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EFFECTIVENESS DIODE LASER AS ADDITIONAL DEVICE ON ROOT CANAL DISINFECTON

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ABSTRACT

Disinfection of the root canal system is an important stage for successful root canal treatment. Traditionally, root canal disinfection is achieved by a combination of mechanical instrumentation, the use of disinfection irrigation solutions and the placement of medicaments between visits. The irrigation solution works by direct contact with the target and has limited penetration depth into the root canal system. Therefore, the irrigation solution is unable to eliminate the microorganisms from the deeper dentinal layers. Over the last few decades, various devices have been developed to improve penetration and effectiveness of irrigation in the peripheral areas of the root canal. One of the root canal disinfected devices that began to be developed was with the use of lasers. There are various types of lasers that exist in the field of dentistry, one of which is a diode laser. Laser diodes in endodontics are an innovative approach to root canal disinfection because it has the ability to penetrate into the dentin. Keywords: irrigation solution, disinfection, laser diode

INTRODUCTION

Endodontics is a branch of dentistry associated with the prevention, diagnosis and treatment of dental pulp pathoses.1 Pulp and periradicular abnormalities occur due to invasion of microorganisms into the hard tissue of the tooth and progress further until it reaches the root canal system.2 The main goal of root canal treatment is the elimination of microorganisms and their products and pathological debris from the root canal system to prevent re-infection.3

Root canal contamination by microorganisms and remaining necrotic soft tissue is considered a major cause of root canal treatment failure.4 At least 300 species of different microorganisms are found in root canal infections.5 The
eradication of deep microorganisms in the tubular system is a major and very important challenge in long-term dental care with root canal treatment.³

Endodontic treatment procedures rely on mechanical instrumentation, irrigation and medicament solutions between visits for disinfection of the root canal system.⁴ The use of an irrigation solution is an important step because it can help eliminate unaffected microorganisms during root canal preparation.⁵ However, irrigation solution works by direct contact with the target and has a limited depth of penetration into the root canal wall, so that the irrigation solution is not capable of eliminating the microorganisms from the deeper dentine layers.⁶ This is the reason for using a combination of disinfection solutions with irrigation devices. Traditionally, the irrigation solution is delivered into the root canal through an irrigation needle. The problem with the irrigation needle technique is the replacement of irrigation along the root canal is inadequate, because the highest flow rate is only found in the lumen of the needle and around the needle tip.⁷

Although the use of an irrigation solution may decrease the number of microbes in the infected root canal, it fails to achieve the total disinfection goal of the root canal system. Therefore, root canal disinfection is a major challenge in endodontology and a fundamental principle important for long-term preservation of teeth with root canal treatment. The use of lasers in the endodontic field is a method developed to meet these challenges. In general, dental lasers provide access to tubular systems previously unattainable by irrigation solutions.⁸

There are various types of lasers that exist in the field of dentistry, one of which is a diode laser. The diode laser in the endodontic is an innovative approach to root canal disinfection because it has the ability to penetrate into the dentin.⁹ This laser is an option because of some advantages. Among others have a relatively small size compared to other lasers and easy to use. The antimicrobial effect of the laser depends on the dose of heat generated.⁵

The effectiveness of laser antimicrobials against microorganisms has been demonstrated in previous studies. However, based on several studies indicating that the laser alone is no more effective when compared to the irrigation solution, Baz and his colleagues conducted an in vitro study in 2012 to 60 single-rooted teeth. The study compared the effectiveness of root canal disinfection between the use of laser diodes, sodium hypochlorite irrigation solutions, and a combination of laser diodes with sodium hypochlorite. The results showed that disinfection using sodium hypochlorite irrigation solution eliminated more bacteria than laser disinfection. However, fast group disinfection of sodium hypochlorite combinations with lasers showed significantly greater amounts of bacterial elimination.¹⁰
Another study of the diode laser against bacteria by Kaifar and friends in 2013 also gave the same results. The laser beams of the diode with the irrigation solution produces the highest rate of root canal disinfection when compared with disinfection using only irrigation solution or diode laser alone. In the study obtained statistically significant differences.\(^3\)

In recent years, research on root canal disinfection techniques has improved, one of which is root canal disinfection with additional laser diodes.\(^4\) Numerous studies suggest that the combination of sodium hypochlorite irrigation solution with a laser diode provides a synergistic effect and can eliminate migrating bacteria to the deeper layers of dentin. Therefore, laser diodes combined with an irrigation solution are able to eliminate more bacteria in order to increase the success of root canal treatment.\(^5\) Therefore, in this paper we will discuss the use of laser diodes as a disinfection enhancer in root canal treatment.

