
amination as early as three months after the injury, but in most cases is not detected until a year after.\textsuperscript{1, 3} In PCO cases, pulp necrosis has been reported in 1 to 16.5 per cent, and the development of apical periodontitis has been estimated at 7.3 to 24 per cent of cases after four years.\textsuperscript{7}

There is agreement that root canal treatment is only indicated in cases of PCO when irreversible pulpitis or apical periodontitis is diagnosed. Such a diagnosis represents 1 to 27 per cent of teeth with this clinical condition.\textsuperscript{4}

Searching for calcified root canals can be challenging and time-consuming and may create a huge loss of tooth structure that is associated with a high risk of fracture and perforation, compromising the prognosis of the tooth.\textsuperscript{4, 8} The rate of treatment failure for PCO has been reported to range from 20 to 70 per cent, and it depends on the clinical experience and knowledge of the anatomy of the operator and also the information provided by 2D and 3D radiographic examinations.\textsuperscript{8, 10}

Nowadays, the use of new technologies has increased the predictability of the treatment of calcified teeth. Dental operating microscopy enhances visibility of the pulp cavity, and the use of ultrasonic tips allows working at greater depth within the root canal system safely, which may help in identifying the root canal. Cone beam computed tomography (CBCT) is extremely helpful in PCO cases, as it allows 3D images without overlapping adjacent structures, which facilitates the identification of the canals and their anatomy, degrees of obstruction and dimensions.\textsuperscript{2, 6, 11}

A new clinical approach to a tooth with PCO, called “guided endodontics,” has been introduced. This technique combines the use of a guiding template with CBCT, which facilitates the location of severely calcified root canals.\textsuperscript{2, 4, 6, 8, 11} The guide design is based on the anatomy of

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**Fig. 6:** Virtual copy of the drill’s (1.2 × 17 mm) position in the 3D template. **Fig. 7:** Adaptation of the printed template on the original cast model. **Fig. 8:** Occlusal view of the template with the incorporated metal sleeve. **Fig. 9:** Control of the position and fitting of the drill into the template.

**Fig. 10:** Control of the adaptation of the template in the mouth. **Fig. 11:** Pencil mark on the palatal surface made through the sleeve to serve as reference point to start the access. **Fig. 12:** Enamel removal with a diamond bur until the dentine was exposed.
the root canal and the architecture of the tooth and adjacent structures, obtained by CBCT images and an impression or intraoral surface scan, respectively. Software associated with CBCT data and 3D intraoral scanning, such as coDiagnostix (Dental Wings) or Simplant (Dentsply Sirona), is used for virtual planning of the access cavity.7, 12 After this, a 3D virtual template is produced to obtain the physical model of the endodontic guide that will orientate the bur into the calcified root canal.7, 12

Guided endodontic access in PCO cases in anterior teeth has been previously reported in the literature and described as a safe and predictable technique to give minimally invasive access to calcified canals. This may help to preserve tooth structure and avoid technical errors, and lead to an improvement in the long-term prognosis.8, 11

Case report

A 22-year-old female patient was referred to a private clinic with a history of pain in the maxillary left central incisor. The patient had a history of a dental trauma that had occurred nine years earlier. The tooth was discoloured and yellow, and it presented tenderness to percussion (Fig. 1). Thermal and electrical sensitivity tests were negative. Radiographic examination showed a severely calcified root canal (Fig. 2). The presence of a radiolucent image compatible with apical periodontitis was confirmed by the CBCT scan (i-CAT, Imaging Sciences International; Fig. 3).

The root canal space could be identified in the apical third with initial radiographic and 3D imaging. Based on the results of clinical and radiographic examination, a diagnosis of necrotic pulp with symptomatic apical periodontitis was made, and root canal therapy recommended. After analysis and discussion with the patient, guided endodontics was chosen as the most appropriate treatment approach.

A silicone impression was taken, and a gypsum dental model was created and scanned (iTero, Align Technology; Fig. 4). Both CBCT imaging and model scans were aligned and processed with coDiagnostix. A virtual copy of a drill with a diameter of 1.2 mm and a length of 17 mm (Meisinger) was superimposed on to the scans in a position that allowed its access to the identified root canal system within the apical one-third of the tooth (Fig. 5). The position of the drill was checked in 3D. Subsequently, the 3D template was exported as an STL file and sent to a 3D printer (Form 2, Formlabs; Figs. 6–9).

After confirming the adaptation of the guide (Fig. 10), a pencil mark on the palatal surface of the tooth was made (Fig. 11), through the sleeve, to serve as reference point to start the opening access. A conventional opening access was initiated with a high-speed long-neck diamond round bur (BR-154, MANI). The enamel in the palatal surface was removed until the dentine was reached (Fig. 12). The bur position was checked in the mouth. The bur was coupled to a low-speed handpiece set to 600rpm. Drilling was performed with pumping movements to penetrate through the calcified part of the root canal under copious irrigation with saline solution. After each millimetre apical advance, radiographs at two different angulations were taken to confirm the correct position of the bur (Figs. 13 & 14). The patent apical root canal was reached, and a rubber dam

Figs. 13 & 14: Radiographic control of the position of the drill and its depth throughout the procedure.
was placed (Figs. 15 & 16). D Finder hand files of sizes 8 to 15 (MANI) was used for glide path creation, and the root canal length was electronically (Root ZX II, J. Morita) and radiographically confirmed (Figs. 17 & 18). The tooth was instrumented up to 35.04 rotary NiTi Silk files (MANI; Fig. 19) with TriAuto ZX2 (J. Morita) and irrigated with 5.25% sodium hypochlorite (NaOCl) during the entire treatment.

A final irrigation protocol was performed with 17% EDTA and 5.25% NaOCl. The irrigant was activated with a calibrated master cone using a manual dynamic activation technique. After drying the root canal, obturation was performed with a single-cone technique with the BioRoot RCS bioceramic sealer (Septodont; Figs. 20 & 21). The access cavity was cleaned and sealed with a glass ionomer cement (Ionoseal, VOCO) and restored with composite resin. A final CBCT scan was done after the treatment to confirm the cantered position of the access (Figs. 22 & 23).

At the six-month follow-up, the tooth was asymptomatic (Fig. 24).

**Discussion**

Nowadays, treatment of teeth with PCO is classified as the highest level of difficulty by the American Association of Endodontists. The literature shows that the success rates of treating teeth with calcified root canals with apical periodontitis did not exceed 62.5 per cent. Still, success rates in this cases increased up to 89 per cent when the procedures were performed by endodontic specialists. Although it has been established that the most experienced endodontists can achieve high levels of success, even with the help of a dental operating microscope, long-neck burs and ultrasonic tips, the accomplishing of an adequate access cavity and the localisation of the root canal may lead to excessive loss of tooth structure, a higher risk of fracture and perforation. In cases of PCO, guided endodontic access may be indicated for more predictable access, allowing maximum preservation of the dental structure and reducing iatrogenic accidents. This may lead to an improved long-term prognosis.

Krastl et al. was the first to describe a guided endodontic technique in vivo in a maxillary central incisor with PCO and apical periodontitis, introducing the term “guided endodontics.” This technique was first described in implantology and then applied to endodontics, surgery and conventional access. The present method consists of accessing and locating root canals by means of a guiding template created by tomographic planning. The template sleeves direct the position of the access bur, increasing the perforation precision during access and reproducing adequate tomographic planning.

Two ex vivo studies were performed to prove the high accuracy of the guided endodontics technique. Buchgreitz et al. concluded that the mean distance between the drill path and the target was less than 0.7 mm, and Zehner et al. showed that deviations of planned and prepared access cavities were low, with means ranging from 0.17 mm to 0.47 mm at the tip of the bur, and the mean angle deviation was 1.8°.

