Innovative endodontics using SWEEPS technology

Tips and tricks

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Conventional endodontic treatment is based on different phases, resulting in the elimination of acute or chronic inflammation of the pulp and periapical area (Table 1).[1–3] The different phases of the therapy are:

- initial cleansing of the endodontic space,
- shaping the root canals to a size sufficient for delivery of irrigants,
- final cleansing and 3D disinfection of the endodontic space, and
- 3D sealing of the endodontic space and restoration of the post-endodontic space and the crown to conclude the therapy.

The cleansing and shaping phases include two different types of cleansing: a chemical cleansing, carried out by different irrigating solutions, and a mechanical cleansing, carried out by endodontic instruments that shape the root canals. However, many studies have demonstrated the incomplete action of the tested instrumentation, which left 35 % or more of the canal surface area unchanged.[4–6] Accordingly, it is the efficient irrigation of the endodontic space that determines the success of the therapy. During the shaping phase, hand irrigation is performed using a syringe with an end- or side-vented needle, alternating with instrumentation using files of different sizes. Besides reducing the bacterial load, irrigants act as a lubricant during filing prior to the final activated irrigation protocol. The purpose of this article is to present an innovative rationale for endodontic therapy using the newest cutting-edge laser technology SWEEPS (shock wave enhanced emission photoacoustic streaming).

Not previously treated	Previously treated
Asymptomatic irreversible pulpitis	
Symptomatic irreversible pulpitis	
Asymptomatic apical periodontitis	Asymptomatic apical periodontitis
Symptomatic apical periodontitis	Symptomatic apical periodontitis

Table 1: Diagnostic classification of endodontic pathology.[1–3]

Irrigating solutions in endodontics

In endodontics, different irrigating solutions are used to kill microorganisms, dissolve the organic components (pulp remnants and collagen), and chelate and remove the inorganic components (calcification and debris).[7] The smear layer is composed of both organic and inorganic components. However, there is no irrigating solution that has all the ideal characteristics.[7] An effective irrigation approach is based on a specific alternating sequence of use of different irrigating solutions, before, during and at the end of the therapy. After creation of an access cavity, root canal therapy is started by cleaning the pulp chamber and canals using an irrigant with antibacterial and pulp-dissolving action.

Sodium hypochlorite

Sodium hypochlorite (NaOCl, 1–6 %) is the main irrigant used in endodontics owing to its high bactericidal activity and pulp tissue dissolution action.[7] Higher NaOCl concentrations achieve faster bacterial load reduction; however, the more concentrated the solution of NaOCl, the thicker it is, resulting in reduced wetting ability. NaOCl is still recognised today as the gold standard solution in endodontics because of its use from the initial to final phases of the therapy.[7] NaOCl has significant biological toxicity risk for periapical tissue when pushed under pressure through the root canal orifice.[8] The outcome is significantly worse for higher concentrations.

EDTA

Irrigation with chelating solutions such as ethylenediaminetetraacetic acid (EDTA, 15–17%) is often utilised during root canal therapy. When alternated with NaOCl, such as in cases of calcified canals and at the end of the treatment, EDTA cleans the canal walls of debris and the smear layer produced during instrumentation, just before the final decontamination. EDTA is slightly irritating but not toxic to periapical tissue.

Chemomechanical systems	Positive pressure systems	Negative pressure systems
XP-endo Finisher	Hand dynamic	EndoVac
	Sonic	
Self-Adjusting File	Multi-sonic	
	Ultrasonic	
	Laser-activated irrigation (PIPS* and SWEEPS**)	

* PIPS = photon-induced photoacoustic streaming. ** SWEEPS = shock wave enhanced emission photoacoustic streaming.

Table 2: Irrigant agitation techniques.

Chlorhexidine

Chlorhexidine (2 %) has good antibacterial properties, but it is not able to dissolve pulp tissue. This suggests its use only in an additional final decontamination step because of its unique substantivity property, which could allow persistent residual antimicrobial action. It is important to prevent interaction between NaOCl and chlorhexidine, by rinsing the canals with distilled water in between solutions to avoid the formation of precipitates that may discolour the tooth and that may contain potentially mutagenic compounds.[9,10] Its inability to dissolve organic tissue also explains the absence of toxicity to periapical tissue.[11,12]

Other solutions

Other chemical solutions have been investigated and used in endodontics. Among these, hydrogen peroxide, iodine, citric acid, ozone (gas) and ozonated water are available, but none of them have demonstrated superior properties and results to the previously cited NaOCl and EDTA solutions. EDTA plus Cetavlon and a mixture of doxycycline, citric acid and a detergent are new solutions that combine different components, surface-active agents and antibiotics which can be very effective and have broader action. The experimental use of nanoparticles is also very promising.

