10.5005/jp-journals-10024-2010

REVIEW ARTICLE

the Journal of CONTEMPORARY DENTAL PRACTICE at www.thejcdp.com

Lasers in Apicoectomy: A Brief Review

[1,2]Zahed Mohammadi, [3]Hamid Jafarzadeh, [4]Sousan Shalavi, [5]Jun-Ichiro Kinoshita, [6]Luciano Giardino

ABSTRACT

Since the invention of laser, various applications for lasers in endodontics have been proposed, such as disinfection of the root canal system, canal shaping, pulp diagnosis, and apicoectomy. One of the major applications of laser in endodontics is apicoectomy. The aim of this article is to review the benefits and drawbacks of laser applications in apicoectomy, including effect on apical seal, effect on dentin permeability, effect on postsurgery pain, effect on crack formation, effect on root-end morphology, effect on treatment outcome, and connective tissue response to laser-treated dentin.

Keywords: Apical seal, Apicoectomy, Dentin permeability, Laser, Treatment outcome.

How to cite this article: Mohammadi Z, Jafarzadeh H, Shalavi S, Kinoshita J-I, Giardino L. Lasers in Apicoectomy: A Brief Review. J Contemp Dent Pract 2017;18(2):170-173.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

In 1916, a German-born theoretical physicist, Albert Einstein stated that photons have the ability of stimulating the emission of identical photons from atoms that have been excited.[1] Ladenburg[2] in 1928 showed some indirect documents for the process of stimulated emission. Fabrikant[3] in 1940 proposed that stimulated emission in gas discharge may have the ability of amplifying the light under suitable conditions. However, the weak point of this study was no long-term follow-up. After the Second World War, Lamb and Retherford[4] showed that nuclear magnetic resonance may produce population inversions. Furthermore, the stimulated emission of radio waves was shown by Purcell and Pound.[5]

The first laser was produced by Maiman[6] by excitation of a ruby rod with intense pulses of the light from a flash lamp. The first actual generating laser (633 nm) was built using a combination of helium and neon.[7]

Potential uses of the ruby laser in dentistry were investigated for the first time by Stern and Sognaes[8] and Goldman et al.[9] As the initial studies were done with ruby laser, some clinicians started using other lasers including carbon dioxide (CO_2; 10,600 nm), argon (Ar; 514 nm), neodymium:yttrium-aluminum-garnet (Nd:YAG; 1,064 nm), and erbium (Er):YAG (2,940 nm).[10] In the discipline of endodontics, for the first time Weichman and Johnson[11] in an *in vitro* study used a high power-infrared (CO_2) laser to help to get a better seal in the apical foramen area. Subsequently, attempts were made to seal the apical foramen using the Nd:YAG laser.

LASER'S CHARACTERISTICS

Light amplification by stimulated emission of radiation is abbreviated to LASER. Laser light is a man-made single photon wavelength. According to Einstein,[1] when an excited atom is stimulated to emit a photon before the process occurs spontaneously, the lasing process occurs.[12] Spontaneous emission of a photon by one atom stimulates the release of a subsequent photon, and so on. Laser is a single wavelength (monochromatic), collimated (very low divergence), and coherent (photons in phase) light. Wavelength of the emitted photon depends on the state

[1]Iranian Center for Endodontic Research, Research Institute of Dental Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic of Iran

[2]Iranian National Elite Foundation, Tehran, Islamic Republic of Iran

[3]Department of Endodontics, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Islamic Republic of Iran

[4]General Dentist, Hamedan, Islamic Republic of Iran

[5]Department of Conservative Dentistry, Showa University Dental Hospital, Tokyo, Japan

[6]Private Practice, Crotone, Italy

Corresponding Author: Hamid Jafarzadeh, Department of Endodontics, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Islamic Republic of Iran Phone: +985138829501, e-mail: hamid_j365@yahoo.com/ JafarzadehBH@mums.ac.ir

of the electron's energy when the photon is released. When the states of electrons of two identical atoms are identical, wavelengths of released photons are identical. The characteristics of a laser depend on its wavelength.[13] Wavelengths emitted at the ultraviolet portion of the electromagnetic spectrum seem to be promising in endodontic therapy. It seems that the most appropriate laser to slow selective removal of necrotic debris from the root canal and to leave smooth, crack-free, and fissure-free melted dentin walls are the ArF excimer laser (193 nm). Further, the XeCl excimer laser (308 nm) can melt dentin and close dentinal tubules.[10,11,13]