The accuracy values of guided splints depend on multiple factors, such as the type of support and study, technique used to produce the template, planning software, discrepancy between the drill and cylinder guide, degree of wear of the drill and number of guides used. Nevertheless,
guided templates have been associated with a number of limitations, such as inaccuracy, high economic cost, long therapeutic time and complications.\textsuperscript{17}

Inaccuracies are partly related to the loose fit between the drill and the sleeve, which is necessary to avoid heat development during preparation.\textsuperscript{8, 18} A recent study performed in mandibular incisors ex vivo reported a mean linear deviation of 0.12 to 0.34 mm from the apical target point. This improvement was achieved by optimising the fit between the bur and the sleeve, which is essential to avoid gaps and consequently deviation in angulation.\textsuperscript{19} A metal sleeve should be placed for controlling the drill; however, a study that did not use a metal sleeve reported a burn on the plastic corridor after drilling.\textsuperscript{20} To avoid the heat created by the tight contact of the rotating bur with the sleeve, care should be taken to irrigate during drilling.\textsuperscript{7} Temperatures generated on the root during drilling may represent an injury to the periodontal ligament and adjacent bone.\textsuperscript{4}

One reason for the higher accuracy measurements of guided endodontics may be related to the fact that, unlike with implant cavity preparation, only a single bur was used.\textsuperscript{8} Another fact is that the template is normally only supported by mucosa, which might lead to an uncertain fit and resiliency on support.\textsuperscript{20} Nevertheless, the mechanical properties of dentine compared with the alveolar bone are different.\textsuperscript{8} This technique is a relatively new procedure and the available drills and sleeves are limited, as implant surgical template fixing drills have been used.\textsuperscript{14} The first studies performed on maxillary teeth used burs of 1.5 mm diameter.\textsuperscript{8, 15} Recently, the use of small-diameter burs of 0.8 mm and 0.85 mm diameters have been used for the treatment of small and narrow roots.\textsuperscript{4, 19, 20} This may have a positive impact not only by preserving the tooth, but also...
by reducing the heat generation on the root. The preparation bur may cause microcracks in the dentine, as the forces generated, particularly by the tip of the bur, are increased compared with post space preparation procedures, because of the larger contact area with dentine walls.\textsuperscript{4} However, there are no guide rings for high-speed handpiece burs, so it is not possible to cut enamel, ceramic and cast restorations.\textsuperscript{16}

This guided approach has been proved to have a sufficient accuracy to establish a safe treatment method for teeth with PCO and no significant difference between operators, which might facilitate endodontic treatment of these difficult cases even for less experienced professionals.\textsuperscript{8, 14} A limitation of this technique is the straight drill path that does not take a curvature into account—although it is rare that a root canal is calcified until its apical third.\textsuperscript{18} It is thus important to consider that this technique has anatomical limitations not only in severely curved canals, but also when radicular grooves, isthmuses or oval roots are present.\textsuperscript{16} A lack of interocclusal distance to accommodate the template and the additional instrument length required are also problems.\textsuperscript{16} Consequently, this technique is contra-indicated in curved canals and limited mouth opening. In these cases, dynamic guided endodontic access should be considered.\textsuperscript{16}

Conventional root canal therapy and apical surgery are alternative treatment options for teeth with PCO. It is possible to achieve success with conventional root canal therapy; however, it is time-consuming and associated with a higher risk of iatrogenic errors and excessive radiation exposure. Regarding apical surgery, this is a more invasive and uncomfortable approach for the patient.\textsuperscript{7}

Access guides are manufactured by overlapping the CBCT data with an intraoral scan of the target area.\textsuperscript{5, 11} The CBCT scan is essential for the preoperative visualisation of the exact location and anatomy of the root canal system in complex cases.\textsuperscript{5} Although it has a high radiation dose, it has contributed to increasing the success rate of endodontic treatment by optimising technical treatment planning.\textsuperscript{14} In 2015, the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology updated their guidelines on the use of CBCT imaging in endodontics. They recommend CBCT imaging for the location of calcified root canals because of the high level of difficulty associated with this procedure.\textsuperscript{11}
Without this guidance, even the most experienced clinicians should be cautious and take several radiographs to ensure the correct insertion position of the instrument used to achieve the canal. The reduction in the number of radiographs with this approach is also of benefit and compensates for the patient’s radiation exposure in CBCT scanning. Still, periodic intraoperative radiographs should be taken to control the drill path. Also, stepwise control is suggested using a microscope, and as soon as a canal can be negotiated, conventional instrumentation can be carried out.

The planning of guided endodontics is very time-consuming compared with conventional root canal therapy because of CBCT acquisition, intraoral scanning, virtual planning and printing (Figs. 25–27). When the root canal disease is symptomatic, usually prompt treatment is needed and the patient and dentist do not want to wait. However, the time that it takes for an endodontic specialist with or without an operating microscope to localise calcified root canals can be more time-consuming than with the help of a 3D guide, as the chair time with this technique is minimal.

The additional cost, including a CBCT scan, intraoral scan, software and fabrication of templates, may be justified by the reduction of iatrogenic errors and the better prognosis of the tooth, compared with the costs for an implant.

Isolation by rubber dam is essential for the success of endodontic treatment. In guided endodontics, the adaptation of the guide is fundamental for the outcome, and so initial access without a rubber dam may be necessary. Once the canal is located, it is mandatory to place a rubber dam before instrumentation of the root canal.

Another disadvantage, as mentioned by Van der Meer et al., is the restricted visualisation of the treatment when the guide is used despite its transparent nature. The intermittent removal of the guide may be needed to ensure that the proper path is still being followed. In the field of endodontics, the use of guided templates assisted by CBCT images has been described not only for treating teeth with PCO, but also for development anomalies that affect the root canal system, apical microsurgery, selective canal retreatment and fiber post removal.

Conclusion

Negotiation of obliterated root canals is a tremendous challenge for clinicians. The use of new technologies, knowledge of pulp anatomy and interpretation of radiographs are the keys to achieving success in the treatment of PCO.

Guided endodontics appears to be a safe, reliable and clinically useful method for treating teeth with PCO. The use of endodontic guides may facilitate the localisation of the canal and allow a more predictable approach to these cases. However, it is still necessary to develop burs with smaller diameters and different lengths to allow access to calcified canals in longer and narrow teeth, such as canines and mandibular incisors. Further improvements are also necessary to allow this technique to be used in the treatment of posterior teeth and curved canals, the guidance of retreatment of selective canals and the removal of fiber posts.

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Irrigation in endodontics—new needle for better results

Drs Franck Diemer, Maël Diemer, Amaury Beaugendre, Vincent Blasco-Baqué, Jean-Philippe Mallet, France

Root canal preparation is an essential step in endodontic treatment aimed at removing the current content of the root canal and preparing the canal or canals for filling. The objective is to prevent the onset or recurrence of apical periodontitis. The use of rotary instruments with continuous rotation has made treatments faster, more comfortable and more predictable over the past 20 years. Many developments in the instrument realm have helped improve endodontic preparation systems. But despite all these advances, the complexity found in root canal systems results in residual unprepared or unpreparable areas that require the complementary use of chemicals.

While most of the bacterial flora is eliminated by mechanical preparation, only endodontic irrigation can ensure intraoperative endodontic antisepsis. Used regularly and copiously, root canal irrigation can effectively remove organic and mineral debris in addition to providing bacterial decontamination. Root canal preparation must therefore be considered a combined chemical and mechanical procedure where the limits of the mechanical instruments are overcome by irrigation solutions.

The market is full of different irrigation systems designed to further enhance this step. Many studies have been carried out to find the “perfect” irrigation solution, one that would meet all the criteria in terms of both efficiency and biocompatibility. Unfortunately, there simply is no such solution at this point. Sodium hypochlorite remains the gold standard of antiseptic solutions, while EDTA or citric acid remain the gold standard among chelating agents, required at the end of the preparation process. However, a needle recently developed by Produits Dentaires SA has given us a new choice of irrigation needle.