**REVIEW**

**a. Root Canal Treatment**

Root canal treatment is a procedure that aims to eliminate the microorganisms causing the infection to form an environment in the root canal system that allows the healing process and maintenance of periapical tissue health.\(^6\) This goal can be achieved through the principle of endodontic triage. Endodontic triage consists of access preparation, root canal preparation and root canal filling. Access preparation plays an important role in determining the next two stages. Good access preparation can provide localization, root canal formation and cleaning, disinfection and filling of the root canal system.\(^6\)

Root canal preparation was done chemomechanically. After mechanical instrumentation, there are a number of untouched root canal areas, either by the use of manual techniques or rotary instrumentation.\(^7\) Therefore, the irrigation solution is used to reach the untouched area. The irrigation solution also has antimicrobial properties as part of the root canal disinfection stage.\(^8\)

The final stage of the endodontic triage is the filling of the root canal. Root canal filling is done to prevent microorganisms and tissue fluid from entering the root canal system that has been done chemomechanical preparation. It is expected to support the healing process and maintain healthy periapical tissue.\(^9\)

**b. Irrigation as root canal disinfection**

When microorganisms are in the root canal, it will be hard to achieve by the body's defense mechanism. Therefore, root canal infection removed by root canal treatment through mechanical procedure with additional chemical such as irrigation is an important stage in chemomechanical preparation.\(^10,11\) The objective of chemomechanical disinfection is to kill
microorganisms, remove dentine debris, dissolve organic and inorganic components that cannot be achieved by mechanical evacuation and as an irritant lubrication in biological tissues.16,17

Root canal disinfection using an antimicrobial irrigation solution and tissue solvent as an essential part of the chemomechanical debridement. Irrigation is a complementary instrumentation that facilitates the disposal of microorganisms, debris and necrotic tissue, especially from unprepared areas.17 The ideal irrigation solution has antimicrobial activity properties, is capable of dissolving organic tissue waste, root canal disinfection, discharges debris from an instrumented root canal, lubrication, and has no cytotoxic effect on periodontal tissue.17

c. Diode Laser
In 1960, Theodore Maiman was a scientist who developed the first laser device using a ruby crystal. A few years later, Laser stands for Light Amplification by Stimulated Emission of Radiation.18

Light Amplification by Stimulated Emission of Radiation or Laser, indicating an energy transmission and not. The laser-emitted light is the result of a process called stimulated emission. Laser is a form of energy in the form of particles called photons and moves in the form of electromagnetic waves.19,20 Wavelength measurements are important for laser light, because they can determine how the laser beam is toward the target and the tissue reaction to a particular wavelength. The wavelength is measured in meters (m).20

Among the various lasers that emerged in the mid-1990s, diode lasers also debuted.21 Laser Diodes are one of the most widely developed types of lasers in the science of dentistry and the like with semiconductor active media that can be made of aluminium, gallium, arsenide and indium.21,22 Laser diodes are available in four different wavelengths, ie laser diodes with wavelengths of 810 to 830nm, 940nm, 980nm and 1064nm.21

Laser diodes can be used in various dentistry procedures. In the diode under use, periodontal pocket therapy, crowning equilibrium, inflamed tissue, pharyngitis and photostimulation of herpetic lesions.21,22 Laser diodes can also be applied to procedures involving hard tissues such as teeth. One of these is in endodontic treatment such as root canal disinfection.21,22
Some of the advantages of diode lasers are the small size and flexibility to a wide range of treatment applications including extensive use in different areas of dentistry (figure 1). The relatively small size of the diode laser also provides other benefits, requiring a relatively small area of the workspace and good portability that are easy to transport and relatively light.

**d. Application of diode laser**

Laser diodes use flexible glass fibers to channel energy to the desired target area. Generally, a flexible glass fiber is inserted into the handpiece so it can be applied to the tissue. There are several things to consider when using glass fiber, such as the selection of fiber diameter to be used. The flexible glass fiber in the diode laser is available in diameters of 200-320 μm. The size of glass fiber diameter of 290 μm is equivalent to file size 20. The thin glass fiber diameter allows the delivery of laser light directly into the root canal so as to effectively provide disinfection effect.

