The effect of partial vacuum on the chemical preparation of the root canal system

By Dr. Philippe Sleiman

From the early 20th century, when Walter Hess and Ernest Zobler demonstrated root canal anatomy with an unprecedented visual clarity, its complexity has fascinated researchers armed with ever better imaging tools—from blue dyes to CT, from CBCT to confocal microscopy, from clear tooth preparations to micro-CT, to name just a few. Thanks to rigorous research and discussion, the diverse intricacy of root canal morphology is well understood and accepted today. However, the question of how to best prepare this space to restore homeostasis remains open to debate, which is conducted both in the scientific and, unfortunately, commercial domains. Our task as scholars and clinicians is to investigate which approaches would be practical and applicable to bring teeth and periodontium back to health in accordance with evidence-based endodontics and principles of minimally-invasive dentistry.

As yet another array of new file systems are launched in the market, we seem to share an understanding that files do not have the ability to clean root canal space, only preparing, i.e. shaping it, while it is the irrigation process that provides a level of cleanliness that can, hopefully, create conditions for the body to heal. Thus, given that the shaping is acceptable (i.e. the files used remove the bulk of the pulp and/or infected dentine without blocking the system with debris as well as maintain the original shape of the canal without any micro-crack formation), it is the chemical preparation that is responsible for treating the system in all its complexity.

For a long time, irrigation remained a somewhat mystical part of the process, with a general agreement that a good rinse is necessary, but without a standardised sequence of irrigation. While various tools for irrigation and activation of solutions were studied extensively, the first sequence was suggested only in 2005, and it made clinicians aware that alternating solutions could be as beneficial as the use of negative pressure in order to achieve a clean root canal space and diminish postoperative pain.

Below you will find descriptions and outcomes of several studies that led to a suggested protocol of irrigation that is presented in the conclusion of the present publication. Investigating irrigation today

The fact that during root canal shaping the system may get blocked by debris led to the question of how to best conduct the chemical preparation so that the dentinal tubules remain open to allow for a better cleaning and, consequently, sealing of the system. Drawing from clinical experience and improved outcomes, Jaramillo et al. have formulated an experimental irrigation sequence based on Sleiman’s 2005 suggestions, and added a negative pressure device to see if it may have added benefits.

Scanning electron microscopy used to evaluate the cleanliness of dentinal tubules at three different levels of the canals demonstrated that our experimental sequence—alternating the use of 6 percent NaOCl and 17 percent EDTA with water in between—had shown a significantly better ability to keep the entrances of dentinal tubules open and avoid the blockage of dentinal tubules by the smear layer and debris during the cleaning and shaping procedure compared with the use of 6 percent NaOCl or 17 percent EDTA alone. The results emphasized the importance of the early use of 17 percent EDTA and not only as a final rinse.

This sequence allows us to use the standard endodontic irrigants during chemical root canal preparation and prevents any chemical interaction between them thanks to the use of distilled water at strategic times. Depending on the pH levels and the nature of the solutions, such chemical interactions may have a variety of consequences, from brown (and in some instances, carciogenic) precipitation to dentine modification, potentially affecting general health and/or quality of the dentine inside the root canal system, which, in turn, may influence the longevity of the link between the sealer and the dentine, thus changing the outcome of the root canal treatment in general.

Another finding of the study that echoed positive clinical outcomes related to the use of negative pressure in combination with the experimental irrigation sequence; the irrigation protocol that included both the Sleiman sequence (alternating between sodium hypochlorite, water, and EDTA) and a negative pressure irrigation device was proven to be the most efficient in opening dentinal tubes and maintaining them open. It may be posited that the negative pressure allows for a formation of a temporary partial vacuum force, which first draws the liquids from the access cavity into the root canal system and then suction them out of the system. Using the macro- and the micro-cannulas of the negative pressure irrigation unit in, correspondingly, the coronal-middle and apical parts of the root canal system, leads to the creation of a vacuum, or a partial vacuum, to be more specific, inside the root canal space. Though its main role is to attract solutions deeper and deeper into the system and safely remove them from within, the partial vacuum created by the negative pressure has a number of other important benefits as Sleiman-Iandolo testing has shown.

