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Laser-Activated Irrigation In Endodontics: A Review Article

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Abstract

Irrigating solutions are necessary in root canal therapy to aid in debridement and disinfection, but their spread and efficacy are sometimes limited by canal anatomy. As a result, it is proposed that irrigants be activated in order to promote their distribution in the canal system and therefore increase irrigation effectiveness. Lasers can be used to activate irrigation, which is known as laser-activated irrigation (LAI).

Clinical Significance: Lasers can be used to activate irrigation during root canal treatment.

Keywords: Root canal treatment, Irrigation, Endodontics, Disinfection, Cavitation, Laser

Introduction

The intricate anatomy of the dental root-canal system, as well as the limited penetration depth of commonly employed irrigants into the dentine, limit the capacity to clean, debride, and disinfect dental root canals. The non-turbulent fluid dynamics of irrigants in the limited canal area, which prevents deep penetration of the irrigant, is one of the most common issues in endodontics. Various agitation techniques, including ultrasonic agitation, have been introduced with the purpose of improving the efficacy of irrigation solutions. However, the efficiency of this technology has been discovered to be limited to the area surrounding the ultrasonic needle, making it ineffectual. Conventional syringe irrigation is the most extensively utilized irrigation method. Because of the complicated three-dimensional microstructure of the root canal system, fluid penetration is limited in the apical canal and beyond the main canal, and it is usually unable to flush away tissue residues and dentine debris. The accumulated hard-tissue debris (AHTD) could affect the root canal filling materials' capacity to close and obstruct disinfection.[1]

Lasers in Endodontics

Lasers have long been utilised in the field of endodontics for the optimization of endodontic irrigation in particular. These technologies are making great inroads into lot of areas of dentistry. Lasers in endodontics are employed using various approaches.[2] They can be used to irradiate and activate fluids delivered into the canal (photosensitizers or irrigants), thereby indirectly acting on the endodontic system. Results suggest that the laser is an effective tool for the removal of debris, the smear layer and obturation materials, as well as being an effective disinfection tool.

Laser-Activated Irrigation (LAI)

Laser-activated irrigation (LAI) is the application of a laser to irradiate frequently used irrigant solutions in the canal.[3] The minimal common denominator of all LAI approaches is the wave-length that may be used: the wavelengths of the erbium lasers are the only ones that are absorbed by the water.

Laser Activated Irrigation (LAI) has emerged as a powerful method of root canal irrigation, thanks to a growing interest in the use of erbium lasers to stir water-based fluids in the intra-canal environment. Cavitation, which involves the creation of vapour bubbles at the fibre tip that expand and then collapse, is responsible for the impact of laser activation. The use of erbium lasers to agitate water-based fluids in the intra-canal environment has sparked a growing interest in Laser Activated Irrigation (LAI), which has proven an effective approach of root canal irrigation. Cavitation, which involves the creation of vapour bubbles at the fibre tip that expand and then collapse, is responsible for the impact of laser activation.[4]

Photon-induced photoacoustic streaming (PIPS) and shockwave-enhanced emission photoacoustic streaming (SWEEPS) are two promising laser-activated irrigation (LAI) methods for root canal irrigation. Typical LAI methods include photon-induced photoacoustic streaming (PIPS) and shockwave enhanced emission photoacoustic streaming (SWEEPS).

A new SWEEPS (Shock Wave Enhanced Emission Photoacoustic Streaming) Er:YAG laser modality is demonstrated, which was designed specifically to improve the cleaning and disinfection efficacy of laser-assisted endodontic operations.[5]

During laser-assisted irrigation of spatially constrained root canals, shock waves are rarely emitted. The novel SWEEPS modality accelerates the collapse of laser-induced bubbles, allowing shock waves to be emitted even into tiny root canals. The shear flows formed by the quick collapse of secondary bubbles near the canal walls, as well as the emitted primary shock waves that reach the smear layer at supersonic speeds, improve the cleaning and disinfecting efficacy of laser-induced irrigation. SWEEPS claims to represent an entirely new way of thinking about root canal therapy, thanks to its precise delivery of shock waves into cleaning solutions and the ensuing increased fluid dynamics.[6]

Both emit erbium laser pulses with a typical wavelength of 2940 nm into the pulp chamber via a fiber tip. Note that under PIPS and SWEEPS activation, the fiber tip can be placed at the inlet of the canal without the need for deep insertion. This is another advantage of the LAI technique. Due to the high energy of the laser pulse, the irrigant will be heated and gasified into vapour bubbles, whose violent expansion and collapse will then drive the irrigant to form a fast flush throughout the root canal system. For PIPS, one single laser pulse with a square waveform is fired in each emission cycle. In contrast, SWEEPS uses synchronized pairs of ultra-short pulses over an optimal time interval to accelerate the collapse of laser-induced bubbles. This feature results in enhanced shockwave emission even inside the narrowest root canals.

For PIPS, several studies have investigated the influence of laser parameters on irrigation effectiveness. The induced flow field in a simplified model with one main root canal has also been measured by microscale particle image velocimetry. As for SWEEPS, there are comparably fewer studies. Less knowledge on the characteristics of the irrigant flow field activated by SWEEPS has been accumulated, let alone the irrigation performance in lateral canals.

When performing laser-activated PIPS endodontics, it is desirable to be able to increase the speed of generated waves in irrigants, with a goal to not only turbulently spread irrigants throughout the root canal system, but also to directly remove the smear layer and disinfect the root canal walls. In spatially confined root canals, single laser pulses do not result in the emission of shock waves in laser-irradiated irrigants. Additionally, the effectiveness of pressure waves cannot be increased by increasing the laser pulse energy. However, enhanced pressure waves travelling at shock speeds can be created in root canals during laser endodontic procedures using the new SWEEPS (Shock Wave Enhanced Emission Photoacoustic Streaming) Er:YAG laser modality. The PIPS technique is a time-saving tool for clinicians. An important advantage of this technique is that the irrigant is propelled throughout the entire root canal system.

In endodontics the cavitation bubble dynamics is determined mainly by the dimensions of the access cavity in the vicinity of the fibre tip, and not by the size, curvature, and complexity of the root canal beneath the cavity. Clinically, the size and shape of the lateral surface of the access cavity depends on the tooth type, the patient, and also on the endodontist's skill and preference.

Conclusion

Throughout several years of development, laser technology has demonstrated a high level of refinement for hard tissue application and soft tissue surgery, and more advancements are possible. In the field of endodontics, PIPS and Laser activated irrigation are described in the literature as a revolutionary and powerful method to activate the irrigant. In conclusion, SWEEPS provides a precise concentration of shock waves into cleaning solutions, allowing tissue, debris, biofilm, and bacteria to be removed from lateral canals and microscopic tubules. As a result, this new modality has the potential to improve the efficacy of current PIPS (Photon Induced Photoacoustic Streaming) laser-induced irrigation operations dramatically.

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