Irrigant activation techniques

The initial irrigation phase and the irrigation during shaping are performed using a syringe with an end- or side-vented needle that can only negotiate the canal up to the middle third. Therefore, it must be considered that the efficacy of hand irrigation is quite limited; thus, supplementary, active and dynamic irrigation (Table 2) is proposed at the end of the treatment to ensure the cleaning of the dentinal walls and the deep decontamination of the endodontic system.[13] Among the various activation methods, we can find systems that heat the irrigating solutions or that activate the solutions by agitation, with positive or negative apical pressure.

Heating

Scanning electron microscope studies on intra-canal heating of NaOCl at 180 °C have proved this method to be more effective for cleaning the canal walls than extra-canal heating at 50 °C, which left a higher quantity of debris and the smear layer widely distributed.[14] Other studies have reported that NaOCl at a concentration of 1 % heated to 60 °C was significantly more effective than 5.25 % at 20 °C. The advantage of using lower concentrations of NaOCl, heated to higher temperatures, could be related to a twofold effect: the same effectiveness and less systemic toxicity than that of non-heated, high-concentration NaOCl.[15]

Agitation techniques

However, the effect of agitation on tissue dissolution was proved greater than that of temperature and with continuous agitation resulted in the fastest tissue dissolution.[16] Comparing the efficacy of various agitation systems, De Gregorio et al. found a limited penetration of the irrigant into lateral canals using an apical negative pressure irrigation system, whereas passive ultrasonic irrigation demonstrated significantly more penetration of irrigant into lateral canals.[17] Nevertheless, it could be reasonable to combine the two techniques, using heated NaOCl and agitating it with the preferred method.

Laser-activated irrigation using SWEEPS

The physical concepts behind laser-activated irrigation and SWEEPS technology have already been explained in a previous issue (4/2019) of this magazine.[18] One of the great advantages of SWEEPS over all of the other activation techniques is its profound effectiveness. Unlike all the other techniques, SWEEPS action is not limited to the vicinity of the tip, as is the case with ultrasonic irrigation, but it is also effective at distant regions of the root canal system.[19,20] For this reason, SWEEPS only requires positioning of the tip in the access cavity to stream the irrigant into all of the endodontic space at the same time. This is different to other techniques, which require needle or tip/

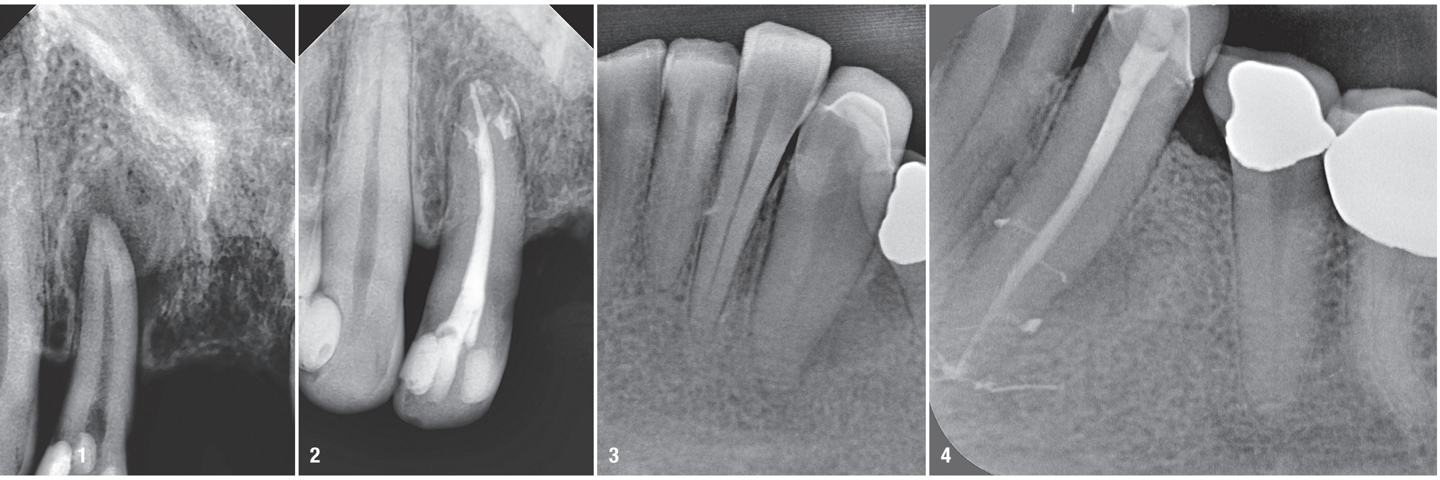

Fig. 1: Tooth #12—the radiograph showed a large periapical lesion. The asymptomatic tooth was prepared with an ISO 25/.06 TF Adaptive file (Kerr Dental). **Fig. 2:** Tooth #12—root canal filling was performed with mineral trioxide aggregate (ENDOSEAL MTA, Maruchi). Note the sealing of the apical ramification, possible because of the effective cleansing and decontamination of the apical terminus. There was almost complete healing after 12 months. **Fig. 3:** Tooth #33—the patient showed a buccal sinus tract that radiographically corresponded to the area between tooth #32 and tooth #33. The CBCT and radiograph showed a large periradicular lesion, especially on the distal side. Preparation was performed with a 20/.07v ProTaper Gold (F1; Dentsply Sirona). **Fig. 4:** Tooth #33—root canal obturation was performed with a sealer and carrier-based gutta-percha (AH Plus and Thermafil, Dentsply Sirona). The radiographic control six months post-op showed that several lateral canals had been filled and the healing process was in progress.