First of all, it can eliminate the airlock (better known in endodontics as vapor lock) inevitably resulting from bubbly chemical reactions between irrigating solutions and the dye deeply into the dentinal tubules (Fig. 2a). To compare commonly used irrigant delivery techniques, a negative pressure irrigation unit was used (EndoVac) as well as a lateral-vented needle, manual activation of the solution, and passive ultrasonic irrigation in combination with the Sleiman irrigation sequence. EndoVac + Sleiman sequence was shown to be the only approach that allowed for a complete removal of the methylene blue dye from the entire root canal system and dentinal tubules over the total time of 25 minutes, while the other approaches failed to achieve a completely clean system (Figs. 2b & c).

The Sleiman sequence goes beyond using water as an intermediate between the two alternating solutions and as the final irrigant (water cooled to between 2.5°C and 4°C and used for postoperative pain control or in a cryotherapy modality also suggested Continued on page 10

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**Fig. 1a**: Pre-treatment radiograph of the mandibular right first molar. **Fig. 1b**: Radiograph after the end of the irrigation protocols. **Fig. 2a-c**: Images showing the removal of dye with different systems.
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3D Endo Software, glide path management and WaveOne Gold

By Peet J. van der Vyver and Farzana Palekar

Radiographic imaging forms an essential part of the diagnosis, treatment planning and follow-up, in modern endodontics. Cone beam computer tomography (CBCT) allows for the visualisation of root canal systems in three dimensions without the superimposition of anatomic structures that occurs with conventional radiographs. CBCT units reconstruct the projection data to produce interrelational images in the axial, sagittal and coronal planes. Due to the higher resolution of limited field of view CBCT units (Fig. 1) their application in endodontics has been expanded. High-resolution CBCT images are ideal for diagnosis of periapical lesions, identification of root fractures and resorption lesions and for the evaluation of root canal morphology, root length and root curvatures.

Dentsply Sirona recently launched 3D Endo Software that allows the clinician to perform pre-endodontic treatment planning of simple and complex endodontic cases, using DICOM (Digital Imaging and Communications in Medicine) data from a CBCT scan. The innovative software allows for the identification of anatomical complexities, design of access cavities, working length measurement, and identification of canal curvatures before the actual procedure. In addition, the software also allows one to choose (from a preloaded database of endodontic file systems), a file or system that will most likely result in optimal canal preparation for that specific shape or diameter of a canal.

The purpose of this article is to demonstrate the benefit of the 3D Endo Software in a complex clinical case that required endodontic treatment. In addition, a different approach to glide path management and root canal preparation for canals that present with multi-planar anatomy will be discussed.

Case report
Preoperative evaluation
The patient, a 25-year-old female, reported with irreversible pulpitis on her maxillary second left molar. The tooth was temporarily restored with Intermediate Restorative Material (IRM, Dentsply Sirona) and the patient complained about continuous food impaction between her maxillary left, first and second molar teeth (Fig. 2). A periapical radiograph revealed that the temporary restoration was not seating at the gingival margin (Fig. 3). Also, visible on the periapical radiograph was evidence of possible curvatures in the mesiobuccal and distobuccal roots. It was decided, with the consent of the patient, to take a limited field of view CBCT scan to explore the anatomy of this tooth. The CBCT scan revealed the presence of three root canal systems when viewed in the axial plane; and in the sagittal plane, evidence of severe root curvatures were present in the mesiobuccal and distobuccal root canal systems.

It was decided to do a more in-depth investigation as a result of this complex anatomy, using the 3D Endo Software (Dentsply Sirona).

3D Endo Software
The data of the limited field of view CBCT scan was exported as a DICOM file and imported into the 3D Endo Software. The 3-D planning of the case was then completed in five easy steps.

In the first step, ‘Diagnosis and Pathology’, the imported scan was reviewed in the axial, sagittal and coronal planes. The software has the ability to present a 3-D reconstructed view where the transparency of the teeth can be changed (Figs. 4a–d).

The second step, ‘3D Tooth Anatomy’, involved selecting the tooth to be examined and the entire volume was cropped to only leave the data of interest behind (Fig. 5). In the third step, ‘Canal System’, the number of root canals were identified and each root canal was then mapped separately by identifying the orifice and radiographic apical foramen of each root canal (Fig. 6).

With the fourth step, ‘3D Canal Anatomy’, the software made a proposal of the canal anatomy (Fig. 7), but the operator can make corrections according to the canal configuration that can be viewed in different planes.

In the software, Figures 8 to 10 show the mapping of the palatal, mesiobuccal, and distobuccal root canal systems.

