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# Photon Induced Photoacoustic Streaming (PIPS) –A Review

KEYWORDS: Endodontics, laser treatment, Er: YAG laser, PIPS.

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**ABSTRACT** *Cleansing and filling of the root canal is necessary for successful long-term root canal therapy. However, the current methods of root canal preparation are not capable of completely cleaning the whole root canal system, whether by hand instruments or by motorized instruments. This is mainly because of the complex anatomy of the root canal system.*

*It seems; therefore, appropriate to search for newer techniques and technologies that can help in disinfection of these anatomical areas.*

## INTRODUCTION

Lasers have been used in endodontics since the early '70s 1, 2 and a growing interest in its use was seen since the late '90s 1. Schoop et al in 2004, stated different wavelengths have been shown to be effective in significantly reducing the bacterial load within infected canals, and this has also been confirmed by studies in vitro,3. Miserendino et al in1989 reported that $CO_2$ laser is not appropriate for endodontic treatment since it cannot be delivered through a suitable fibre optic system into the root canal system,4. Also when $CO_2$ laser is irradiated on the tooth surfaces a high temperature elevation is seen. Dederich et al in 1984 used Nd: YAG laser to irradiate root canal wall dentin and obtained a melted, recrystallized surface,5. .Furthermore, it may also cause closure of the exposed dentinal tubules without dentin surface cracking. 6, 7. Kaitsas et al in 2001 stated that Nd:YAG laser did not show effective results in debriding and cleaning the root canal surfaces and the smear layer was only partially removed,8. There was high effectiveness on the dentin surfaces bacterial load reduction after erbium laser irradiation, but depth of penetration was low because of the high absorption of the laser energy on the dentin surface ,3.As compared with syringe irrigation and passive ultrasonic irrigation (PUI), laser activated irrigation (LAI) resulted in more effective removal of debris in the root canals, 9. A strong modulation in the reaction rate of NaOCl was seen with the laser activation method ,significantly increasing the production and consumption of available chlorine and oxygen ions in comparison to ultrasound activation, 10. DiVito et al in 2011 has reported the use of an Er:YAG laser, along with a newly designed radial and stripped tip, in combination with 17% EDTA and 6% sodium hypochlorite solution using a low energy (20 mJ)and very low pulse duration (50 microseconds) which resulted in effective debris and smear layer removal and showed minimal or no thermal damage to the dentinal structure through a photoacoustic technique called Photon Induced Photoacoustic Streaming (PIPS).

The purpose of this article is to introduce the experimental background of this laser technique in removing bacterial load in areas where traditional methods may fail to succeed and to introduce the clinical protocol.

## BACKGROUND

Imaging suggests that the working mechanism of an Erbium laser in root canal treatment irrigation method can be attributed to cavitation effects inducing high-speed fluid motion into the canal. 10 .It is suggested that the fibre be placed in the middle third of the canal, 5 mm from the apex and kept stationary to accomplish this streaming 11. Photon Induced Photoacoustic Streaming technique showed a strong agitation of the liquids inside the canals and this phenomena takes places by activating the irrigant solution through a profound photoacoustic and photomechanical phenomenon in the endodontic system, which generates a faster streaming of fluids distant from the source in comparison with passive ultrasonic irrigation (PUI) and it is three fold greater in magnitude. The use of low-energy (20 mJ at 15 Hz, 0.3 W average power, or less) generates a thermal effect which is minimalistic. 12.Temperature variations were measured with thermocouples placed 5 mm from the apex on the external root surface. A temperature increase of 1.2 degree C of thermal rise after 20 seconds and 1.5 degrees C after 40 seconds of continuous radiation was seen. Strong shock wave is generated by water molecules that absorb each impulse and leads to effective streaming of fluids inside the canal while also avoiding side effects seen with other methodologies. The tapered and stripped lateral emitting tip positioned stationary superior to the canal orifice minimizes ledging , apex transportation or perforation, charring as seen in the canals with end firing tips.13 Root canal surfaces irrigated with 2 ml of 5.5% sodium hypochlorite solution, and 2 ml of 17% EDTA irradiated for 20 seconds showed clean, open tubules with essentially no smear layer or debris remaining. According to Peters et al 14. PIPS showed greater reduction in bacterial contamination and less bacterial mass contained in apical canals cross sections compared with ultrasonic activation and syringe irrigation. In laser activated irrigation the laser tip has to placed 1mm from the apex and other traditional techniques requires the placement of the tip 5mm from the apex. The PIPS technique eliminates the need to introduce the tip into the root canal system due to its profound and distant effect, 11.The tip has to be placed in the coronal portion of the pulp chamber and left stationary. A 2940-nm Er:YAG laser with a newly designed, 14-mmlong, 400-micron diameter tapered tip is used,13.The final 4mm is stripped from the back to allow for greater lateral emission of energy compared to the frontal tip. This allows for improved lateral diffusion of low energy and enhanced photoacoustic waves.

## CLINICAL PROTOCOL

A 2940-nm Er: YAG laser with a newly designed, 14-mmlong, 400-micron diameter tapered tip is used and left stationary in the coronal orifice, 13 .It is activated for 30 seconds. (20 mJ, 15 Hz, 50 microseconds) dur-

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ing the irrigation between each instrumentation used. 1) Access the pulp chamber using a # 6 carbide round or cylindrical bur. A clear glide path should be created as usual. 2) It is important to establish the correct working length using a# 8 or #10 K hand file introduced in the canal. The working length should be confirmed using both radiologic as well as electronic confirmation. 3) Using NITI instruments for canal preparation is the golden standard in endodontics and allows for standardised shaping and obturation of root canals. 4)The PIPS technique is used between each shaping file step as it allows for increased streaming of fluids into the endodontic system.This technique has the ability to move irrigants three dimensionally without needing to enlarge the canal size. An improved debridement and decontamination of the endodontic system is possible with minimally invasive canal preparation. 5) In case of vital teeth an apex preparation of #20-25 and for necrotic and retreated teeth an apical preparation closely related to the previous condition of the tooth anatomy should be performed, 15 .

## CONCLUSION

The PIPs technique when used helps in safe and effective debriding and decontamination of the root canal system,15. It has no thermal effect on the dentinal walls by the virtue of decreased energy settings, short pulse duration and placement of the tip in the orifice of the canal (away from the target site).The dentin surface and its collagen are undisturbed and clean, 13.This technique allows the clinician to deliver treatments in less time and the need to enlarge the canal system is minimal and therefore allows a more biomimetic preparation which can be obturated three dimensionally.

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