Irrigation in endodontics

Irrigation is an essential part in endodontic treatment. It is irrigation that allows us to prepare a root canal antiseptically. Irrigation is, therefore, required from the time of accessing the pulp chamber until the restorative material is introduced into the root canal.

The anatomies of root canal systems are highly variable and can be very complex, so it will usually be impossible to mechanically prepare the entire system. However, it is still imperative to clean the entire root canal system to achieve effective cleaning and to perform a successful endodontic treatment. For this reason, irrigation is the mandatory complement to the preparation of canals with rotary instruments, which, while reducing the bacterial count in instrumented areas by up to 90 per cent, have no effect in areas that are not and cannot be instrumented.

Various different irrigation systems are currently in use. Root canal irrigation with a syringe and a needle is still the most common procedure today. Syringes are generally classified according to the design of their tips. Luer tips (which are not necessarily Luer-Lock tips) are conical, with a 6 per cent slope. Luer-Lock tips feature the same conical design but also provide a locking mechanism.
for the needle that prevents the needle from accidentally sliding off the syringe. All needles have some form of connector with which to attach them to the syringe. The length and thickness of the needle can vary greatly, depending on the procedure to be performed. Its diameter is measured in gauge numbers, which vary from 8 to 30, responding to 4.57 mm and 0.31 mm, respectively. The higher the gauge number, the slimmer the needle. It is quite possible to encounter two needles with the same lengths but different diameters.

The needle can end in a bevel, it can feature one or several lateral openings. Being familiar with these different needles is particularly relevant in endodontics. It has been demonstrated that closed-ended needles must be used to prevent irrigation solution to invade the periapical space. The pertinent studies were based on visualising and examining the trajectories of irrigant particles of the irrigation solution at the root-canal level.4

Until now, there were three needles of particular interest to the practice of endodontics:

- Irrigation needles with rounded foam tips and a lateral opening of the Irrigation Probe type (Kerr Hawe). The diameter of the needle opening is small enough for enough pressure to build to lift the dentine and pulp debris present.
- Irrigation needles with notched ends, of the Endoneedle type (Elsodent). These have the advantage that the passage of the needle is blocked 3 mm away from the apex, preventing the pressurised liquid from irritating the periodontal ligament with its “water cannon” effect.
- Irrigation needles with two lateral openings at different levels and a foam tip, of the Endo Irrigation Needle type (Transodent). These allow effective cleaning of the entire root canal in an atraumatic way. Like the others, they are available in several diameters, 27- and 30-gauge being the most suitable for endodontics depending on the width of the canal encountered.

The main limitation of this widespread irrigation method is irrigation in the apical third, as the irrigation solution does not reach any further than 1 mm from the tip of the needle.5 The latter must therefore be brought as close as possible to the apex (Fig. 1a) to be effective in the apical last few millimetres of the root canal. Thus, in order to increase the efficiency of irrigation, the forced protrusion of the solution by different methods presents good results.1

At present, we know that passive ultrasonic irrigation of the root canal is more effective than syringe/needle irrigation in removing residual pulp tissue and dentine debris and also allows a more significant reduction in the level of intra-canal bacteria.13,14 However, studies on the removal of dentine slurry have been inconclusive to date, although they tend to suggest a higher efficacy of passive ultrasonic irrigation.

The purpose of any endodontic treatment is to provide a good root canal filling (Fig. 2). Bolles et al. (2013) demonstrated the importance of root canal irrigation on the penetration of endodontic sealer cement. Sonic systems exhibited a slightly higher percentage of cement penetration compared to conventional irrigation.15

It is generally accepted that the oral environment is a complex ecosystem that comprises about 1,010 bacterial species. In the root canal, 450 species have been identified, although any given root canal will generally not contain more than 5 to 30 species simultaneously.3 The composition of the bacterial flora and the location of microorganisms in the root canal depend on several factors: the amount of oxygen available, bacterial access to nutrients, the status of the host defences, the prevailing pH level and others.16 These bacteria readily organise themselves into a biofilm, a true “endodontic plaque”, and are considered to be the main cause of endodontic treatment failure.17 According to Costerton, a biofilm is a community of bacteria aggregated into microcolonies, embedded in a gangue matrix that they have secreted, and adhere to an inert or biological surface. In this arrangement, bacterial species appear more resistant to root canal disinfection agents than bacteria with a plankton-like organisation. The irrigation solution must, therefore, be effective against isolated...
bacteria, as well as bacteria grouped together in biofilm communities.\textsuperscript{18}

The smear layer is a coating layer created by preparation instruments. This layer covers the surface of the root-canal walls and can reach a thickness of 5 µm and a depth of 40 µm in the dentinal tubuli. It consists of organic and inorganic substances (dentine slurry, pulp debris, micro-organisms).\textsuperscript{19}

This smear layer can interfere with the success of endodontic treatment\textsuperscript{19,20} by harbouring bacteria responsible for secondary or persistent infections, blocking the irrigation liquid from entering the dentinal tubuli (Fig. 1c), thus causing deep bacterial persistence and preventing a good definitive seal by inhibiting the penetration of the tubuli by the sealing cement. It is essential to remove the smear layer at the end of the instrumentation process and before the obturation step.

Irrigation should, therefore, begin as soon as the pulp chamber is opened, using a 2.5 % sodium hypochlorite solution. Copious amounts of it should be introduced (up to 4 ml per canal have been recommended in the literature) and renewed between instrument passages. Some studies even state that the canals should always be filled with irrigation solution to prolong its action on the dentine walls.\textsuperscript{1,20}

Solutions can be introduced into the root canal by different methods. A needle recently developed by Produits Dentaires SA, the IrriFlex (Fig. 3), appears to be particularly interesting. This slightly conical 30-gauge needle is made of plastic and possesses two lateral vents arranged back to back just short of its closed end. This unique device facilitates an efficient lateral flow and reflux of the solution while controlling the extrusion risk. In effect, this means that the needle must never get stuck in the root canal (meaning that the preparation must be sufficient at all points) and that the liquid is ejected slowly and at low pressure, 1 to 2 mm from the working length (Fig. 1a). The lateral flow is conducive to the cleaning of isthmus and root canal irregularities.

Once the root canal preparation is complete, and before proceeding to obturation, it is necessary to remove the smear layer created by the instruments (Fig. 1c). For this purpose, a 17 % EDTA solution (or 5 % citric acid) is applied for two minutes, at a quantity of 2 ml per canal. A final copious 2.5 % NaOCl rinse (two minutes, 3 to 5 ml per canal) provides additional disinfection and completes the opening of the dentinal tubuli (Fig. 1b).

A comparative scanning electron microscopic (SEM) study\textsuperscript{21} on debris removal showed that the IrriFlex needle/syringe system was more effective than the conventional Endoneedle/syringe system. The IrriFlex needle displays interesting properties during root canal irrigation. This might be explained by its flexible nature that allows it to penetrate root canal network more easily without breaking, but also by the presence of several lateral openings at the same level, which balances the pressure and flow of the expelled irritant. These openings ensure extra broad exposure of the entire root canal.

Endodontic treatment requires root canal preparation instruments that work in synergy with an irrigation solution. The complexity of root canal systems prevents sufficient cleaning by mechanical preparation alone, mandating the additional use of chemical agents. The IrriFlex needle appears to be a promising device, showing superior results to the traditional syringe/needle method. It is flexible and has a very small diameter (30-gauge), which allows simple and efficient access to the apical areas of curved roots.

Editorial note: A list of references is available from the author.
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Despite the fact that degradation and dissolution of gutta-percha and sealer jeopardise positive treatment outcomes, these legacy materials are still used in diverse protocols for root filling canals. This paper reviews the historical cognitive dissonance in endodontics; the biochemical seal created by gutta-percha and sealer diminishes over time with negative sequelae and yet, they remain the gold standard of obturation. Bioceramics possess physical, chemical and biologic properties that demonstrate the ability to overcome the limitations of traditional root filling materials. They are bioinert (non-interactive with biological systems), bioactive (interactive with surrounding tissues) and biodegradable (eventually replaced or incorporated into tissue). These properties facilitate conservative root canal shaping, thus preserving natural tooth structure (Figs. 1a–d).