During the fifth step, ‘Treatment Plan’, the software projected ISO size 06 instruments into the canals (Fig. 11), which allowed the operator to visualise the internal anatomy of the canals, check straight line access, and modify the proposed access if necessary. A rubber stop on the files can then be digitally adjusted to a coronal reference point of choice that will then indicate the proposed working length for each root canal system. This view can also be rotated in 3-D to alert the operator of the angle and direction of curvatures in the root canal systems (Fig. 12). The step after ‘treatment plan’ is to select a master file from a preloaded database of endodontic file systems that will most likely result in optimal canal preparation for that specific shape or diameter of a canal. Considering the s-shaped curvatures in all three root canal systems as well as the sharp curvatures in different planes, it was decided to use the Primary WaveOne Gold file (25/07) in the palatal canal and the Small WaveOne Gold file (20/07) for root canal preparation in the two challenging buccal root canal systems (Fig. 13). The selected instruments were then displayed in the root canal systems and the operator again digitally rotated and visualised the root canal anatomy in 3-D (Fig. 14).

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Use of diode laser in the treatment of gingival enlargement during orthodontic treatment

By Dr Carlo Fornaini

I
n recent decades, we have witnessed the substantial development and expansion of the use of fixed orthodontic appliances. While their application has many advantages, several problems related to the health of the soft tissue may sometimes appear during treatment. In fact, the use of fixed orthodontic appliances may provoke labial desquamation, erythema multiforme, gingivitis and gingival enlargement. Gingival enlargement is a very common complication during orthodontic treatment, but fortunately, it seems to be transitory and generally resolves after orthodontic therapy, even if sometimes incompletely. Gingival overgrowth induced by orthodontic treatment shows a specific fibrous and thickened gingival appearance, different from fragile gingiva with marginal gingival redness common in allergic or inflammatory gingival lesions.

Several clinical studies suggest that orthodontic treatment may be associated with a decrease in periodontal health, causing a hypertrophic form of gingivitis. However, the actual pathogenesis of gingival enlargement is not yet completely understood, although probably involves increased production by fibroblasts of amorphous ground substance with a high level of glycosaminoglycans. Increases in mRNA expression of Type I collagen and up-regulation of keratinocyte growth factor receptor could play an important role in excessive proliferation of epithelial cells and increased development of gingival enlargement, on the basis of some studies, in cases of poor oral hygiene status. However, there is no clear definition on its aetiology, although it is probably associated with the inflammatory response induced by the corrosion of orthodontic appliances, particularly those of nickel, linked to an inflammatory response considered a Type IV hypersensitivity and manifested as nickel-induced allergic contact stomatitis, even if its aetiology has not yet clearly been defined.

The treatment of these conditions is surgical. Histological and histochemical studies have demonstrated that the removal of the gingival papilla can promote the formation of normal connective tissue. Because the classic intervention performed by scalpel has some disadvantages, mainly linked to the discomfort for the patient (e.g. anaesthesia by injection and sutures), there has been great interest in the utilisation of laser technology. The laser can be used in two modes: surgical and non-surgical. The surgical modes can be used to remove the gingival papilla, while the non-surgical modes can be used to treat the gingiva.

The first laser appliance was built by Maiman in 1960, and some years later, it was successfully employed in medicine and in oral surgery with several advantages. It may provide excellent incision performance with sealing of small blood and lymphatic vessels, resulting in haemostasis and reduced postoperative oedema. Furthermore, target tissues are disinfected as a result of local heating and production of an eschar layer, which results in a decreased amount of scarring owing to decreased postoperative tissue shrinkage, allowing one to avoid the use of sutures.

Diodes, the last generation of laser used in dentistry, have several advantages, such as reduced cost and size, and offer the operator the possibility to work both in continuous and chopped mode. Based on our experience, we can confirm that this technology may represent a new approach to the resolution of gingival enlargement during orthodontic treatment, with better comfort for the patient during and after surgery.

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by Sleiman and investigated by Vera et al. — it also stipulates that when using the macro- or the micro- cannula of the negative pressure irrigation unit for chemical preparation, every five seconds a two-to-three-second pause should be made when no irrigant is added. It is during this pause that the partial vacuum is created by the cannula, which will draw out all the fluids, residues and gases from all the root canal system. Once the system has been drained, the partial vacuum established inside the root canal system in its entirety can attract a fresh portion of irrigant for a faster and cleaner preparation of the root canal system.

