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Comparison between Laser and Sodium Hypochlorite in the Disinfection during Root Canal Treatment

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Abstract

Introduction: Various laser techniques have been considered as alternative methods for root canal disinfection and are suggested to more effectively affect bacteria located deep in the dentine than traditional chemo-mechanical methods. This review aimed to investigate the role of dental laser in the disinfection of root canals during endodontic treatment.

Methods: A search was conducted using PubMed and Medline using combinations of certain keywords. The results of this search were limited to English language articles. Lastly, the reference lists from published articles were checked. Moreover, we included studies that utilized various wavelengths ranged from 600 to 2940 nm of the electromagnetic spectrum which included LED, halogen lamps Nd:YAG Er, Cr:YSGG Er:YAG and quartz tungsten halogen with blue light laser.

Results: The initial search process yielded 254 publications. Nine were included in the systematic review and were assessed. The main reason for the assessment of low quality was that no study reported a rationale for sample size: none presented a power analysis. None of the assessed studies reported blinding, during either the operative procedure or outcome analysis. As described later, heterogeneity in performance was extensive.

Conclusions: Results showed that although dental laser precisely reduces canal bacterial count, sodium hypochlorite was more effective. Laser light can affect bacteria further than 1mm in dentin, hence results showed that this laser is effective for sealing dentinal tubules and eliminating bacteria such as Escherichia coli and Enterococcus Faecalis. So it is recommended to use this laser with the rinsing solution for canal disinfection.

Keywords: Disinfection, Laser, Root canal, Dentine, Anti-bacterial.

Introduction

Laser light depends on typical properties of electromagnetic radiation, while in nature most of the light is white, laser light is monochromatic, coherent and focused [1]. Dental lasers may emit visible or invisible light. The waves of laser light are coherent. Working of the laser and its effect on biological tissue is determined by interaction of laser radiation parameters, such as: wavelength, physical characteristics of the illuminated tissue, energy radiation, continuous or pulsed mode, diameter of the laser beam, and the exposure time. Laser beam passing through the tissue can be reflected, absorbed, transmitted and scattered [2].

The development of new delivery systems, such as thin and flexible fibers, as well as new endodontic tips, allowed this technology to be applied in various endodontic procedures. The main goal of endodontic treatment is to complete disinfection and elimination of the pathogenic microorganisms from the root canal system. It has been known that microbial infection plays an important role in the development of necrosis in the dental pulp and formation of periapical lesions. It is well established that eradication of bacteria from root canals is difficult, and current endodontic techniques are unable to consistently disinfect the canal systems20 [3].

New approaches to disinfecting root canals have been proposed recently that include the use of high-power lasers, as well as disinfection of the root canal by using photodynamic therapy [4]. Disadvantages of conventional root canal treatments include their skill-dependent nature, long treatment time, possible weakening of teeth due to widening of the root canal, and use of medicaments such as sodium hypochlorite [5]. A disadvantage with irrigates might also be their inability to penetrate the deeper parts of dentinal tubules where microorganisms may reside. Field of antibacterial chemotherapy is a constant challenge. The current problem of bacterial drug resistance perhaps best illustrates the continuing requirement both for new agents and new approaches to eliminate infection from root canal system [6].

Some studies suggested that it would be superior to develop adjunctive antibacterial therapeutic strategies to chemo-mechanical methods to target residual microorganisms and thus enhance the healing rates of teeth with infected root canals [7]. There is still lack of evidence for understanding the exact way of killing microorganism using the laser. The high-power diode laser has been tested in several areas of dentistry, with promising results for the disinfection of root canals [8]. It has depends on the tissue the laser beam acts. The target components of the tissue on which the laser beam acts are referred to as chromophores, such as water, protein, melanin, hemoglobin, hydroxyapatite, and other minerals. In this way it will achieve the desired absorption which is optimal for biological effects of lasers on tissue. It is important to note that the commercially available dental instruments all have emission wavelengths ranging from 488 nm to 10,600 nm and are all nonionizing radiation [9]. In dental scientific and professional literature many experimental and clinical studies are described, as well as case reports that use different types of lasers of different wavelengths, such as: Carbon dioxide (CO 2) lasers Nd:YAG lasers (1064nm) Er:YAG (2.94μm) and Er:YSGG lasers Argon (488, 514nm) and krypton (513nm), and diode laser. Due to extremely wide range of applications, diode lasers are now the most widely used types of laser devices in dentistry [10].