file or probe insertion up to the apical third of each canal or so for irrigation after the root canals have been prepared. Thus, SWEEPS can be used from the initial phase up to the final phase of the therapy, permitting a progressive decrease in the bacterial load before any file is used. The efficacy and effectiveness of SWEEPS rely on both chemical activation of the endodontic solutions by agitation,[21,22] improving the ability of irrigants to kill bacteria and to dissolve tissue, and mechanical flushing action to clean the root canal wall.[23,24]

Researchers have found the SWEEPS dual modality to be more effective than the single-pulse modality SSP (super-short pulse; PIPS, photon-induced photoacoustic streaming).[25–28] Using the SWEEPS dual-pulse modality, the sudden expansion of the second bubble, generated by the second laser pulse, exerts additional pressure on the first bubble, leading to its violent collapse, during which shock waves are emitted also in very small canals. Furthermore, shock waves are emitted from the collapsing secondary cavitation bubbles that form naturally throughout the entire length of the canal during laser-activated irrigation.[25–29] The secondary cavitation bubbles are in close proximity to the canal walls during their collapse, generating shear stress and vortical flows that are able to remove debris, the smear layer and biofilm from the root canal surface, as well as from undetected and uninstrumented anatomical areas, such as isthmuses, lateral canals, loops and ramifications, thereby increasing the cleaning and decontamination mechanism even further (Figs. 1–4). The enhanced pressure generation along the root canal consequently also increases the depth of penetration of irrigants into dentinal tubules.[25–28]

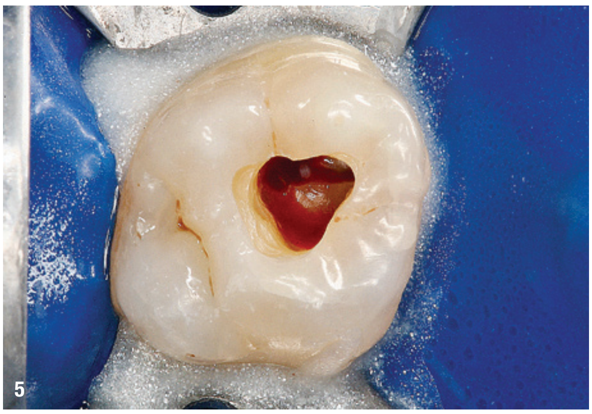

Fig. 5: Proper isolation for SWEEPS is important. A liquid dam was interlocked beneath the dam clamp. Traditional access cavity preparation of the maxillary first molar was performed using a cylindrical or round diamond bur under magnification (4.5–6.0x).

Clinical protocols

Proper patient draping with a waterproof bib to protect clothing is highly recommended. Local anaesthesia is performed in all cases (asymptomatic and symptomatic) to avoid any unpleasant sensation of internal pressure during the treatment. A dental dam is then applied, and a liquid dam is interlocked beneath the clamp to ensure complete isolation (Fig. 5). In case of occlusal or proximal decay or a defective filling, complete removal of the carious tissue and filling must be performed, followed by composite reconstruction of the entire tooth crown; this preliminary step is mandatory to minimise leakage and reinfection. Furthermore, good marginal sealing prevents any irrigant extrusion during laser-activated irrigation.

Access cavity preparation

At this point, the access cavity is opened using a small carbide, or cylindrical or round diamond bur under magnification (4.5–6.0x). Traditional access cavity preparation, following the laws of centrality and concentricity, is advisable (Fig. 5).[30] Several studies have demonstrated the lack of usefulness of ultra-conservative "ninja" access cavity preparation in terms of fracture strength and preservation of the original canal anatomy during shaping compared with traditional access cavity preparation, particularly at the apical level. Furthermore, standardised access cavity preparation is advisable when the X-SWEEPS modality is chosen for laser-activated irrigation. Future publications will explain this topic in depth in order to establish the correct laser settings to be used with standardised access cavity preparation volumes. Whatever the pathology is, the concept is to minimise the root canal shaping, optimising the cleansing and decontamination of the endodontic space by exploiting the chemo-mechanical flushing of SWEEPS. The main difference between asymptomatic and symptomatic pulpitis and apical periodontitis therapy is in the longer or shorter initial NaOCl SWEEPS-activated irrigation phase. Retreatment also involves a few differences in the energy applied during the initial phase when filling material has to be removed.

