ORIGINAL RESEARCH

Comparative Evaluation of Antimicrobial Efficacy of Diode Laser (Continuous Mode), Diode Laser (Pulse Mode), and 5.25% of Sodium Hypochlorite in Disinfection of Root Canal: A Short Study

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Abstract

Introduction: The success of endodontic treatment is achieved by the complete elimination of pulpal infection and protection from future invasion of microorganisms. Due to the complex structure of the root canal, complete eradication of microorganisms is not possible and is a major challenge for successful endodontic treatment. Therefore, microbiological studies are needed to explore the effect of various disinfection methods.

Aim and objective: The aim of this study is to compare the effectiveness of root canal disinfection by using a diode laser (in pulse and continuous modes) and sodium hypochlorite by microbiological assessment.

Materials and methods: Forty-five patients were selected and randomly divided into three groups. After gaining patency to the root canal the first sample from the root canal was taken using a sterile absorbent paper point and transferred to a sterile tube containing a normal saline medium. Biomechanical preparation was performed with Dentsply Protaper hand files of each corresponding group and was disinfected with group I (diode light amplification by stimulated emission of radiation (LASER) 980 nm with 3 W in continuous mode for 20 seconds), group II (diode LASER 980 nm with 3 W in pulse mode for 20 seconds), group III (irrigated with 5.25% of sodium hypochlorite for 5 minutes). Pre- and post-samples of each group were inoculated on sheep blood agar and examined for any bacterial growth. After the microbial evaluation of the total microbial count of pre- and post-samples, the data obtained were tabulated and statistically analyzed.

Results: The data were evaluated and analyzed using analysis of variance (ANOVA) on Statistical Package for the Social Sciences (SPSS) software. Groups I, II, and III all three groups showed significant differences ($p < 0.01$) and an overall reduction in the microbial count at postbiomechanical preparation (BMP) as compared to pre-BMP with the highest being in laser in continuous mode (group I) (91.9%), followed by 5.25% sodium hypochlorite (group III) (86.5%) and LASER in pulse mode (group II) (72.0%) the least.

Conclusion: The study concluded that the diode laser in continuous mode is more efficacious than the diode laser in pulse mode and 5.2% sodium hypochlorite, respectively.

Keywords: Diode laser, Microbiological studies, Root canal disinfection.

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Introduction

The success of endodontic treatment is achieved by the complete elimination of pulpal infection and protecting it from the future invasion of microorganisms. The most likely routes of infection are exposure to the pulp in direct contact with the oral cavity or *via* accessory canals, open dentinal tubules, or periodontal pockets. The sequence of events and procedures in the control of endodontic infections consists of host defense mechanism, systemic antimicrobial therapy, extirpation of infected pulp, biomechanical preparation and irrigation, intracanal medicaments, hermetically sealed obturation followed by coronal restoration. But still, there are failures in endodontic treatment and one of the reasons for the failure is the contamination of the root canals with microorganisms and their propagation in lateral canals. So, to prevent the failure root canal disinfection is done with the irrigating solution.[1,2]

Irrigating solution has antimicrobial properties. It facilitates the instrument's cutting efficiency and removal of the smear layer from the inaccessible area. Conventionally and most commonly used irrigating solution is sodium hypochlorite which dissolves infected tissue, and has an excellent cleansing ability and antimicrobial properties, when used along with mechanical instrumentation it reduces the number of infected

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canals by 40–50% but are not been able to completely disinfect the canals. Sodium hypochlorite is known to cause ill effects on vital tissues. It can result in the breakdown of blood cells, ulceration, and necrosis (Hülsmann M et al.)[3] Keeping in mind the drawbacks of conventional irrigants, in recent years newer methods of disinfecting the root canals such as lasers have been introduced.

The term LASER was first introduced by Gordon Gould in 1959.[4] Among the lasers, the diode laser is the most advantageous type of LASER due to its capability to penetrate deeper into dentinal tubules and superior antimicrobial effect that leads to promising results in root canal disinfection.[5,6] In today's treatment regimens complete eradication of persisting microorganisms in the root canal is a major challenge and is essential for the long-term success of root canal-treated teeth. Thus, the aim of this study was to compare the effectiveness of root canal disinfection by using a diode laser (in pulse and continuous modes) and 5.25% sodium hypochlorite by microbiological assessment.

Materials and Methods

The study was conducted in the Department of Pedodontics and Preventive Dentistry, Career Post Graduate Institute of Medical and Dental Sciences, Lucknow, Uttar Pradesh, after obtaining ethical clearance from the institution written consent from parents was taken. Forty-five patients in the range of age 11–14 years were selected and randomly divided into three groups, each group having 15 patients (Table 1).