Various laser techniques have been considered as alternative methods for root canal disinfection and are suggested to more effectively affect bacteria located deep in the dentine than traditional chemo-mechanical methods. Laser techniques are also reported to substantially reduce bacterial load when used as an adjunct to conventional treatment. The bactericidal effects when lasers are used in conjunction with root canal treatments depend on the type of laser used, but the exact killing effects are not fully understood. Nd:YAG lasers are thought to eradicate bacteria mainly by thermal effects, whereas the suggested bactericidal mechanism of action for Er:YAG lasers is linked to the strong water absorption of the laser output. Lasing parameters such as pulse length, these influence and irradiance are also suggested to be involved in the anti-bacterial effect. Lasers are also used in techniques that employ photoactivated substances or photosensitizers; however, the mode of action is completely different [11]. This review aimed to investigate the role of dental laser in the disinfection of root canals during endodontic treatment.

Methods

A search was conducted using PubMed and Medline using certain keywords. The following key words or combinations were used for the search strategy: 'laser' (and also 'CO 2 ', 'Er:YAG', 'Er,Cr:YSGG', 'Nd:YAG', 'Diode', and 'KTP'), 'smear layer', 'root canal', 'permeability', 'dentine' and 'scanning electron microscopy'. To supplement the PubMed search, the terms endodontics, root canal treatment, root canal therapy and laser were used to search CENTRAL and the ISI Web of Knowledge. The results of this search were limited to English language articles. Lastly, the reference lists from published articles were checked. Moreover, we included studies that utilised various wavelengths ranged from 600 to 2940 nm of the electromagnetic spectrum (LED, halogen lamps Nd:YAG Er,Cr:YSGG Er:YAG and quartz tungsten halogen with blue light lamp). Additionally, we did not incorporate literature reviews, commentaries, interviews, updates and short communications in our inclusive criteria.

All articles were at first considered individually by two authors; non-peer-reviewed articles and those dealing with commercial laser technology were eliminated. Relevant publications were retrieved, followed by interpretation. Original scientific studies that fulfilled the selection criteria were read in full text and evaluated using a data extraction form. Findings were discussed until consensus was reached. Neither process was blinded. The quality of each included publication was assessed as high, moderate or low. All abstracts of these publications were read, and the reference lists of relevant publications were hand-searched. Ten articles were read in full text and interpreted according to a data extraction form files.

Results and discussion

The initial search process yielded 254 publications. Nine were included in the systematic review and were assessed. The main reason for the assessment of low quality was that no study reported a rationale for sample size: none presented a power analysis. None of the assessed studies reported blinding, during either the operative procedure or outcome analysis. As described later, heterogeneity in performance was extensive. When considering the use of lasers inside root canals (RC), there are a number of restrictions that cannot be overlooked. An optical fiber with a width varying between 200 μm or more can be easily introduced into the deeper areas of the RC, even in the case of a (gentle) RC curvature [12]. Care should be taken when using the fibre tip in the proximity of the apical foramen as there may be transmission of laser light beyond the foramen. Although the goal was not achieved, sufficient data were obtained to encourage further study. When the CO_2 laser is used at moderate laser energies, dentinal tubules are sealed and permeability is reduced [13]. Therefore, there are no indications that the CO_2 laser can be used in the RC, as this type of laser requires direct visualization of the entire canal surface for complete exposure. The different morphological findings are due to a heterogeneous distribution of laser energy along the RC. In the cervical third of the RC, the laser fibre is oriented more perpendicularly; at middle and apical thirds the laser fibre is positioned parallel to the RC wall [14].