Laser photons interact with tissue in four ways: They are transmitted through tissue, scattered within tissue, reflected from tissue, or absorbed by tissue. Absorption of laser beams by the tissues is mainly due to the presence of free water molecules, proteins, and pigments. The absorption coefficient strongly depends on the wavelength of the incoming laser. Absorption by water molecules plays a significant role in thermal interactions. The absorption coefficient for water is 0.020 for diode laser (800 nm), 0.00029 for argon laser (514 nm), 860 for CO_2 laser (10,600 nm), 12,000 for Er:YAG (2,940 nm), and 0.61 for Nd:YAG (1,064 nm).[14]

EFFECT ON APICAL SEAL

Marques et al[15] assessed the influence of parameters of the Er:YAG laser on the apical sealing of apicectomized teeth. Findings revealed that the apicectomies carried out with 400 mJ/6 Hz showed the smallest infiltration value. Karlovic et al[16] showed that cavities prepared with Er:YAG laser have significantly lower micro leakage for all tested materials. Wong et al[17] compared the apical seals achieved using retrograde amalgam fillings or the Nd:YAG laser. They reported that no statistically significant difference was found in bacterial leakage between the laser-treated group and the retrograde amalgam group.

EFFECT ON DENTIN PERMEABILITY

According to Gouw-Soares et al,[18] CO_2 and Er:YAG lasers used for root-end resection and dentin surface treatment showed a decrease in permeability to methylene blue. Komori et al[19] used different types of lasers [Er:YAG, holmium:YAG (Ho:YAG) laser, and CO_2 laser] on resected roots of extracted human teeth to investigate the clinical application of lasers on hard tissue. After resection by these techniques, morphological changes in the resected surface were studied by both optical microscope and scanning electron microscope (SEM). These studies have concluded that Er:YAG laser induced smooth clean surfaces without thermal damage signs. Ho:YAG laser, however, produced some thermal damage. Relatively large spaces between canal walls and gutta-percha were showed after Ho:YAG laser irradiation.

Moritz et al[20] studied the CO_2 laser effect in apical surgery using color penetration tests and SEM. The root canals and sections were irradiated with 0.5 W low power in continuous wave mode for 20 seconds. Infrared spectroscopy showed that thermal stress for adjacent tissues was moderate. Comparison with nonirradiated surfaces showed that CO_2 laser decreased color penetration at the section. Furthermore, irradiation of the canal wall resulted in acceptable surface sealing. These results were approved by SEM examination. Arens et al[21] revealed that apicoectomy with laser may reduce the dentinal tubule permeability. Application of Nd:YAG laser has been also shown to have the ability of reduction in permeability of resected roots.[22]

CONNECTIVE TISSUE RESPONSE TO LASER-TREATED DENTIN

Maillet et al[23] assessed the connective tissue response over time to implanted root segments with bur-cut or Nd:YAG laser-cut surfaces. Results showed that tissue repair about the root surfaces resected with Nd:YAG laser was delayed when compared with those resected with a bur.

EFFECT ON POSTSURGICAL PAIN

Payer et al[24] showed that low-level laser therapy had no significant effect on postsurgery pain. In a double-blind randomized clinical trial, Kreisler et al[25] evaluated the effect of low-level laser application on postoperative pain after endodontic surgery and found that it can be beneficial for the reduction of postoperative pain.

EFFECT ON CRACK CREATION

Aydemir et al[26] evaluated cracks on root end following resection and cavity preparation with a laser and two established techniques. They concluded that laser resection and root-end preparation technique cannot affect the number of cracks formed on surfaces. Camargo Villela[27] showed that ErCr:YSGG laser caused no crack on the apical root surface. Rahimi et al[28] compared the effect of Waterlase laser and ultrasonic root-end cavity preparation on the integrity of root end and showed no significant difference in crack formation. Batista de Faria-Junior et al[29] evaluated the time required and quality of retrograde cavity preparations using ultrasonics or ErCr:YSGG laser and found that ultrasonics as better than laser. Wallace[30] showed that Waterlase laser may induce no crack or even very low percentage of cracks when used for root-end cavity preparation.