Objectives of root filling

Debridement, disinfection and the prevention of re-infection are the mandates of root filling. Endodontic disease is a biofilm-mediated infection. The most common endodontic infection is caused by surface-associated growth of microorganisms. The application of the biofilm concept to endodontic microbiology depends on understanding the pathogenic potential of root canal microflora, which require new approaches for disinfection.2,3

Bioceramic dispersion root filling
Revision of legacy obturation protocols

Dr Kenneth S. Serota, USA

Fig. 1a: Bioceramic scaffolds are porous structures that facilitate cell penetration and tissue-in-growth. Fig. 1b: Scanning electron microscopic (SEM) evaluation of root section filled with gutta-percha and AH Plus Root Canal Sealer. Note the gap between the gutta-percha, the sealer and the dentine (attribution Drs Ørstavik and Eldeniz).

Fig. 1c: Canals were filled with EndoSequence BC Sealer and sectioned at sequential distances from the apex. The gutta-percha cone facilitates dispersion of the sealer into the apical seat and irregularities of the root canal space (attribution Drs Trope and Debelian). Fig. 1d: Microstructure of calcium orthophosphate cement after hardening. Mechanical stability is provided by the physical entanglement of crystals.
There are three basic requirements for a root filling material:

1. Prevent coronal leakage after the root canal is filled and the final restoration placed.
2. Entomb surviving microflora in the interfacial dentine so they cannot reassert their presence and communicate with the periradicular tissues.
3. Prevent influx of periapical fluids to provide nutrients for residual microflora in the root canal space.

Gutta-percha and sealer

Gutta-percha was discovered in 1656 by John Trades-cant and introduced to medicine by Dr William Mont-gomerie in 1831. In 1867, GA Bowman used gutta-percha cones as the sole material for root filling. It was not until 1925 that UG Rickert recommended the use of sealer with a GP cone.

The clinical performance of classic root filling materials substantiates what Aristotle expressed as historical truth; practical individuals study not the eternal principle, but the relative and immediate application. In vi tro, in vivo and clinical outcome studies done on single cone or lateral condensation techniques demonstrate failure of their primary function, sealing. Salivary hydrolytic enzymes have the ability to break down the coronal seal. Microbial products destroy and decompose gutta-percha, resulting in the loss of adaptation of gutta-percha to canal walls, thereby reducing the coronal seal and by extrapolation, the apical seal.

History: lateral condensation

Lateral condensation techniques enhance the ability to control the length of the root filling. However, if there is poor canal preparation, inadequate application of pressure or a mismatched spreader and gutta-percha cone, residual spaces between the gutta-percha cones are filled with sealer. Lateral condensation has a low core/sealer ratio, which potentiates apical leakage. Sabeti et al. found no difference in treatment outcomes when a root filled canal was compared to a canal left empty.

Fig. 2: Chart shows in vitro evaluation of saliva penetration in the root canals. The seal achieved with gutta-percha alone is indistinguishable from the negative control (attribution Drs Khayat et al.). Fig. 3: Table shows expansion/shrinkage of popular sealers. Silicone and epoxy-resin sealer expand slightly before shrinking. By contrast, bioceramic sealer expands slightly on setting but does not shrink.

Fig. 4a: Chemistry associated with the hydration reaction of bioceramic material (calcium silicates) with water (moisture present in canal and tubuli) creates calcium silicate hydrate and calcium hydroxide. Fig. 4b: Precipitation reaction of the bioceramic (calcium phosphate). The hydroxyapatite co-precipitated within the calcium silicate hydrate phase produces a composite-like structure, reinforcing the set cement. The bioactivity of the calcium-silicate-based materials has been shown to produce mineralisation within the subjacent dentine substrate, extending deep within the tissues (attribution Dr Martin Trope).
This study and others emphasise the poor quality of current root filling techniques and the importance of a coronal restoration for positive treatment outcomes. Furthermore, there is an overriding technical flaw with lateral condensation; overzealous application of apically directed pressure can result in vertical root fractures.\(^{15-17}\)

**The Schilderian epoch**

Dr Schilder’s transgressive articles, *Vertical Compaction of Warm Gutta-Percha and Filling Canals in Three Dimensions*, address technical adjustments to traditional obturation techniques. Warm vertical condensation enabled gutta-percha to replicate the microstructural anatomy of the root canal space to a demonstrably greater degree than any previous technique.\(^{18,19}\) Despite the enhanced rheology, gutta-percha neither adhered to nor penetrated the interfacial dentine. The sealer was integral to achieving a positive treatment outcome. Schilder and Goodman\(^{20}\) established the hypothesis that warm vertical condensation pushed a greater volume of filler material into the apical space and theoretically the material would not shrink on cooling; however, regardless of enhanced gravitometrics, leakage studies on gutta-percha alone and gutta-percha and sealer showed their inability to create an impervious apical seal.\(^{21}\)

**Carrier-based obturation**

The prototype of carrier-based thermoplasticised gutta-percha obturators was developed by Dr WB Johnson in 1978. Traditionally, the beta formulation of gutta-percha was used for its improved stability, hardness and reduced stickiness. Alpha phase gutta-percha was chosen for CB as it demonstrates low viscosity, it flows with less pressure or stress and creates a more homogenous filling.\(^{22}\)
The latest iteration of carrier-based obturators is GuttaCore (Dentsply Sirona), a system made entirely of gutta-percha with a core obturator prepared with cross-linked gutta-percha. This method of obturation appears to have significantly less voids and gaps than lateral compaction.\textsuperscript{23}

The volume of sealer is the weak link in the chain of success; volume must be minimised by the density of the core/filler regardless of the technique used. With the new array of equipment for identifying, shaping and cleaning the root canal space, reliance on ineffective materials and techniques mandate a paradigm shift in root filling. When tested in an \textit{in vitro} model, microbes will permeate the length of the canal space in two hours if only gutta-percha is present in the canal without sealer. The leakage can be delayed for up to thirty days with the use of sealer. Traditional sealers generally shrink on setting and wash out in the presence of tissue fluids\textsuperscript{24} (Fig. 3), whereas bioceramic sealer do not.

**Bioceramic nano-technology: the reckoning**

Bioceramic materials (calcium phosphate) include alumina, zirconia, bioactive glass, hydroxyapatite and resorbable calcium phosphates.\textsuperscript{25–29} They are used as joint or tissue replacements in both medicine and dentistry as they are chemically and dimensionally stable, biocompatible and osteoconductive. Bioceramic sealers are composed of tricalcium silicate, dicalcium silicate, colloidal silica, calcium phosphate monobasic, calcium hydroxide and a thickening agent. Zirconium oxide is used as the radiopacifier and the material is aluminium-free. The chromogenic effects of all root sealers increase when excess sealer is not removed from coronal dentine of the pulp chamber.\textsuperscript{30}

Bioceramics are ideal for use in endodontics as they are not affected by moisture or blood contamination and, therefore, technique sensitivity is not an issue, unlike most other sealers where moisture negates their performance. Being that they are hydrophilic, residual moisture in the canal and dentinal tubuli are biochemically a positive factor. In the context of creating an impervious seal, they are dimensionally stable and expand slightly on setting, ensuring a long-term seal due to the hydration reaction forming calcium hydroxide and later dissociation into calcium and hydroxyl ions.\textsuperscript{31} \textit{In vitro} testing by Prati and Gandolfi stated that bioceramic materials can expand by 0.2–6\% of their initial volume.\textsuperscript{32} In addition, they are shown to penetrate into dentinal tubules at a greater degree than AH Plus in both single cone and warm vertical techniques at 2 mm to apex (P <0.05).\textsuperscript{33}

