International Scholars Journals

African Journal of Dentistry ISSN: 2167-0405 Vol. 4 (1), pp. 036-038, August, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Short Communication

Applications of lasers in endodontics

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Accepted 3 June, 2016

LASER (light amplification by stimulated emission of radiation) devices transform light of various frequencies into chromatic radiation that is capable of mobilizing heat and power when focused at a close range. They are usually named after the active medium employed, which can either be a container of gas, a crystal, or a solid-state semi conductor.

Key words: LASER, light, radiation, semi conductor.

INTRODUCTION

Laser energy is a form of electromagnetic energy that moves in waves at a constant speed, and its basic unit of energy is known as 'photons'. These photons have two major properties: wavelength and amplitude (Coluzzi, 2008). The amplitude and intensity of laser waves are directly related with larger amplitude, resulting in a greater amount of work done (Coluzzi, 2008). Wavelength (λ) is defined as the horizontal distance between any two corresponding points on the wave. Although it is usually measured in metres, dental lasers use smaller units such as nanometres or micrometres. This measurement is important for the delivery of laser light as well as its reaction with tissues (Convissar, 2010). Moreover, wavelength helps identify the type of laser suitable for a particular tissue type (Parker, 2007). Dental lasers function by producing waves of photons that are specific to each wavelength (Miserendino and Pick, 1995). The first laser was created by Maiman in 1960 (Mathew and Thangaraj, 2010) and used in endodontics for the first time by Weichman and Johnson (1971) who attempted to seal the apical foramen *in vitro* using a high powered infrared laser (Weichman and Johnson, 1971). Technology has improved considerably since then, and dental lasers have now become a crucial part of clinical practice. The purpose of this paper was to summarize the applications of lasers in endodontics.

APPLICATIONS

Determination of pulp vitality

Laser doppler flowmetry is a device used to determine pulp vitality based on red blood cell flux in the pulp tissue. Light beams from the optical fibre enters the tissue, is absorbed to some extent by the blood cells and another fibre tip collects the scattered light and provides information about pulp vitality. It is a non-invasive technique and allows painless diagnosis of the tooth (Gazelius et al., 1986). It is also reproducible and has become well-recognized as the gold standard for pulpal blood flow determination (Wilder-Smith, 1988). It is particularly useful for the detection of pulp vitality in traumatized and/or immature teeth (Singh et al., 2013). However, it takes longer than other vitality determination techniques, and also requires a special device. Therefore, it is not conducted as a routine procedure in clinical practice.

Direct pulp capping and pulp amputation

Lasers can be used for haemostasis and cavity disinfection during pulp capping and amputation. Yazdanfar et al. (2015) used diode lasers during pulp capping and found that this technique was more effective than the conventional one. Similarly, the erbium chromium laser was also found to be more successful (Olivi and Genovese, 2006; Jayawardena et al., 2001). Lasers can also be used to decrease dentin permeability insensitive teeth with no pulp exposure (Stabholz et al., 2004).

Pulpotomy and root canal preparation

There are several studies that report about root canal wall preparation using dental lasers. Shoji et al. (2000) reported that Er-YAG created cleaner dentin surfaces than drilling during root canal preparation, and this was corroborated by Moogi et al. (2010). However, some studies have reported the side effects of using lasers in root canal dentin. Ebihara et al. (2002) showed that using Er:YAG laser on root canal dentin without water cooling can cause minor cavities and ablation. Altundasar et al. (2006) showed that Er,Cr:YSGG laser can cause melting and carbonization of root canal dentin, and these findings were similar to those reported by Harashima et al. (1997). Moreover, root canal surfaces may often be left untouched as laser light moves in a linear direction (Stabholz et al., 2004). Therefore, it was only recommended for straight and slightly curved root canals (Singh et al., 2013). These limitations also play a role in the limited uptake of lasers for root canal shaping in dental practice.

Root canal disinfection and irrigation

The ability of lasers to disinfect root canals is well-reported (Gutknecht et al., 2004; Maden et al., 2013; Wang et al., 2007). Gutknecht et al. (2004) showed that 980 nm diode lasers could reduce *E. faecalis* up to 97% from infected bovine dentin disks, while Maden el al. (2013) obtained similar results using Nd: YAG lasers on dentin surfaces infected with *Candida* species. Photo-activated disinfection (PAD) is another laser-activated disinfection technique requiring a photosensitizing dye and a specific wavelength. This combination has the ability to kill bacteria in planktonic suspensions (Williams et al., 2003). It causes bacterial membrane distribution by releasing free radicals or reactive oxygen species (Bhatti et al., 2002). Bago et al. (2013) used the PAD technique, high power diode lasers, sonic activated irrigation and conventional irrigation to remove *E. faecalis* from straight root canals and reported that PAD and sonic activated irrigation had better effects than the other techniques. Despite the efficacy of lasers in disinfection, their use in direct contact with root canal walls may result in the side effects mentioned. PAD techniques have a lower risk of causing root canal wall deformation as they use low power lasers. However, it involves an additional step of dyeing the root canal wall and the laser light is only effective on stained root canal. Therefore, laser assisted root canal irrigation has gained popularity.

Er-YAG lasers can activate irrigants and also have a cavitational effect on them (Matsumoto et al., 2011). Although Deleu et al. (2013) showed no significant differences between laser activated irrigation and ultrasonically activated irrigation, several other studies have reported that the former produced better results than the latter (De Moor et al., 2009; De Moor et al., 2010; de Groot et al., 2009).

Although laser activated irrigation presented good results, apical extrusion of the irrigation solution was reported to be suspicious. George and Walsh (2008) claimed that laser activated irrigation had a higherrisk of apical extrusion, leading to the development of the photon-initiated photoacoustic streaming (PIPS) technique. This method involves the introduction of a special fibre tip through the root canal orifice, decreasing thermal damage and the risk of apical extrusion (DiVito et al., 2011). Arslan et al. (2014a; b) found that the PIPS system had superior effects compared to the sonic and ultrasonic systems when used for calcium hydroxide and debris removal. On the other hand, Deleu et al. (2013) did not observe any differences between the PIPS technique and ultrasonically activated irrigation.

Vertical root fracture diagnosis and treatment

Vertical root fractures have become increasingly common among endodontically treated teeth, and they are difficult to diagnose accurately and treat effectively. However, there are very few studies examining the use of lasers in diagnosing vertical root fracture cases. Although Kimura et al. (2009) used diagnodent for vertical root fracture detection *in vivo*, this technique appears to be impractical for clinical use. Vertical fractures can be treated using a surgical approach on the fracture side, which involves cleaning of the fracture line and filling with composite resin or bioactive materials. Thereafter, lasers can be used to accelerate soft tissue repair, and this has been performed previously using low power laser therapy (Nogueira et al., 2012)

Conclusion

Although there are several improvements in laser technology, laser energy requires extra procedures and materials for application and protection, and this can extend the clinical time for both patients and doctors. Moreover, the side effects of laser light in root canals have been reported in several studies. Thus, we conclude that these devices do not seem very practical compared to the manual techniques.

Conflict of Interests

The authors have not declared any conflict of interests.

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