Clinical cases

In the images above, we present some of the typical cases demonstrating the cleanliness of the root canal system achieved as shown by the lateral and/or accessory canals visualised upon 3-D warm vertical condensation (Figs. 3–6).

The case of a failing root canal treatment with apical infection and an internal resorption in the apical area was referred to us (Fig. 7). After removing the previous filling, chemical preparation was performed, with the help of the partial vacuum, inside the system the chemicals were able to clean the resorption area without an aggressive effect on the periodontal ligament; this has led to a truly three-dimensional obturation. The 4-month follow-up image (Fig. 8) confirms a fast healing of both the apical area and the area of the resorption lesion.

Conclusions

Realising that a 100 percent disinfection of the root canal space remains unattainable, we continue to strive for perfection in our attempts to develop viable clinical protocols that would allow lowering the inflammatory and/or bacterial load so that our patients’ bodies can heal. Based on the supporting research and testing as well as on a history of sustainably high treatment outcomes for both primary endodontic treatment and retreatment of vital and non-vital teeth, we would like to propose our irrigation protocol as a fast, safe, and, most importantly, evidence-based technique of chemical preparation.

The Sleiman irrigation protocol requires 6 percent (or 5.25 percent, if the 6 percent concentration is not available) NaOCl, 17 percent EDTA, distilled water or normal saline. For the best results it is recommended to use a negative pressure irrigation unit to introduce and remove the solutions in order to benefit from the partial vacuum force; however, it must be said that using other introduction techniques in combination with the Sleiman sequence of irrigants will also improve chemical preparation results and lead to a cleaner root canal space.

• Access cavity; manual files to locate orifices; manual files for initial scouting—NaOCl
• H2O
• Machine files for root canal preparation—EDTA
• In between machine files—NaOCl
• H2O (cold for cryotherapy)
• Drying the root canal system—EndoVac

The whole irrigation procedure should follow the ‘5 sec introducing solution + 3 sec pause’ guideline to achieve the best effect of the partial vacuum.

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3D Endo Software, glide

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Pre-endodontic restoration

At the following visit, the tooth was anaesthetised, and a rubber dam placed. The furcation-filling material was removed, revealing evidence of canals as indicated by canals indicator solution (Fig. 15). The canals were removed and the pulp was exposed (Fig. 16). A pre-endodontic restoration was performed using the Paladent V3 matrix system (Dentsply Sirona; Fig. 17) in combination with SDR bulk fill flowable resin (Dentsply Sirona) and ceram.x® Tetric one composite resin (Dentsply Sirona; Fig. 18). After the pre-endodontic restoration, an access cavity was prepared and the canals were located under magnification.

Caviton preparation and glide path

The pulp chamber was filled with Gutta Percha (Dentsply Sirona) before the canals were carefully negotiated to full working using pre-curved size 08 K-Files (Fig. 19). Working length measurements obtained from an electronic apex locator reading corresponded with the lengths obtained from the 3D Endo Software. These measurements were also confirmed radiographically (Fig. 20). A reproducible glide path was prepared in each root canal system with the size 08 K-File in an M4 Reciprocating handpiece (Fig. 21), followed by making a size 10 K-File ‘super loose’ (Fig. 22). A ProGlider (Dentsply Sirona) was used in a rotary motion to expand the glide path in the palatal root canal (Fig. 23). Considering the sharp and severecurvatures in the two buccal canals, it was decided to convert the ProGlider instrument into a manual file to expand the glide path in these tortuous canals with more safety (Fig. 24). The manually adapted ProGlider was used to expand the glide path in a more controlled manner to facilitate working length. In addition, to work more safely during the canal preparation of the two challenging buccal root canals, it was also decided to use the reciprocating WaveOne Gold Glider (Dentsply Sirona; Fig. 25), after the ProGlider instrument to further expand the glide paths. The WaveOne Gold Glider was used in 4-8 backstroke brushing motions from working length, in the two buccal root canal systems. Root canal preparation, irrigation, and obturation

As mentioned before, WaveOne Gold files (Dentsply Sirona) were selected for root canal preparation. The palatal canal was prepared with the reciprocating WaveOne Gold Glider instrument (Fig. 26), and the two buccal root canals with the Small WaveOne Gold file up to working length (Fig. 27).