Bioceramic material may be an essential element in indirect and direct pulp capping and pulpotomy procedures that are an integral part of endodontic therapy’s goal of maintaining the vital pulp to ensure a healthy periapical periodontium. For all these reasons, premixed bioceramic materials are seen as an alternative material of choice for pulp capping, pulpotomy, perforation repair, root end filling and obturation of immature teeth with open apices, as well as for sealing root canal fillings of mature teeth with closed apices.\textsuperscript{34,35}

When setting, the pH of the bioceramic is above 12 due to a hydration reaction forming calcium hydroxide and dissociation into calcium and hydroxyl ions, which could explain the antibacterial properties of biocermatics (Fig. 4a). The release of calcium hydroxide and its interaction with phosphates on contact with tissue fluids forms hydroxyapatite. This may explain the osteoconductive potential of the material (Fig. 4b).\textsuperscript{36} Calcium phosphate is the main inorganic component of the hard tissues (teeth and bone). Consequently, the literature notes that many bioceramic sealers have the potential to promote bone regeneration. The amount of Ca\textsuperscript{2+} released from Endo- sequence BC Sealer is far higher than that from AH Plus mainly after seven days. A concordance was also observed between pH and the amount of Ca\textsuperscript{2+} released in both analysed materials. A possible explanation for the high amount of Ca\textsuperscript{2+} released by bioceramic cements could be associated with setting reactions, including hydration reactions of calcium silicates.\textsuperscript{37}
A scientific paradigm shift in root filling

As the root filling paradigm shifts to bioceramic sealers, the practitioner can execute a bio-minimalistic antimicrobial protocol for root canal treatment, leaving a thicker and stronger root. Bioceramic sealer is used with a dedicated gutta-percha cone impregnated and coated with nanoparticles of bioceramic, thus eliminating the gap between the core and sealer. This combination has been shown to be similar or better than conventional endodontic sealers as observed in in vitro and in vivo animal studies.38

Bioceramic dispersion protocols

- In order to ensure an exact shape at the apical terminus (circular or ovoid) and intimacy of fit of the bioceramic nanocoated gutta-percha cone, an .02 stainless steel file is used to refine the apical seat.
- The gutta-percha cone designed for use with bioceramic sealer is fit to working length is impregnated with bioceramic nanoparticles, mated to the taper of the prepared canal, EndoSequence BC Points (Brasseler USA, Figs. 5a & b).
- When used with anatomically dedicated files (XP-3D Shaper and Finisher (Brasseler USA), the apical seat created minimizes sealer extrusion (tug back is not required).
- Traditional compaction techniques require maximal volume of the gutta-percha core and minimal volume of sealer. Bioceramic dispersion root filling requires minimal gutta-percha and maximal sealer volume.
- 0.05 mm of the apical tip of the dedicated gutta-percha cone is removed to prevent sealer extrusion.
- The master apical file coated with sealer is used in a counter clockwise motion to deposit sealer at the apical seat.
- An aliquot of EndoSequence BC sealer is injected into the coronal and middle thirds of the root canal space using Intra Canal Tips designed for the sealer cartridge (Fig. 6).
- A lentulo spiral positioned no less than 2 to 3 mm short of the apical seat is used to flow the sealer down the tip of the spiral (slow-speed in forward mode) (Fig. 7).
- The gutta-percha cone delivers the bioceramic sealer from the coronal reservoir to the apical seat without heat or pressure; the bioceramic capillary condensation of sealer adheres to the interfacial dentine and disperses into the dentinal tubuli to develop an impervious apical and intracanal seal (Figs. 8a & b, Figs. 9a & b).
- In contrast to lateral condensation, carrier-based obturation and warm vertical condensation, the gutta-percha cone must be delivered slowly and incrementally to length. The preservation of dentine resulting from the integration of the XP-3D file system and the EndoSequence BC gutta-percha point is shown in the postoperative radiograph (Fig. 10).
- Calibrated “beds” are developed for footings or cementation of fibre posts. The fibre post (.04 taper) determines the depth of the post channel created by the instrumentation before the obturation. This drill-less method prevents additional intracanal dentinal weakening. Fibre posts with a #50 tip and .04 taper are invariably the maximum size necessary in molars and premolars. In anterior teeth, the tip size is dependent on the intracanal diameter.

Conclusion

All variables in an equation are interdependent. In the case of endodontic success, each procedural event is accountable for positive treatment outcomes; however, regardless of its importance, if a concomitant event does not provide a suitable biologic conclusion, failure ensues. Biominimalism in root canal space preparation requires a root filling material that replicates the internal anatomy of the root canal space, adheres to interfacial dentine and creates an impervious, irreversible seal at all portals of exit. The last mile of the bioceramic endodontic marathon will be to obviate the need for a gutta-percha core of any formulation.

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

about

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Post-anaesthetic necrosis of palatal bone

Drs Pamela Kassabian, Valerie Batrouni, Edgard Jabbour, Philippe Sleiman, Lebanon

Introduction

Various dental procedures demand application of local anaesthetics, which are used in modern day practice. Generally, few complications are associated with this procedure such as tissue necrosis, infections, trismus, prolonged pain, needle breakage, and paraesthesia.

The palate is a favourable site for soft tissue lesions because it has a rich blood supply via the greater and lesser palatal arteries, which play a role in wound healing and sustaining metabolism and by providing oxygen and nutrients.

Patients in need of palatal injection, may present many risk factors that should be taken into consideration, especially the ones that compromise the blood supply. Osteonecrosis usually affects the patients that are given drugs to reduce loss of bone density (osteoporosis or cancer patients) such as bisphosphonate because it is responsible of the cessation of bone remodelling and bone turnover by the basic osteoclast-inhibiting effect. Blood supply can also be compromise in diabetes patients and patients undergoing radiotherapy. Bacterial infections, fungal infections, and some viruses like herpes zoster have been associated with spontaneous necrosis of the maxilla, in fact, trauma induced by the insertion of the needle or the solution itself can lead to burning and swelling of the tissues, which could reactivate latent viruses.

Clinical case description

The patient was referred to our clinic after having a severe pain on his upper right incisor. The tooth was very mobile and a swelling was showing in the buccal area (Fig. 1). According to the available dental record, the patient received restorative treatment, ceramic crowns, 40 days before he showed up (Fig. 2). Vitality test was not accurate due to the fact that he was in pain and the tooth was very mobile. Figures 3 and 4 show the severe bone loss. In order to confirm vitality of the tooth, I decided to drill the ceramic from the palatal side, the patient reacted immediately, which meant that it was a vital tooth (Fig. 5). Radiographs confirmed bone damage from the palatal side, but also revealed that the apex was still surrounded by healthy bone.

Further investigation proved that the patient had repeated anaesthesia injections in the palatal area, which probably led to this clinical situation. A CBCT scan (Figs. 6 & 7) showed the severe bone damage from the palatal to the buccal side, as well as the area where the injection was made and the apex it is still surrounded with healthy bone.

In cases of bone necrosis, it is recommended to avoid any kind of treatment and deal with the infection to stop bone damage. Two antibiotics were recommended: Dalacin C 300 mg two daily and Metronidazole 500 mg two daily for ten days.

The patient was followed for five days later the tooth started to become more stable and the buccal swelling was going down, two weeks later the tooth become even much stable. The patient continued his mouth wash. At one-month follow up, he reported some strange things coming from his palate (Fig. 8). Under microscope
During the examination, I recognised some necrotic bone at what could be the site of the repeated injections. Carefully, several pieces of necrotic bone were removed (Fig. 9) and the area washed with chlorhexidine solution.

It took almost 45 days for the tooth to regain its normal stability. The small cavity was filled and the vitality was checked again, confirming the tooth vitality.

A six-month follow up radiograph showing the bone regain its normal (Figs. 10 & 11).

**Conclusion**

The palatal tissues are susceptible to local complications on account of their dense, firm, and adherent nature. Local tissue changes can be produced or influenced by ischemia, osmotic pressure, and pressure from injection, irritating effects of the vasoconstrictors, preservatives, and antioxidants, adventitious metal ions or trauma.