The temperature rise in the dentine induced by the Nd:YAG laser is, in this respect, also dependent on the direction of the dentinal tubules. Dentinal tubules running parallel to the surface prevent significant heat penetration, whereas those running in a transverse direction to the surface (i.e. parallel to the laser beam) allow the penetration of heat. This finding supports a light-propagating theory for the spreading effects of laser beams in dentine [15]. The absorption of Nd:YAG laser energy is improved by the application of black ink [16]. This reduction in permeability of the dentine walls can ensure that the RC filling seals more effectively. It is thought that morphological changes caused by the Nd:YAG laser may positively influence the marginal sealing of RC fillings. The latter effects are the result of too high a thermal damage. Its wavelength is within the infrared range, and thin and flexible fibers can be used. The diode laser has lower penetration depth in the dentine than the Nd:YAG laser and, therefore, a lower risk of unwanted temperature rise in periarticular structures. At the same time, this means it is less efficient in the case of very deep infections [17]. As their wavelengths are similar, the diode laser affects RC walls only slightly differently than the Nd:YAG laser. Therefore, similar effects are to be expected, for example the closing and the opening of dentinal tubules. The diode laser may close the dentinal tubules and, in the presence of smear layer, this effect is more pronounced. The effect of the diode laser on removing the smear layer also leads to reduced apical dye leakage after obturation in vitro [18]. The effects of this nanosecond-pulsed, frequency-doubled Nd:YAG laser on dentine, demonstrated that it can achieve complete smear layer removal. The smear layer is apparently not removed and it appears that dehydration caused contraction of the remaining smear layer.

More research on this wavelength is needed to clarify tissue interaction of the KTP laser with RC walls and consequent smear layer removal. With the heat resulting from laser energy accumulation, care has to be taken not to overheat the target tissue. Water mist during irradiation not only enables rapid ablation, but also provides thermal protection. When preparing the apical area with its thinner dentine walls, considerable care should be taken to avoid destroying the apical terminus of the RC [19]. Erbium lasers at ablative settings that are used too close to the apical foramen may open the foramen and ablate apical bone; it is advised that the laser fiber is kept up to 2 mm from the apical constriction. If the appropriate parameters are selected during exposure of the RC walls to the laser beam, the effects on periodontal tissues during RC preparation using Er:YAG will be minimal [20]. This is also helped by moving the fiber in a helicoidal manner along the RC walls. As only a small amount of water has to be vaporized, little energy is needed for the ablation process 88 , so safety can be optimized. Experimental studies on the efficacy of Er:YAG laser irradiation for cleaning RC walls have demonstrated that this type of laser is more effective in removing the smear layer than other types of lasers and endodontic irrigates [21]. The dentinal walls mostly show open tubules and are free of debris or a smear layer. The laser effects depend, among other factors, on the power setting, the mode of energy delivery, the type and condition of the laser, the target tissues and water cooling. As the laser is used in a circular motion while withdrawing the optical fiber (this withdrawal might otherwise have been slower or even have halted in certain areas), in some of the areas irradiated, not all of the tubules are completely open. Differences in power settings do not appear to result in significant differences in the efficacy of smear layer removal [22]. When comparing Er:YAG laser and EDTAC (EDTA and centrimide) solutions, both means of cleaning the RC wall increased the ability of RC sealers containing calcium hydroxide to adhere to human dentine [23]. Differences in power outputs, the diameter of the fiber, and the use of the fiber with or without water spray cooling appear to influence the occurrence of carbonization and cracks [24].