Asymptomatic and symptomatic irreversible pulpitis

In the case of irreversible pulpitis, the pulp is irreversibly inflamed, with or without acute symptoms. The patient's age and preoperative radiograph give information on a possible immature apex; this condition contra-indicates a full-power SWEEPS irrigation and suggests a more careful intervention and lowering of the energy used (more to follow). Once the pulp chamber has been opened, excessive bleeding may be present, indicating the presence of inflamed pulp tissue inside the chamber and root canals. In this case, one-visit therapy is advisable. The treatment starts with NaOCl irrigation by syringe (3–5 ml) and simultaneous activation by Er:YAG laser (2,940 nm; LightWalker AT, Fotona), using the dual-pulse (25 µs duration) Auto-SWEEPS modality for 30–40 seconds. The resting time after irrigation can be extended to 1–2 minutes to allow more NaOCl pulp dissolution. A flat- or radial-ended SWEEPS tip (400 µ) is used. The pulp tissue may show different grades (levels) of inflammation, up to initial necrotic degeneration. It is important to consider at this stage whether the pulp tissue itself is preventing any extrusion of the irrigant so that full-power Auto-SWEEPS activation (20 mJ at 15 Hz and 0.6 W) can be performed up to almost complete pulp dissolution, which is indicated by a progressive decrease in bleeding. According to the tooth type and condition, this initial phase can be repeated for two to three cycles for single-rooted teeth and up to three or four cycles for premolars and molars.

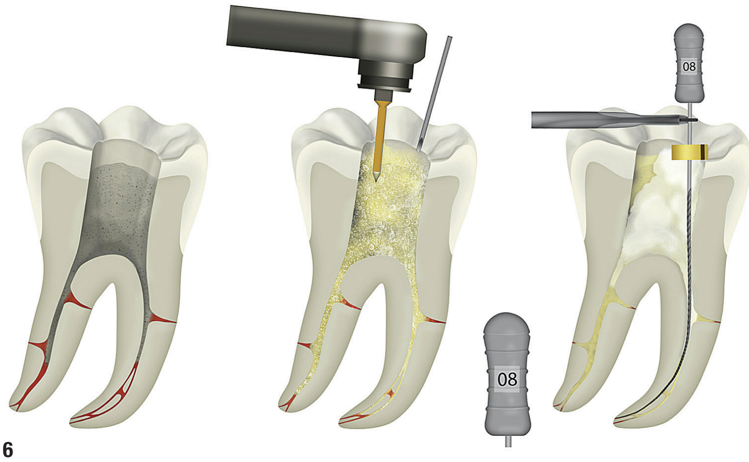

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Fig. 6: After the cavity access has been prepared, laser-activated irrigation of NaOCl using SWEEPS is performed in the access cavity. Then lubricant gel containing urea peroxide is placed on the file (or in the cavity) to lubricate and avoid tissue plugging when sliding the file to the apical constriction. *(Courtesy of Dr Giovanni Olivi)*

The initial irrigation phase also decreases the bacterial load. The access cavity can now be observed under magnification (6–10 x) in order to locate all canal orifices. If the orifices are not all visible, the use of ultrasonic tips can easily discover orifices hidden under calcification in the pulp chamber. These are usually located at the angles, at the floor–wall junction and at the terminus of the root developmental fusion lines. Then pre-flaring of the orifices and enlarging of the coronal thirds of the canals allow easy and direct access to the canals. Subsequently, a direct glide path to the apical third is established by hand or dedicated rotary instruments, up to 3–4 mm from the apex. This manual or rotary instrument step produces debris and dentine chips that must be removed by Auto-SWEEPS NaOCl irrigation, again for 30–40 seconds, followed by 30 seconds of resting time. At this point, use of a small stainless-steel hand file (ISO 06 to 10) is recommended with a cream containing urea peroxide or EDTA to lubricate and avoid tissue plugging when sliding the file to the anatomical opening to scout the canal and determine the anatomical length (Fig. 6). It must be emphasised that by now most of the pulp tissue will have already been dissolved by NaOCl and the possibility of dislodging pulp remnants or debris inside unreachable anatomical areas is very difficult if the previous phases have been correctly followed. Also, the bacterial load is highly decreased so that apical transportation of bacteria is minimal or absent. Use of an electronic apex locator and radiographic confirmation provide verification of the anatomical length of the tooth.