Restorable permanent single-rooted teeth with closed apices showing signs of irreversible pulpitis were included in the study. Each patient included in the study were having one or more of the following symptoms:

- Spontaneous pain.
- Tender on percussion.

Intraoral periapical (IOPA) X-ray of the involved tooth was taken and the following teeth were excluded:

- Previously endodontically treated teeth.
- Presence of large periapical lesion which cannot be treated by endodontic therapy.
- Teeth with an incompletely formed apex.
- Teeth with Internal or external resorption.
- Any generalized disorder or antibiotic therapy within the previous 2 months.

Treatment was done under aseptic conditions using a rubber dam. After gaining patency to the root canal the pre-BMP from the root canal was taken using a sterile absorbent paper point and transferred to a sterile tube containing normal saline medium after that working length was determined using IOPA X-ray. Biomechanical preparation was performed with Dentsply Protaper hand files (Dentsply Maillefer, Switzerland) of each corresponding group and was disinfected (Fig. 2).

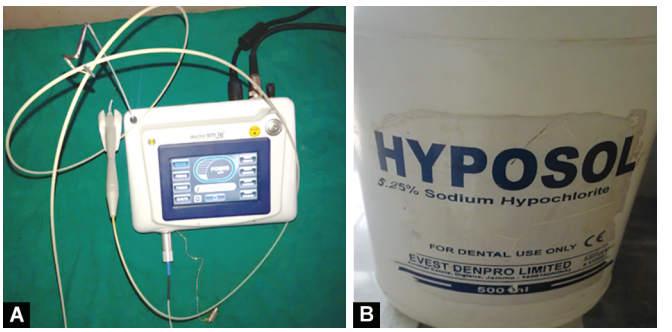
Group I: Diode LASER (Doctor Smile simpler diode laser, LAMBDA SpA) (Fig. 1A) of 980 nm with 1.5 W in continuous mode for 20 seconds. Then rinsed with normal saline, post-BMP sampling was done using a sterile absorbent point and transferred for culture (Fig. 3).

- Group II: Diode LASER (Doctor Smile simpler diode laser, LAMBDA SpA) (Fig. 1A) of 980 nm with 3 W in pulse mode for 20 seconds. Then rinsed with normal saline, post-BMP sampling was done using a sterile absorbent point and transferred for culture (Fig. 4).
- Group III: Irrigated with 5.25% of sodium hypochlorite (Hyposol, Prevest) (Fig. 1B) with a side vent syringe and kept for 5 minutes. Then rinsed with saline, post-BMP sampling was done using a sterile absorbent point and transferred for culture (Fig. 5).

Pre and post-samples of each group were inoculated on sheep blood agar by pour plate method and examined for any bacterial growth in an anaerobic jar at 37°C for 48 hours. Plates were examined with the help of a hand lens and each colony type was recorded and counted (Fig. 6). After the microbial evaluation of total microbial count of pre and post-sample data obtained were tabulated and statistically analyzed.

Results

The tabulated data were statistically analyzed *via* ANOVA test on SPSS software (windows version 17.0) All three groups showed significant ($p < 0.01$) overall reduction microbial count (Fig. 7) at post-BMP as compared to pre-BMP with the highest being in LASER in continuous mode (Group A) (91.9%), followed by 5.25% sodium



Figs 1A and B: Showing (A) Doctor Smile-simpler diode laser; (B) prevestdenpro limited 5.25% of sodium hypochlorite

Table 1: Distribution of samples

Total number of samples (n = 45)	*Groups*	*Disinfection of root canal by*
45	Group I *n* =15	Diode LASER (Doctor Smile simpler diode laser, LAMBDA SpA) (Fig. 1A) o 980 nm with 1.5 W in continuous mode for 20 seconds
	Group II *n* =15	Diode LASER (Doctor Smile simpler diode laser, LAMBDA SpA) (Fig. 1A) of 980 nm with 3 W in pulse mode for 20 seconds
	Group III *n* =15	Irrigated with 5.25% of sodium hypochlorite (Hyposol, Prevest) (Fig. 1A) for 5 minutes