The obturation of a greater number of RC ramifications using gutta-percha cones and/or sealer after treatment with Er,Cr:YSGG following mechanical instrumentation has also been demonstrated. Cone-shaped fiber tips have been tested and these produce fewer thermal effects and fewer morphological changes than conventional flat-end fiber tips. Hollow fiber optic tips, with advantages including easy manufacture in different shapes, greater adaptability, low cost, and a lower loss of transmission, were also tested. However, a fiber tip with conical and spherical sections showed a larger burning area in the frontal profile in addition to producing lateral burning. According to many studies, a better cleaning of the RC walls was achieved with this technique compared with the use of NaOCl [6, 25]. A radial-firing tip developed for the Er,Cr:YSGG, but not yet marketed, now opens up possibilities for the homogeneous removal of the smear layer from RC walls . Although the temperature increase during Er:YAG laser irradiation should not be high , melting and fusing in the opening of dentinal tubules, caused by 40 mJ of irradiation, has been noted. Irradiation durations and the energy levels in different types of laser influence morphological changes in root dentine walls. Thermal damage may, therefore, be limited with

during tissue irradiation when the laser intensity is high and the interaction time is short. At present, the ablation efficiency of this type of laser still needs further investigation. Finally, it should also be mentioned that Er:YAG and Er,Cr:YSGG lasing may create ledges, zipping, perforations and over-instrumentation in the RC due to their ablative action [26]. Proper power settings should be used to avoid ledges and even perforations where curvatures are above 15 degrees. Therefore, care should be taken when the erbium laser fiber is used in the curved RC. This also applies to the preparation of RC orifices. This vapor, at high pressure, starts expanding at high speed and provides an opening in front of the fiber for the erbium light. As the energy source stops, the vapor cools and starts condensing, while the momentum of expansion creates a lower pressure inside the bubble. Consequently the water seems to rush into the bubble from the back, causing the imploding bubble to be shaped like a sickle. It has to be emphasized that this phenomenon of formation of vapor bubbles or cavitation is specific to erbium lasers, the process is the result of liquid absorbing the specific wavelength generated by these lasers [27].

Conclusions

Results showed that although dental laser precisely reduces canal bacterial count, sodium hypochlorite was more effective. Results showed that although laser is effective in canal disinfection, sodium hypochlorite had more antimicrobial effects than certain types of laser such as Nd:YAG laser. Antimicrobial effect of this laser without the presence of photosensitizing colors along with significant increase in heat was observed. Pathogens which grow as biofilm can hardly be eliminated by direct laser irradiation. Laser light can affect bacteria further than 1mm in dentin, hence results showed that this laser is effective for sealing dentinal tubules and eliminating bacteria such as Escherichia coli and Enterococcus Faecalis. So it is recommended to use this laser with the aforementioned rinsing solution for canal disinfection.

Conflict of interests

The authors declared no conflict of interests.

References

1. Williams, D., Laser basics. Anaesthesia & Intensive Care Medicine, 2008. 9(12): p. 550-552.
2. Verma, S.K., et al., Laser in dentistry: An innovative tool in modern dental practice. National journal of maxillofacial surgery, 2012. 3(2): p. 124.
3. Kimura, Y., P. Wilder-Smith, and K. Matsumoto, Lasers in endodontics: a review. International endodontic journal, 2000. 33(3): p. 173-185.
4. Plotino, G., et al., New technologies to improve root canal disinfection. Brazilian dental journal, 2016. 27: p. 3-8.
5. Holliday, R. and A. Alani, Traditional and contemporary techniques for optimizing root canal irrigation. Dental update, 2014. 41(1): p. 51-61.
6. Giardino, L., et al., Antimicrobial effectiveness of combinations of oxidant and chelating agents in infected dentine: an ex vivo confocal laser scanning microscopy study. International Endodontic Journal, 2018. 51(4): p. 448-456.
7. Pourhajibagher, M., Adjunctive antimicrobial photodynamic therapy to conventional chemo-mechanical debridement of infected root canal systems: A systematic review and meta-analysis. Photodiagnosis and Photodynamic Therapy, 2019. 26: p. 19-26.
8. de Souza, E.B., et al., High-power diode laser in the disinfection in depth of the root canal dentin. Oral Surgery, Oral Medicine, Oral Pathology, Oral

Radiology, and Endodontology, 2008. 106(1): p. e68-e72.

