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Magda Wojtkiewicz

Managing Editor

Modern endodontics: What is next?

In the field of endodontics, as in many other fields of dentistry, developments in science and research have enabled dental professionals to succeed in diagnosis, treatment planning and treatment. The future of dentistry and endodontics is facing a change curve. Change is the only constant in the future, and those who adapt well and embrace innovation can succeed. Technological advancements make complex procedures easier and more successful, but demand new approaches and changes in the perception of root canal therapy.

Endodontics has experienced major changes. Firstly, the rapid spread of information and technology has transformed endodontics forever in the best possible way. Such a transformation has made endodontic procedures safer, easier and more predictable and thus less stressful for the patient and dentist. Secondly, endodontics has been incorporated into an interdisciplinary approach to dentistry. As endodontic treatment has become more predictable, more dental professionals have taken it into consideration in preparing complex treatment plans. Thirdly, increased longevity means that patients want to keep their own teeth for as long as possible, enjoy good health and have quality of life. Fourthly, the success rate and predictability of endodontic treatment have made it serious competition for implant treatment.

These changes have started a new era in endodontics, one in which root canal therapy is no longer regarded as a risky procedure with unpredictable results. New, innovative root canal therapy methods have now replaced conventional procedures, being safer and giving long-lasting results. Cone beam computed tomography, nickel–titanium files, apex locators, irrigation and microscopes are only some new technologies which have changed completely the way dentists perform root canal therapy.

The complexity of root canal systems is still a challenge for the newer and more advanced technologies to solve. The rapid developments in science and technology promise a bright future for root canal therapy. Advancements in 3D printing, microscopic equipment and sonic frequencies can benefit root canal procedures immensely.

Magda Wojtkiewicz
Managing Editor


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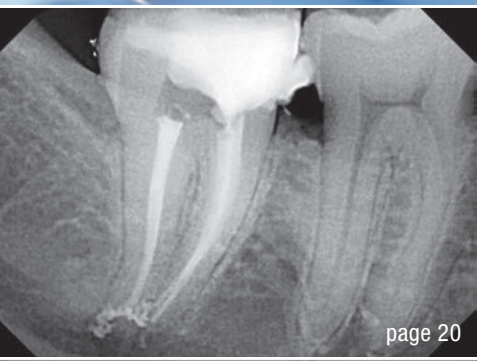
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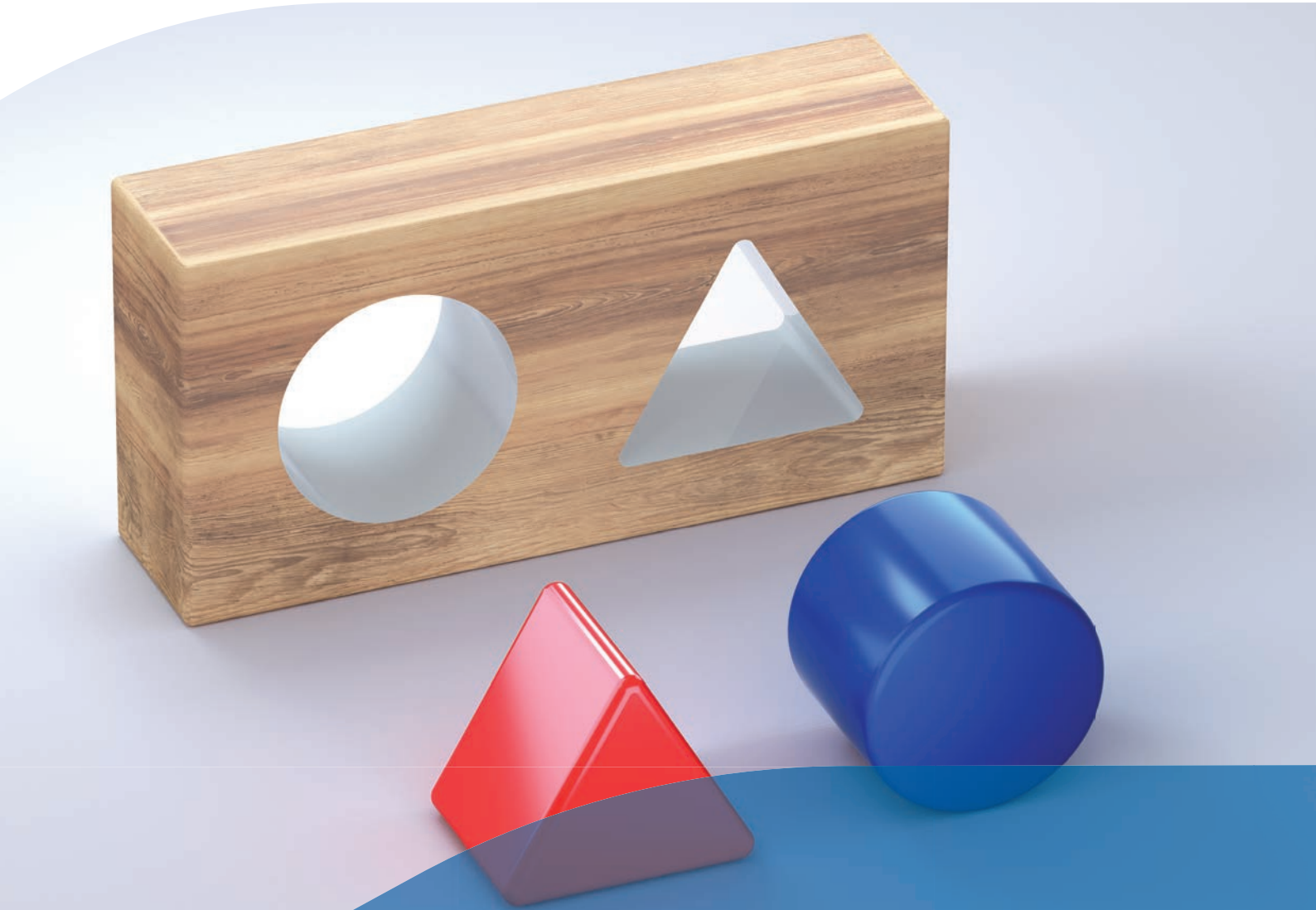

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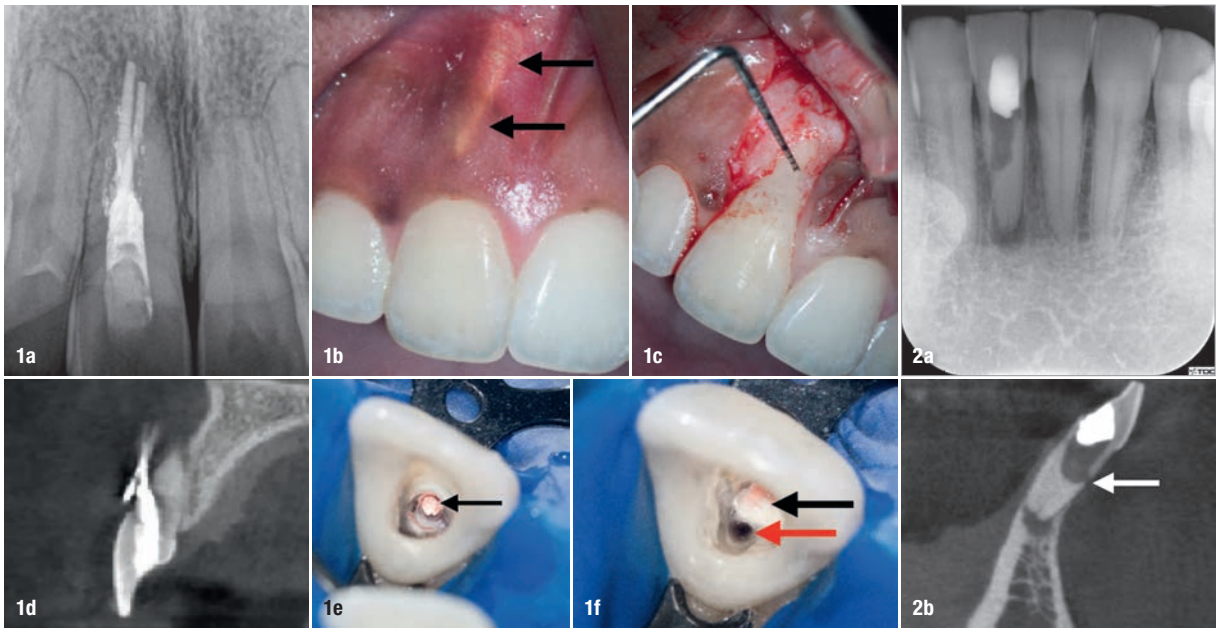
Armamentarium for dentine conservation during endo treatment

Drs Bobby Nadeau, Viraj Vora & Dale Jung, Canada & USA



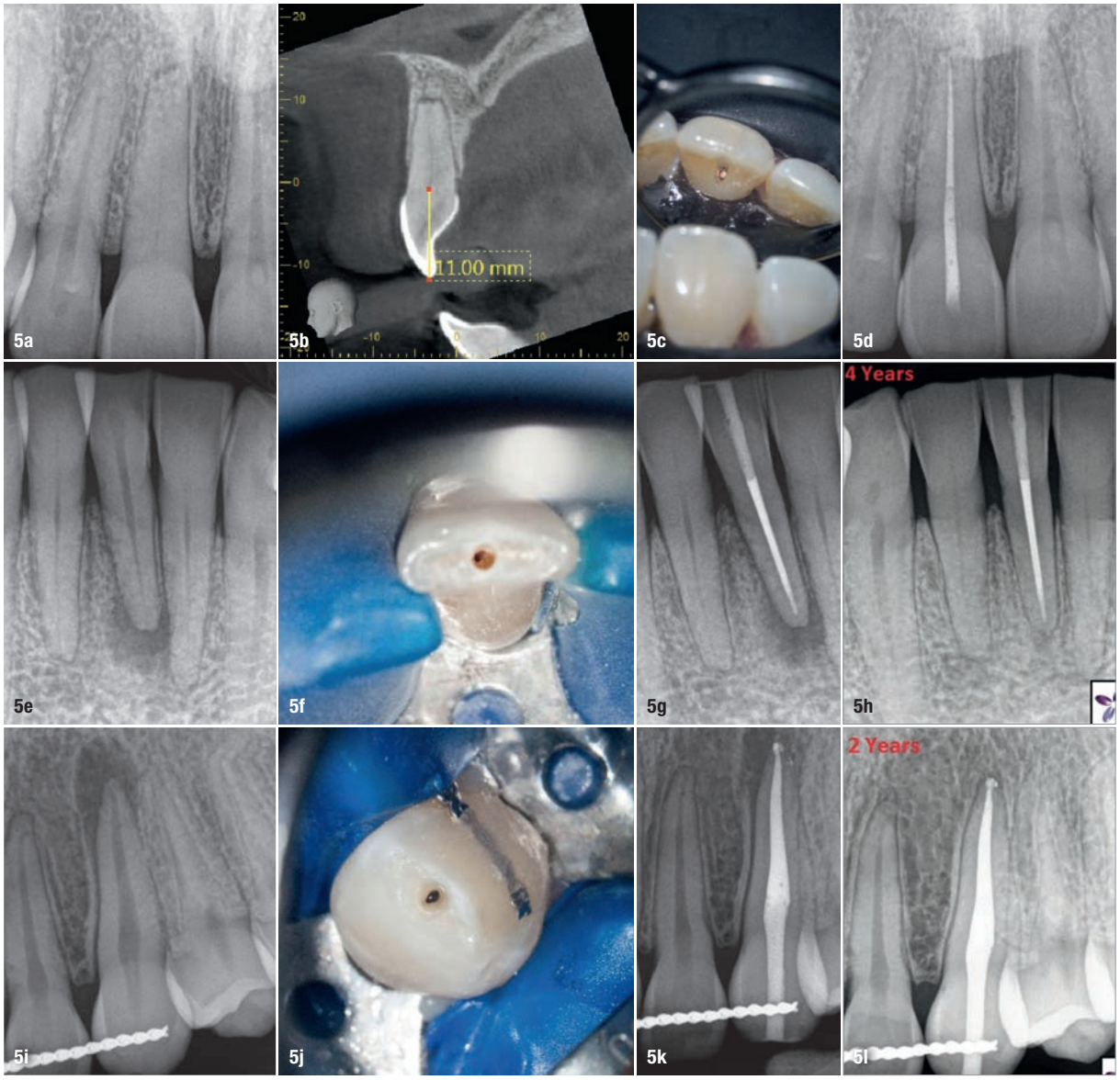
Figs. 1a–f: Cingulum access using round burs promotes facial gouging and perforation **(a)**. Gutta-percha showing under soft tissue **(b)**. Perforation confirmed clinically **(c)**. Pre-op sagittal slice showing facial perforation. Facial perforation (black arrow; **e**). True canal (red arrow; **f**). **Figs. 2a & b:** Cingulum access using round burs promotes violation of the peri-cervical dentine, an inverse funnel effect and perforation (white arrow).

Introduction

"Primum non nocere" [first do no harm]—Hippocrates

In today's society, as life expectancy increases, patients expect their teeth to last a lifetime, healthy dentition being important for a good quality of life.[1–4] Endodontic therapy is usually the last resort for retaining natural teeth, and teeth requiring root canal therapy are often structurally compromised owing to caries and cracks. Minimally invasive surgical techniques have been utilised in medicine for many years;[5] however, their adoption in dentistry has been much slower. As newer technologies emerge and develop, minimally invasive approaches have become possible today in endodontics while still adhering to biological principles of treatment. As clinicians, in order to provide a high quality of care, we all want to know what the best currently available evidence is.

Figs. 3a & b: In cases with attrition, the access is created in the middle of the incisal edge. Dental dam isolation that includes some adjacent teeth can help the clinician to visualise the angulation of the root to be treated. (Case treated by Dr Bobby Nadeau) **Fig. 4:** Conical carbide burs such as the EndoGuide bur (SS White Dental; left) have a tip less than half that of the corresponding round bur (right).

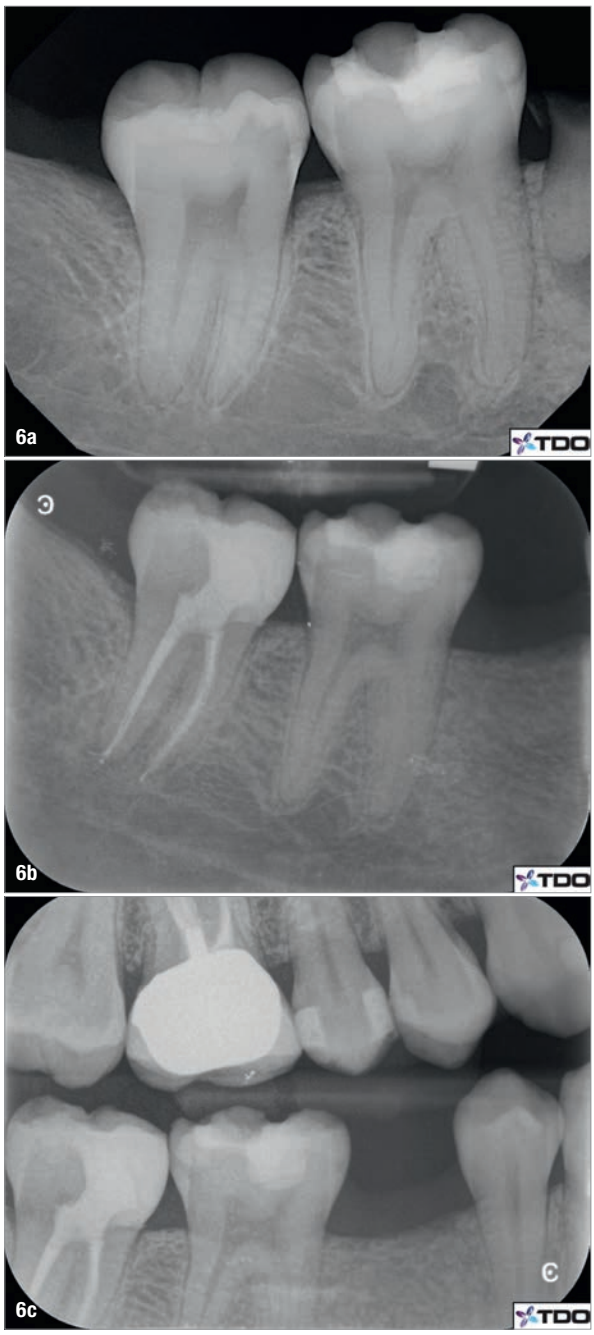


Figs. 5a–l: Incisal access allows for maximum peri-cervical dentine preservation. CBCT can be used for access cavity planning in calcified cases **(a–d)**. All cases are immediately restored at the time of obturation. Four-year **(e–h)** and two-year **(i–l)** follow-ups showing complete radiographic healing. Both teeth were asymptomatic and functional. (Cases treated by Dr Viraj Vora)

The quality of the evidence for the long-term effectiveness of the mechanical objectives of endodontic therapy is weak, and thus treatment protocols are highly variable among clinicians and often the treatment approaches that are the most expedient prevail. Traditional objectives have been focused on maximising the visual field of access cavity preparation and preparing canals to certain dimensions to facilitate a certain appearance of the radiographic obturation, which is used as a proxy for cleanliness of the canal systems.[6,7] The long-term survival of endodontically treated teeth (ETT) has been investigated through epidemiology.[8–16] These studies suggest that maintaining dentine and achieving appropriate restorative management during endodontic procedures are two of the most critical factors for tooth survival and longevity, which is really what our patients desire. Minimally invasive endodontics stem from the restorative requirements for ETT to survive in the long term. Some approaches to achieving adequate immediate restoration of ETT were described in our previous article.[17] The current article discusses the armamentarium available to the clinician to maintain residual dentinal structure during endodontic therapy without compromising root canal disinfection and obturation. The two main opportunities for maintaining dentinal structure present to the clinician during access cavity preparation and root canal instrumentation.

Armamentarium for conservative access cavity preparation

Access cavity preparation is defined as the removal of a coronal portion of the pulp complex to facilitate canal location and debridement.[18] Despite the lack of compelling clinical



Figs. 6a–c: Example of caries-leveraged access design **(a)**. The tooth was immediately restored at the time of obturation **(b & c)**. (Case treated by Dr Dale Jung)

evidence, a set of rules for endodontic access, established at a time when the endodontic armamentarium had significant limitations, continue to be promoted today to achieve endodontic success while decreasing procedural time and difficulty. These rules include complete unroofing of the pulp chamber and complete visualisation of the pulp chamber floor, wall-to-floor junctions and canal orifices with one view.[18] This concept of straight-line access was meant to provide the clinician with convenience, at a time when high magnification and illumination, flexible heat-treated nickel–titanium (NiTi) instruments and cone beam computed tomography (CBCT) were not available. With the advent of these new technologies, instead of prescribing a one-size-fits-all access cavity design, it is now possible to customise the access based on the tooth's particular presentation, in order to maintain as much healthy dentine as possible and achieve the best possible outcome for our patients.

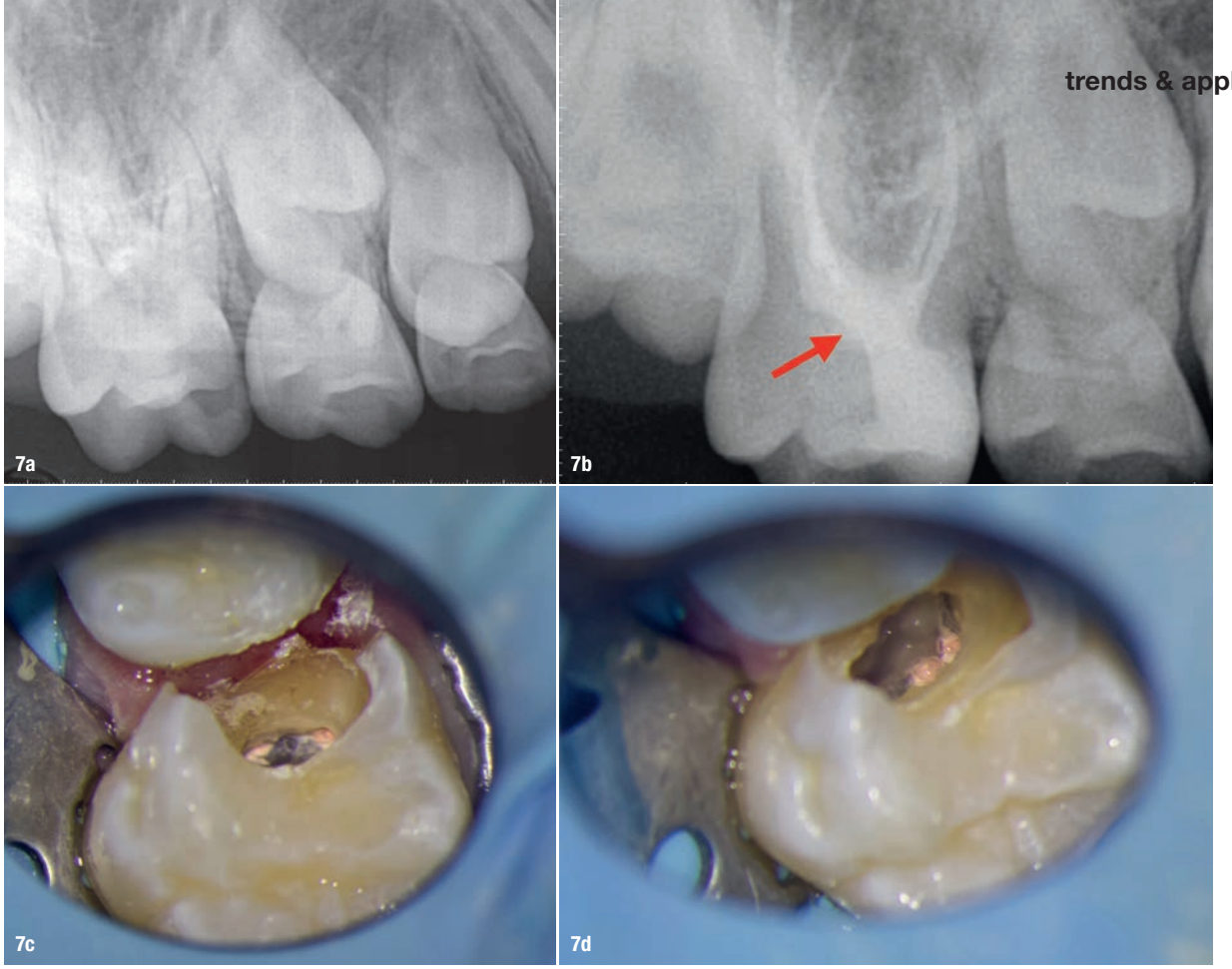
Access cavity design in anterior teeth

Traditional access cavity design in anterior teeth involved entry on the lingual or palatal surface using a round bur, through the cingulum (cingulum access), complete lingual shoulder removal and full pulp horn unroofing, leading to a triangular access outline form.[7] This approach was chosen to favour the aesthetic demand; however, unnecessary internal dentine removal, facial gouging, perforation and weakening of the tooth at a critical location (peri-cervical dentine) often occurs (Figs. 1a–f & 2a & b).[19] As mentioned in our previous article, peri-cervical dentine (PCD) is the dentine located 4 mm coronal and 6 mm apical to crestal bone. It has been proposed that PCD plays a crucial role in transferring occlusal forces along the root and that maintaining intact PCD is arguably the single most important factor in achieving long-term retention of ETT.[20] Cingulum access, owing to the initial orientation of the bur angulated towards the facial surface of the tooth, can also increase the risk of facial perforation. Two previously published articles in the endodontic literature suggesting a more incisal approach for anterior endodontic access have recently been revisited.[21,22] The new model for anterior access involves moving the entry point away from the cingulum and towards the incisal edge.[19] This allows for the preservation of PCD, the least amount of dentine removal, the straightest path to both the facial and lingual/palatal canals, and better canal debridement compared with cingulum access.[21] In cases in which there is attrition, the access is initiated in the middle of the incisal edge (Figs. 3a & b). Bur selection is also critical for anterior access. Round burs, which have traditionally been recommended for endodontic access, are contra-indicated. The inherent shape of a round bur creates an inverse funnel, in that the size of the access cavity becomes wider as the bur progresses deeper (Figs. 2a & b).[23] Using a bur that minimises gouging and maintains the narrowest part of the access cavity preparation near the PCD is recommended (Fig. 4).[19] This approach maintains as much PCD as possible as the PCD is an area under severe tensile forces when the anterior tooth is in function (Figs. 5a–l).[24] Additionally, data from a CBCT scan, if indicated, can help the clinician visualise the coronal projection of the canal and plan the exact entry point in order to achieve straight-line access (Figs. 5a–l). Dental dam isolation that includes some adjacent teeth can help the clinician to visualise the angulation of the roots (Figs. 3a & b).