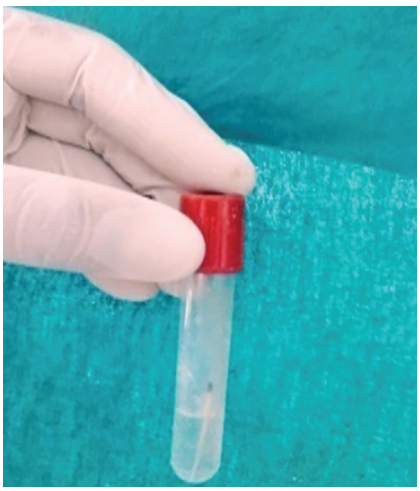


Fig. 2: Showing sample collected in normal saline as a transport medium

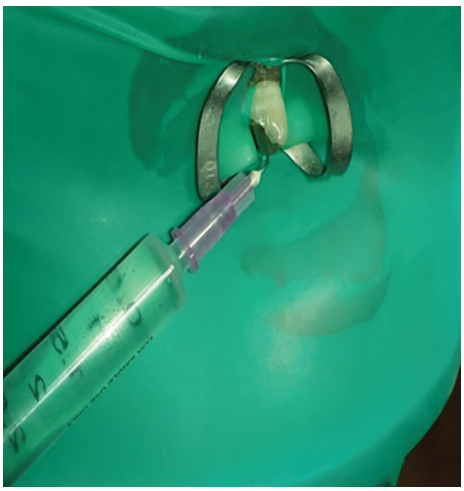


Fig 5: Irrigated with 5.25% of sodium hypochlorite

Fig 3: Diode LASER with continuous mode for 20 seconds

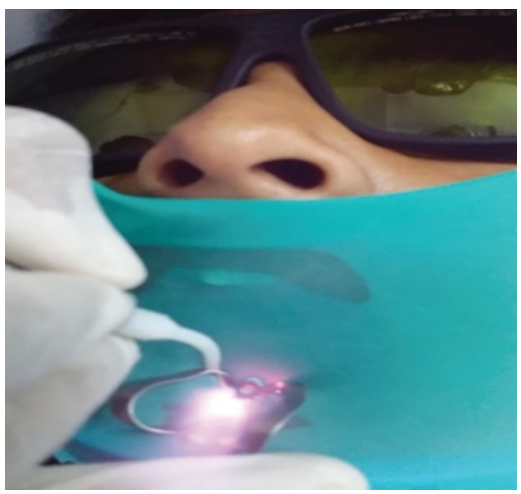


Fig. 4: Diode LASER in pulse mode for 20 seconds

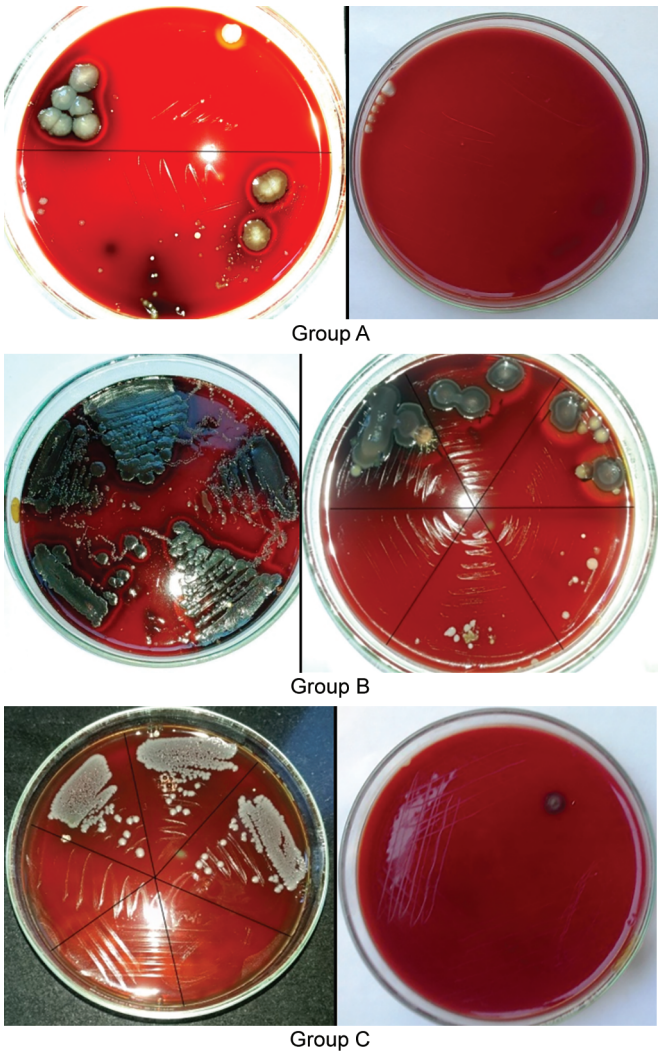


Fig 6: Showing pre- and post-samples of bacterial growth of each group inoculated on sheep blood agar, preoperative bacterial growth