After canal preparation, the canals were dried with a size 10 K-File (Ultradent) and the solution activated for 1 minute with the EDDY Endo Irrigation Tip (VDW) driven by an air scaler (SONICflex LUX 2000L, KaVo). Thereafter, final disinfection was achieved by activating 3.5 %, heated sodium hypochlorite for three minutes which was followed by the EDDY Endo Irrigation Tip.

The canals were dried with paper points and obturated using matching gutta-percha points, Pulp Canal Sealer (Kerr) and the Calamus 2.0 Obturation Unit (Dentsply Sirona). Figure 28 shows the final result after obturation.

Discussion

According to the European Society of Endodontology’s position statement, the use of CBCT in endodontics should only be considered if additional information from the reconstructed three-dimensional images will potentially aid in the diagnosis and/or enhance the management of the tooth with an endodontic problem. A limited field of view CBCT scan should be considered as the imaging modality of choice for teeth with the potential for extra canals and suspected complex root canal morphology.

The 3D Endo Software that was used in this case report not only allowed the operator to scroll through the tomographic slices in the coronal, axial and sagittal planes, but facilitated a 3-D image of the root canal anatomy prior to treatment. Only after visualising the severe curvatures and the tight Filiform in the buccal root canal direction was the complexity of this case realised. This information was vital for the treatment-planning phase of this case. According to the information obtained from the 3D Endo Software, the authors could select the ideal instruments for canal negotiation, glide path and canal preparation, irrigation and obturation. According to Tehorz (2017), the option to plan endodontic cases in 3-D before the actual file descent is a significant gain for modern endodontics, and can help to prevent procedural errors, especially in complex cases. It is important to note that in this case report the working length measurements obtained from the 3D Endo Software and the apex locator correlated with each other. However, it always advised to verify the software readings with an apex locator, as several parameters such as the access cavity design and position, the amount of coronal preflaring and the choice of reference point can have an influence on the working length measurement.

The most challenging clinical aspect of this case was to negotiate the canals to patency, to create reproducible micro motions, to expand the glide paths to a level where the maximum safety could be secured before introducing the root canal preparation instruments. The glide path preparations were managed with the use of K-Files (Kerr) and the reciprocating M4 handpiece followed by expanding the glide paths with the ProGlider and the WaveOne Gold Glider instruments.

In 2006, West recommended using K-Files with an initial watch winding motion to remove restricted dentine in a shorter time, followed by a 4-8 backstroke brushing motions, until the file felt completely loose in the challenging canal systems.

The WaveOne Gold Primary and Small files were selected for root canal preparation in this case. These files are made of a highly flexural resistant material, as described above for the WaveOne Gold Glider, to produce a file with super-elastic NiTi metal properties. The WaveOne Gold Primary file (Dentsply Sirona) is 30 % more resistant to cyclic fatigue, 80 % more flexible, and 23 % more efficient than the conventional WaveOne Primary instrument. This unequal clockwise (CW) and counter-clockwise (CCW) reciprocating motion with the WaveOne Gold system has the following advantages over continuous rotation systems:

- Binding of the instruments into the root canal dentine walls is less frequent, reducing torsional stress.
- There is a reduction of the number of cycles within the root canal during preparation results in less stressful result on the instrument.
- Improved safety, as the CCW disengaging angle is designed to be less than the elastic limit of the NiTi alloy.
- There is decreased risk of instrument fracture.
- It allows the file to easily progress towards working length without using potentially dangerous inward pressure.

WaveOne Gold files are characterised by a parallelogram (with two 85 degree cutting edges), off-centred, cross-section. According to Ruddle, this design limits the engagement between the file and the dentine to only one or two contact points. This way, the file will subsequently reduce taper lock and the screw-in effect, improve safety, and cutting efficiency. The newly designed files is also manufactured with an oval, rounded tapered and semi-acute guiding tip to ensure that the files progress safely along canals with a secured and confirmed reproducible glide path.

Conclusion

The preparative planning stage using the 3D Endo Software provided the authors with vital information regarding the complex root canal anatomy that influenced the choice of materials and techniques in this case report. Because the root canal anatomy is so complex and the likelihood of misinterpretation is high, preoperatively, the authors realised that there would be a high risk of either losing working length or instrument fracture during canal preparation. It was therefore very important to secure the canals by means of glide path preparation and enlargement prior to root canal preparation.