Access cavity designs in posterior teeth

Restorative- and caries-leveraged access

Tooth structures of no value, as described by Clark and Khademi, include tertiary dentine, undermined enamel,



Figs. 7a–d: Caries-directed mesialised access **(a)**. The soffit was preserved for added strength (red arrow; **b**). Straight-line access to the two mesiobuccal orifices **(c)** and two distobuccal orifices **(d)** was achieved. The tooth was immediately restored at the time of obturation. (Case treated by Dr Bobby Nadeau)

caries and restorations.[23] These areas should therefore be leveraged during access cavity preparation (Figs. 6a–c). The premise of classic endodontic access is to gain straight-line access into the root canal systems usually through all coronal structures or dental materials, whereas carefully removing materials of no value (leveraging) allows for better visualisation and greater volume of residual dentine, which is the foundation for fracture resistance and long-term retention of ETT.[25,26]

Leveraged access designs often lead to the preservation of the soffit. The soffit consists of undermined dentine at the level of the pulp chamber roof, and this is thought to provide additional strength (Figs. 7a–d).[20] Advancements in dental materials include modern flexible martensitic heat-treated NiTi rotary files with regressive taper that can be prebent (Fig. 8), high magnification and illumination, and smaller burs allowing access to canal orifices even in the absence of true straight-line access. Data from 2D and 3D (CBCT) radiography can also be utilised to approximate the depth of the pulp chamber and design the access cavity. Figures 7a–d and 9a–j are examples of caries-/restorative-leveraged mesialised/distalised access designs. Buccally and lingually located structures that can be leveraged can also dictate the access entry point (Figs. 10a–f & 11a–f).

Stepped access

The stepped access cavity design can be used in both anterior and posterior teeth. It is the design of choice for most access cavities through indirect restorations like crowns and onlays. It involves cutting a larger outline in restorative materials down to the level at which dentine is encountered (Figs. 12a–e & 13a–d).[23] The clinician can then assess the location and angulation of the entry point to the pulp chamber based on its anticipated location and dentine colour map. The stepped access can also leverage direct restorative materials, leading to an unobstructed path to dentine, which facilitates conservative access to the pulp chamber (Figs. 14a–f & 15a–f).

Fig. 8: Modern flexible martensitic heat-treated NiTi rotary files can be prebent for easier insertion in contracted access cavities and for predicable root canal negotiation. The DC Taper rotary file system (SS White Dental) is an example of rotary files with regressive taper.

Truss access

The truss access exemplifies the orifice-directed access approach. The truss access is best indicated when there is mesial and/or distal caries or a proximal restoration. In mandibular molars with minimal canal convergence and a wide platform at the level of the pulpal floor, the truss access is the access of choice in order to achieve a straight-line path to the canals while maintaining maximal residual dentine. This preserved dentinal structure arguably helps to resist tensile and compressive forces by bracing the lingual and buccal dentine walls (Figs. 16a–d). This type of access should be carefully planned using 2D radiography (adequately angled bitewing radiograph) and CBCT if indicated. Because distal canals of mandibular molars usually project towards the mesial aspect and are the larger canals, it is usually recommended to gain access to the distal canal orifices first (Figs. 17a–f). The presence of restorative material can guide the clinician to the pulp chamber or canal orifice. Once the distal canal orifices have been located, based on preoperative radiographic data, the distance from the distal canal orifices to the mesial canal orifices can be calculated. This distance can be transferred clinically using a periodontal probe to locate the entry point to the mesial canals. This type of access requires acquired skills and can have the potential to create additional damage if not executed properly. Misdirection or the use of round burs can lead to iatrogenic errors and unnecessary gouging. Thus, proper case selection and the proper armamentarium, including adequate preoperative radiographs and tapered burs, are required. By using bent endodontic hand files or ultrasonic tips and by activating the irrigating solutions, disinfection of the pulp chamber is not compromised (Figs. 18a & b).

Figs. 9a–j: Examples of mesialised and distalised caries-/restorative-leveraged access designs **(a–f)**. The teeth were immediately restored at the time of obturation. The one-year follow-up showed radiographic healing despite the conservative instrumentation and maintenance of over half of the pulp chamber roof **(g–j)**. (Cases treated by Dr Viraj Vora)

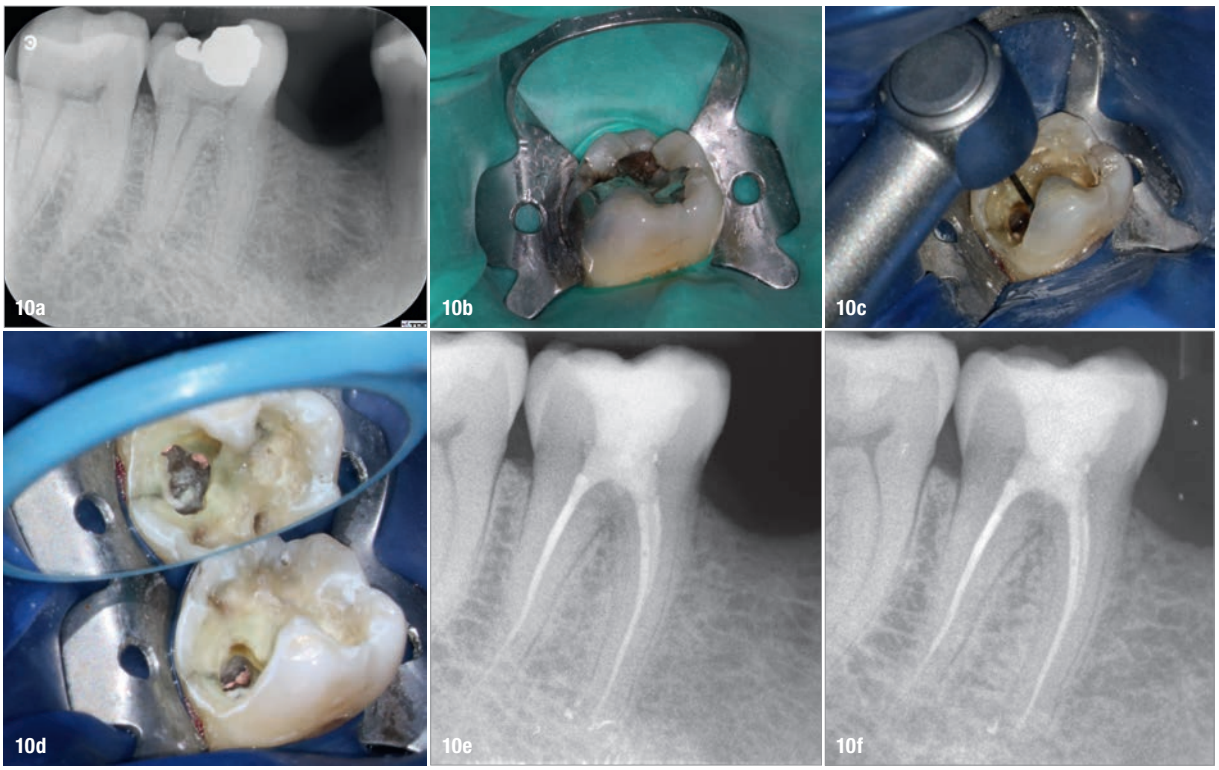
Access design for the minimally restored or non-restored posterior tooth

As a general rule, for mandibular and maxillary molars, the most coronal portion of the pulp chamber is usually the mesiobuccal pulp horn, and this can sometimes be confirmed by a preoperative bitewing radiograph (in the absence of radiopaque coronal restoration). Therefore, the clinician should consider penetrating the pulp chamber by aiming at the expected location of the mesiobuccal pulp horn or canal orifice. Access can subsequently be extended as needed, to locate all canal orifices. Additionally, owing to the anatomy of most molars, the straight-line access to the distal canals (in mandibular molars) and to the distobuccal and palatal canals (in maxillary molars) inherently projects coronally to the mesial aspect.[23] Therefore, full unroofing of the distal portion of the pulp chamber is not necessary to gain straight-line access to these canals, as this can lead to unnecessary gouging of dentine and weakening of PCD. Owing to these factors, a conservative access in these teeth may have a slight mesial tilt (Figs. 19a–h).

Furthermore, the law of centrality states that the pulp chamber is located at the centre of the tooth, and the root canal is located at the centre of the root at the cementoenamel junction level.[27] Based on this, access design in virgin or minimally restored premolars will often be centralised (Figs. 20a–g). Preoperative probing can help determine the outline of the expected canal orifice location of any tooth type at the level of the cementoenamel junction.

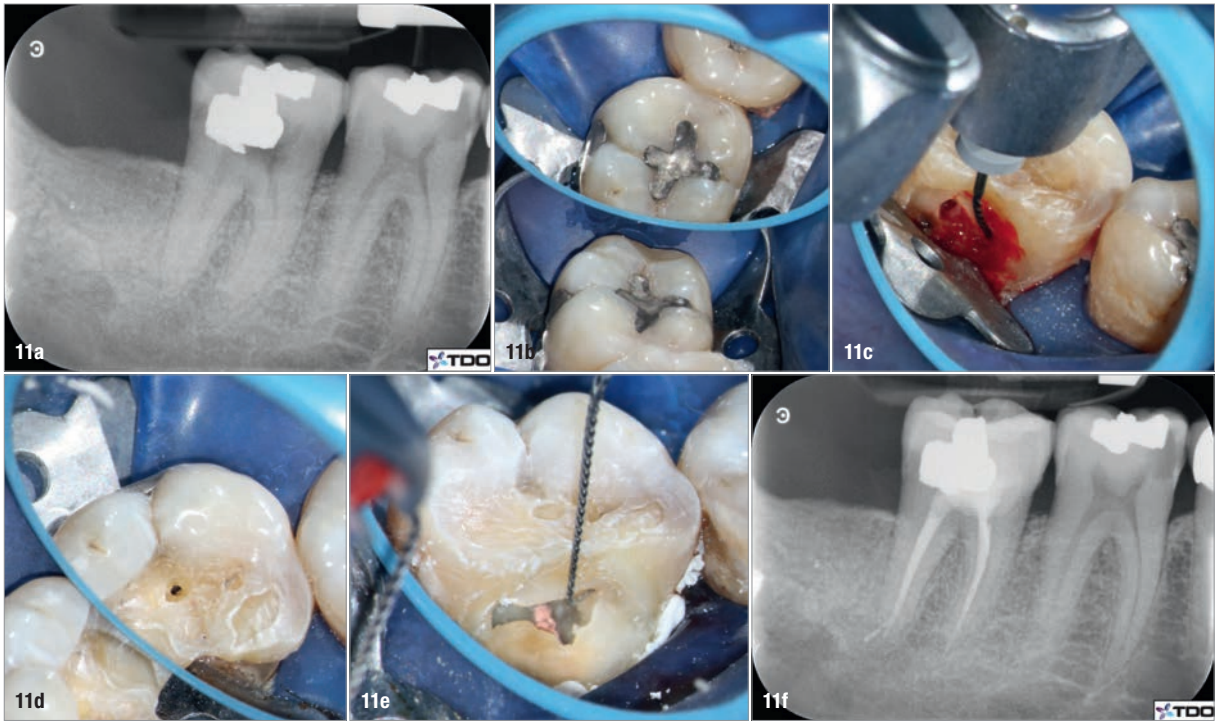
Armamentarium for conservative root canal instrumentation

For many years, the purpose of root canal instrumentation has been based on concepts from the 1970s and centred around the mechanical objectives that would “ensure the

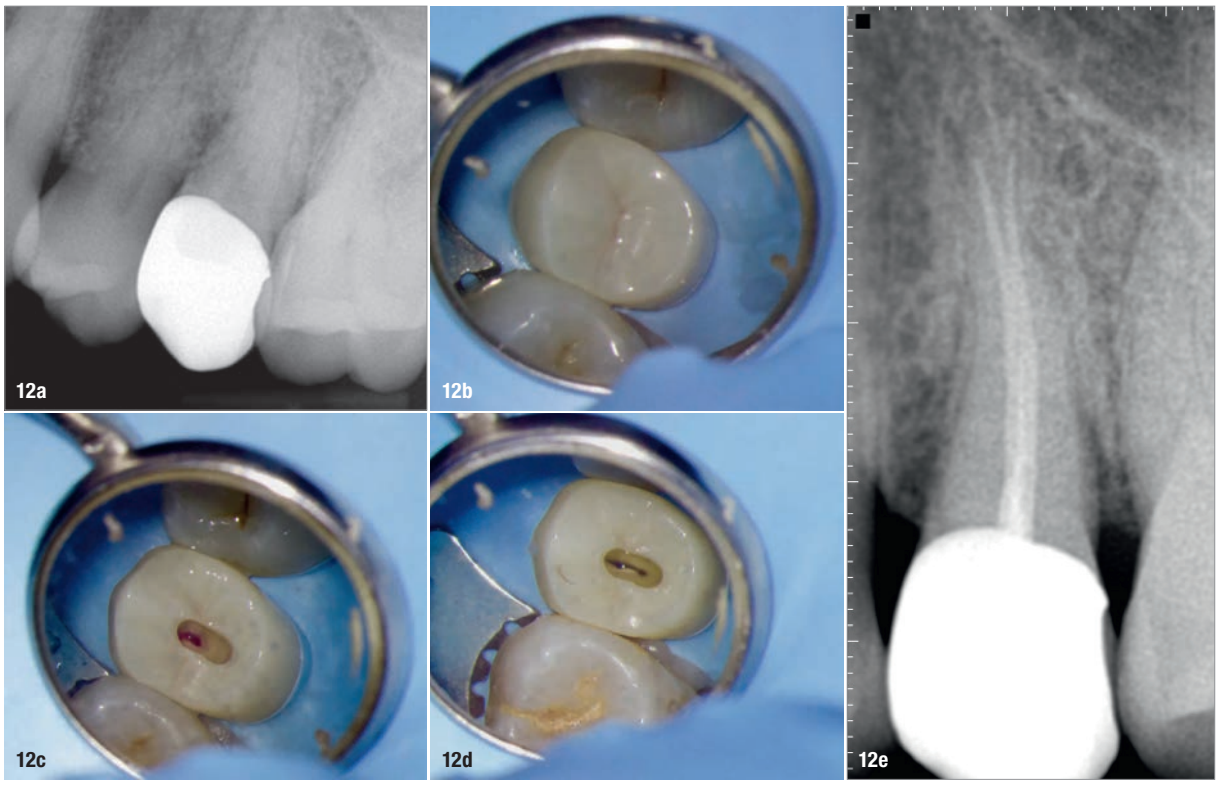


Figs. 10a–f: Initial situation **(a)**. The restorative material **(b)** was leveraged, leading to a buccally positioned access cavity **(c & d)**. Radiograph of the tooth, which was immediately restored at the time of obturation. **(e)**. The one-year follow-up showed radiographic healing, and the patient was asymptomatic and functional **(f)**. (Case treated by Dr Dale Jung)

biological goals for long-term success".[6,28] The focus of such objectives was to create a canal preparation with a diameter that increases coronally and decreases apically. Based on these objectives, an apical size and taper of at least 25/.08 has been recommended in order to allow for deep exchange of irrigating solutions and resistance form



Figs. 11a–f: Initial situation: radiograph **(a)**; intra-oral **(b)**. The carious lesion was leveraged, leading to a lingually positioned access cavity **(c)**. A separate access hole was created on the occlusal surface to gain access to the buccal canals **(d)**. A bent instrument was used to clean under the pulpal roof **(e)**. Radiograph of the tooth, which was immediately restored at the time of obturation **(f)**. (Case treated by Dr Dale Jung)



Figs. 12a–e: Stepped access in a maxillary premolar with a crown **(a & b)**. A larger access outline was cut in the crown material down to the dentine **(c)**. The buccal canal was accessed, and the preparation was slightly extended to include the palatal canal **(c & d)**. Radiograph of the tooth, which was immediately restored at the time of obturation **(e)**. (Case treated by Dr Bobby Nadeau)

Figs. 13a–d: Stepped access: a larger access outline was cut into the crown material until the dentine was reached. The pulp was penetrated conservatively based on its anticipated location **(a–c)**. Radiograph of the tooth, which was immediately restored at the time of obturation **(d)**. (Case treated by Dr Dale Jung)

for 3D obturation.[29] This approach is based on the theory that deep exchange of irrigating solution and deep compaction of thermally softened gutta-percha lead to enhanced disinfection and allow for obturation with a fluid-tight seal, which in turn leads to successful treatment.[30] These procedural clinical end points are surrogate measures that have weak correlations to a clinical outcome of interest to our patients. Surrogate measures are specific dependent variables used to evaluate treatment effectiveness and facilitate investigation in cases in which the actual clinical outcome of interest cannot be evaluated. The use of surrogate measures often generalises findings and omits to capture individual patient factors. Furthermore, the mechanical objectives mentioned also served as a solution to the instrument limitations at the time: stiff stainless-steel hand files, large hand pluggers, and a lack of magnification and illumination.

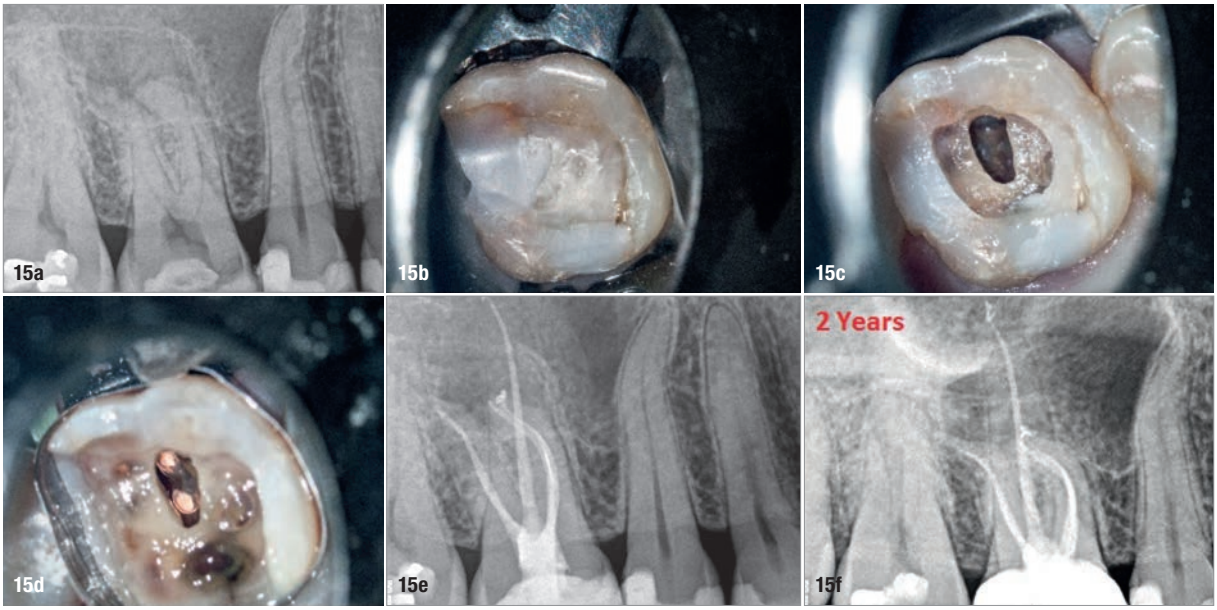
It is now increasingly evident that attempting to fulfil those mechanical objectives may in fact decrease the survival rate of ETT by contributing to structural failure associated with excessive root dentine removal.[31] Both traditional shaping techniques and contemporary conservative canal instrumentation approaches lack the high level of evidence needed to confirm their superiority over one another, but observational studies overwhelmingly suggest that ETT are extracted much more commonly owing to structural failure such as vertical root fracture, compared with true endodontic failure (Figs. 21a–f).[8–16] Therefore, without

Figs. 14a–f: Stepped access in a maxillary molar with direct restorative material **(a & b)**. A larger outline through the restorative material was cut **(c)**. The mesiobuccal pulp horn was accessed first **(d)**. The access cavity was enlarged enough to gain straight-line access to the remaining canals **(e)**. Radiograph of the tooth, which was immediately restored at the time of obturation **(f)**. (Case treated by Dr Bobby Nadeau)

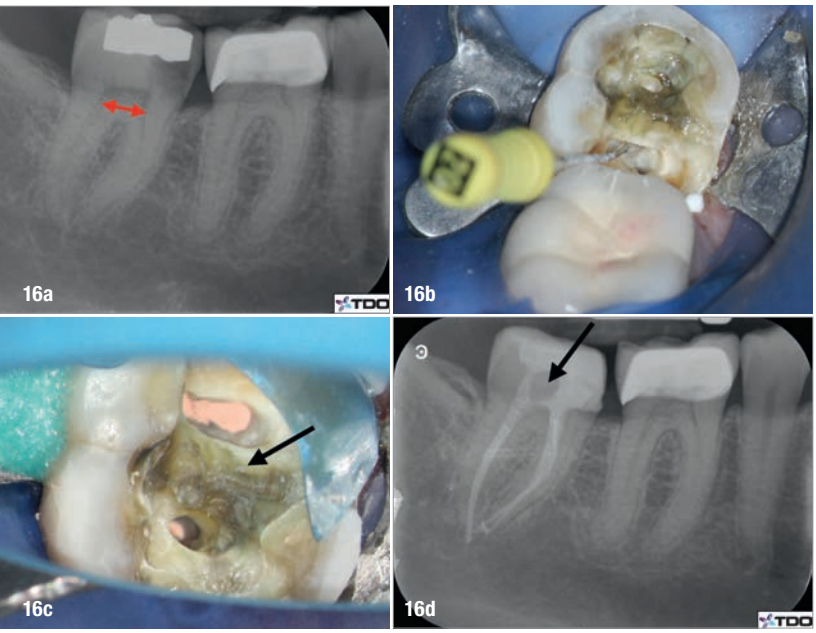
ignoring the biological objectives of disinfection and obturation, particular attention should be given to conserving residual root canal dentine. This section discusses the armamentarium used for conservative root canal instrumentation and disinfection and obturation of such canals.