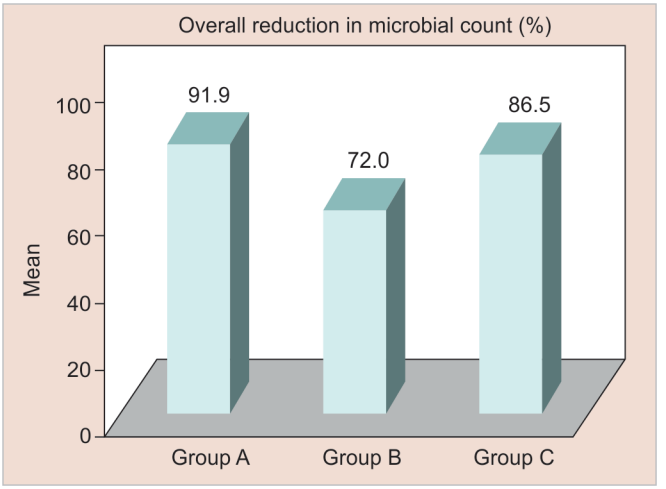


Fig. 7: Showing overall reduction in microbial count

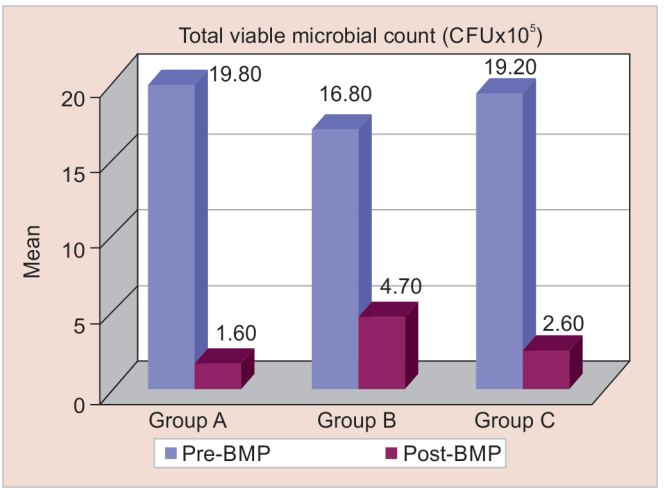


Fig. 8: Showing total viable microbial count

hypochlorite (group III) (86.5%) and LASER in pulse mode (group II) (72.0%) the least. All the treatment groups were effective against microorganisms and exhibited a significant reduction in viable bacteria count pre- and posttreatment (Fig. 8).

Light amplification by stimulated emission of radiation (LASER) in continuous mode for root canal disinfection improves antimicrobial efficacy by 19.9 and 5.5% to diode laser in pulse mode and sodium hypochlorite.

Discussion

The primary objective of endodontic treatment is the disinfection of the root canal and its lateral canal or the network of dentinal tubules. Root canal treatment of the diseased tooth leads to the conservation and improvement of the form and function of natural teeth. Irrigating solutions like sodium hypochlorite is the considered to be ideal and the most commonly used irrigating solution in endodontics. Walker in 1936 was the first to use double-strength chlorinated soda solution (5% NaOCl) in root canal irrigation.[5–7] Even though sodium hypochlorite dissolves vital and necrotic tissues but is not so effective against bacteria hence unable to disinfect the canals completely.[8] Their benefits, vital and necrotic tissue dissolving, and disinfecting capability of a root canal, have been demonstrated in several investigations. Siqueira et al. in an *in vitro* study evaluated the efficacy of 4% NaOCl against *Enterococcus faecalis* and found that 4% NaOCl was significantly more effective than saline solution.[9] Berber et al. in their study found that a 5.25% concentration of NaOCl was the most effective solution.[10] Sodium hypochlorite is not only a pulp solvent and root canal irrigant, it has significant antimicrobial properties due to its ability to penetrate into the cell wall of bacteria and its chemical binding with bacterial protoplasm (Pashley et al.).[4] Other irrigants like ethylenediamine tetraacetic acid is a chelating agent which is used to remove the debris and smear layer but has no or minimal antimicrobial efficacy. Chlorhexidine gluconate has a wide range of antibacterial activity, even to most resistant *E. faecalis*, but it does not catabolize proteins and dissolve the necrotic pulpal as sodium hypochlorite does.