Different approaches to the apical constriction can be used: working to the anatomical length or 1 mm shorter,

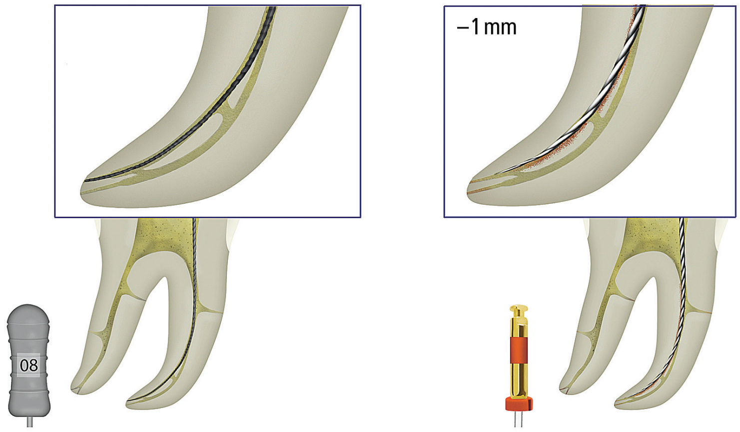

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Fig. 7: In order to prevent possible over-instrumentation of the apex with enlarging of the apical opening, the authors suggest working to 1 mm shorter than the anatomical length. **Fig. 8:** Recapitulation with the smaller first instrument (ISO 06 or 08) is performed to the apical anatomical constriction (working length + 1 mm) to ensure apical patency and remove any possible dentinal plugs produced during instrumentation. The last millimetre is just cleansed and disinfected by SWEEPS. *(Courtesy of Dr Giovanni Olivi)*

in order to prevent possible over-instrumentation of the apex with enlarging of the apical opening. This is one reason for possible extrusion at the end of treatment (Fig. 7). At this point, the canals can be minimally prepared. Because SWEEPS technology does not require the tip to be placed in the canal, it is not necessary to prepare the canals to a large size. This results in a more conservative and biomimetic result: 20/.06 and 25/.06 are sufficient to warrant a hermetic apical obturation. These two or three mechanical preparation steps are always alternated with Auto-SWEEPS NaOCl irrigation and recapitulation with the smaller first instrument (ISO 06 or 08) used at the apical anatomical constriction to ensure apical patency and remove any possible dentinal plugs produced during instrumentation (Fig. 8).

Asymptomatic and symptomatic apical periodontitis

Chronic pathology can last for years without symptoms and without temperature hypersensitivity, and diagnosis can be done occasionally during check-ups with radiographic control. It ranges from minimal lamina dura dilatation to larger periapical radiolucent lesions. If symptomatic, the tooth presents with a painful dull ache, intermittent pain, gingivae that can be sore to the touch, up to excruciating pain in cases of flare-ups, possible buccal swelling and a possible visible buccal sinus tract, and the tooth is tender to percussion. More frequently, such a tooth has undergone previous dental treatments, such as a full-crown or deep restoration with or without recurrent caries, and may have untreated deep decay (cavity) extending to the pulp chamber. In this case, carious removal and cavity filling reconstruction are preliminarily performed as previously mentioned.

When creating the access cavity, the chamber and the canals are usually empty, with no pulp tissue. Sometimes, especially in molars, the pulp condition can differ from one canal to another. Some may present with minimal bleeding. In case of swelling and a periapical abscess, pus may flow out of the tooth from the opening into the canal orifices. Treatment starts with two to three cycles of saline irrigation (3–5 ml by syringe) and simultaneous activation by Er:YAG laser (2,940 nm; LightWalker AT), using the dual-pulse (25 µs duration) Auto-SWEEPS modality for 30–40 seconds, at 20 mJ and 15 Hz. This preliminary irrigation with saline, besides its initial cleansing and antibacterial action,[33] helps to test the patency of the apical constriction to the pressure applied. Frequently, chronic periapical inflammation can lead to an enlargement of the apical constriction so that irrigant extrusion can occur, especially in cases of apical contraction larger than ISO 40–50. Then NaOCl irrigation is activated by Auto-SWEEPS, using a low energy, 10 mJ, at 15 Hz for 30 seconds to start the decontamination and lubrication of the canals prior to using the ISO 10 hand file to explore the canal and verify patency and anatomical length. Once apical patency and working length are established, new NaOCl irrigation activated by Auto-SWEEPS is performed. The possibility of decreasing the energy output from 20 mJ to 15 or 10 mJ allows reduction of the streaming pressure to the apex. However, the dual-pulse Auto-SWEEPS modality promoted an almost constant flow rate for different pulse energies of between 10 mJ and 20 mJ, compared with the single-pulse modality SSP, indicating superior safety of Auto-SWEEPS regardless of the pulse energy.[29]

Furthermore, the pressure efficacy is higher for a smaller fibre tip diameter (400 vs 600 µ), and radial-ended fibre tips are slightly less effective for generating pressure in comparison with cylindrical tips.[28] To simplify, in case of a larger apical size, it is suggested to use the Auto-SWEEPS modality with a larger size tip (600 µ), preferably with the radial-ended tip (X-Pulse). This management of energy and tip choice allow beginner users to work carefully in case of altered apical anatomies. When the apical opening is more than ISO 40–50, a simple operation that permits control of any unwanted irrigant extrusion is the use of a particularly smooth needle file of different calibres (from ISO 40 to ISO 100). The apical end closes the apical opening of the canal while laterally all the irrigant flows throughout the canal.