Shaping and obturation

Perhaps the most critical factor involved in achieving conservative root canal shaping is the clinician's choice of instruments. Large, stiff instruments that will remove excessive dentine or will increase the likelihood of root



Figs. 15a–f: Stepped access in a maxillary molar with direct restorative material **(a & b)**. A larger outline through the restorative material was cut to allow unobstructed access to the underlying dentine **(c & d)**. Radiograph of the tooth, which was immediately restored at the time of obturation **(e)**. The two-year follow-up showed radiographic healing, and the patient was asymptomatic and functional **(f)**. (Case treated by Dr Viraj Vora)

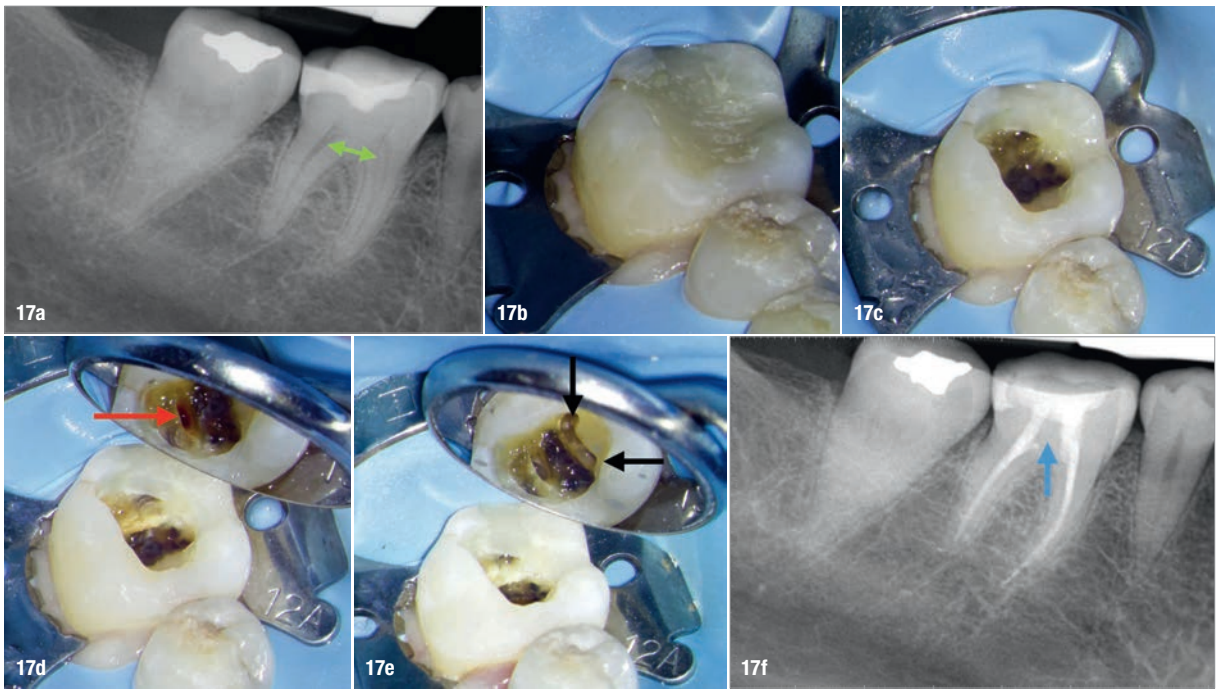


Figs. 16a–d: Dual-entry truss access is the design of choice in teeth with wide platforms (red arrow; **a**). The mesial caries was leveraged, whereas the distal canal was accessed separately **(b)**. The preserved truss (black arrows; **c & d**) is thought to preserve structural strength. The tooth was immediately restored at the time of obturation. (Case treated by Dr Dale Jung)

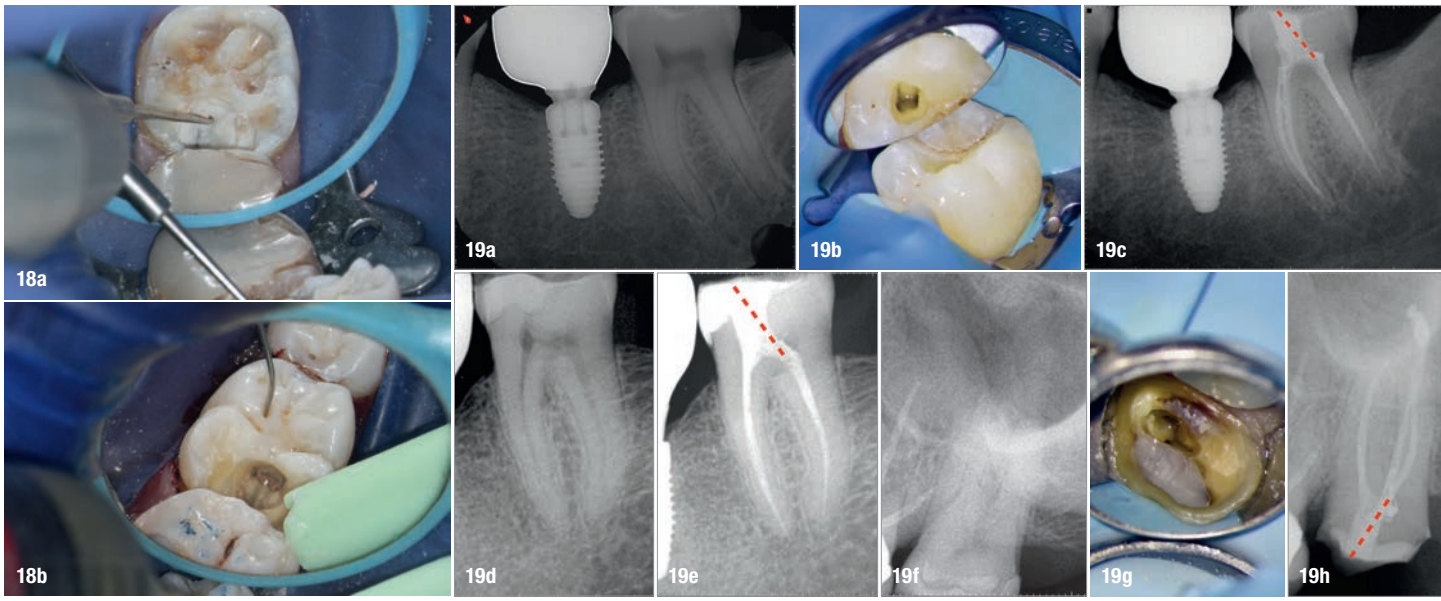
perforation or instrument separation such as Gates–Glidden drills, large orifice openers, large stainless-steel hand files, and rotary files with excessive coronal taper or lacking flexibility should be avoided. As a general rule, instruments for conservative and safe shaping should be made of heat-treated NiTi material and have a regressive taper at their coronal portion. Different heat-treated regressive-taper rotary file systems are currently on the endodontic market. They have a significantly smaller diameter at the level of the canal orifice compared with popular rotary or reciprocating files. For instance, the most widely used files today have a maximum flute diameter at the level of the orifice ranging from 1.00 mm to 1.20 mm, and constant 0.04% taper rotary files have a maximum flute diameter at the same level ranging from 0.84 mm to 0.89 mm. Most regressive-taper files with the same tip size have a maximum flute diameter at the same level of about 0.64–0.69 mm. These smaller maximum flute diameter values translate to more dentine preservation (Fig. 22).

The decision to end the shaping procedure once a certain apical size has been reached depends on many factors, including preoperative size and curvature of the canal, how easily the files progress apically during instrumentation, and the clinician's comfort and ability to eventually obturate the canal. Therefore, different clinicians may develop different comfort zones for a range of apical size preparations. Regardless of the apical size, the maintenance of the PCD should remain one of the main focuses of shaping procedures.

Although conservation of residual dentine during endodontic therapy may be one of the most important controllable factors in achieving patient-centred outcomes,

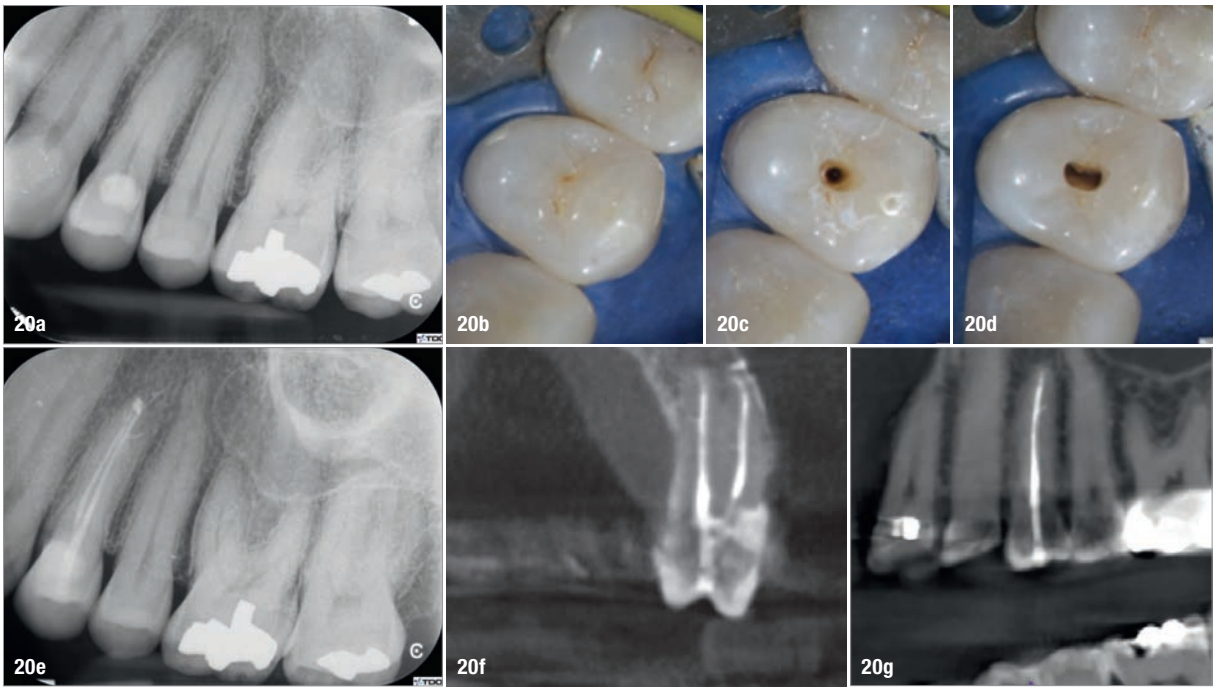


Figs. 17a–f: A mandibular molar with a wide platform (green arrow; **a & b**). The occlusal restorative material was removed **(c)**. The larger distal canal orifice was accessed first (red arrow; **d**). Based on pre-op radiographic measurements, the mesial canals were accessed second (black arrows; **e**). Preserved truss for additional strength (blue arrow). Radiograph of the tooth, which was immediately restored at the time of obturation **(f)**. (Case treated by Dr Bobby Nadeau)

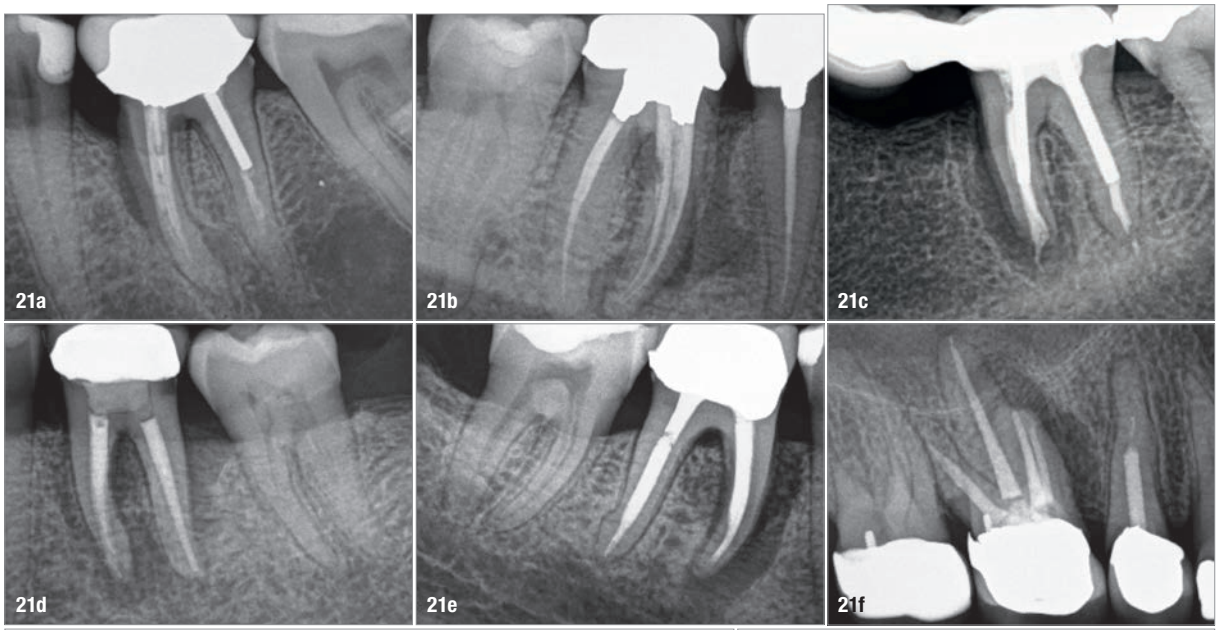


Figs. 18a & b: In truss access cavities, microsurgical ultrasonic tips **(a)** and syringe irrigation and suction **(b)** can be used to clean and disinfect under the truss. (Case treated by Dr Dale Jung) **Figs. 19a–h:** Access design for minimally restored or non-restored posterior teeth can involve penetration at the level of the mesiobuccal pulp horn and subsequent extension as needed. Straight-line access to the distal canals projects coronally in the mesial direction (red dotted lines; **c, e & h**). Note the mesial position and angulation of the restored access cavities **(c, e & h)**. (Cases treated by Dr Bobby Nadeau)

disinfection and obturation procedures should not be omitted. The use of a 30-gauge tip irrigation needle with a closed end and a side port helps bring irrigating solutions deeper into the canal. Since smaller canal preparations may lead to less exchange of irrigating solutions, it is usually recommended to use an inter-appointment medication, such as calcium hydroxide paste, especially if the tooth presents with symptoms, a sinus tract, swelling or a periapical radiolucency of significant size. Thirty-gauge delivery tips that can be prebent are useful when delivering inter-appointment medication deep in the canal. Sonic and ultrasonic instruments also help activate irrigating solutions and are a good adjunct for enhanced disinfection.



Figs. 20a–f: Upper left first premolar with pulp necrosis **(a)**. The access cavity in virgin or minimally restored premolars is centred within the occlusal surface **(b–d)**. Radiograph of the tooth, which was immediately restored at the time of obturation **(e)**. The four-year follow-up CBCT scan suggested that 3D obturation had been achieved despite the contracted access cavity and minimal shaping **(f & g)**. The patient was asymptomatic and functional. (Case treated by Dr Dale Jung)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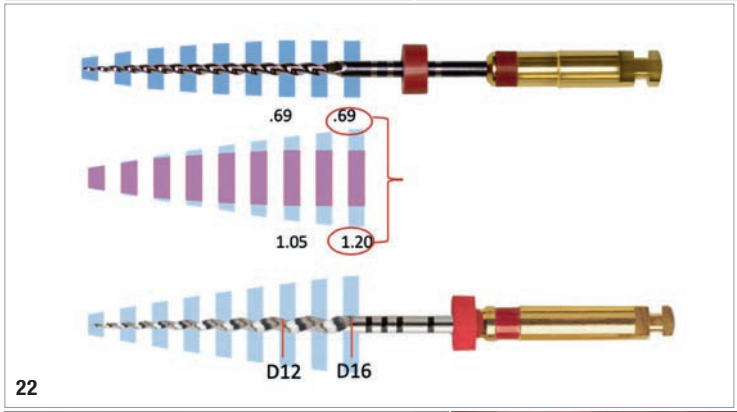

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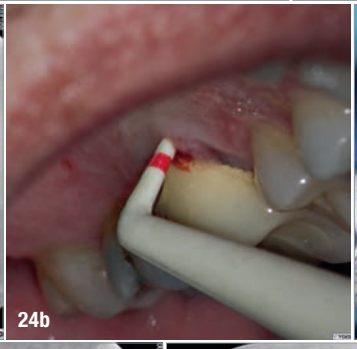
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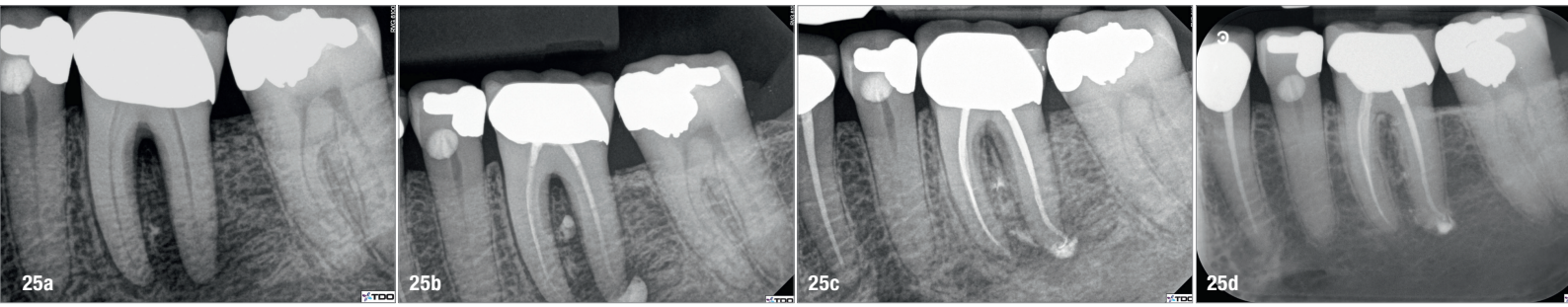

Figs. 21a–f: Vertical root fractures associated with overzealous root canal shaping. **Fig. 22:** Rotary files with regressive taper (top) have a much smaller maximum flute diameter at the level of the orifice (D16) compared with the most widely used rotary files (bottom). *(Image: © SS White Dental)* **Figs. 23a & b:** The use of non-standardised medium-fine gutta-percha cones **(a)** and extra-fine heat tips facilitates obturation when the warm vertical compaction technique is used **(b)**. **Figs. 24a–e:** A maxillary left first molar with a 12 mm probing **(a & b)**. The canals were minimally instrumented, and the access was immediately restored at the time of obturation **(d)**. The patient was asymptomatic and functional, the deep probing had healed, and there was radiographic healing at the three-year follow-up **(e)**. (Case treated by Dr Dale Jung) **Figs. 25a–d:** Initial situation **(a)**. Placement of inter-appointment calcium hydroxide medication **(b)**. Conservatively instrumented canals and immediate restoration of the access cavity **(c)**. The patient was asymptomatic and functional, and there was radiographic healing at the three-year follow-up **(d)**. (Case treated by Dr Dale Jung)

Dense obturation to the apical foramen in minimally shaped canals is still a desirable procedural outcome. The common issue clinicians encounter when transitioning to more conservative instrumentation is difficulty during the obturation phase of treatment. While standardised gutta-percha cones are available, there have been issues with the predictability of the fit of these cones. It is the authors' opinion that the use of smaller, non-standardised gutta-percha cones helps with cone fitting. Most conservatively instrumented canals can be obturated with laser-verified medium-fine fitted gutta-percha cones (Fig. 23a). The use of small heat tips also helps when warm vertical compaction of gutta-percha is used as the obturation technique (Fig. 23b). Figures 24a–e and 25a–d show that radiographic healing at follow-ups can be predictably achieved while maintaining maximal residual radicular dentine.

Conclusion

Patients perceive value for endodontic therapy when it provides a useful service, especially when weighing the investment of time and money required to reach a desirable outcome. The main obstacle facing any clinician when introducing and implementing a new approach to endodontics is the cognitive dissonance he or she may face for the beliefs he or she holds to be true against what he or she currently practises. Access design and canal instrumentation have been continuously changing over the years, and as better and more user-friendly technologies emerge, clinicians can now perform the same clinical steps with a minimal procedural footprint while achieving desirable patient-centred outcomes. Dynamic navigation, using CBCT data, for conservative endodontic access is on the horizon and will pave the way for an exciting next decade in endodontics.

Editorial note: A list of references is available from the publisher. This article originally appeared in Oral Health Magazine*, and an edited version is provided here with permission from Newcom Media.*

about

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Dr Viraj Vora graduated with a DDS from the University of Western Ontario (renamed Western University) in London in Canada and with an MSc and a certificate of specialty in endodontics from the University of Michigan in Ann Arbor in the US. Dr Vora is in full-time private practice in Vaughan in Ontario in Canada limited to microscopic conservative endodontics and restorative dentistry. He can be contacted at viraj@endodonticcentre.ca.

Endodontic treatment of maxillary left first molar with complicated root canal system

Dr Paulina Piasta-Kiełkiewicz, Poland

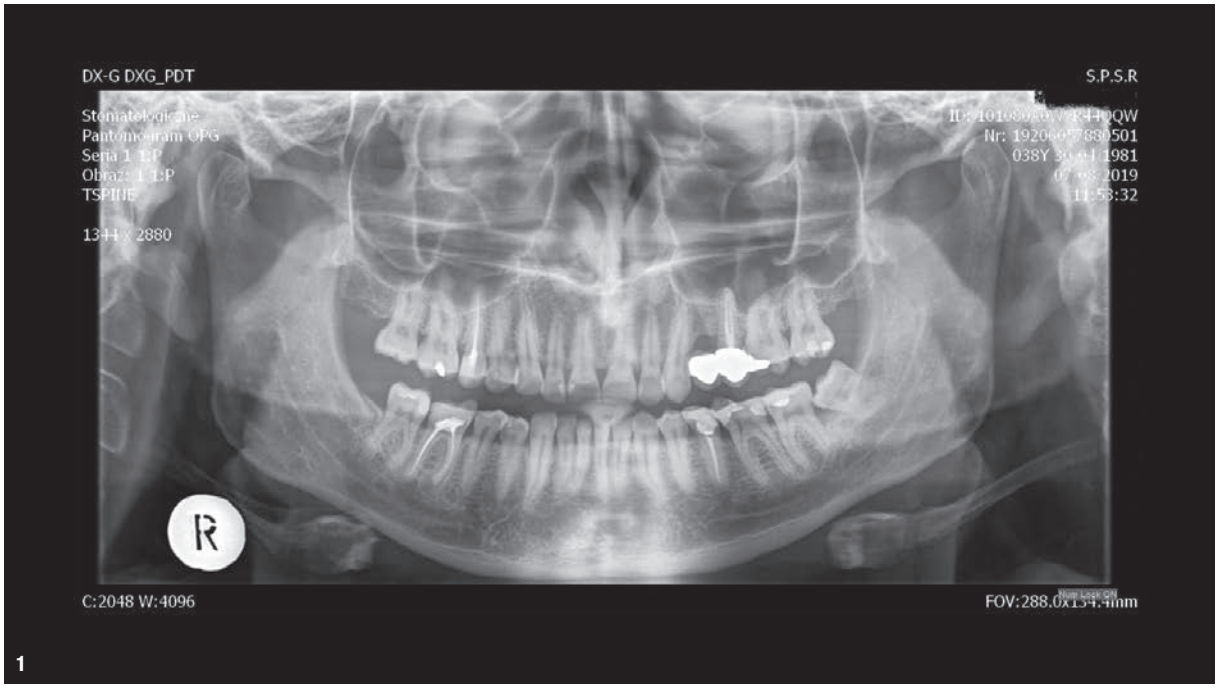


Fig. 1: Panoramic radiograph.

The patient reported on in this article was referred to my dental office by his general dental practitioner. There was a large cavity and symptoms of irreversible pulpitis in tooth #26. The 38-year-old male patient had reported to his general dental practitioner with the complaint of toothache in the left upper jaw. The maxillary left first molar was diagnosed as the cause of his complaint. The cavity had been partially prepared, and the mesial wall temporarily restored.

The patient had an interesting history of the area extending from tooth #24 to tooth #26. Tooth #24 had been extracted many years before owing to vertical root fracture. About four years before, a titanium implant replaced it, but there was no osseointegration and the implant was removed. The patient decided on a partial metal–ceramic bridge for several years before attempting another implantation.