Lasers were introduced in endodontics as an adjunct to conventional treatments. The antimicrobial efficacy of erbium-doped yttrium aluminum garnet, neodymium-doped yttrium aluminum garnet (Nd: YAG), diodes laser, and photo-activated disinfection had been investigated by many researchers. The diode laser is a solid-state semiconductor laser that has gained escalating success in dentistry due to its compactness and reasonable cost. The wavelength of a diode laser used in dentistry ranges between 800 and 1064 nm. By using an optical fiber as the delivery system it emits continuous and gated pulsed mode.[11] The principal action of laser is photothermal that is, the thermal effect on tissue depends on the irradiation mode and settings. Due to the deeper penetration of LASER in the dentinal tubules contributing to a more antimicrobial efficacy Moritz et al. examined bacteria count reduction in root canals with diode laser at a wavelength of 810 nm and found that irradiation at 4 W, on even circling movements for 5 seconds there is a maximum rise in 6°C temperature on the root surface and complete sealing of the dentinal tubules.[7] Kreisler et al. conducted an *in vitro* study on bactericidal efficacy in root canals by using 809 nm diode laser alone, and in combination with NaOCl/H_2O_2, and found that diode laser might be used as an adjunct to conventional root canal treatment.[12] Gutknecht et al. evaluated intracanal diode irradiation with 1.5 W output and they found a 7°C temperature rise in the external root surface and with 980 nm of diode laser irradiation at 2.5 W power output in continuous and chopped mode and found a rise in temperature never exceeded 7°C, which is considered to be safe for periodontal tissues.[13]

At infrared wavelengths that is, at 1064 nm and 980 nm, intracanal diode irradiation causes morphological changes at the apical portion of the root such as clean dentinal surface, closed dentinal tubules, and recrystallization of the dentine. In the majority of cases, the effect is directly associated with the amount of energy delivered. In a study conducted by Gutknecht et al., a diode laser of 810 nm was capable of reducing bacterial contamination up to 88.38% with an output of 0.6 W in continuous working mode. Thus, concluded that the efficacy of the diode laser was directly related to the amount of energy and thickness of dentin.[14] Kouchi et al. found that the diode laser at a wavelength of 980 nm can eradicate bacteria to a depth of 1100 µm in dentin[15] when compared to the penetration power of chemical disinfectants, which is limited to 130–300 µm (Berutti et al.).[16]

Schoop et al., investigated that Nd: YAG and diode lasers both are effective against *E. faecalis* at 1 W but when the power increased to 1.5 W only the diode laser was found to be efficacious against the microorganisms which were also used in our study.[17]

In this study, the overall reduction microbial count was highest in LASER in continuous mode (group I) (91.9%) which was in accordance with the finding of Gutknecht et al. found that that the diode laser when used in disinfecting deep layers of infected root canal dentinal wall, it reduces the number of bacteria with the mean of 74% with a 500 µm thick slice[5] another study by de Souza et al. found that irradiation with diode laser provides increased disinfection of deep radicular dentin up to 100%.[18] Mohit et al. analyzed the efficacy of 5.25% of sodium hypochlorite (group I), 2 % of chlorhexidine (group II), a mixture of tetracycline, acid, and detergent (group III), and 810 diode lasers (group IV) in reduction of microbial count on 40 patients. Statistically significant differences were observed between group I (71.5 %) or group II (73%), and III (85 %), when compared to group IV as the total microbial reduction was 90 % and concluded that diode laser with 810 nm wavelength reduces the microbial count more significantly.[19] Naik et al. assessed the efficacy of root canal disinfection in deciduous teeth by using a diode laser and sodium hypochlorite (NaOCl) based craniomandibular dysfunction (CMD) on 12 patients aged 5–8 years and found that the post diode laser application colony forming units was 100% reduced when compared to CMD with 3% NaOCl, where it was 98.46% reduction.[20]

The results of the present clinical trial are in accordance with the study conducted by Gutknecht et al., de Souza et al., G Mohit et al., and Naik et al. showed that the laser was a more effective tool in reducing the microbial count than the routinely used method, that is, biomechanical preparation with sodium hypochlorite irrigation. The favorable results could be due to more disinfecting capability of the diode laser in continuous mode than pulse mode and to arrive at any concrete conclusion further investigations are necessary.

Conclusion

To conclude in the current study, we found that the diode laser in continuous mode is more effective than the diode laser in pulse mode and 5.2% sodium hypochlorite. For achieving a definitive conclusion more clinical trials with larger sample sizes and longer follow-ups should be conducted to correlate the factors contributing to the efficacy of diode laser in continuous mode.

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