Calcified canals

Sometimes canal restrictions and calcifications, due to tertiary dentine formation, may be found, hindering the negotiation of the canal (Figs. 9 & 10). In case of a multi-rooted tooth, another canal may be accessible and the usual protocol can be applied up to completion of root canal filling (Figs. 11–13). In a separate session, the calcified canal is irrigated by EDTA solution, activated and forced by full-power Auto-SWEEPS, at 40 mJ and 15 Hz (Figs. 14 & 15). The single-pulse USP mode (25 µs) can also be more effective for pressure generation. Note that, if the canal is obstructed by calcification while the other canals have already been prepared with files, this procedure at higher energy is very safe. EDTA in this case is used to chelate and soften the dentine, but sometimes the use of a thin, rigid ultrasonic tip is necessary to remove the calcification in the coronal third. Stainless-steel hand files with EDTA gel can be used to help bypass the blockage in the middle and apical thirds.

Final irrigation protocol

At the end of the preparation and before the final irrigation protocol, the root canal system has already been cleansed and disinfected by the SWEEPS protocol used from the beginning of the therapy. Further research is required to confirm the reported efficacy and effectiveness of SWEEPS's cleansing ability and pressure generation regarding decontamination. Several researchers have reported the superior decontamination results of the SSP modality using PIPS.[34–36] Therefore, this evidence-based protocol is used for the final NaClO disinfection (Fig. 16).

Continue using the tip size and shape (flat- or radial-ended) chosen:

– Two cycles of 30-second EDTA (15–17 %) irrigation by syringe is performed, delivered in the access cavity and activated by Auto-SWEEPS at 20 mJ and 15 Hz. In case of an open apex, the energy can be reduced to 15 or 10 mJ. Each cycle is followed by 30 seconds of resting time, to allow the solution to react on the dentinal walls. At this point, gutta-percha points can be tested after calibrating length and apical size. Apical friction and retention should be checked and adjustments made if necessary. This simple operation contributes, with its hand dynamic action, to irrigation efficacy.
– One cycle of 30-second irrigation with distilled water (or water directly from the 0/1 laser spray) is performed to rinse the canals before the final decontamination.

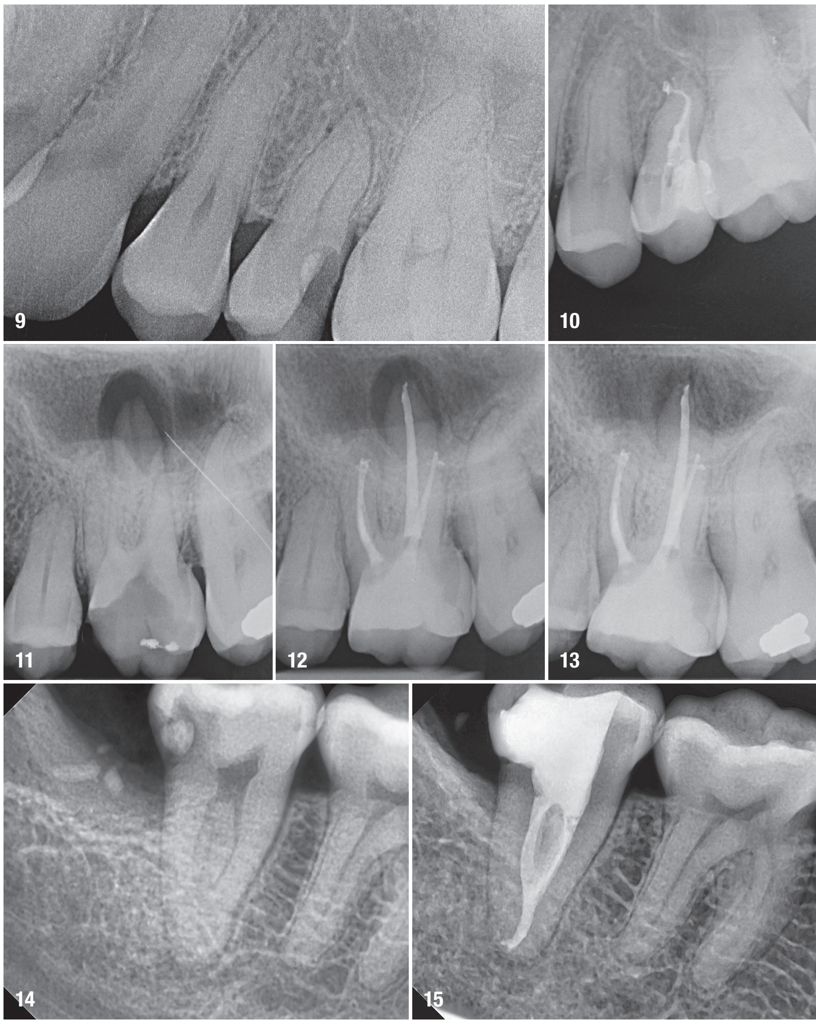
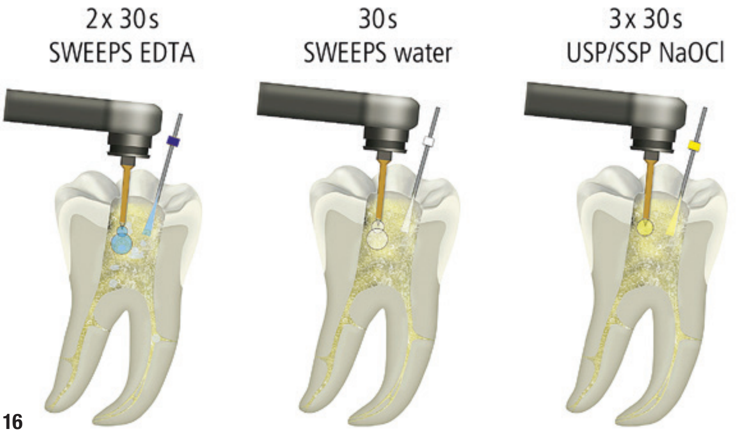