On examination, it was noticed that tooth #26 was tender to cold and sweet. A panoramic radiograph revealed the presence of dental caries penetrating to the pulp chamber (Fig. 1).

I decided on single-visit endodontic treatment. The treatment began with administration of local anaesthetic and dental dam isolation. Crown access was performed with a diamond bur and ultrasonic tip (CAVI 2-D, VDW), which was also used to perform the removal of the coronal portion of the pulp and canal localisation. On access, four canals were identified by inspection with an endodontic probe. The working length of the palatal canal was 21.5 mm (C-PILOT, ISO size 10, VDW), of the mesiobuccal and distobuccal canal was 21.0 mm (C-PILOT, ISO size 10), and of the second mesiobuccal canal was 20.0 mm (C-PILOT, ISO size 8). An electronic apex locator was used for working length confirmation. As can be seen in the panoramic radiograph and dental radiograph (Fig. 2), the canals were quite narrow and curved, so I decided to use rotary files (VDW.ROTATE, VDW).

To achieve a successful treatment, all canals have to be cleaned and shaped to the working length. In this case, it was very important to respect the natural curvature of the canals. For this reason, a single-length technique was performed. VDW.ROTATE files were used in the following sequences: 15/.04, 20/.05 and 25/.06 for the mesiobuccal and distobuccal canal; and 30/.04, 35/.04 and 40/.04 for the palatal canal. To prevent canal transportation in the second mesiobuccal canal, the master apical file was 25/.04. A dental operating microscope (Leica M320, Leica Microsystems) was a helpful tool during endodontic treatment.

Copious irrigation with 5% sodium hypochlorite was performed during the shaping and cleaning procedures. Copious irrigation with 5% sodium hypochlorite was performed during the shaping and cleaning procedures. An ultrasonic tip (Endo Chuck, EMS) and sonic powered irrigation tip (EDDY, VDW) were used to activate the irrigants. At the end, the canals were irrigated with 17% EDTA, and this solution was kept in the canals for 2 minutes. The canals were dried with paper points. An epoxy-amine root canal sealer and a master gutta-percha cone were placed in the canals and the canals were obturated using the continuous wave obturation technique. Glass ionomer cement was used as a temporary filling material (Fig. 3). The patient was referred for final restoration to his general dental practitioner.

Fig. 2: Initial radiograph. **Fig. 3:** Post-op radiograph.

about

Dr Paulina Piasta-Kiełkiewicz graduated from the Medical University of Warsaw in Poland in 2010. From 2010 to 2011, she completed a postgraduate internship at the medical clinic of the Military University of Technology in Warsaw. Dr Piasta-Kiełkiewicz has completed additional theoretical and practical courses on endodontic treatment. She works in a private clinic in Warsaw focused mainly on endodontics.

Driving on autopilot

Dr Richard J. Gray, USA

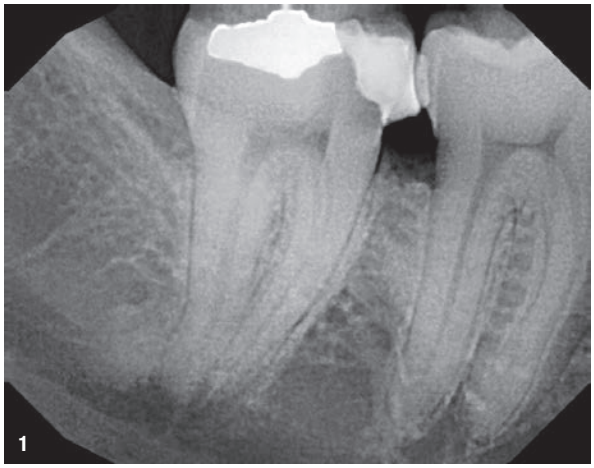


Fig. 1: Pre-op radiographic image of tooth #47.

Introduction

Long, narrow root canals are a real challenge even for renowned endodontic experts. Just like a good navigation system in your car, modern endodontic motors help you keep track on the long and winding road to the apex. In the following case, the clever co-pilot navigated the author safely through the treatment of a necrosis in tooth #47—indicating "traffic jams" as well as recommended "stops".

Mobility researchers and development departments of car manufacturers all share the dream of autonomous driving. When navigating through S-shaped canals by sight or following the tactile feedback, endodontic experts sometimes wish for the luxury of a fully automatic co-pilot too, a co-pilot who knows when it would be recommendable to change files and when a "pit stop" should be made for rinsing. In the following report, the author describes his first test drive with a brand new endodontic motor and his experience "on the road".

Fig. 2: Fully automatic endodontic motor. (© Coltène/Whaledent)

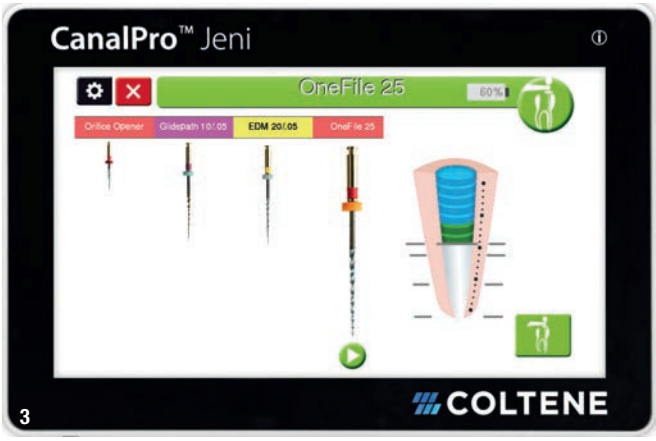
The long and winding road

This spring, a 33-year-old patient was referred to our practice complaining of pain in the right lower jaw. Radiographic diagnostics revealed, among other things, that the root canals were longer than usual. The mesial canals were 23 mm long, and the distal canal 22 mm. In addition, the canals were clearly narrowed in the apical third. Successful navigation through the root canal system would therefore become particularly difficult. Tooth #47 also showed a conspicuous brightening in the radiographic image (Fig. 1). The diagnosis was necrosis with asymptomatic periapical periodontitis. The patient agreed to the necessary root canal therapy.

Owing to the given anatomical conditions, we chose the CanalPro Jeni endodontic motor to support the treatment. Jeni is a new type of digital endodontic assistance system developed by the international dental specialist COLTENE (Fig. 2). Jeni is named after its inventor, Prof. Eugenio Pedullà. While preparing an S-shaped canal, the Italian endodontic specialist came up with the idea of applying the concept of autonomous driving to the endodontic field for a safe and less error-prone root canal therapy. The result is a fully automatic endodontic motor that finds its own way through the canal. Being so proud of his groundbreaking invention, Pedullà wished the device to be named after him: Jeni.

Bumpy road ahead

Like an experienced driver assistance system in a car, Jeni navigates the user safely and quickly through the canal. Thanks to complex algorithms, the endodontic motor controls the variable file movements every millisecond. The rotational movement, speed and torque are continuously adjusted to the conditions in the canal. In the following case, the main objective was to perform a safe and reliable procedure despite the demanding anatomy. This required a motor that minimises file stress and optimally manages torque forces by correcting the file movement. The motor should also react in time to obstacles or a restricted working field. Especially in long, narrow canals, it helps to have a "lane assistant" that knows when a file change is recommended.



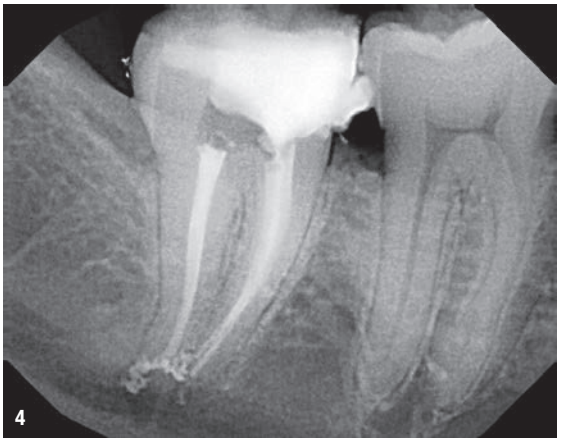


Fig. 3: Choosing the sequence via touch screen. (© Coltène/Whaledent) **Fig. 4:** Course of the root canal in the post-op radiograph.

After applying a dental dam and creating an access, we first probed the canals using size 8–15 hand files. With the help of the apex locator, the appropriate working length was quickly established. The actual preparation was done with flexible nickel–titanium (NiTi) files. In the main program of the Jeni endodontic motor, different file systems can be selected via touch screen (Fig. 3). Currently, the HyFlex CM or EDM and the MicroMega One Curve or 2Shape from COLTENE are preset in the software. The Doctor's Choice program also allows you to store individual sequences of up to eight files, but you cannot use the assistant function of the fully automatic Jeni mode in this section, for example the fine adjustment of the rotational movement. Since updates can be uploaded at any time via a micro SD card, further alternative configuration options are certainly conceivable in the future.

In order to be able to explicitly use the recommendation on file changes as well as the automatic rinsing announcements, the HyFlex EDM was used in the given case in the following sequence: first a 15/.03 file was used, followed by a 20/.05 file. The majority of the work in the mesial and distal canals was performed by the universal file 25/~ HyFlex EDM OneFile. A 40/.04 file was used for the filigree work. With this sequence, all canals were successfully cleaned and shaped.

It was astonishing how easily the file adapted to the changing pressure exerted on the instrument. The dentist simply holds the handpiece while the motor does the rest. With Jeni, endodontic beginners and experts alike can enjoy a completely new treatment experience. It is a bit like driving a high-powered car on autopilot: thanks to its sophisticated technical features, the machine has enough power to cope with uneven surfaces, but automatically corrects its course in order to drive around tight corners. The dentist works constantly with light pressure from coronal to apical, which makes the system extremely efficient. At the same time, it eliminates the small pecking motion normally associated with preparation based on tactile feedback. Root canal therapy is therefore much faster and less prone to errors now.

However, the most amazing thing of all is that, in Jeni mode, the endodontic motor even knows when it is time to irrigate. After the acoustic signal, the current file was removed from the canal and rinsed with sodium hypochlorite and then with chlorhexidine at appropriate intervals. Obturation was performed as usual with gutta-percha points in combination with bioceramic sealer. The final radiograph shows the root canal system following the natural anatomy. It had been thoroughly prepared and reliably sealed with gutta-percha (Fig. 4). The satisfied patient was discharged. The long-term results hopefully will be seen in the follow-up.

Conclusion

Long, narrow root canals pose particular challenges to the resistance and flexibility of modern NiTi files. Digital endodontic assistance systems help the dentist by adjusting the variable file movement. The reliable co-pilot thus navigates the dentist step by step through the mechanical and chemical preparation. Thanks to the constant processing from coronal to apical, canal shaping is much more efficient and less error-prone than it used to be—almost like driving autonomously with a high-powered car on the autobahn.

about

Dr Richard Gray returned to USC to complete his endodontic residency, graduating in 2000. Upon completion of his residency, he moved back to Mesa in Arizona, where he opened his endodontic office. In October 2007, Dr Gray was recalled to active duty and sent to Iraq in support of Operation Iraqi Freedom. Dr Gray currently maintains his private practice in Midlothian in Virginia in the US. He might be contacted at apexendo@hotmail.com.

Improved endodontic efficiency with Er:YAG AutoSWEEPS modality

Dr Tomaz Ivanusic, Slovenia

Introduction

The standard method of endodontic irrigation via hand syringe has been found to be inefficient for purposes of cleaning and disinfection owing to the highly complex anatomy of many root canal systems. For this reason, laser-activated irrigation (LAI) has been developed as a more modern solution to enhance the irrigation process.[1–8]

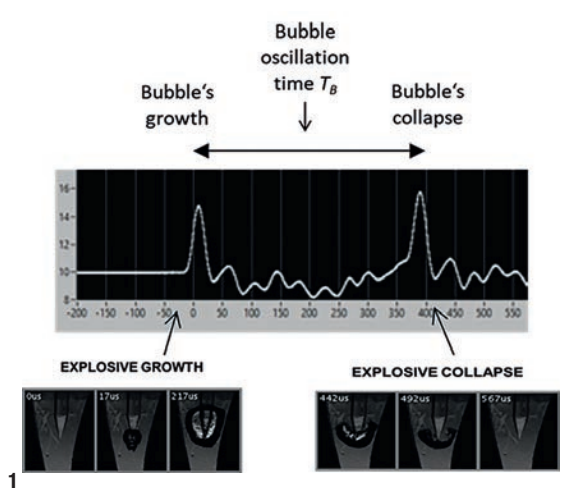


Fig. 1: The acoustic signal after the emission of a single Er:YAG laser pulse. The initial rapid growth and final explosive collapse of the laser-generated bubble (below) during the bubble's oscillation time (T_B) result in two acoustic signal peaks (above).

LAI represents an important advantage in comparison with other irrigation techniques that require a different tip or needle to be inserted up to the apical area.[9–11] During LAI procedures, Er:YAG laser pulses are delivered through a fiber tip inserted in irrigant-filled pulp chamber. Owing to the high absorption of the erbium wavelength (λ = 2.94 µm) in the irrigant (EDTA and sodium hypochlorite solution), a vapour bubble is generated at the end of the submerged fibre tip,[12] and the rapid expansion and collapse of the bubble (Fig. 1) results in secondary cavitation and fluid motion along the entire root canal system.[13, 14] In theory, this leads to significantly enhanced chemomechanical irrigation.[4, 15]

However, the intensity of the bubble collapse within the root canal is substantially reduced owing to friction on the cavity walls. The shock waves that are usually present in an unconstrained environment after a bubble's collapse are diminished or not present at all within the narrow confines of the root canal.[16, 17]

SWEEPS mode (dual-pulse)

To resolve this limitation and intensify the bubble collapse within the root canal, a newer approach utilising a recently developed dual-pulse SWEEPS (shock wave-enhanced emission photoacoustic streaming) modality was introduced. With the SWEEPS mode, pulses are designed to start with sharp initial intensity peaks that enhance the dynamics of the photoacoustic irrigant streaming process. Moreover, a second laser pulse is applied just before the collapse of the first laser pulse's bubble.[16–18] Figures 2 to 4 show the dual-pulse emission of the SWEEPS modality as measured for the latest-generation SkyPulse Endo Er:YAG laser system (Fotona).

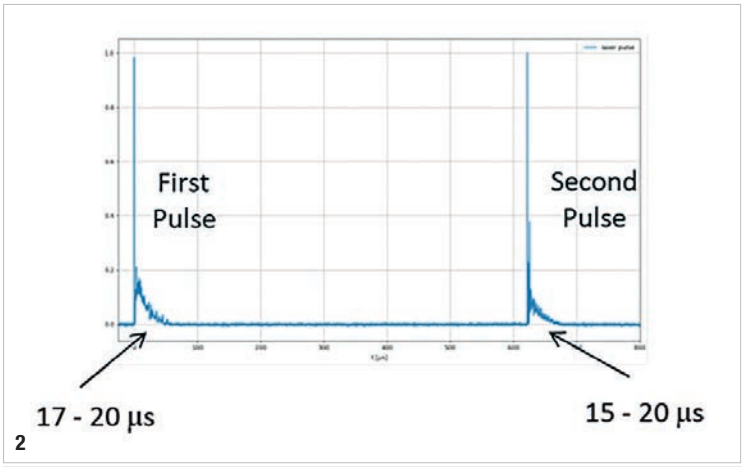
The sudden expansion of the second bubble generated by the second laser pulse exerts additional pressure on the initial bubble, leading to its accelerated collapse, during which shock waves are emitted. Furthermore, shock waves are emitted from the collapsing secondary cavitation bubbles that are formed throughout the entire length of the canal during laser-induced irrigation.[17]

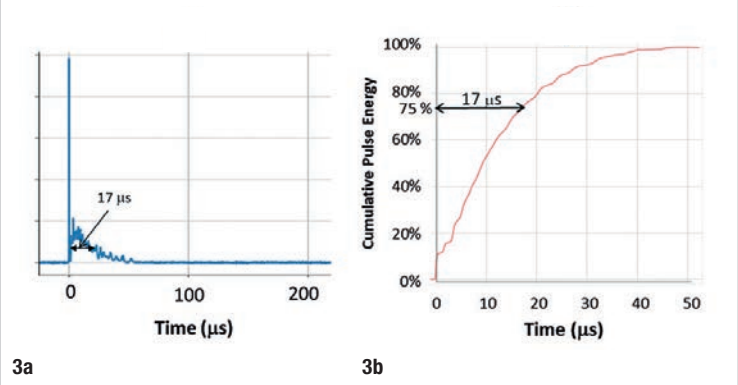
The largest enhancement of shock waves and internal irrigant pressure occurs when the temporal separation (T_{SWEEPS}) between the two SWEEPS laser pulses does not deviate substantially from the optimal separation time, that is, the resonant time (T_{res}), corresponding to the time when the second laser pulse of the SWEEPS pulse pair is delivered near the end of the collapse phase of the primary bubble generated by the first laser pulse ($T_{res} \approx 0.9 \times T_B$; T_B = cavitation bubble oscillation time; Fig. 5).[17,19]

AutoSWEEPS mode

A real-world challenge involved in using SWEEPS in dental practice, however, is posed by the fact that the bubble oscillation time T_B critically varies depending not only on the laser parameters that can be controlled but also on the particular endodontic access cavity dimensions of the treated tooth, T_B being longer for smaller cavity dimensions (Fig. 6).[17,19]

With this variability in mind, a special AutoSWEEPS laser modality was recently developed,[16,20,21] in which the temporal separation between the pair of laser pulses is continuously swept back and forth between 200 µs and 650 µs. This ensures that during each sweeping cycle there is always at least a 50 µs wide temporal separation range when the pulses are separated by $T_{SWEEPS} \approx T_{res}$, as needed for optimal enhancement. The sweeping functionality also ensures that the optimal conditions are approximately reached along the depth of the access cavity by matching the changing diameter conditions during the AutoSWEEPS cycle.





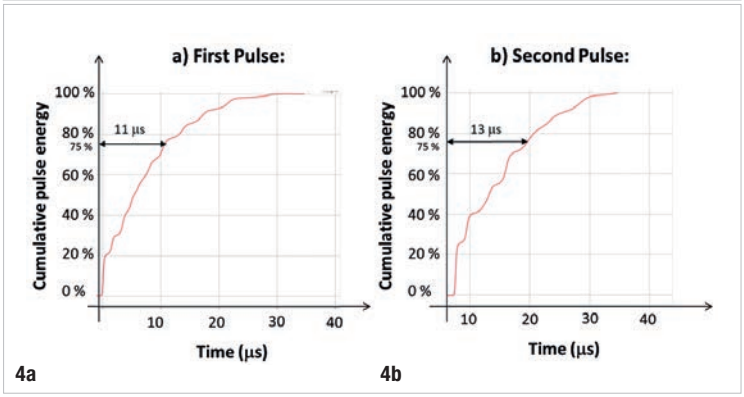


Fig. 2: Temporal shape of the latest-generation SkyPulse Endo's dual-pulse SWEEPS mode with nominal single-pulse durations of 25 µs. Measurement was taken for $E_{SWEEPS} = 2 \times E_L = 2 \times 20$ mJ at the SWEEPS mode repetition rate of 15 Hz. **Figs. 3a & b:** Temporal shape of the first pulse of the SWEEPS pulse pair shown in Figure 2 **(a)**. Temporal delivery of the cumulative laser energy during the pulse **(b)**. The pulse duration of 17 µs represents the time when 75% of the total laser pulse energy of E_L = 20 mJ has been delivered. **Figs. 4a & b:** Temporal shape of the first pulse **(a)** and the second pulse of SWEEPS mode as measured for $E_{SWEEPS} = 2 \times E_L = 2 \times 10$ mJ at the SWEEPS mode repetition rate of 15 Hz **(b)**.

Compared with the standard single-pulse SSP (super-short pulse) modality (also known as PIPS, photon-induced photoacoustic streaming), AutoSWEEPS has been reported to be about 50% more effective in generating pressure within the root canal, resulting in significantly better penetration of irrigants into the dentinal

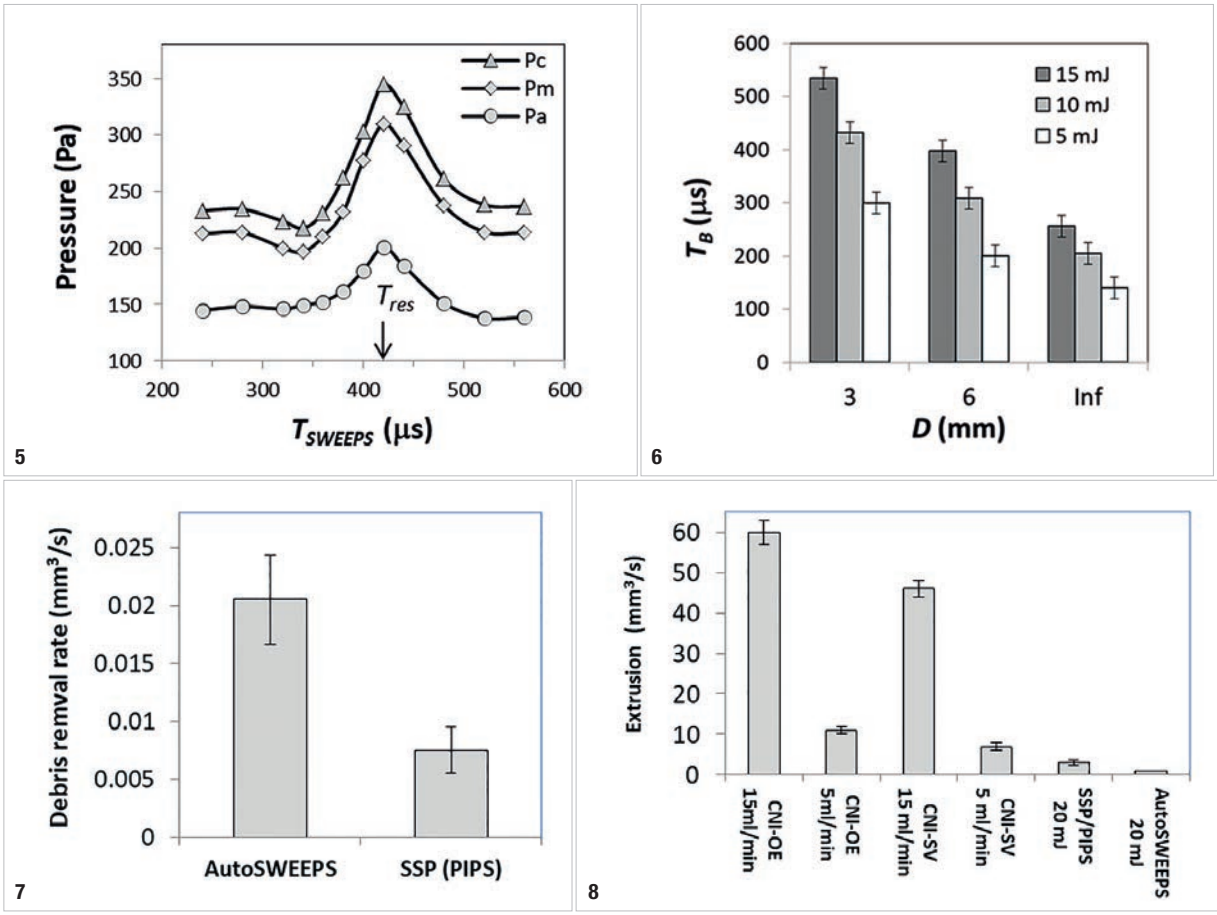


Fig. 5: Measured pressure in the coronal (P_c), medial (P_m) and apical (P_a) areas of the root canal, as a function of the temporal separation (T_{SWEEPS}) of the SWEEPS dual pulses. **Fig. 6:** Dependence of the cavitation bubble oscillation time (T_B) on the diameter D (3 mm, 6 mm and "Infinite") of an irrigant-filled cavity.[19] **Fig. 7:** Comparison of the debris removal rate of AutoSWEEPS and SSP (PIPS) Er:YAG laser modalities.[22] **Fig. 8:** Mean values of irrigant extrusion in groups using conventional needle irrigation with an open-ended needle (CNI-OE) or side-vented needle (CNI-SV), using flow rates of 5 ml/min. or 15 ml/min., and using LAI with SSP (PIPS; 20 mJ) or AutoSWEEPS (2 × 10 mJ).[21]

tubules.[22] In a recent study, the efficacy of hard-tissue debris removal from the root canal system by AutoSWEEPS irrigation was compared with SSP laser-assisted irrigation, as well as with ultrasonically activated irrigation using micro-computed tomography.[23] The AutoSWEEPS modality resulted in significantly improved debris removal in each portion of the root canals compared with SSP and ultrasonically activated irrigation (Fig. 7). Additionally, studies indicate that the new SWEEPS method does not increase the risk of apical extrusion compared with single-pulse LAI or standard syringe irrigation (Fig. 8).