EFFECT ON ROOT END MORPHOLOGY

deMoura et al[31] using Zekryaburs or Er:YAG laser, with or without subsequent direct Nd:YAG laser irradiation (apical and buccal surfaces) and indirect irradiation (palatal surface) showed that there were no differences in cut quality between Er:YAG laser and burs or between two surfaces treated with Nd:YAG with direct irradiation. However, morphological changes were less common on surfaces submitted to indirect irradiation comparing those directly irradiated. Duarte et al[32] showed that laser treatment may produce more irregular surfaces comparing the bur.

EFFECT ON TREATMENT OUTCOME

In an attempt to increase the successful rate of endodontic surgical procedures, Gouw-Soares et al[18] showed that Nd:YAG laser may result in dentinal tubules sealing and bacterial reduction. Er:YAG laser resulted in no discomfort, less contamination of surgical site, and no smear layer. However, better healing achieved with Ga-Al-As laser.

Friedman et al[33] studied different retrofilling materials and CO_2 laser in apical surgery. The best results obtained in roots retrofilled with amalgam/varnish, whereas the worst material was composite resin, with significant difference. Usage of CO_2 laser during apical surgery did not affect the results.

SAFETY OF LASER IN APICOECTOMY

In an *in vitro* study, Bodrumlu et al[34] showed that Er:YAG laser for apicoectomy in different pulse durations can be used with an acceptable safety for apical resection in the presence of sufficient water.

REFERENCES

1. Einstein A. Zur quantenttheorie der starlung. Phys Zeit 1917;18:121-128.
2. Ladenburg R. Research on the anomalous dispersion of gases. Zeit Phys 1928;48:15-25.
3. Fabrikant VA. Emission mechanism of a gas discharge. Trudy 1940;41:236-296.
4. Lamb WE, Retherford CR. Fine structure of the hydrogen atom. Part I. Phys Rev 1950 Aug;79(4):549-572.
5. Purcell EM, Pound RV. A nuclear spin system at negative temperature. Phys Rev 1951;81:279-280.
6. Maiman TH. Simulated optical radiation in ruby. Nature 1960 Aug;187(4736):493-494.
7. Javan A, Bennet W, Herrott DR. Population inversion and continuous optical maser oscillation in a gas discharge containing a He-Ne mixture. Physiol Rev Lett 1961 Feb;6:106.
8. Stern RH, Sognaes RF. Laser beam effect on dental hard tissues. J Dent Res 1964;43:873.
9. Goldman L, Hornby P, Meyer R, Goldman B. Impact of the laser on dental caries. Nature 1964;203:417.
10. Sulewski JG. Historical survey of laser dentistry. Dent Clin North Am 2000 Oct;44(4):717-752.
11. Weichman JA, Johnson FM. Laser use in endodontics. A preliminary investigation. Oral Surg Oral Med Oral Pathol 1971 Mar;31(3):416-420.
12. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. Periodontology 2000 2004 Aug;36:59-97.
13. Clayman L, Kuo P. Lasers in maxillofacial surgery and dentistry. New York: Thieme; 1997. p. 1-9.
14. Rossmann JA, Cobb CM. Lasers in periodontal therapy. Periodontology 2000 1995 Oct;9:150-164.
15. Marques AM, Gerbi ME, dos Santos JN, Noia MP, Oliveira PC, Brugnera Junior A, Zanin FA, Pinheiro AL. Influence of the parameters of the Er:YAG laser on the apical sealing of apicectomized teeth. Lasers Med Sci 2011 Jul;26(4):433-438.
16. Karlovic Z, Pezelj-Ribaric S, Miletic I, Jukic S, Grgurevic J, Anic I. Erbium:YAG laser versus ultrasonic in preparation of root-end cavities. J Endod 2005 Nov;31(11):821-823.
17. Wong WS, Rosenberg PA, Boylan RJ, Schulman A. A comparison of the apical seals achieved using retrograde amalgam fillings and the Nd:YAG laser. J Endod 1994 Dec;20(12):595-597.
18. Gouw-Soares S, Stabholz A, Lage-Marques JL, Zezell DM, Groth EB, Eduardo CP. Comparative study of dentine permeability after apicectomy and surface treatment with 9.6 micron TEA CO_2 and Er:YAG laser irradiation. J Clin Laser Med Surg 2004;22(2):129-139.
19. Komori T, Yokoyama K, Matsumoto Y, Matsumoto K. Erbium:YAG and holmium:YAG laser root resection of extracted human teeth. J Clin Laser Med Surg 1997 Feb;15(1):9-13.
20. Moritz A, Gutknecht N, Goharkhay K, Schoop U, Wernisch J, Pöhn C, Sperr W. The carbon dioxide laser as an aid in apicoectomy: an *in vitro* study. J Clin Laser Med Surg 1997;15(4):185-188.
21. Arens DL, Levy GC, Rizoiu IM. A comparison of dentin permeability after bur and laser apicoectomies. Compendium 1993 Oct;14(10):1290, 1292, 1294.
22. Stabholz A, Khayat A, Ravanshad SH, McCarthy DW, Neev J, Torabinejad M. Effects of Nd:YAG laser on apical seal of teeth after apicoectomy and retrofill. J Endod 1992 Aug;18(8):371-375.
23. Maillet WA, Torneck CD, Friedman S. Connective tissue response to root surfaces resected with Nd:YAG laser or burs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996 Dec;82(6):681-690.
24. Payer M, Jakse N, Pertl C, Truschnegg A, Lechner E, Eskici A. The clinical effect of LLLT in endodontic surgery: a prospective study on 72 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005 Sep;100(3):375-379.
25. Kreisler MB, Haj HA, Noroozi N, Willershausen Bd. Efficacy of low level laser therapy in reducing postoperative pain after endodontic surgery – a randomized double blind clinical study. Int J Oral Maxillofac Surg 2004 Feb;33(1):38-41.
26. Aydemir S, Cimilli H, Mumcu G, Chandler N, Kartal N. Crack formation on resected root surfaces subjected to conventional, ultrasonic, and laser root-end cavity preparation. Photomed Laser Surg 2014 Jun;32(6):351-355.
27. Camargo Villela Berbert FL, de Faria-Júnior NB, Tanomaru-Filho M, Guerreiro-Tanomaru JM, Bonetti-Filho I, Leonardo Rde T, Marcantonio RA. *In vitro* evaluation of apicoectomies and retropreparations using different methods. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010 Oct;110(4):e57-e63.