Epinephrine is usually the vasoconstrictor employed in a concentration ranging from 1/50,000 to 1/200,000, it reduces systemic toxicity and prolongs the duration of anaesthesia. The high concentration of the vasoconstrictor 1/50,000 and the repeated injections in the same area at the same appointment cause a greater risk. The vasoconstrictor stimulates the 1 receptors of the peripheral blood vessels of mucus membranes leading to ischemia and may cause a trophic ulcer at the site of injection.

Complications leading to osteonecrosis may be related to many systemic and iatrogenic factors affecting the blood supply: diabetes is associated with vascular problems, which might compromise the wound healing process. Bacterial infections that usually affect immune-compromised people, malnutrition, and poor oral hygiene may also result in ulceration, bone exposure with sequestrum formation and even tooth loss. Viral infections like herpes zoster is an acute viral infection caused by reactivation of the varicella zoster virus that resides in the dorsal root and cranial nerve ganglia. This virus can affect the innervations of the periosteum that lead to alteration of the blood flow and subsequently bone necrosis. Systemic medications like bisphosphonate cause the cessation of bone remodelling and bone turnover by the basic osteoclast-inhibiting effect of these drugs. Post-radiation osteonecrosis is associated with tissue necrosis because when a tissue is radiated, it becomes hypovascular, hypocellular, and hypoxic, knowing that the mandible is more susceptible than the maxilla because it obtains its blood supply primarily only from the inferior alveolar artery.

The treatment of osteonecrosis is centred on systemic antibiotic agents such as penicillin and metronidazole, debridement of non-vital tissues, local antibacterial rinses and improving nutrition, hygiene, and treatment of underlying diseases if present.

**Recommendations to minimise local anaesthetic complications:**
- Slow deposition of local anaesthetics without pressure,
- Knowledge of the palatal anatomy,
- Knowledge of dental anaesthetic dose and the risk of the repeated injections in the same area at the same appointment.

**Contact**

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Ceramic implant vs endodontic treatment

Dr Dr Johann Lechner, PhD, Germany

Introduction

Where are the evaluation criteria to determine the success of endodontic treatment? Why are there no additional tools to determine local painlessness versus a systemic toxicity focused approach? How can patients be convinced to get their root fillings replaced with immediate ceramic implants? In the following, scientific based arguments will be given from an author having 16 years of experience in ceramic implants. His scientific based publications are being released in international PubMed indexed medical journals and the research on this topic was published in the International Journal of General Medicine (“Stimulation of pro-inflammatory cytokines by volatile sulfur compounds in endodontically-treated teeth”, Lechner, von Baehr).

New methods to reduce risks

Researchers in the field of modern dental endodontics are well aware of the problem of bacterial colonisation in the tubules of root-filled teeth (RFT), and new methods for reducing these risks are constantly being developed. A control X-ray image is standard practice and considered to be the only method used for the diagnostic assessment of RFT. However, X-ray scans are insufficient, since chemically defined toxins cannot be visually identified. Even though X-rays of root canal treatment do not show anomalies, these areas often contain bacteria, as well as inflamed or necrotic tissue, which proves that not all periradicular inflammations can be diagnosed with the help of X-rays. Anaerobes are sulfate-reducing bacteria and are most frequently isolated from primarily and secondarily infected root canals. Persistent microorganisms in endodontically-treated teeth are the main producers of methyl mercaptan, dimethyl sulfide and diethyl sulfide (Merc/Thio). In the past, there was no process available to reliably identify RFT, using the suspected outgas of Merc/Thio produced by bacterial degradation products and biogenic amines in the form of volatile sulfur compounds (VSC). Thus, we expanded our investigation to develop an additional evaluation criterion in order to semiquantitatively determine the presence of VSC, using a volatile sulfur hydrogen compound indicator (VSHCI).

The chairside test

Hydrogen sulfide can be displayed by utilising the chairside test called OroTox. The procedure is painless and simple to perform: A nonsterile paper tip—or alternatively, a small sponge, is inserted into the sulcus of the suspected tooth. After one minute it is removed and the sample from the sulcus fluid is inserted into the volatile compound reagent container. After five minutes, the staining of the reagent is examined: The more hydrogen sulfide compounds are present in the sample, the more the indicator liquid turns yellow. The VSCI detects the elevated discharge of bacterial toxins in the sulcus of the suspected teeth, based on six gradings (0 = zero; 1 = moderate; 2 = evident; 3 = clear; 4 = strong; and 5 = extremely strong). The degree of colouration of the reagent may be used to semiquantitatively determine the amount of toxin that can be resorbed in the sulcus (Fig. 1).

The chairside test helps dentists to decide whether RFT should be viewed as critical for a patient with immunological diseases, due to a high Merc/Thio content, even if X-rays of the root tip do not indicate signs of change. We have evaluated the ex vivo immune response of peripheral blood mononuclear cells (PBMC) to VSC in 354 patients with systemic diseases. The findings correlate with semi-quantitative values of a volatile sulfur compound indicator (VSCI) applied directly to the RFT. Our data elucidate the role of VSC in patients with immunologic diseases and the role of the chairside test OroTox in correlation to IFNg and IL-10 sensitisation in PBMC. The connection between
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ex vivo-stimulated cytokines and endodontically-derived sulfur components is supported by the fact that the number of interferon gamma and/or interleukin-10 positive sensitised patients declined significantly three to eight months after the extraction of the corresponding teeth. Figure 2 shows a patient with dramatically lowered levels of IFNg and IL-10, after the exchange of RFT with high levels of VSC, with regard to the OroTox test.

Identifying disease correlations

Scientific research finds that diabetes correlates significantly with a higher prevalence of periapical radiolucencies in endodontically treated teeth. In contrast, critics of root canals believe that they may contribute to immunological diseases and consider X-ray imaging to be insufficient for the purpose of determining possible systemic effects of toxins that derive from root fillings. Apical periodontitis (AP) is a chronic inflammatory disorder of the periradicular tissues caused by bacterial invasion at the apex of the tooth root. There are epidemiologic studies proving the correlation between AP and various diseases. For example, AP is associated with increased rates of myocardial infarction (with acute coronary syndromes occurring 2.7 times more frequently in patients with such infections), as well as clinical depression, increasingly severe depression and a reduced quality of life. Moreover, AP is also associated with an increase in the translocation of gram-negative bacteria. A study on a total of 248 patients with acute myocardial infarction, as well as 249 healthy controls underlines that patients, who have experienced a myocardial infarction, had a higher risk of developing inflammatory processes—especially of endodontic origin—than healthy patients. Patients presenting lesions of endodontic origin or pulpal inflammation had an increased risk of developing a coronary heart disease. Bacterial DNA that is typical for an endodontic infection, mainly oral viridans streptococci, was measured in 78.2 % of thrombi, and periodontal pathogens were measured in 34.7 %. Dental infections and oral bacteria, especially viridans streptococci, are associated with the development of an acute coronary thrombosis. There is also a significant correlation between periodontitis and depression.

However, there is no data showing a correlation between VSC levels in the root canals of patients with AP and systemic and immunological diseases. We presented a study, which is one of the first to statistically link a group of patients to multiple systemic and immunological diseases (SyD) with endotoxin levels originating from AP (Dentistry, Volume 8, Issue 3; “Impact of Endodontically Treated Teeth on Systemic Diseases”; Lechner, von Baehr). The study indicates that endodontically treated and root-filled teeth may enhance immunological and systemic disturbances on the one hand and may be involved in the development of SyD on the other hand. Vice versa, the presence of SyD may influence, in some way, local inflammatory reactions such as AP. High local H₂S values with the reagent, as well as a high frequency of immunosensitisation to biogenic amines in patients with SyD amplify this correlation. With regard to the increasing prevalence of immune system diseases, widespread endodontic measures should be assessed more critically. For practitioners, the local measurement of VSC, using the OroTox test, draws attention to the correlation between the outcome of endodontic treatment and systemic diseases. For more than 15 years, we offer ceramic implant replacements as an alternative to RFT in order to help successfully avoiding SyD in our patients.