Conclusion

In conclusion, the AutoSWEEPS modality as can be found in the latest-generation SkyPulse Endo Er:YAG laser systems has been shown to produce improved shock wave generation and significantly enhanced flushing action.[20] Enhanced penetration of irrigants into the dentinal tubules is also achieved owing to the increased pressure generated along the depth of the root canal[22] without increasing the risk of apical extrusion.[21]

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

about

Dr Tomaz Ivanusic graduated from the University of Ljubljana's Faculty of Medicine in Slovenia in 2017. After graduation, he served a one-year internship, where he gained experience in different dental specialties. Already as a student, he actively participated in international congresses and events. In 2018, he was chosen to join a group of 16 prospective young dentists who attended an advanced course in aesthetic dentistry in Lisbon in Portugal. Dr Ivanusic currently practises in a private clinic in Slovenia, mostly performing endodontic, restorative and periodontal treatments with a special focus on laser dentistry. He also conducts lectures in preventive and restorative dentistry and works part-time as a researcher, lecturer and trainer.

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Autogenous transplantation followed by conservative root canal therapy: Three years follow-up

Dr Jenner Argueta, Guatemala

Introduction

Although the final goal of the endodontic therapy is to provide symptom-free functional teeth with healthy periapical tissue long term,[1] the severely damaged structure sometimes does not allow the clinician to succeed in the pursuit of saving natural teeth. In these scenarios, alternative treatments such as crown lengthening, autogenous transplantation or even implant placement should be considered with the objective of maintaining occlusal stability and functionality.[2,3]

Autogenous transplantation refers to the repositioning of a tooth to another extraction site in the same patient; this can also apply to a tooth replanted into a surgically formed recipient site.[4] In the past decades, the success rate reported for this procedure has increased in studies evaluation periodontal tissue healing and radicular resorption. The success rate reported in cases with complete root formation is 84%, and the success rate in teeth with non-complete root formation reaches 94%.[5,6] The most significant factor related to the success rate is the viability of the periodontal ligament attached to the root surface of the transplanted tooth; the viability of the periodontal membrane on the radicular surface will decrease after 18 minutes of extra-oral time.[7,8] This procedure tends to be technique-sensitive; operator skills and experience will play a crucial role in a successful outcome.

The transplanted tooth often presents with the crown structure totally intact. A large percentage of this cases will need root canal therapy; however, the removal of tooth structure needed for access cavity preparation and root canal shaping may undermine the strength of the tooth under functional load.[9] Recently, conservative endodontic approaches have been recommended to minimise tooth structure removal and to preserve the very important peri-cervical dental tissue.

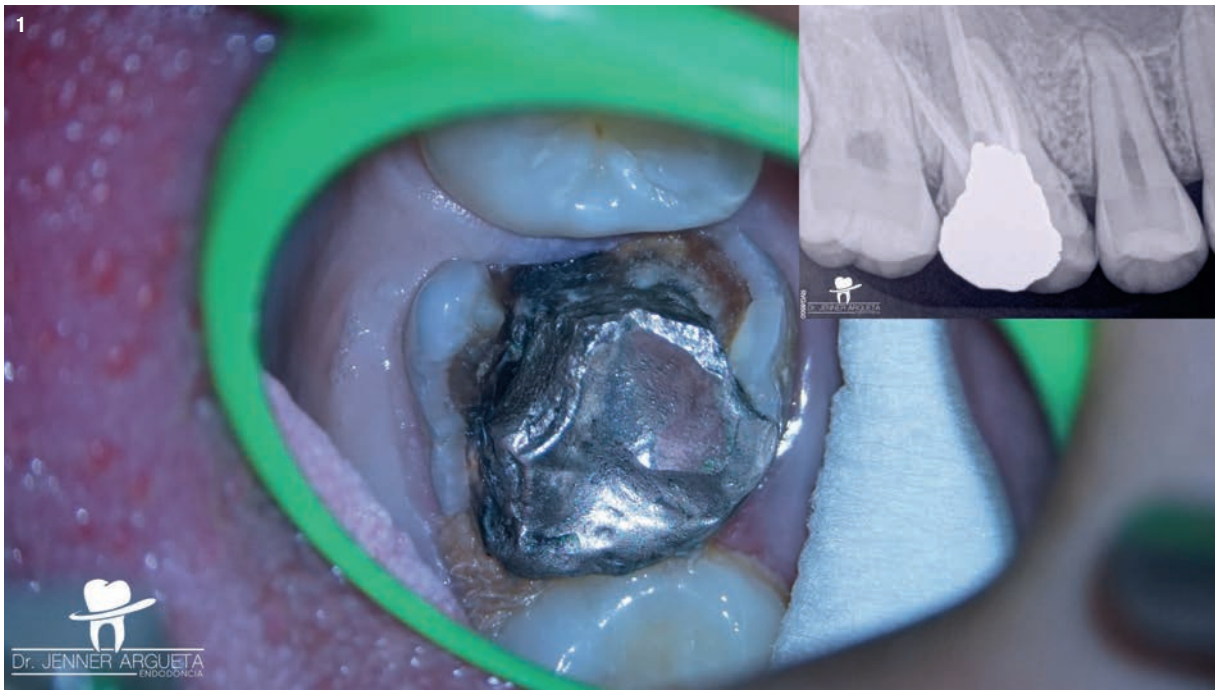
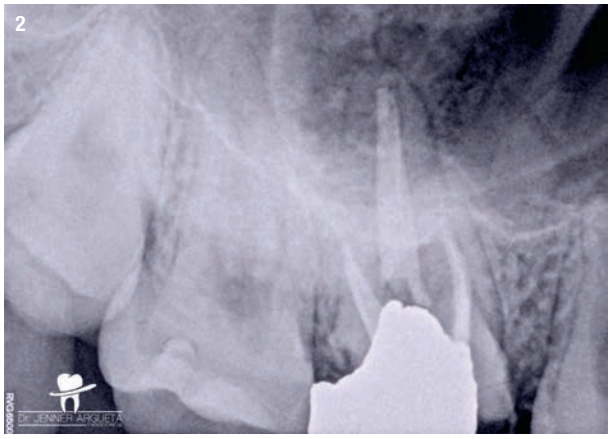


Fig. 1: Severely destroyed maxillary first molar with an old amalgam restoration, previous root canal therapy and recurrent caries.



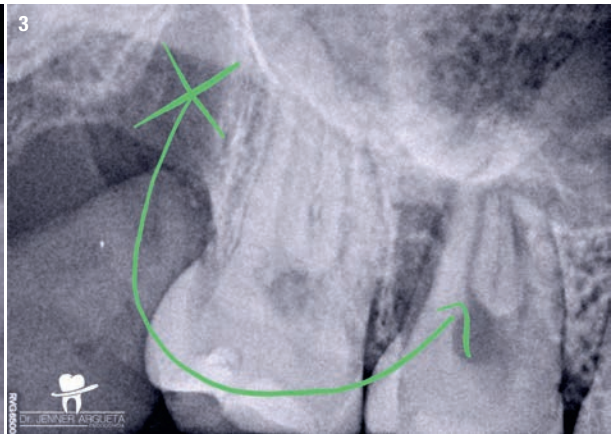


Fig. 2: Periapical radiograph of the maxillary right molar. Tooth #18 was to be transplanted to the site occupied by tooth #16. **Fig. 3:** Tooth #18 transplanted to the site previously occupied by tooth #16.

Among the different developments in dentistry that have made possible conservative approaches in endodontic practice are flexible endodontic files with controlled memory alloy and enhanced cyclic fatigue resistance, visual magnification, bioactive endodontic sealers, and sonic and ultrasonic irrigant activators.[9–11] The development of these technologies has been crucial for making the conservative endodontic approach possible, prioritising the preservation of dentine, especially in the cervical region.[12]

Case report

A 16-year-old female patient was referred to the office for evaluation of tooth #16 (Fig. 1). The referring dentist asked that we apply all the available resources to save the tooth. The diagnosis was previously treated and symptomatic periapical periodontitis. After detailed examination, it was concluded that the tooth was not restorable. With the parents' and patient's agreement, we decided on an autogenous transplantation of tooth #18 to the site of tooth #16 after its extraction (Fig. 2). The orthodontist had determined that tooth #18 was to be extracted, and it was intended that the patient's occlusion should be balanced by the end of the orthodontic treatment. Teeth #16 and 18 were extracted in the least traumatic way possible. After minor bone remodelling of the socket using low-speed burs, the third molar was transplanted to the recipient site (Fig. 3). A nylon monofilament flexible splint was used to keep the tooth in place (Fig. 4). Fifteen days later, the splint was removed, healthy soft tissue was observed, the patient

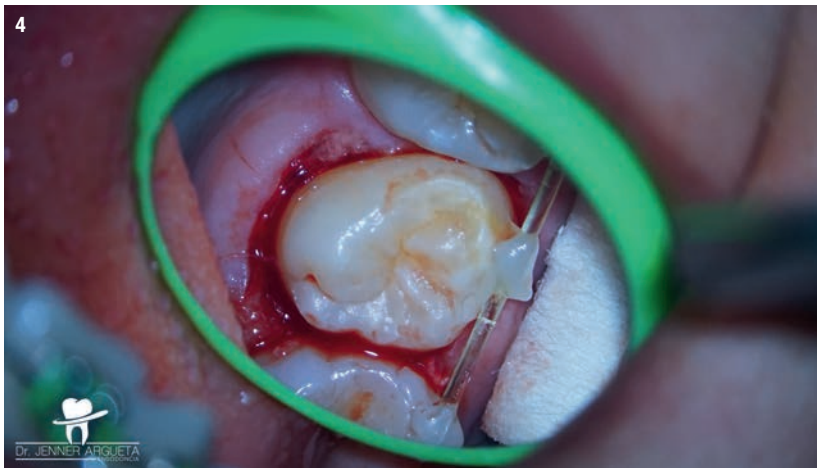
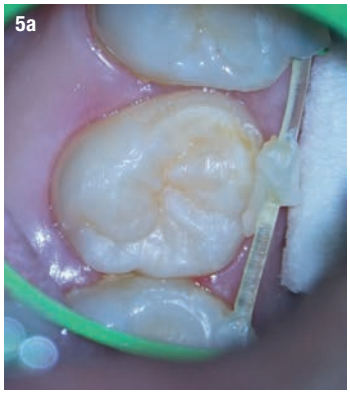
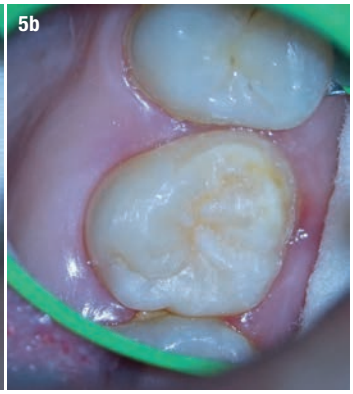
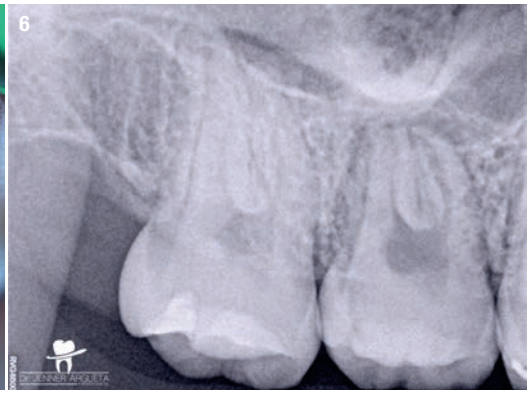


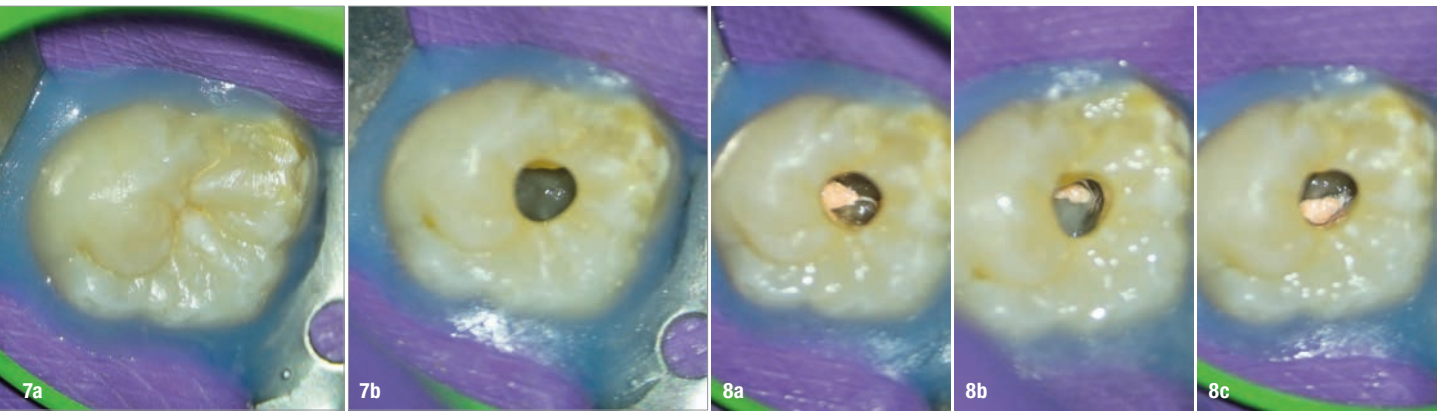
Fig. 4: A nylon monofilament flexible splint was used to stabilise the transplanted tooth in the recipient site.







Figs. 5a & b: Fifteen days post-op. Healthy periodontal tissue was evident around the transplanted tooth, before **(a)** and after **(b)** splint removal. **Fig. 6:** Eight-month post-op radiograph. The retromolar area had healed, but the transplanted tooth showed signs of pulp necrosis and periapical disease.



Figs. 7a & b: Clinical photographs of the tooth just before initiating the root canal therapy **(a)** and just after finishing the endodontic access opening **(b)**. **Figs. 8a–c:** Root canal entrances obturated and pulp chamber floor cleaned palatal **(a)**, mesiobuccal **(b)** and distobuccal **(c)**.

was asymptomatic, and the tooth was stable in the site (Figs. 5a & b).

The original plan was to proceed with the root canal therapy three weeks after the replantation, but unfortunately, the patient did not attend the appointment. According to Tsukiboshi, it is not advisable to do the root canal therapy during the first two weeks, because of the risk of causing additional injury to the periodontal ligament, and it is advisable to proceed with the root canal therapy just after two weeks postoperatively in order to decrease the risk of inflammatory root resorption.[6]

The patient showed up to the clinic eight months later with signs and symptoms of pulp necrosis and acute periapical abscess; a periapical radiolucency was present, and the retromolar area was healed (Fig. 6). In cases like this, where the coronal structure remains intact, it is advisable to take a conservative approach to the root canal therapy, using new technology available in endodontics to achieve good results. The endodontic access opening was created using high-speed burs and ultrasonic tips. The cleaning and shaping protocol was performed with flexible needles and controlled memory files (Aurum Blue, Meta Biomed), especially important properties for entry to the root canals through the conservative access (Figs. 7a & b). The use of endodontic files in the stabilised martensitic stage (controlled memory) will offer more resistance against cyclic fatigue.[11,13,14] A calcium silicate-based endodontic sealer was sonically activated (CeraSeal and EQ-S, Meta Biomed) and gutta-percha was used to obturate the root canals (Figs. 8a–c). This stage of the treatment might be challenging when such a small endodontic access is created. The use of a calcium silicate-based endodontic sealer facilitates the obturation process, and the sonic activation helps to distribute the material all along the cleaned and shaped root canal system (Fig. 9). An adhesive coronal restoration was placed in the same appointment, a dual-polymerised core material (NexCore, Meta Biomed) for the pulp chamber and a compactable composite for the occlusal surface (Ezfil, Meta Biomed; Figs. 10a & b). The patient thereafter began orthodontic treatment, and the tooth was functional and the patient asymptomatic. The three-year follow-up radiograph showed healthy periapical tissue (Fig. 11).

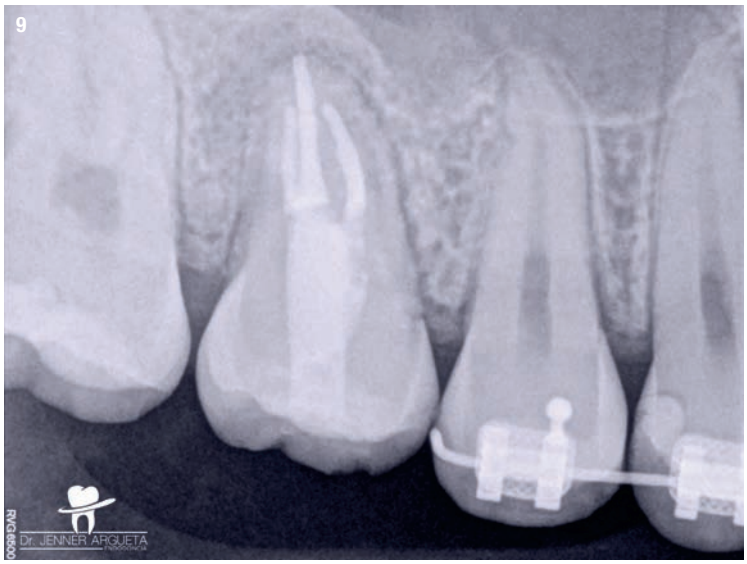
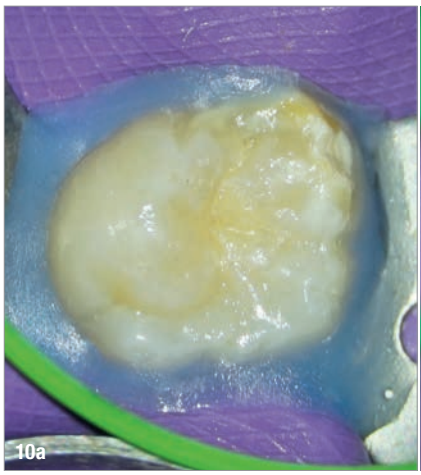


Fig. 9: Final radiograph of the root canal therapy and coronal restoration. Placing the coronal filling material into the pulp chamber tends to be complex with such a small access opening.

Discussion

Complications reported in autogenous transplantation cases include tooth fracture during extraction, root resorption, replacement resorption (rare), loose attachment, poor oral hygiene during the postoperative period and pulp necrosis (common), and root canal therapy will be necessary in most cases.[15,16] Among the advantages are that orthodontic movement will be possible, the procedure can be performed even in growing patients, and it offers the capacity to preserve the alveolar ridge and functional adaptation, which is very important in comparison with osseointegrated implants, which are stationary and do not erupt, resulting in infraocclusion in growing patients. One of the



Figs. 10a & b: Adhesive coronal restoration, just before **(a)** and after **(b)** removal of the isolation. **Fig. 11:** Three-year follow-up radiograph. The periapical area had healed.

most cited advantages of this procedure is that typically a severely destroyed tooth can be exchanged for a tooth in perfect structural condition.[4, 15, 17]

When root canal therapy is necessary in the transplanted tooth, it is advisable to plan the treatment according to the status of the coronal and radicular structure. The preservation of the dental tissue should be a main goal, including the pursuit of minimally affected tooth resistance against occlusal load and functional stress. One of the greatest risks when performing conservative root canal therapy is that, while working through conservative access openings, the files will work under increased flexural stress; flexural stress will be higher at the entrance of the root canal owing to the lack of straight-line access. Cyclic fatigue might increase also at curvatures, leading to greater transportation and changing of original root canal anatomy. If cyclic fatigue is one of the major risks related to conservative endodontic openings, the use of files with enhanced cyclic fatigue resistance is advisable.[18]

Aurum Blue is a four-file root canal instrumentation system in the stable martensitic structural stage (Fig. 12). The cross section, taper, nickel–titanium alloy and electropolished surface treatment were designed and combined together to offer a good balance between cyclic and torsional fatigue resistance and high flexibility. All the files smaller than 25/.05 have a square cross section, and larger sizes have a convex triangular cross section. These files are recommended to be used at 500 rpm with 2 Ncm torque.

The CeraSeal calcium silicate endodontic sealer is a useful option for the use of the single-cone obturation technique (Fig. 13). This technique greatly facilitates the sealing of the root canal system when conservative endodontic procedures are performed. CeraSeal's physical characteristics render it capable of providing a stable 3D seal,[19–21] all without the need for vertical or lateral compaction procedures, whether warm or cold. The single-cone obturation technique can be used safely in combination with calcium silicate cements, owing to their physical and dimensional stability, good sealing properties, antibacterial potential, biocompatibility and bioactivity, being capable of stimulating periapical tissue repair.[20–22] These materials are able to set in humid environments; this point is of major relevance considering the fact that dentine has a moisture content of approximately 20% and that working in moisture-saturated environments is a constant in the dental profession.[20, 21, 23]

Conclusion

Considering all the biological and functional advantages of autogenous transplantation of a tooth in comparison with an implant placement and all the possibilities of a minimally invasive approach to endodontic treatment using new technology applied to endodontic devices, files and sealers, autogenous transplantation may be a valid treatment alternative, especially in young and compliant patients.[3]

about

Dr Jenner Argueta earned his degree in dentistry and master's degree in endodontics from Universidad de San Carlos de Guatemala, where he achieved multiple awards as an outstanding student. He is a certified researcher at the Guatemalan national council for science and technology and teaches endodontics at the Universidad Mariano Gálvez de Guatemala. Dr Argueta also runs a clinical practice focused on micro-endodontics and micro-restorative dentistry. He was president of the Academia de Endodoncia de Guatemala (endodontic academy of Guatemala) from 2016 to 2020 and is the Guatemalan representative for the Latin American Endodontic Association.
Dr Argueta can be contacted at jennerargueta@gmail.com.