In addition to diameter, which is useful to noting is the speed of movement of the fiber end during treatment. Burned tissue are an unwanted side effect due to excessive force or movement of the fiber ends too slowly. The glass fiber is placed 2mm from the working length, then with the circular motion moving from apical to corona. The movement aims for the laser beam to reach the overall root dentine (figure 2).
DISCUSSION

The elimination of bacteria in the inner dentin layer is a challenge and will affect long-term maintenance of root canal treatment. The irrigation solution applied during conventional root canal treatment works through direct contact with bacteria. Due to the limited depth of penetration, the irrigation solution causes bacteria that are in the dentin layer not affected by the disinfection effect.21

The diode laser disinfection effect can be ascribed to the diode laser penetration capability of up to 1,000 μm into the dentin tubule. This is very different when compared to root canal disinfection using a finite irrigation solution penetrating up to 100 μm, whereas the penetration of microorganisms can reach a depth of 1,000 μm (Figure 3). The diameter of the dentinal tubules decreases significantly in the deeper dentin layers, so the penetration of the irrigation solution is limited. Laser rays with properties and characteristics, as well as increased focal intensity, allow laser light to penetrate into the dentinal tubules and affect the effectiveness of antimicrobials.18,27

The introduction of laser in the field of endodontics has increased the effectiveness and success of root canal treatment. In general, dental lasers provide accessibility to the dentin tubule system so that better penetration can be achieved.23 Root canal disinfection using laser diodes is a new approach in the endodontic field. Laser beams are considered capable of reaching areas that are unattainable by traditional techniques. The bactericidal effect of the diode laser is obtained from the resulting heat dose. The effectiveness of antimicrobial lasers against different microorganisms has been demonstrated in previous studies. However, based on several studies indicating that the laser alone is no more effective when compared to the irrigation solution,8

Baz and his colleagues conducted an in-vitro study in 2012 to 60 single-rooted teeth. The study compared the effectiveness of root canal disinfection between the use of laser diodes, NaOCl solutions, and the combination of diode lasers with NaOCl. The results showed that disinfection using NaOCl irrigation solution eliminated more bacteria when compared with disinfection using laser diode. However, the test group of NaOCl combination disinfection with laser diodes showed significantly greater amounts of bacterial elimination. The combination of the NaOCl irrigation solution with the diode laser provides a synergistic effect and can eliminate the migrating bacteria in the deeper layers of dentin. Therefore, laser diodes combined
with an irrigation solution are able to eliminate more bacteria in order to increase the success of root canal treatment.\textsuperscript{19}

The temperature 7\textdegree C is considered the highest biologically acceptable temperature threshold to prevent periodontal damage.\textsuperscript{19} Several studies have concluded that the use of a 980nm diode laser for root canal treatment results in an increase in temperature at the external root surface. Hmaed et al (2010) in his study found that the highest increase in temperature on the external root surface after the use of a diode laser with an irrigation solution was 4\textdegree C. Irrigation solutions are considered effective in minimizing thermal changes in the root canal and external root surfaces\textsuperscript{20}. In the same year, another study by Hmaed et al gave results that the 980 diode laser was able to induce cavitation on water-based media through the formation and explosion of water vapor.\textsuperscript{19}

The pressure waves generated by the diode laser are thought to play a role in clearing debris in the root canal. This is derived from the diode laser's ability to generate pressure waves and form cavitation. Cavitation is the formation of vapor bubbles in the liquid. This process causes the formation of pressure waves characterized by rapid changes in pressure and high amplitude. The pressure of the bubbles produces an explosion that affects the surface, causing shear forces, surface deformation and material release at the surface. In the root canal, the bubble pressure has the potential to damage the biofilm of the microorganism, rupture the cell wall of the microorganism and release the smear layer and debris. Bubble pressure can also improve the solution of the irrigation solution thus increasing the ability of disinfection.\textsuperscript{19}

CONCLUSION

The main goal of root canal treatment is disinfection of the root canal system from bacteria that cause pulp or periapical abnormalities. When bacteria infect the pulp tissue, the bacteria also penetrate into the deeper dentine root layer. The eradication of bacteria deep in the tubular system is a major challenge and an important part of the long-term maintenance of teeth with root canal treatment.

The irrigation solution applied during conventional root canal treatment works by direct contact with the target bacteria. However, the effect of irrigation solution is only limited to the most superficial layers of root dentin due to the limitation of penetration ability of the irrigation solution, so that bacteria in the deeper dentine layer are not affected by the disinfection effect. Considering the weakness of the irrigation solution in root canal treatment, new methods have been developed to obtain effective root canal clearance, one of which is the laser.

Lasers are the latest choice in combating root canal microorganisms, especially in deep dentine tubules. Different types of lasers are emerging, one of which is the diode laser which is the
most popular type of laser because of its penetration ability and antibacterial effect and its size is relatively small compared to other types of lasers.

The antimicrobial effect of the laser depends on the dose of heat generated. Based on several studies it has been proven that the laser alone is no more effective than the irrigation solution. However, the combination of irrigation and laser diode solutions resulted in significantly better disinfection. Therefore, the diode laser is effective as a root canal disinfection device because the irrigation solution combined with the diode laser has been shown to have a synergistic effect and can eliminate migrating bacteria to the deeper layers of dentin.

REFERENCES