Fig. 9: The symptomatic maxillary second premolar showed a periapical lesion on radiographic examination. The preparation of the buccal and palatal canals was performed with a 25/.08v ProTaper Gold (F2) to 4 mm short of the radiographic apex. A size 10 hand instrument was used up to 2 mm short of the apex. **Fig. 10:** The calcified canals hindered the negotiation of the apical constriction. Full-power Auto-SWEEPS (40 mJ, 15 Hz) activation of 15 % EDTA solution was able to force through the blockage to cleanse and disinfect the last 2 mm of the confluent curved canals. Obturation was performed with Thermafil and AH Plus sealer. **Fig. 11:** A symptomatic maxillary first molar with large mesioocclusal decay and a large periapical lesion. **Fig. 12:** Root canal preparation was performed with a 25/.06 ProTaper Next X2 (Dentsply Sirona) in the buccal canals and 40/.06 X4 in the palatal canal, which demonstrated pre-existing apical resorption. Obturation was performed with EndoSequence BC Sealer (Brasseler) and gutta-percha. The first and second mesiobuccal canals merged into one unique larger canal in the apical third. **Fig. 13:** The three-month post-op radiographic examination showed that healing was progressing rapidly. **Fig. 14:** Radiograph showing deep distal caries with a large periapical lesion on symptomatic tooth #47. The mandibular molar presented with a typical C-shaped canal, and it was prepared with an ISO 25/.06 TF Adaptive file. **Fig. 15:** Auto-SWEEPS (20 mJ, 15 Hz) activation of 4 % NaOCl and 15 % EDTA solution was able to dissolve the tissue and debris from the complex radicular anatomy, allowing a sealer (EndoREZ, Ultradent) to fill the full endodontic space (five-month post-op radiograph).



16

Fig. 16: SWEEPS final irrigation protocol: at the end of therapy, the final irrigation protocol entails two cycles of 17 % EDTA activated by Auto-SWEEPS for 30 seconds each and 30 seconds of resting time, followed by rinsing with distilled water activated by SWEEPS for 30 seconds, then three cycles of 5 % NaOCl activated by USP/SSP for 30 seconds each and a resting time of at least 30 seconds. A final distilled water rinse completes the protocol.

- Three cycles of 30-second NaOCl (5 % minimum) irrigation using a syringe is performed, delivered in the access cavity and activated by SSP at 20 mJ and 15 Hz. The resting time after each cycle can be easily extended from 30 seconds up to 120 seconds, if needed (acute infection). The energy can be reduced to 15 or 10 mJ in order to prevent any risk of extrusion. If the apical size is larger than ISO 40–50, a thin, smooth file of the same apical master size is chosen to occlude the apical terminus before the disinfection cycles start.
- Before obturation, the canals must be rinsed with distilled water agitated by laser and dried using sterile paper points.

Root canal filling

The final obturation can be performed as usual. However, the use of flowable sealer is recommended to better fill the previously inaccessible endodontic areas, the cleansing and decontamination of which were made possible by SWEEPS. Additionally, the proven combination of carrier-based gutta-percha and warm vertical condensation is recommended for complete 3D obturation.