Cyclic fatigue resistance of several nickel–titanium glide path rotary and reciprocating files

Dr Sławomir Gabryś, Poland

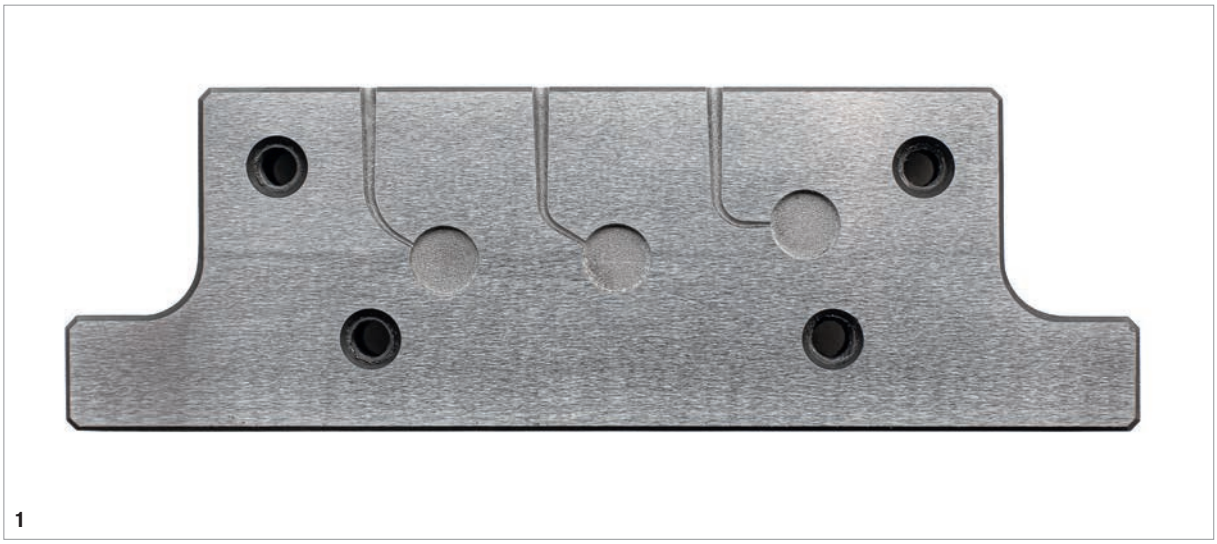


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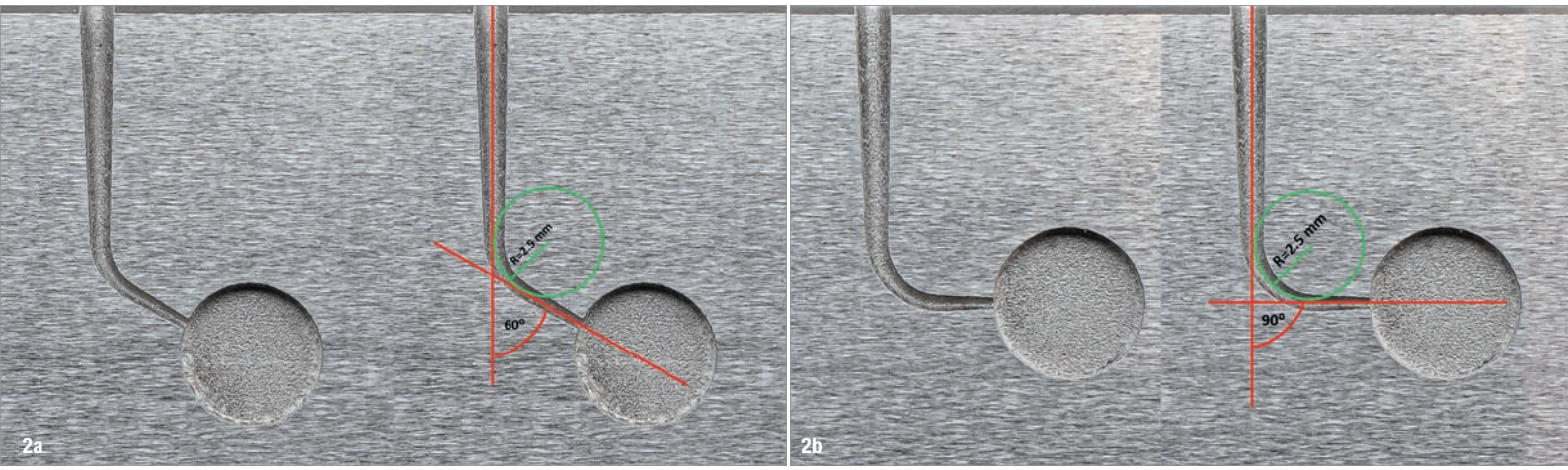
Fig. 1: The custom-made device with artificial stainless-steel canals for cyclic fatigue tests.

Introduction

The purpose of root canal widening is to remove infected dentine and to create space for irrigants and obturation. Giving the widening a cone shape which constricts towards the apex is the basis for correct canal treatment.[1] For the past 30 years, mechanical nickel–titanium (NiTi) files have been used to achieve that.[2] The first stage of canal preparation is exploration and creation of a glide path. West defines "glide path" as: "smooth radicular tunnel from canal orifice to physiologic terminus (apical constriction)".[3] He also says that the glide path is ready when a size 10 file, the one we use to prepare a glide path, moves in the canal from its orifice to the physiological terminus without any difficulty: the "super loose No. 10".[4] But in many cases (narrow and curved canals), creating a glide path just with size 10 file might be insufficient. Often, it is necessary (before the actual mechanical preparation) to expand the size of the glide path to size 15 or 20. This is done to reduce torsional stress that affects the file and thus results in a smaller number of broken shaping files.[5] The larger size glide path can be achieved with hand stainless-steel files, but in the case of difficult canals (narrow and curved), reaching working length with a size 15 file, not to mention a size 20 file, might be very difficult or even impossible. Additionally, preparation with relatively stiff stainless-steel files may cause mishaps, such as ledge formation or transportation of the original canal path.[6] Therefore, special mechanical NiTi files have been introduced. They work in either rotary or reciprocal motion and are dedicated to creating a glide path. Their advantage is, undeniably, a shorter time, in comparison with hand files, necessary to complete the task and, in consequence, a less tired operator.[7] Also, more flexible NiTi files reduce mishaps during canal preparation (ledge formation and transportation).[6,7] Initially, glide path mechanical systems consisted of several files, for example the three-file system PathFile (Dentsply Maillefer), but with the trend of reducing the number of files needed to prepare a canal, glide path mechanical systems too have been reduced to single-file ones. Within the last few years, several single-file systems have been introduced, and they operate in either rotary or reciprocal motion.

Endostar EP Easy Path files (Poldent), which have recently been introduced to the market, are made of a heat-treated NiTi alloy produced using the Amber HT Technology developed by Poldent. These files have an S-shaped cross section, are designed to operate in constant rotation, reciprocal motion and combined Optimum Torque Reverse



Figs. 2a & b: Artificial canals used in this study: 16 mm long with the angle of curvature 60° and radius (R) of curvature 2.5 mm **(a)**; 16 mm long with the angle of curvature 90° and radius of curvature 2.5 mm **(b)**.

motion, and cut in a clockwise (CW) direction. At the tip, they are 0.14 mm in diameter and have a variable taper: 0.04 mm/mm for the first 3.00 mm from the tip, and the taper becomes smaller in the direction of the handle.

RACE EVO (FKG Dentaire) is a recently introduced system of files for canal preparation, and it contains a glide path file of 0.15 mm in diameter at the tip and with a constant taper of 0.04 mm/mm. These files are made of an NiTi heat-treated alloy. They have a triangle cross section, are designed to operate in rotary motion at high speed, 800 to 1,000 rpm, and cut in a CW direction.

WaveOne Gold Glider files (Dentsply Sirona) are made of a modified heat-treated NiTi alloy called Gold-wire. They have a rhomboid cross section, are designed to operate in reciprocal motion and cut in a counter clockwise (CCW) direction. At the tip, they are 0.15 mm in diameter and have a variable, increasing taper: from 0.02 mm/mm at the tip to 0.06 mm/mm close to the handle.

ProGlider files (Dentsply Sirona) are made of a modified NiTi alloy called M-Wire. They have a square cross section, are designed to operate in rotary motion and cut in a CW direction. They are 0.16 mm in diameter at the tip and have a variable, increasing taper: from 0.02 mm/mm at the tip to 0.08 mm/mm at the handle.

R-PILOT files (VDW) are made of M-Wire. They have an S-shaped cross section, are the first glide path files in the market operating in reciprocal motion and cut in a CCW direction. They are 0.125 mm in diameter at the tip and have a constant taper of 0.04 mm/mm.

HyFlex EDM (COLTENE) is a system of files for canal preparation, and it contains a glide path file of 0.10 mm in diameter at the tip and with a constant taper of 0.05 mm/mm. It is manufactured from controlled memory NiTi wire subjected to electric discharges, leading to shaping via melting and vaporisation. The files have a changeable shape cross section, which is quadratic in the apical part and trapezoidal in the coronal part of the instrument. They are designed to operate in rotary motion and cut in a CW direction.

Even though they have obvious advantages, NiTi files for mechanical glide path preparation, similarly to NiTi shaping files, can fracture inside the canal. A few factors may be distinguished which influence resistance to fracture:

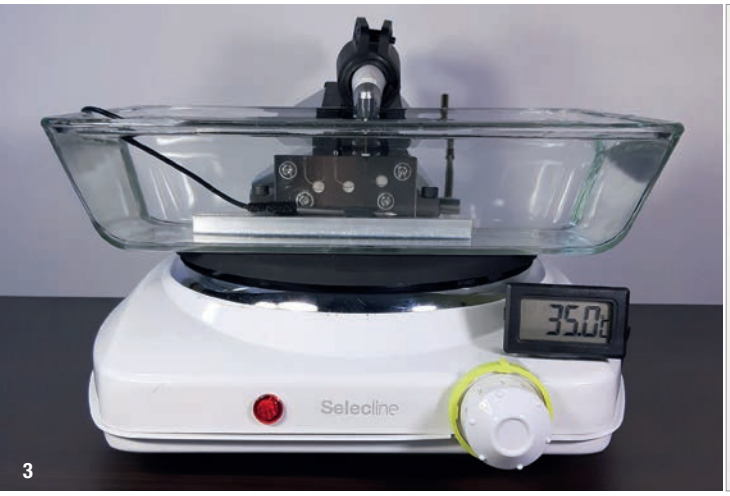


Fig. 3: The cyclic fatigue test device submerged in distilled water in a heatproof glass dish placed on the electric stove. **Fig. 4:** Micro-caliper for measuring fractured instruments.

Mean & standard deviation of the time to fracture

File	Mean (SD) time to fracture (s)	
	60° curvature	90° curvature
Endostar EP Easy Path	244.5 (25.4)	175.7 (12.5)
RACE EVO	108.6 (9.3)	68.6 (6.2)
WaveOne Gold Glider	163.4 (11.3)	109.4 (6.8)
ProGlider	109.0 (13.6)	53.1 (5.4)
R-PILOT	134.9 (15.2)	71.5 (8.6)
HyFlex EDM	126.8 (15.1)	61.2 (9.6)

Table 1

the design of a file (its size, taper and cross section), the type of motion it operates in (rotary or reciprocal) and the type of alloy the file is made of (including heat treatment of the NiTi alloy).[8]

Most research on cyclic fatigue of NiTi files has been conducted at room temperature, but in clinical work, the files operate at a higher temperature, which probably is about 35 °C.[9] Several recent studies have proved that the temperature at which the fatigue test is conducted may have a significant influence on the results.[10,11] Also, for NiTi glide path files, an increase of temperature in which a fatigue test is conducted leads to shortening of the time to fracture.[12] Therefore, in order to bring the conditions of this test as close to the clinical conditions as possible, the fatigue test was conducted at 35 °C. The purpose of this paper was to examine the resistance to fracture of endodontic glide path files (of various design and of NiTi alloy heat-treated in different ways) in cyclic fatigue tests performed in two types of curvature.

Mean & standard deviation of the fractured fragment length

File	Mean (SD) fragment length (mm)	
	60° curvature	90° curvature
Endostar EP Easy Path	3.86 (0.13)	3.90 (0.12)
RACE EVO	4.01 (0.12)	3.97 (0.14)
WaveOne Gold Glider	3.83 (0.16)	3.74 (0.17)
ProGlider	3.75 (0.10)	3.70 (0.12)
R-PILOT	3.74 (0.10)	3.71 (0.12)
HyFlex EDM	3.87 (0.16)	3.84 (0.14)

Table 2

Materials and methods

A total of 120 new endodontic files were used for this research:

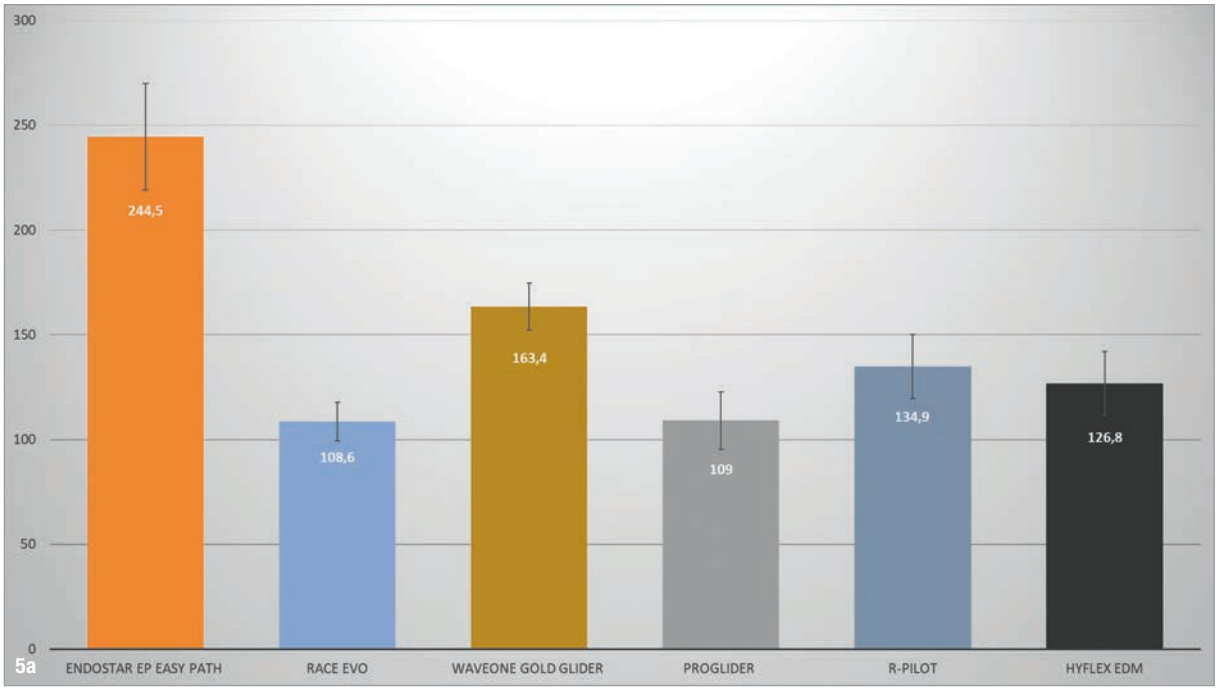
- 20 Endostar EP Easy Path files;
- 20 RACE EVO files;
- 20 WaveOne Gold Glider files;
- 20 ProGlider files;
- 20 R-PILOT files; and
- 20 HyFlex EDM files.

All files were 25 mm long. They were examined under the stereomicroscope Leica M50 (Leica Microsystems) at 20× magnification. No defects or deformations were found; therefore, all files were subjected to this study. Ten files of each kind were subjected to a cyclic fatigue test in a water bath of 35 ± 1 °C in two types of curvature: 60° and 90°.

For the test, three endodontic electric micromotors were used, depending on which motion the tested files operated in. The Endostar Provider electric motor (J. Morita) was used for the Endostar EP Easy Path, RACE EVO and HyFlex EDM files. The Endostar EP Easy Path and HyFlex EDM files worked at 300 rpm, and the RACE EVO instruments worked at 800 rpm (in accordance with the producer's recommendations).[13] The X-Smart Plus electric motor (Dentsply Sirona) was used for the WaveOne Gold Glider and ProGlider files. The instruments worked in dedicated reciprocal motion for WaveOne files and rotary motion, respectively, at 300 rpm. The VDW.SILVER RECIPROC electric motor (VDW) was used for the R-PILOT files, and the dedicated RECIPROC ALL program was used.

A stainless-steel device containing artificial canals (Fig. 1) was used for the test. The first canal had a curvature of 90° and a radius of 2.5 mm, and the second had a curvature of 60° and a radius of 2.5 mm. The length of both canals was 16 mm (Fig. 2). During the test, the entire stainless-steel device was submerged in a glass dish filled with distilled water at 35 °C. The water temperature was constantly monitored with a digital thermometer (ST-9290, ATM) equipped with a measuring probe, which was placed under the water close to the canal being used for the test (the measuring accuracy declared by the producer is 0.1 °C). The glass dish was placed on a metal stove top, which continuously heated the water and kept it at 35 ± 1 °C (Fig. 3).

Every file worked in the assigned motion (rotary or reciprocal) inside an artificial canal until fracture. The time to fracture was measured with a digital stopwatch (Junsd JS-307, Shenzhen Junsd Industry Co.). The accuracy provided by the producer is 0.01 seconds. In this test, the time to fracture was rounded to full seconds



Figs. 5a & b: Mean time to fracture (in seconds) for the files operating at a 60° curvature **(a)** and a 90° curvature **(b)**.

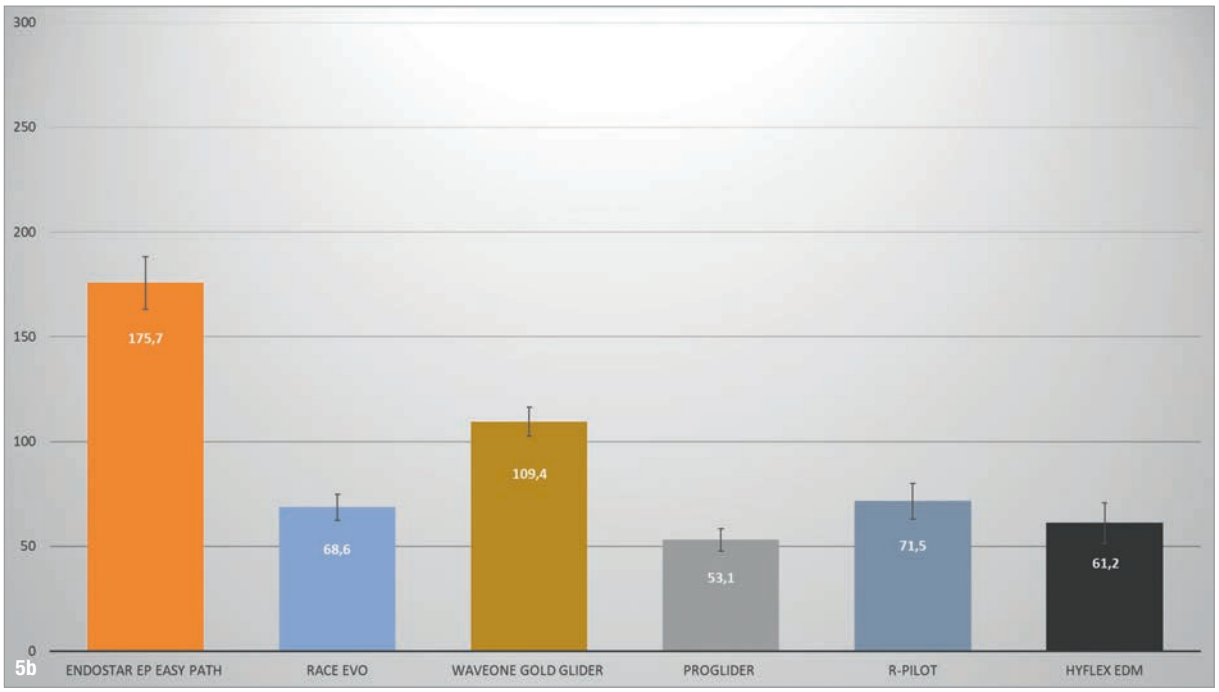
according to mathematical rules. The broken fragment of each file was measured with a digital caliper (Magnusson; Fig. 4) to check the positioning of each file in the canal. The producer declares the measurement accuracy to be 0.02 mm. The same measuring devices (thermometer, stopwatch and caliper) were used in the same way for all files to assure measurement repeatability. Therefore, any potential measurement mistakes relate to all tested glide path files and did not interfere with the final results.

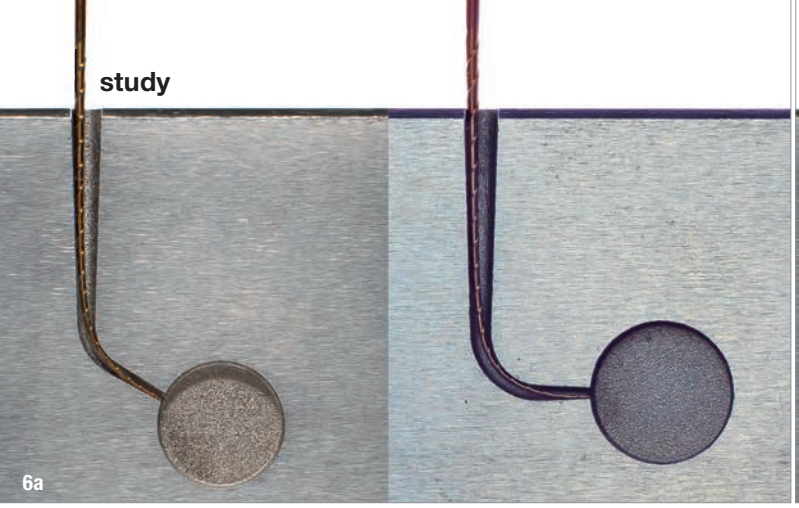
Statistical analysis

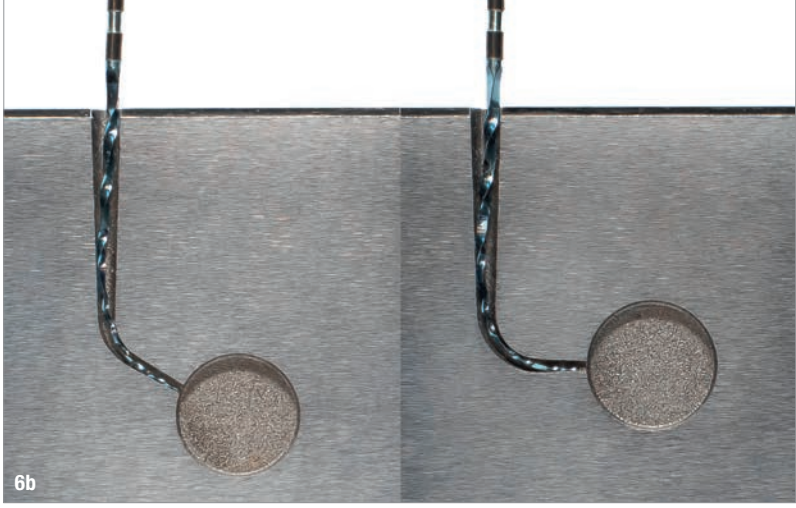
Statistical analysis was performed with IBM SPSS Statistics (Version 25). The Kruskal–Wallis test showed statistically significant differences between files within the scope of the compared variables. When statistically significant differences were noted, the post hoc Games–Howell test was used. It helped to check exactly which files were statistically different. The Wilcoxon signed-rank test was used to look for statistically significant differences between the files while comparing their time to fracture in the 60° and 90° curvatures. The level of statistical significance was set at $p < 0.05$.

Results

The mean time to fracture and standard deviation are shown in Table 1. The post hoc test analysis showed that, for the 60° curvature, the mean time to fracture for the Endostar EP Easy Path files was statistically significantly







Figs. 6a–f: Positioning of the tested files in artificial canals (60° curvature [left] and 90° curvature [right]): the Endostar EP Easy Path **(a)**, RACE EVO **(b)**, WaveOne Gold Glider **(c)**, ProGlider **(d)**, R-PILOT **(e)** and HyFlex EDM files **(f)**.