28. Rahimi S, Yavari HR, Shahi S, Zand V, Shakoui S, Reyhani MF, Pirzadeh A. Comparison of the effect of Er, Cr-YSGG laser and ultrasonic retrograde root-end cavity preparation on the integrity of root apices. J Oral Sci 2010 Mar;52(1):77-81.
29. Batista de Faria-Junior N, Tanomaru-Filho M, Guerreiro-Tanomaru JM, de Toledo Leonardo R, Camargo Villela Berbert FL. Evaluation of ultrasonic and ErCr:YSGG laser retrograde cavity preparation. J Endod 2009 May;35(5):741-744.
30. Wallace JA. Effect of Waterlase laser retrograde root-end cavity preparation on the integrity of root apices of extracted teeth as demonstrated by light microscopy. Aust Endod J 2006 May;32(1):35-39.
31. deMoura AA, Moura-Netto C, Barletta FB, Vieira-Júnior ND, Eduardo Cde P. Morphological assessment of dentine and cementum following apicectomy with Zekrya burs and Er:YAG laser associated with direct and indirect Nd:YAG laser irradiation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010 Apr;109(4):e77-e82.
32. Duarte MA, Domingues R, Matsumoto MA, Padovan LE, Kuga MC. Evaluation of apical surface roughness after root resection: a scanning electron microscopic study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007 Dec;104(6):e74-e76.
33. Friedman S, Rotstein I, Mahamid A. *In vivo* efficacy of various retrofills and of CO_2 laser in apical surgery. Endod Dent Traumatol 1991 Feb;7(1):19-25.
34. Bodrumlu E, Keskiner I, Sumer M, Sumer AP, Telcioglu NT. Temperature variation during apicectomy with Er:YAG laser. Photomed Laser Surg 2012 Aug;30(8):425-428.