Conclusion

Er:YAG laser, *in vivo* at very low energy, combined with the innovative dual-pulse SWEEPS technology, allows further optimisation of the already effective SSP procedure (PIPS) during root canal therapy in everyday practice. The ability to effectively activate the irrigants directly at start of the root canal therapy plays an important role in the advantage of laser-activated cleansing and decontamination over the conventional chemomechanical preparation. SWEEPS promotes shock wave energy to clean and disinfect the root canal system with fewer files than needed during standard root canal therapy. SWEEPS promotes fluid streaming throughout the entire root canal system, even in the microscopic areas that conventional treatments cannot reach. The chemomechanical flushing action of SWEEPS produces superior cleansing and decontaminating action over conventional irrigation methods, reducing the need for canal shaping and allowing new flowable sealer and gutta-percha to obturate the endodontic space three-dimensionally. In this way, the root canal preparation size can be minimised, preserving more dental structure without losing the efficacious action of the irrigants.

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Dr Giovanni Olivi graduated cum laude in Medicine and Surgery (MD) from the Università Cattolica del Sacro Cuore in Rome in Italy and in Dentistry (DDS) from the University of Rome Tor Vergata. He is a contracted professor and scientific coordinator of the laser dentistry proficiency course and Master of Science in Laser Dentistry at the Università Cattolica del Sacro Cuore in Rome. He is the President of the International Academy of Innovative Dentistry and an active member of the Italian Society of Endodontics.

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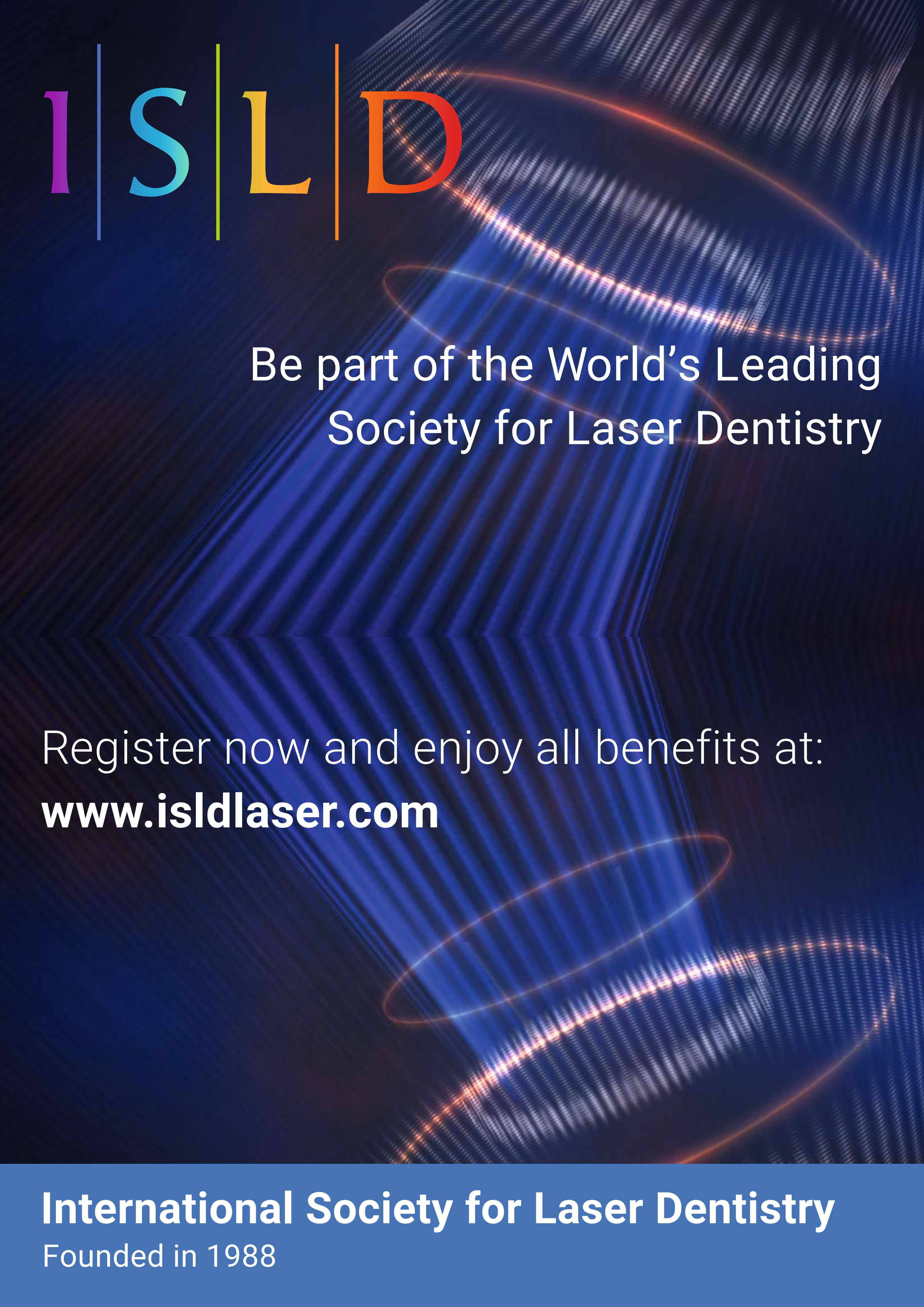
Literature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