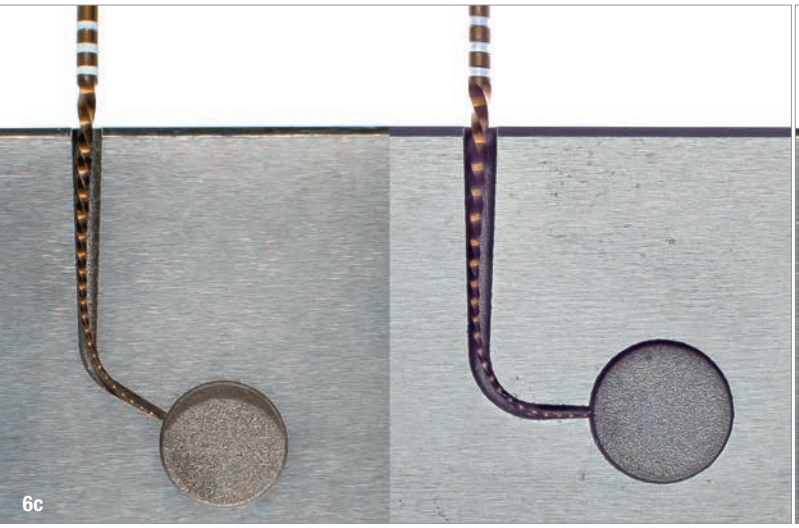
higher than for all the other files ($p<0.001$). The mean time to fracture for the WaveOne Gold Glider files was statistically significantly higher than for the RACE EVO ($p<0.001$), ProGlider ($p<0.001$), R-PILOT ($p=0.002$) and HyFlex EDM files ($p<0.001$). The mean time to fracture for the R-PILOT files was statistically significantly higher when compared with the RACE EVO ($p<0.001$) and ProGlider files ($p=0.009$).

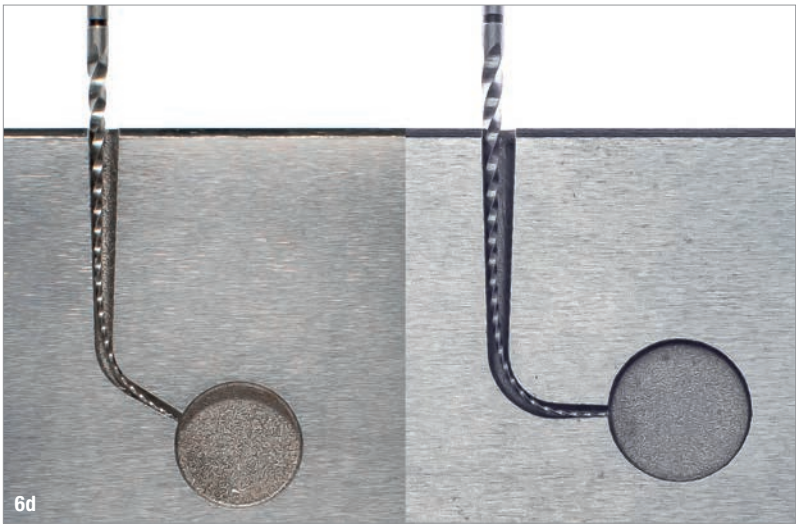
For a curvature of 90°, the mean time to fracture for the Endostar EP Easy Path files was statistically significantly higher in comparison with all the other files ($p<0.001$). The mean time to fracture for the WaveOne Gold Glider files was statistically significantly lower than that for Endostar EP Easy Path files ($p<0.001$) and higher than that for all the other files ($p<0.001$). The mean time to fracture for the ProGlider files was statistically significantly lower than for all the other files ($p<0.001$), with the exception of the HyFlex EDM files. The mean time to fracture for files of the same type was statistically significantly lower for a 90° curvature than for a 60° curvature (the differences will be at the same level; Fig. 5).

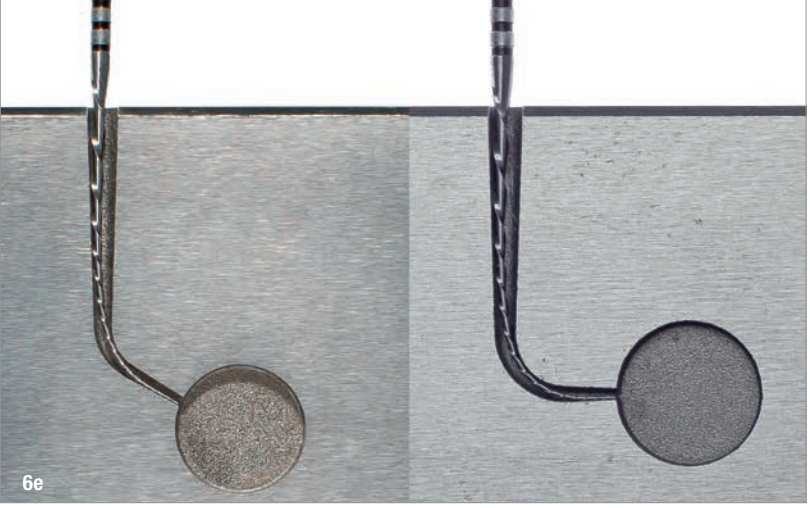
The mean length of the broken file fragments and standard deviation are given in Table 2. The analysis found statistically significant differences. For a 60° curvature, the mean length of broken fragments for the RACE EVO files was statistically significantly higher than for the ProGlider ($p=0.001$) and R-PILOT files ($p=0.001$). For a 90° curvature, the mean length of broken fragments for the Endostar EP Easy Path files was statistically significantly higher than for the ProGlider ($p=0.02$) and R-PILOT files ($p=0.03$), and it was statistically significantly higher for the RACE EVO files than for the WaveOne Gold Gilder ($p=0.04$), ProGlider ($p=0.002$) and R-PILOT files ($p=0.004$). The analysis of the mean length of fractured fragments of the same type of files operating in 60° and 90° curvatures did not show any statistically significant differences ($p>0.05$).

Discussion

Files for mechanical preparation of glide paths were subjected to cyclic fatigue tests at 35 °C because there is very little research on such instruments performed at a temperature close to that of clinical work. The tested instruments are one-file systems for creating glide paths. Additionally, the Endostar EP Easy Path and RACE EVO files were introduced to the market recently, and there is very little research on them. Files for mechanical preparation of glide paths are especially recommended for very curved canals, so their resistance to cyclic fatigue is clinically very important.[14]



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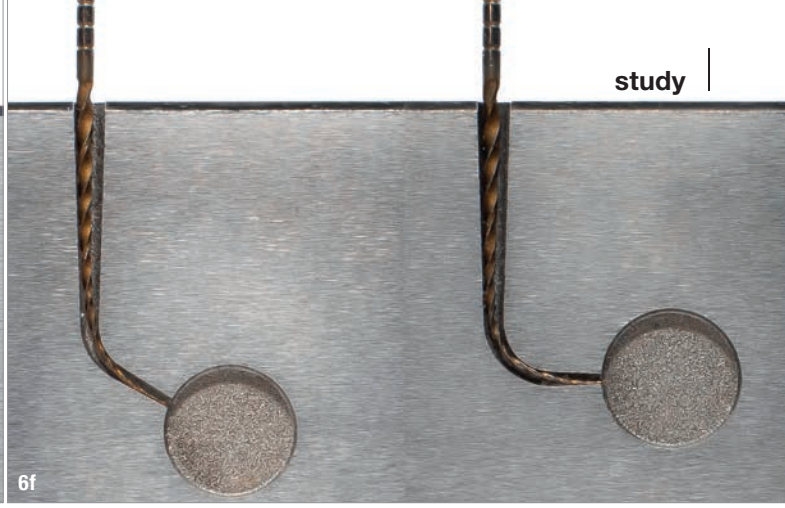
6f

The files were tested in the type of motion and at the rotation speed suggested as basic by the producers of each of the instruments. The time to fracture was not related to the number of rotations to fracture, even though such data can be found in many papers.[15,16] This was not done because precise calculation of rotations to fracture for files operating in reciprocal motion (WaveOne Gold Gilder and R-PILOT) is not possible. In order to convert time to fracture into number of rotations to fracture for reciprocal motion files, we would have had to obtain precise data: the rotation speed for the partial CW rotation of the instrument and the rotation speed for the partial CCW rotation, the length of the pause between these two types of rotations (CW and CCW), which is necessary to change the direction of rotation in the handpiece, and finally accurate angles of partial rotation by which the file moves in both directions (CW and CCW) in a given reciprocal motion.[17,18] This data is not available; therefore, calculation of number of rotations to fracture for reciprocal motion was not possible. Providing just time to fracture for the RACE EVO files produces fairly poor results because they operate at a very high speed, 800 rpm. As research has shown, with a higher rotation speed, the time to fracture becomes shorter in a cyclic fatigue test.[19,20] The producer of these files recommends working at such high speed, but during clinical work, it must be remembered that the time to fracture of these files in curved canals will be shorter.

The tested files have different designs (size, taper and cross section) and are made of NiTi alloy that has undergone different heat treatments. In fatigue tests, the size of a file in the centre of the curvature in which it operates has an influence on the results.[21] The width of the files at the point of fracture is not the same, because they have different sizes and tapers. There is no available precise data for the files of varying taper, their exact size at each millimetre from the tip. Therefore, when comparing files, we must take into consideration that they could fracture in a place where their size is different. As Plotino et al. showed in their research, matching the size of a canal with the tested files may influence the test results because of a different trajectory of a file in the canal.[22,23] In the present research, a canal of the same size and taper was used for all the files (the diameter at the end of the canal was 0.35 mm and the taper 0.06 mm/mm). This caused a small (but statistically significant) difference in positioning of the Endostar EP Easy Path and RACE EVO files in comparison with other files. The difference was the mean distance from the tip at which the fracture occurred. This difference was below 7%, but the level of statistical significance employed was $p<0.05$, which must be considered in comparing the files. The mean length of broken fragments for files of the same type, at both curvatures, was the same, so it did not have any influence on the test. The positioning of files in the artificial canal is illustrated in Figure 6.

All the tested instruments are made of NiTi alloy heat-treated in different ways. As research performed by Gambarini et al. and Zinelis et al. showed, heat-treated NiTi files are more resistant to fracture in fatigue tests.[24,25] In the present research, different types of NiTi heat treatment could not be compared because of the different design of the tested files. Glide path files, during clinical work, are also affected by significant torque (in relation to their small size). Future research should also concentrate on the resistance to torsion of these files at a temperature typical of clinical work.

Conclusion

Being aware of the limitations of the testing performed, it can be stated that increasing the curvature angle at which glide path files operate causes shortening of the time to fracture of all the tested files.

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

about

Dr Sławomir Gabryś graduated with a DDS from the Jagiellonian University School of Medicine in Cracow in Poland. He is a member of the Polskie Towarzystwo Endodontyczne (Polish association of endodontics) and the European Society of Endodontology and a core member of the Dental Masters Group. Since 2011, he has cooperated with the research department of Polskie Towarzystwo Endodontyczne. For eight years, with Poldent, he has conducted the postgraduate endodontic programme Endo Akademia.

Slow down everyone—dentistry does not need to be done at speed

Part 1

Dr Miguel Stanley, Portugal

Dentistry in many parts of the world is being taken over by financially driven practices, and there seems to be a growing number of clinics that are focused only on the bottom line and, as such, see the largest number of patients possible a day, putting themselves and their patients at risk. How? By not taking the appropriate amount of time to process patients' information, properly discuss treatment options with them and prepare the operatory for therapy and in many cases by not placing a dental dam when needed. Currently on the website of one of the largest producers of toothpaste globally, Colgate-Palmolive, is the following statement on the use of the dental dam: "The downsides to using rubber dams are practical and psychological. According to the *Journal of Clinical and Diagnostic Research* study, some dental professionals report that they are reluctant to use dams due to the added time and cost, [and] their lack of training around this dental tool."[1] I think that we need to seriously change this unacceptable state of affairs. For me and all of the dentists who are part of our global network, the use of dental dams should be mandatory, as it is there not to protect the dentist, but to protect the patient! It should be a basic right for dental patients.

Slow Dentistry is aimed at creating a global network of like-minded dentists, practice managers, small business owners and hygienists who are committed to practising a form of dentistry that is patient-centric in terms

Fig. 1: A Slow Dentistry clinic usually works with less stress and is more focused on creating long-lasting relationships with its patients.

Fig. 2: At the White Clinic we do not cut corners, we see fewer patients a day per chair, and since late 1999, we have not booked more than one patient per hour per chair.

of hygiene and safety, thereby distinguishing themselves from their peers in their region. For that, four very simple and universally accepted cornerstones were created that could be applied in any country, under any circumstances, and require no technology or special training. The premise was for Slow Dentistry to be able to be as ubiquitous as possible and to allow the largest number of people to join. We believe that dentists who practise according to these four simple cornerstones, taught in every school around the world, care a little bit more for themselves, their team and their patients and, as such, practise higher standards of care. They are different from those who focus simply on filling out paperwork and doing treatments just to make profit. A Slow Dentistry clinic usually works with less stress and is more focused on creating long-lasting relationships with its patients based on the ethical premise that goes back to the Hippocratic oath to do no harm.

Often, we are so focused on the mechanics of dentistry and the major tasks that we forget the little ones, and as the famous saying goes, “the devil is in the details”. One of the most important details in dentistry is treatment room disinfection between appointments—proper disinfection, not simply tidying up the treatment room as happens regularly around the world. Who can claim that they have not cut corners on this important step when in a rush? Consider that apparently some dentists actually feel comfortable saying that they do not place dental dams because it takes too much time and skill, knowing full well how important it is for safety, not to mention the overall outcome and longevity of restorative dentistry and most importantly root canal therapy.

When I started my private practice at the end of 1999, I had no real benchmark, and no guidelines were given to me, as I took over an old practice that had not really changed its modus operandi since the 1970s. I wanted to be modern, and I wanted to be good! So when I set up the White Clinic, I established protocols of safety and security and even the workflow that is still in place today. This meant that I had to do my homework and talk to the technicians who set up the treatment rooms and the sales representatives who sold me the disinfection products and have them teach me what would be the ideal way to disinfect the dental unit and used rotary instruments. I learned, quite frankly, that if you follow the guidelines it is virtually impossible to properly disinfect the treatment room, all surfaces and the floor and clear the air (open a window) after performing a treatment, whether with or without the generation of aerosols, in under 10 minutes. Therefore, when clinics are seeing in excess of 20 patients per chair a day, I always wonder what is going on with room disinfection. Or when I see dentists doing 20 or 30 restorations a day, I wonder if they are really taking the time to place dental dams.

Figs. 3 & 4: The daily average of the last five years was 35 patients a day in the clinic—and that is divided over the seven dental chairs.

So how do we do it at the White Clinic?

It is simple. We do not cut corners, we see fewer patients a day per chair, and since late 1999, we have not booked more than one patient per hour per chair. We have seven chairs in the clinic and so that means no more than 56 patients a day. We are open for eight working hours a day from Monday to Friday and so that would be the maximum capacity allowed. The daily average of the last five years was 35 patients a day in the clinic—and that is divided over the seven dental chairs. This means that it is possible for us to really focus on our patients, creating quality relationships, to make sure that we have proper consent and that they have a clear understanding of the treatment to be performed and to give the dental assistants the necessary time to properly disinfect between appointments. Moreover, we even have a special team for sterilisation so that the dental assistants can properly focus on their tasks.

A clear example of this would be our oral hygiene appointment. It is a good example because the protocol is always the same. For 20 years, our oral hygienists have worked with a dental assistant by their side, and the time allocated to each patient is 1 hour. The actual intervention usually ends 5 to 10 minutes before the hour, and the following patient's actual intervention will start 5 to 10 minutes after the hour, leaving roughly 45 to 50 minutes of chair time to perform a good deep cleaning procedure properly. In the time in between that, the dental assistance exchange the disinfected tips, making sure everything is properly prepared for the next appointment, and the hygienist talks to the patients, writes the clinical notes, and has some time to rest, have a glass of water and get ready for the next intervention.

Many of my peers claim that it is impossible to do so and make any money from dentistry. I always answer, how can you practise dentistry without focusing on safety and hygiene? What are you selling at the end of the day? Is it not trust? Should we decide what is important for the patient? In the pre-COVID-19 world, I can understand fitting in as many patients a day as possible, resulting in packed waiting rooms and rushing from patient to patient. In a world after COVID-19, this is no longer possible. If your business plan is all about volume so that you can charge less and

Fig. 5: All you have to do is slow down and understand what your priorities are. They should be to work safely, ethically and responsibly.

attract more patients, this is at the expense of basic safety protocols like room disinfection and placing dental dams.

Portugal is not the wealthiest country in Europe; it is actually one of the poorest countries in Europe. We do not have socialised dentistry; it is almost 99% private. Practising this way for 20 years has not always been easy, but one thing is for sure: at the end of the day, our patients feel safer with us. We had many patients return to our clinic after having left us for years to go to cheaper clinics for follow-up and maintenance and, during 2020 as a consequence of the pandemic, come back to the White Clinic because they finally understood that the premium that they paid was for hygiene and safety.

Moreover, when you work this way, there is undoubtably a great deal less stress at the end of the day for the clinical staff. Mental health is a major topic in dentistry today, and if you do your research you will probably find that, in some industrialised countries, suicide among dentists is one of the highest in any industry. Is it because the job is stressful? I do not think so! I believe that dentistry is actually a very rewarding job, as long as you are given time to practise it. I think many dentists go home over-worked, undervalued and stressed because they know that at the end of the day they did not do things perfectly and safely and often did not put the patient at the centre of their care. Everything we do is founded on scientific principles and clinical evidence. The basic cornerstones of Slow Dentistry are undeniably true. No dentist needs to invest in any superior education or technology to implement them. All you have to do is slow down and understand what your priorities are. They should be to work safely, ethically and responsibly.

Disclaimer

Slow Dentistry is part of the non profit Foundation for Excellence in Dentistry, based in Switzerland. I have no financial interest in the organisation. It was created to improve dentistry as a whole, and as part of my legacy work towards the industry. www.Slowdentistry.com

Editorial note: This is the first article in a four-part series on Slow Dentistry and its principles and advantages. A list of references is available from the publisher.

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Dental fitness: The future concept of sustainable dentistry

Prof. Ivo Krejci, Switzerland

Dental fitness is a concept of modern dentistry focused on tooth preservation and aims to maintain the lifelong clinical health of teeth. To achieve this goal, a highly specialised personal dental coach is proposed to patients who would like to benefit from this concept.

Introduction

Caries and periodontitis are among the most common chronic, incurable, multifactorial diseases in the world, and one of their peculiarities is the infection of the oral biofilm with potentially cario- and periodonto-pathogenic bacteria. Since infection is unavoidable in the social context, the vast majority of the population may harbour these bacteria in the oral cavity for life. Although periodontitis is most likely and caries probably related to medical problems, neither disease, in contrast to several chronic medical conditions, leads to premature death. This may be one of the main reasons why caries as well as periodontitis are perceived by the population as bothersome but not threatening.

The current treatment concept for combating caries and periodontitis is based on imperfect basic prevention and temporary cope with late symptoms represented by cavitated carious lesions and deep periodontal pockets. This concept is complex and extremely expensive. Furthermore, it does not remedy the causes of the diseases, because a causal therapy that would lead to complete healing is currently not available. Once affected by symptoms of periodontitis and/or caries, the patient remains a lifelong nursing case, and the more severe the symptoms become during his life, the more complex and expensive the temporary treatments become. Finally, many teeth have to be extracted because their preservation is no longer possible for technical and/or financial reasons.

It is not difficult to deduce from these statements that further research efforts in the field of treatment of late symptoms will not solve the problem. Much more promising for the future are modern approaches that deal with the causes of caries and periodontitis in order to extirpate both pandemic diseases. They rely on the rapid development of sequencing technologies, epigenetics, big data and machine learning, to name but a few.

Until that time, a paradigm shift is possible for today's clinical routine, aiming to refine symptom control with patients' collaboration using modern diagnosis, personalised prevention and non-invasive treatment of preclinical symptoms to such an extent that complex and cost-intensive restorative and periodontal treatments, and in particular tooth extraction, become the exception. This paradigm shift has been conceived of as dental fitness by the author, together with Daniela Krejci-Sparr.

Goal of dental fitness

Dental fitness aims to keep people's teeth healthy throughout their entire lives. Within this concept, dental health is defined as the absence of clinical symptoms, but allows for preclinical symptoms which must be arrested at this level. The aim is to keep the natural biological structures clinically healthy in order to avoid having to reconstruct or regenerate them. In patients who are already affected by clinical symptoms, dental fitness is intended to halt or at least to slow their progression as much as possible and to prevent the occurrence of new clinical symptoms.

Prerequisites for dental fitness

In order to successfully implement the concept, several prerequisites must be fulfilled. The most important and difficult one is getting patients interested in the concept. The healthier they feel and the younger they are, the more difficult it is to persuade them of the necessity of the concept for their lifelong oral health. Yet, it is precisely in this group that it makes the most sense to introduce such a concept. The second prerequisite is a precise diagnosis, which entails the recognition of symptoms in their preclinical early stage. The third prerequisite is the adaptation of the organisation, the financial plan as well as the staff of the dental office to the concept. The fourth prerequisite is the specific high-tech infrastructure and expertise necessary for putting dental fitness into practice.

Practical implementation of dental fitness

Dental fitness is based on the concept of medical fitness. At the first appointment, for which the patient should not be in the dental chair, the concept of dental fitness is explained and any questions are answered. In case this appointment cannot be charged to the patient, it might be regarded as a marketing investment. It is crucial to convey the awareness that only the patient himself or herself can keep his or her teeth healthy and that he or she must take responsibility for his or her own dentition. If the patient is really interested and ready to participate in the programme, several basic parameters for the dental fitness concept are determined at the following appointment, during which, based on a precise diagnosis, the individual personal goals of dental fitness

are determined together with the patient. In this first phase, the goals should be realistic and not too ambitious. If clinical symptoms already exist or if there are factors such as calculus or imperfect restorations that could hinder the optimal implementation of dental fitness, these are professionally treated.

The next step is the personalised selection of the dental fitness exercises and tools as well as the definition of the dental fitness programme through which the patient can achieve his or her personal goals. The dental fitness exercises and tools are physically presented to the patient and practically taught. The patient then practises first in the dental office under supervision until he or she has mastered the exercises and then performs them at home once or twice a day. Within two to three months, the patient is recalled in for a control appointment and, if necessary, for the correction of his exercises. It is also possible to adapt or refine the recommended tools and excercises if the patient, who in fact becomes a client, is not able to reach the agreed goals.

The next control and remotivation appointment takes place after another two to three months. If the outcome of this appointment is satisfactory and the patient has not developed any further subclinical symptoms, it is possible to enter the lifelong monitoring phase. Depending on the individual situation, the monitoring intervals are between three and 24 months, and the next monitoring interval is individually determined at each subsequent session based on the actual screening of preclinical symptoms.

If preclinical symptoms are diagnosed in one of the monitoring sessions, the first approach is to try to stop the progress of these symptoms with the patient's help by intensifying his personal dental fitness efforts. A short-term monitoring interval is temporarily set for this purpose. If the measures taken have led to the arresting of the symptoms, it is possible to switch back to a longer monitoring interval. In case of symptom progression, the personal dental coach will use professional non-invasive methods to try to stop it. Minimally invasive professional measures are only required if the patient has not attended monitoring sessions for a lengthy period for whatever reason leading to clinical symptoms which make such procedures necessary. However, this should be the absolute exception.