9. Walsh, L., The current status of laser applications in dentistry. Australian dental journal, 2003. 48(3): p. 146-155.

10. Coluzzi, D.J., Fundamentals of dental lasers: science and instruments. Dental Clinics, 2004. 48(4): p. 751-770.

11. Betancourt, P., et al., Er, Cr: YSGG laser-activated irrigation and passive ultrasonic irrigation: comparison of two strategies for root canal disinfection. Photobiomodulation, Photomedicine, and Laser Surgery, 2020. 38(2): p. 91-97.

12. Blanken, J.W. and R.M. Verdaasdonk, Cavitation as a Working Mechanism of the Er, Cr: YSGG Laser in Endodontics: A Visualization Study. Journal of Oral Laser Applications, 2007. 7(2).

13. Mohammadi, Z., Laser applications in endodontics: an update review. International dental journal, 2009. 59(1): p. 35-46.

14. Martín Biedma, B., et al., Comparative study of root canals instrumented manually and mechanically, with and without Er: YAG laser. Photomedicine and Laser Therapy, 2005. 23(5): p. 465-469.

15. Keiser, G., et al., Review of diverse optical fibers used in biomedical research and clinical practice. Journal of biomedical optics, 2014. 19(8): p. 080902.

16. Goya, C., et al., Effects of pulsed Nd: YAG laser irradiation on smear layer at the apical stop and apical leakage after obturation. International endodontic journal, 2000. 33(3): p. 266-271.

17. Saydjari, Y., T. Kuypers, and N. Gutknecht, Laser application in dentistry: irradiation effects of Nd: YAG 1064 nm and diode 810 nm and 980 nm in infected root canals—a literature overview. BioMed research international, 2017. 2016.

18. Wang, X., et al., Effects of diode laser irradiation on smear layer removal from root canal walls and apical leakage after obturation. Photomedicine and laser surgery, 2005. 23(6): p. 575-581.

19. Moura-Netto, C., et al., Nd: YAG laser irradiation effect on apical intracanal dentin-a microleakage and SEM evaluation. Brazilian dental journal, 2011. 22: p. 377-381.

20. Bahcall, J., et al., Preliminary investigation of the histological effects of laser endodontic treatment on the periradicular tissues in dogs. Journal of Endodontics, 1992. 18(2): p. 47-51.

21. Takeda, F., et al., Effect of Er: YAG laser treatment on the root canal walls of human teeth: an SEM study. Dental Traumatology, 1998. 14(6): p. 270-273.

22. Meire, M., et al., Effectiveness of different laser systems to kill Enterococcus faecalis in aqueous suspension and in an infected tooth model. International Endodontic Journal, 2009. 42(4): p. 351-359.

23. Picoli, F., et al., Effect of Er: YAG laser and EDTAC on the adhesiveness to dentine of different sealers containing calcium hydroxide. International Endodontic Journal, 2003. 36(7): p. 472-475.

24. Yamazaki, R., et al., Effects of erbium, chromium: YSGG laser irradiation on root canal walls: a scanning electron microscopic and thermographic study. Journal of endodontics, 2001. 27(1): p. 9-12.

25. Iandolo, A., et al., Intracanal heating of sodium hypochlorite: Scanning electron microscope evaluation of root canal walls. Journal of Conservative Dentistry: JCD, 2018. 21(5): p. 569.

26. Pini, R., et al., Laser dentistry: a new application of excimer laser in root canal therapy. Lasers in surgery and medicine, 1989. 9(4): p. 352-357.

27. Asnaashari, M. and N. Safavi, Application of low level lasers in dentistry (endodontic). Journal of lasers in medical sciences, 2013. 4(2): p. 57.


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