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

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Hi! I am Dr Anna Maria Yiannikos and I am very happy to share the 6th part of this new loved series filled with communication protocols with you. This series includes the most popular and challenging scenarios that might occur in your dental practice and presents successful ways of how to deal with them—so your patients will always leave your practice feeling satisfied and thinking: “My dentist is THE BEST!”

Each article of this series will teach you a new, easy to use specialised protocol, which can easily be customised and adapted to your own dental clinic’s requirements and needs right from day one.

Let’s start with today’s challenging topic which is... how to deal with economic crisis. If we have a look on how patients and their habits change during a depressed economic period, you will notice that your patients will:
- reduce their spending,
- set stricter priorities, and
- feel anxiety and anger regarding the near future.

But, they will still spend their money…Your goal thus is, to encourage them to have their treatments done, to offer them different services, to promote your services with a unique attitude and last but not least to maintain or even increase your income.

5 effective ideas

Yes, you can still increase your income. Are you wondering how? Discover five effective ideas on how to do so immediately.

1. Make the appropriate changes without having a panic attack
If these changes include reducing the prices of your treatments, which one will you choose? Will you reduce the price of fillings or crowns? Make the right choice based on price elasticity rules. The right answer is, to decrease the price of crowns, otherwise your revenues will reduce enormously. Do not reduce the salaries of your talented employees, but let the unproductive ones or the one who you feel is an obstacle for you and your clinic go.

2. Introduce special services
Increase the value of your treatment by introducing special package services, for example, offer laser cavity preparation with no extra charge or combine dental cleaning with fluoridation without any additional cost for the fluoridation.

3. Extend credit periods
Offer layaway plans or extend the credit periods and ask your suppliers for the same for yourself. However, remember to negotiate profitably!
4. Challenge penny-wise behaviour
If you realise, for example, that the patient could afford to have the crown done, but chooses to postpone it due to fear of the future, explain in detail what the consequences and the costs of postponing the treatment will be. Highlight the fact that the tooth might break and the cost would be tripled when treating it then instead of now.

5. Continue educating your patients
Share your knowledge with your patients through your YouTube videos or by giving VIP seminars. What is your ultimate goal? It is, to emphasise the quality and the differentiation of your services, and to clearly show that you are THE expert and that the treatments you offer your patients are so special and valuable that they need to have them, now!

Are you ready?
This is very useful insight, don’t you think? I am sure that you are looking forward to the next issue of roots magazine, where I will present the 7th part of this unique new series of communication concepts to you, teaching you how to offer VIP services for your distinguished patients. You want these patients to choose you, so,

I will share 5 revolutionary tips with you that will guarantee you this delicious outcome.

Until then, remember that you are not only the dentist of your clinic, but also the manager and the leader. For further questions and requests for more information and guidance, keep in touch by sending me an e-mail to dba@yiannikosdental.com or via our website www.dbamastership.com. I am looking forward to our next trip of business growth and educational development!

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Established in 1956 in Takanezawa (north of Tokyo), Japan, by Founder Masao Matsutani, MANI is a manufacturer and supplier of medical instruments to over 120 countries worldwide. The company is very proud of its long history of research, innovation, and manufacturing quality. Its singular goal is “Contributing to people's happiness in the world through developing, manufacturing, and delivering the product that can help doctors and patients”. In addition, the company strives to improve the quality of people’s lives by providing “The Best Quality in the World, to the World”. More than a slogan, this is MANI’s passion at every level.

MANI has a storied history. Highlights among many innovations since the company began include producing the world’s first “18-8” stainless steel surgical needle in 1961. In 1991, MANI introduced the world’s smallest drilled eyeless needle (27µm) for trial and developed a skin stapler for medical use in the same year. In 2013, MANI developed state-of-the-art metal skeletons for stent grafts. To date, the company holds 310 patents (including 221 non-Japanese patents) and has 148 patents pending (including 126 non-Japanese patents). MANI meets and exceeds the highest manufacturing and quality assurance standards and is ISO 13485, and MDD 93/42/EEC (CE Marking—EC Medical Device) certified, among other certifications.

A truly global company, the surgical, ophthalmic, eyeless (needles), and dental divisions of MANI have consolidated subsidiaries in Vietnam, Myanmar, Laos, the People’s Republic of China and Germany. MANI has been traded on the First Section of the Tokyo Stock Exchange since 2012. MANI dental products are sold and represented worldwide through a group of carefully chosen dealers selected for their clinical and product knowledge.

And finally, the MANI team is a company made up of individuals dedicated to a common goal: helping to improve the quality of people’s lives globally. Regardless of the country in which they work, MANI employees are selected for their honesty, manual dexterity, and desire for continuous improvement. Such crucial personal qualities ensure that both MANI’s labour and product quality are of the highest standard.

Given the company’s proud history and constant effort to improve our products, MANI can truly and humbly say from its hands to yours, “The Best Quality in the World, to the World”.

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VDW celebrates its 150th anniversary

VDW celebrates its 150th birthday and looks back on one and a half centuries of expertise in developing innovative products for root canal treatment. Since its founding in 1869, the company has grown into one of the leading brands in this field. With passion for endodontics, VDW is dedicated to offering comprehensive endodontic care and improving tooth preservation globally.

Founded in Munich in 1869, VDW was a pioneer in laying the foundations of root canal therapy. An important milestone was marked in 1972 when the three German companies—ANTÆOS, BEUTELROCK and ZIPPERER—merged to Vereinigte Dentalwerke, abbreviated as VDW.

A quick expansion of its global market position and pioneering product innovations paved the way for further growth—the company became one of the leading endodontic brands worldwide.

Today, the VDW headquarters and high-tech production facilities are still based in Munich and are delivering over 200 products to more than 80 countries worldwide. VDW provides an Endo-System throughout all treatment steps with products and services linked to one another, enabling dentists to benefit even more from VDW’s profound endodontic expertise.

“For 150 years now, we have been setting standards for modern endodontics with our dedication to quality, precision and innovation”, says Sonja Corinna Ludwig, Director Global Sales and General Manager. “We stand for Endo Easy Efficient and I am convinced that this commitment will lead the company into a successful future.”

With the motto “Join our ride”, VDW invites all partners, employees and customers to celebrate its 150th birthday at IDS 2019 at Booth B050 in Hall 10.1.

VDW • www.vdw-dental.com/150years
Highly innovative and quality products

Meet Meta Biomed at IDS 2019

Since its establishment in 1990, Korean medical technology company Meta Biomed has been recognised as a leading innovator in endodontics and restorative dentistry. After establishing its European headquarters in Mülheim, Germany, in 2016, the company has become a formidable force on the continent and has continued to grow. The 2019 International Dental Show (IDS), to be held in Cologne, Germany, from 12 to 16 March, will see the company launch a range of new endodontic and restorative dentistry products, specially designed with the dental professional in mind.

A focus on innovation

Meta Biomed is known for its emphasis on research and development, which has led to its highly innovative and quality products being available at reasonable prices. Its portfolio of endodontic products is said to grow with a never-seen-before diagnostic device that will premiere at IDS 2019, along with numerous new products. In addition, customers looking for a bioceramic root canal sealer are promised to find their needs met in the near future.

An enhanced restorative portfolio

Essentially, endodontics and restorative dentistry share the common goal of saving the natural tooth. With the expansion of Meta Biomed’s endodontic line, it makes sense that the company’s range of restorative dentistry solutions will expand thanks to the launch of an entirely new product portfolio that aims to meet this goal. At IDS 2019, the company will introduce three new products that are intended for the global market and are currently undergoing intense testing. By doing so, the company is increasing its efforts to gain a stronger foothold in the large restorative dentistry market.