Implementation feasibility for dental fitness

Owing to the relatively low aggressiveness of caries and periodontitis progression in the vast majority of cases, a rather relaxed fitness programme is sufficient for most patients. Assuming appropriate information, instruction and motivation of the patient, it is postulated that the dental fitness concept can be successfully communicated and applied not only to highly motivated, but also to relatively unmotivated patients. In many cases, a monitoring session scheduled every 12 to 24 months may be sufficient to prevent the appearance of clinical symptoms, especially if the screening for preclinical symptoms is regularly applied so that in case of progression, these symptoms may be arrested by appropriate non-invasive professional therapeutic measures.

Costs of dental fitness

In a patient with good compliance and a life expectancy of more than 80 years, it is estimated that lifelong dental fitness can be financed at the price of two implant-supported crowns—and this not only for a single tooth, but for the entire dentition.

The role of the dentist in dental fitness

In the dental fitness context, the dentist is no longer a dental technician working on patients as is the case in traditional repair-oriented dentistry. Rather, he or she is a personal dental coach who, thanks to his or her expert knowledge and social skills, enables the patient to maintain his or her own teeth in good health for the rest of his or her life with the least investment of time and money.

Advantages of dental fitness

The dental fitness concept has many advantages for patients: with a minimal investment of time and money, they can preserve their natural teeth until the end of their lives, resulting in the best possible sustainability as of today. But there are also several advantages for dentists. The concept offers the opportunity to lead a team of collaborators who can take care of the major part of the labour needed, thus taking care of a much larger number of patients than the individual dentist alone. As a result, dentists become health managers, focusing mainly on diagnostics and planning, as well as on human resources, business and operational management. When working clinically on patients, they carry out relatively low-risk, micro-invasive and high-quality interventions. This may increase job satisfaction and attractiveness and reduce stress levels for both dental professionals and patients.

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about

Prof. Ivo Krejci is professor and chairman of the Division of Cariology and Endodontology and director of the department of preventive dentistry and primary dental care at the University of Geneva in Switzerland, where he maintains an intramural private practice. He also serves as the scientific consultant for the school of dental hygienists in Geneva. Over the course of his career, Prof. Krejci has written over 350 articles and book chapters on topics in restorative dentistry, as well as several textbooks. Furthermore, he has supervised more than 60 doctoral theses and has lectured at numerous international scientific meetings and continuing education courses. He can be contacted at ivo.krejci@unige.ch.

Environmental sustainability in endodontics

By Monique Mehler, Dental Tribune International

Over the years, researchers have investigated the total annual carbon footprint of dental services in various countries. Now, a life cycle assessment (LCA) was conducted at the Faculty of Dentistry at Malmö University in Sweden in order to investigate and evaluate the environmental impact of a routine two-visit root canal treatment. In an interview with Dental Tribune International, the three main authors Linnea Borglin, Drs Hal Duncan and Brett Duane shared some insights into the findings.

What inspired your research team to analyse the global resource use and environmental output of the endodontic procedure?

Borglin: This study originated from a master's thesis at Malmö University.

Duane: Stephanie Pekarsi, our co-author, Linnea and I tried to think of three fairly resource-intensive elements of dentistry that we should study and decided on periodontal treatment, an examination and an endodontic procedure. This paper came from the third study.

Were there any challenges you had to face during the LCA? If so, what were they?

Duane: It was a challenge measuring all the elements. Also trying to find specific energy use of equipment, for example the autoclave and the washing detergent used to wash dental clothing!

Why did you decide not to include travel to and from the dental clinic in your assessment methodology?

Research suggests that staff and patient travel make up the most significant percentage of carbon dioxide emissions.
Duane: Travel was central to earlier English and Scottish studies. In this study, we wanted to concentrate on the materials and processes over which we have a greater degree of control; hence we excluded travel.

Borglin: In this way, we could focus on identifying other environmentally harmful processes more specific to an endodontic procedure.

I have been conducting some research regarding eco-friendly dentistry, and my feeling is that sustainability is not a top priority for the average dental professional. Do you agree with this conclusion? And if so, what do you think are the main reasons that hold dentists back from reducing their carbon footprint?
Duane: Many dentists are trying to survive financially and juggling all the additional protections needed for patients so when you mention sustainability, you can get blank looks. I think it wasn't a priority at all say 5 years ago, but there is a growing number of dentists, especially in the younger generation which realise the importance and relevance of this area of dentistry. There are so many barriers to dentists being involved in sustainability and there are few facilitators. We need a comprehensive programme of education, an incentivisation programme; basically, sustainability needs to be normalised and embedded in everything we do.

Do you have any tips for the endodontic team on how they can reduce the environmental burden of endodontic care?
Duncan: As modern root canal therapy uses a large number of instruments such as files, which in many jurisdictions are considered to be of single use only, the drive towards more sustainable endodontics should firstly be aimed at reducing the number of patient visits. Single visit treatment will reduce factors such as the number of files, sterilisation costs, and patient and operator time. A second way to improve sustainability would be to limit exposure and to consider vital pulp treatment for cases exhibiting symptoms of pulpitis.

> "Single visit treatment will reduce factors such as the number of files, sterilisation costs, and patient and operator time."

The employment of minimally invasive techniques where possible reduces treatment times, cost and instrument use and, in doing so, the environmental burden. Finally, if local rules allow, and if compliance with cross-infection regulations can be ensured, instruments should be reused.

Editorial note: The study, titled "Environmental sustainability in endodontics. A life cycle assessment (LCA) of a root canal treatment procedure", was published on 1 December 2020 in BMC Oral Health.

According to researchers, editors of journals need to be cognisant of sustainability in dentistry as a developing area and facilitate the publication of high-quality research.

Since dental students had to suspend their clinical training during the pandemic, some dental schools around the world have announced that they will not be taking in new students in 2021.

COVID-19 and dental education: Will dental schools admit new students in 2021?

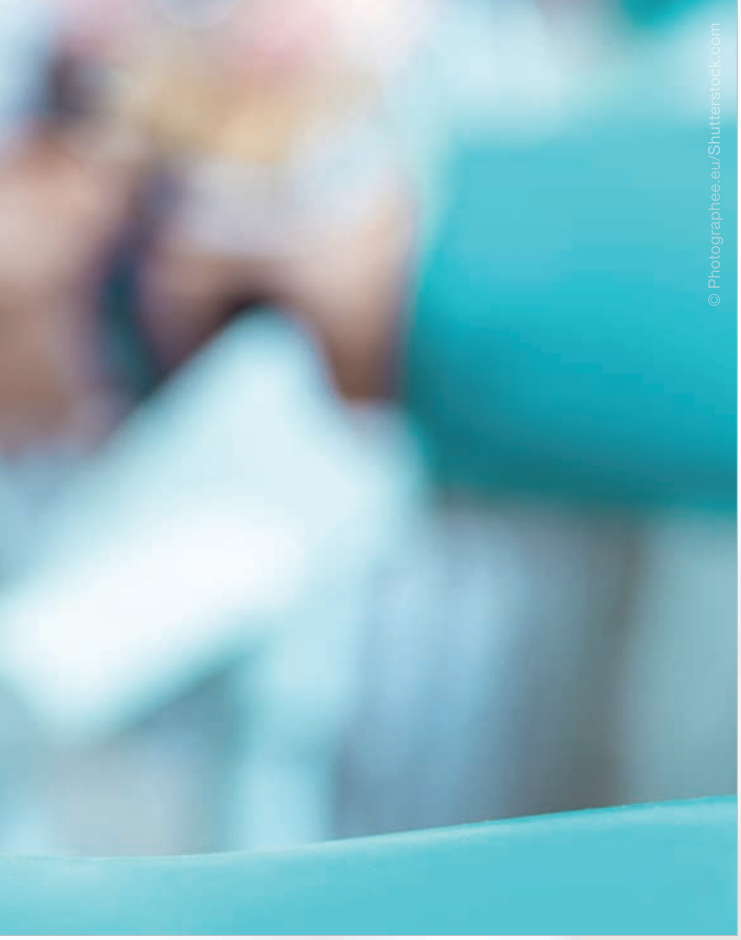
By Iveta Ramonaite, Dental Tribune International

Since the COVID-19 pandemic has severely restricted access to clinical practice, students around the world have been adversely affected by the far-reaching consequences the pandemic has had on dental education. To make the most of the current situation, numerous schools have instituted video and virtual platforms in order to familiarise students with standard clinical procedures. However, the knowledge gained through online learning is limited, and some students are now being asked to repeat the 2020–2021 academic year in order to complete the necessary clinical training. To this end, some dental schools have announced that they will not be admitting new students in 2021.

Owing to the high risk of the virus spreading through aerosol transmission in clinical practice, dentistry has been severely affected by the pandemic. This has manifested itself in a lack of the in-person training for dental students which is crucial for the successful completion of their education. Students have also been burdened by various fears and worries caused by factors such as the necessity to adapt to the updated infection control protocols and the need to rise to academic challenges.

The gravity of this situation is clearly evident in Scotland. Since final year dental students have been unable to graduate owing to a lack of practical clinical experience, Universities Scotland, the representative body of Scotland's 19 higher education institutions, has announced that dental schools will not be accepting new students in September 2021. Mairi Gougeon, Scotland's public health minister, was quoted as saying that the decision was difficult but necessary.

"The quality and calibre of dental treatment in Scotland is outstanding and it needs to be protected by taking the



appropriate measures in education to ensure future dental professionals have reached the General Dental Council's standard of clinical competence and can enter the workforce with confidence," she noted.

To help avoid crippling debt for students, the Scottish government will be offering financial support to those who have been asked to repeat their final year. According to Gougeon, affected students will be eligible for a bursary equal to the amount of their student loan.

Dental schools in Europe are yet to make the decision

Discussing the situation in Europe, a spokesperson at the European Dental Students' Association (EDSA) told DTI: "We know that a lot of students are particularly worried about their lack of experience and the impact it will have on their future education and job prospects. Every student has the right to build a successful career and to receive dental training that prepares him or her to deliver safe and effective oral health care to the population he or she serves. If a student has received insufficient clinical experience to provide this, then a limited extension to the length of his or her course may be appropriate, depending on the local context."

According to some sources, several universities in Malta and Greece have already chosen to extend their terms. Other countries are considering taking the same action but have not yet made the final decision.

Talking about possible extensions to the length of courses, the association noted that any extensions granted to students should be proportional to the amount of clinical time missed. However, EDSA noted that dental schools should consider carefully all the options available to safely increase the provision of clinical teaching and to avoid extensions where possible, since these may lead to financial burden. The spokesperson added: "Students must be protected from the financial impact of extending their studies. They should not pay additional fees, and schools and governments should seek to provide financial support for living costs, especially for those who may struggle in the case of an extension."

Dental schools in the US still accepting students

Although the COVID-19 pandemic has severely disrupted dental education in Scotland, the situation is not the same in some other parts of the world. For example, for dental schools in the US, it is business as usual. Dr Karen P. West, president and CEO of the American Dental Education Association, told DTI: "Dental education continues to move forward in the US, and all existing dental schools in the country are continuing to accept new students this year. In fact, applications to schools are thriving."

Students in the country have been quick to adapt to the changes in teaching and learning and have embraced the shift to virtual classrooms, with all its possibilities. "Although the COVID-19 pandemic disrupted learning last year, schools adapted and developed innovative educational environments in which to teach and learn. In accordance with the Centers for Disease Control and Prevention guidelines for patient care in the COVID-19 environment, students are providing clinical care, and competency assessments are continuing," she noted.

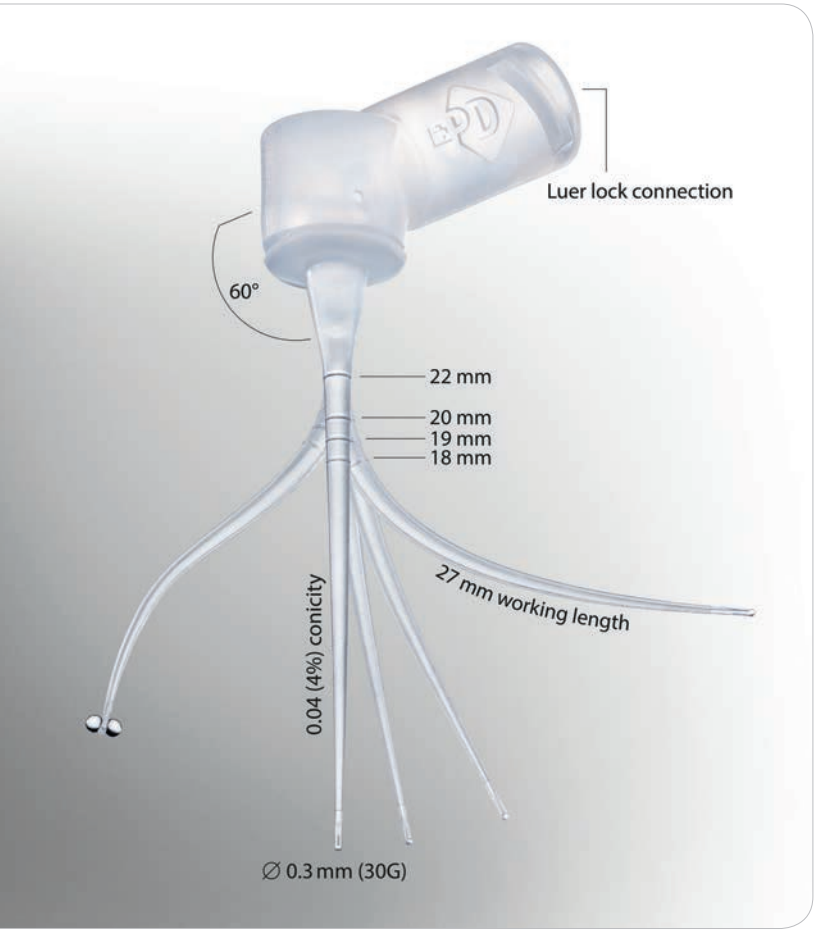
"Although the COVID-19 pandemic disrupted learning last year, schools adapted and developed innovative educational environments in which to teach and learn."

"Students are not being asked to repeat the 2020–2021 academic year based on COVID-19 alone. To their credit, faculty and students quickly adjusted to the changed environment, embracing virtual learning options that have allowed dental education to grow and flourish in new and ground-breaking ways," West concluded.

The glide cleaning revolution

IrriFlex—flexible root canal irrigation needle

A new generation of irrigation needle designed and manufactured by Swiss endodontic company PD (Produits Dentaires) enables more effective cleaning and disinfection in root canal therapy owing to its unique flexibility and exceptional irrigation capabilities. The IrriFlex needle solves a common problem for dentists: how to irrigate complex root canal systems completely and efficiently.



IrriFlex safely performs powerful and complete irrigation of the root canal to improve removal of residue, such as debris, the smear layer and biofilm, in areas impossible to reach with conventional metal needles.

Combining a soft polypropylene body with a unique lateral solution delivery, PD has designed a 30-gauge needle that can easily adapt to the canal anatomy, irrigate effortlessly and clean areas once impossible to reach. The result is enhanced cleaning and irrigation for a more efficient, comfortable treatment compared with conventional metal needles.

PD's needle design encompasses two side vents positioned back to back at the tip for powerful lateral irrigation and a tapered shape to match root canal preparation, unlike metal needles. The 4% tapered design maximises the shear stress along the root canal walls to improve mechanical cleaning efficacy.

The needles are produced in a clean room certified ISO 7 and delivered in individual sealed pouches designed for single-patient use, thus maximising safety. With this new needle, PD supports general dentists and specialists in performing root canal irrigation more efficiently, comfortably and safely. More information can be obtained at www.pd-irriflex.com.

www.pd-dental.com

Removers leave a lasting impression

Single-file retreatment system for endodontic treatment proves convincing for dentists in practice test

After the market launch of its new retreatment files last year, Swiss dental specialist COLTENE recently launched a test initiative among dentists and endodontic specialists, followed up by a survey on their experience with the Remover for the HyFlex and MicroMega file systems (Fig. 1). The verdict of first-time users is conclusive: in particular, switching in a retreatment from various hand files to a single nickel–titanium (NiTi) file provides significant benefits in dental practice. The removal of insufficient endodontic restorations has become a standard treatment in practices owing to an increase in retreatment. The new Removers employ the latest technologies, such as asymmetrical design, electropolishing and thermal treatment, to make treatment safe, easy and fast. A look at the responses from the clinicians surveyed shows that the benefits were clearly seen in practice: "The new Remover makes gutta-percha removal very easy and fast", "Perfect harmony between efficient removal and sensitive tactile feedback", "Respects complex root canal anatomies" and "Makes my endodontic life more convenient" were among the dentists' comments. One endodontic expert concluded as follows: "A single instrument for removing old gutta-percha, the HyFlex Remover fulfils the dream of many dentists."

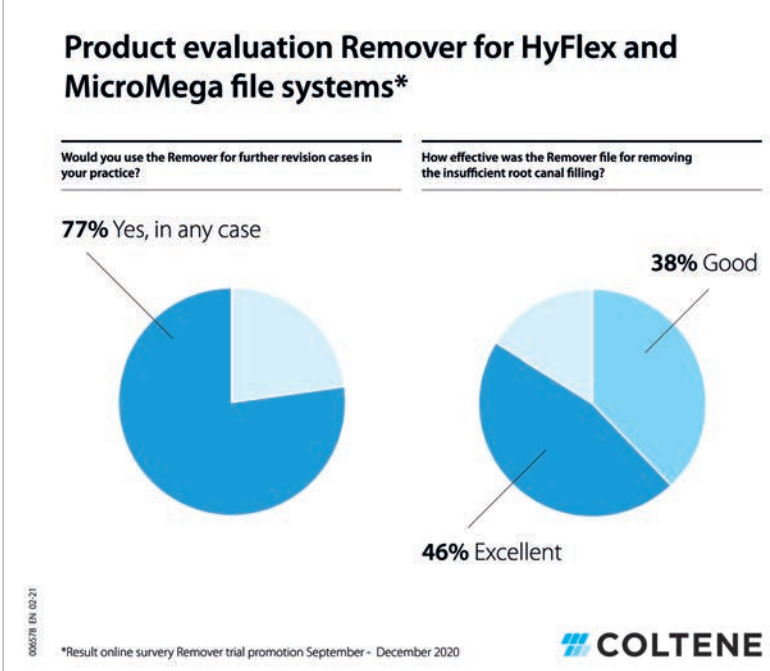


Fig. 1: Online survey results for the Remover files.

Fast, reliable, intuitive—participants in test confirm excellent efficacy and faster treatment

As part of a Europe-wide test initiative, individual and group dental practices were given the opportunity to try out the Remover extensively over the past few months. The initial survey results confirmed that more than 80% of the participants regarded the file as demonstrating excellent or good efficiency at removing insufficient obturation material. Almost half of the respondents were thus able to perform their work significantly faster than before. The 30/.07 Remover is optimally designed for the situation of a previously prepared canal and, owing to its intricate shape, adapts to the natural contour of the canal to efficiently loosen the existing dental material. The file removes gutta-percha mechanically from the root canal, thereby eliminating the need for an additional solvent which may be toxic for the patient. At the same time, the surrounding tooth structure benefits from the intelligent file design: a non-cutting tip provides additional safety during preparation. Handling is extremely simple and intuitive, as was confirmed by more than 80% of the respondents. More than three-quarters were instantly so convinced of the advantages that they said that would not wish to do without the new file in their practices in the future.

The Remover file is available in 19 and 23 mm lengths (Fig. 2). A large number of cases can be treated with the 19 mm file. The last millimetres can then be cleaned with the matching HyFlex EDM and CM or MicroMega 2Shape and One Curve files to give an optimum result. The Remover file is fully integrated into these file systems, which are then also used to perform the subsequent finishing of the missing root canal cleaning.

Integration into the dental practice

COLTENE will again offer a series of training courses, practical workshops and webinars in 2021 on the optimal integration of the new files into COLTENE's NiTi systems as well as on various application issues in endodontics. On www.coltene.com or one of the innovation leader's social media channels, interested dentists can currently find out about the latest trends and ideas from the dental world in the comfort of their own homes. This way, even endodontic beginners will be able to achieve competent and efficient preparation after only a short time.

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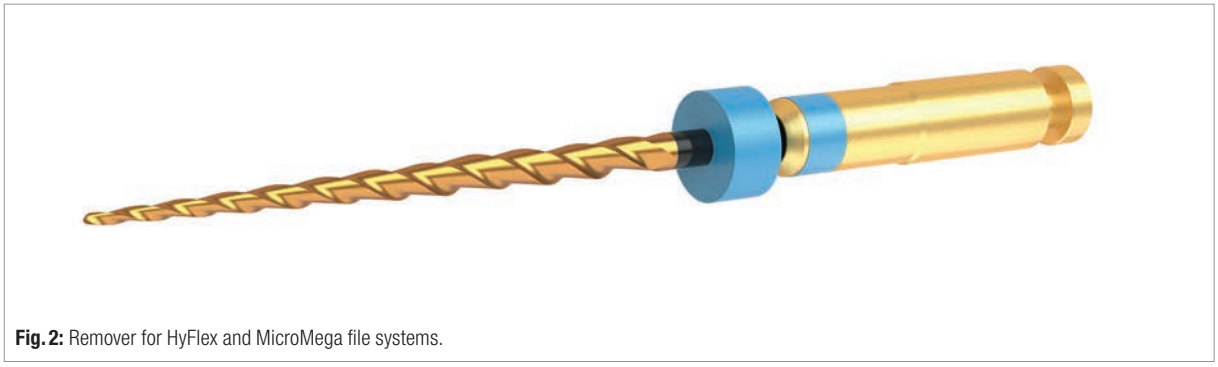

Fig. 2: Remover for HyFlex and MicroMega file systems.

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- all the image (tables, charts, photographs, etc.) captions;
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We can run an unusually long article in multiple parts, but this usually entails a topic for which each part can stand alone because it contains so much information.

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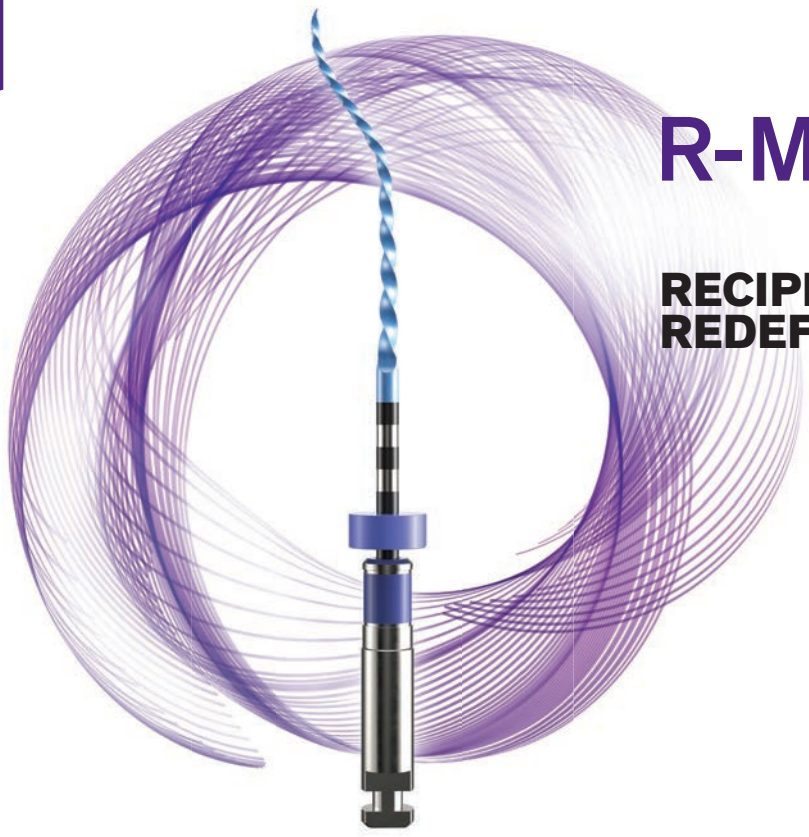

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