Education: A key success factor

The speed at which dental technology advances is faster than ever before, which is why Meta Biomed will be offering a variety of educational programmes before and around IDS 2019. For example, it will have several slots at the show’s popular Speakers Corner—the pre-

Connect with Meta Biomed at IDS 2019

Although the company has branches and sales representatives in Korea, Europe, China, Japan, Vietnam and the United States; Meta Biomed is looking to expand its global network of dental distributors. To find out more about how you can collaborate with this pioneer in the dental industry, contact them at www.meta-biomed.com.

Meta Biomed will be exhibiting at IDS 2019 and welcomes all attendees to visit them at Booth B060 in Hall 11.1 to experience their high-performing products first-hand or to talk to a friendly company representative.

Meta Biomed • www.meta-biomed.com
Kohler Medizintechnik of Stockach in Germany has introduced updated and enhanced versions of the Lee MTA Pellet Forming Block and Lee MTA Carver. Although the Lee MTA Block has been available in the dental marketplace for several years, the Kohler version has several improvements. Following the recommendations of a number of European endodontists, Kohler has added two larger grooves (1.2 mm) to the block to allow for the dispensing of a larger volume of MTA. Also, each of the grooves now has laser-marked measurements (0.6 mm, 0.8 mm, 1.0 mm and 1.2 mm). This makes the block much easier to read and use.

The new ENDOBLACK Lee MTA Carver is much more ergonomic than any version from other companies. It has a larger, more light-weight black PEEK handle (weighing only 12 g). It also has the Kohler ENDOBLACK surface to provide for better visibility during use, as well as greatly reduced reflected light during procedures.

Combined, these two products are superior to older syringe or carrier devices, which have problems with too-large cannula sizes, excessive quantities of MTA being delivered, difficulty in delivery of MTA to some areas of the mouth, and clogging of and damage to those devices.

Kohdent Roland Kohler Medizintechnik • www.kohler-medizintechnik.de

Especially for the orthograde revision of an endodontic treatment, guttapercha removers according to Dr Yoshi Terauchi are very suitable. The instruments have been proven for years in their daily clinical use, yet there is nothing that cannot be made even better. Thus, manufacturer Kohler and Dr Terauchi have modernised the removers. Now, micro-hooks boasting outstanding tensile strength and stability on the fine working ends ensure firm hooking into the guttapercha, and these are produced to the utmost precision.

The new handles are made of PEEK, a shape- and colour-stable high-performance plastic, and are extremely light, each instrument weighing only 12 g. Furthermore, the black surface of the handles reduces light reflection under magnification. The handle design combines the advantages of simple cleaning and sterilization with outstanding grip.

The guttapercha removers are available in four versions, adapted to different clinical situations: with working ends of 30 mm or 18 mm in length, and hooks to the left or right or the top or bottom.

Kohdent Roland Kohler Medizintechnik • www.kohler-medizintechnik.de
Sign up to the finest e-read in dentistry
Last summer, the world of endodontics met in the German capital of Berlin for ROOTS SUMMIT 2018, which proved an overall successful for everyone involved. Seeking to expand on that accomplishment, the ROOTS SUMMIT team has started working on securing the next venue for its 2020 edition, which is going to be held in the Czech Republic. The event is again being organised in cooperation with Dental Tribune International.

On 1 July at the ROOTS SUMMIT 2018 closing ceremony, at which the three ROOTS SUMMIT founders, Stephen Jones and Drs David Jaramillo and Freddy Béliard, spoke, the announcement was made that the event would move to Prague in two years’ time. Only a few days later, Jones has confirmed that ROOTS SUMMIT 2020 will be held at the Cubex Centre Praha—a just-opened event venue in the heart of the city with over 3,700 m² of exhibition space—from 21 to 24 May.

He said, “If there is a location that could exceed the success had at ROOTS SUMMIT Berlin 2018, it would definitely be Prague. We chose Prague, as it is centrally located and quite economical to visit. The ease of getting there from the countries where a significant number of our attendees of the last two ROOTS SUMMITs joined us from, as well as our relationship with the local endodontic association, and the proximity to our partners at Dental Tribune International will also ensure that the meeting is up to the standards we have set.”

Jones continued that the final details on the programme were being worked out and attendees could expect the same high scientific level that has characterised past ROOTS SUMMITs, with more of a focus on post-endodontic restorative techniques.

“We look forward to having you with us and to sharing a great weekend of impartial scientific and clinical endodontics, and some very good times,” Jones concluded. To ensure inclusion and broad coverage of endodontic experiences, the ROOTS SUMMIT 2020 organisers are extending a sincere invitation to attend to everyone who has an interest in the specialty. Those interested in the event can find the most up-to-date information on the ROOTS SUMMIT Facebook page. More details about the 2020 programme will soon be available on www.roots-summit.com.

ERRATUM

We hereby inform you that we have noticed a text error in roots, issn 2193-4673, Vol.14, Issue 3/2018 which we would like to correct as follows:

Article: Has the enigma of the single instrument been solved? by Dr Guillaume Jouanny, page 42

The following sentences should be replaced with:

Using a vertical reciprocating motion → using up-and-down movements
A reciprocating motion → an up-and-down motion
Reciprocating movements → up-and-down movements

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Cologne, Germany
www.ids-cologne.de

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10–13 April 2019
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www.aae.org

**KRKDENT**
11–13 April 2019
Krakow, Poland
www.krakdent.pl

**Dental Salon**
22–25 April 2019
Moscow, Russia
www.dental-expo.com/dental-salon

**APDC & SIDEX**
8–12 May 2019
Seoul, Korea
www.apdc2019.org

**Digital Esthetics**
The 16th SSER International Congress of Esthetic Dentistry
9–11 May 2019
Bucharest, Romania
www.sser.ro

**Expodental**
16–18 May 2019
Rimini, Italy
www.expodental.it

**British Dental Conference & Dentistry Show**
17–18 May 2019
Birmingham, UK
www.thedentistryshow.co.uk

**Sino Dental**
9–12 June 2019
Beijing, China
www.sinodent.com.cn/en

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16–21 September 2019
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www.aaoms.org
ROOTS SUMMIT

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www.ROOTS-SUMMIT.com
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- the complete list of sources consulted and
- the author or contact information (biographical sketch, mailing address, e-mail address, etc.).

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Text length

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.

In short, we do not want to limit you in terms of article length, so please use the word count above as a general guideline and if you have specific questions, please do not hesitate to contact us.

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We also ask that you forego any special formatting beyond the use of italics and boldface. If you would like to emphasize certain words within the text, please only use italics (do not use underlining or a larger font size). Boldface is reserved for article headers. Please do not use underlining.

Please use single spacing and make sure that the text is left justified. Please do not centre text on the page. Do not indent paragraphs, rather place a blank line between paragraphs. Please do not add tab stops.

Should you require a special layout, please let the word processing programme you are using help you do this formatting automatically. Similarly, should you need to make a list, or add footnotes or endnotes, please let the word processing programme do it for you automatically. There are menus in every programme that will enable you to do so. The fact is that no matter how carefully done, errors can creep in when you try to number footnotes yourself.

Any formatting contrary to stated above will require us to remove such formatting before layout, which is very time-consuming. Please consider this when formatting your document.

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Please place image references in your article wherever they are appropriate, whether in the middle or at the end of a sentence. If you do not directly refer to the image, place the reference at the end of the sentence to which it relates enclosed within brackets and before the period.

In addition, please note:

- We require images in TIF or JPEG format.
- These images must be no smaller than 6 x 6 cm in size at 300 DPI.
- These image files must be no smaller than 80 KB in size (or they will print the size of a postage stamp!).

Larger image files are always better, and those approximately the size of 1 MB are best. Thus, do not size large image files down to meet our requirements but send us the largest files available. (The larger the starting image is in terms of bytes, the more leeway the designer has for resizing the image in order to fill up more space should there be room available.)

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