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Original Research

Evaluation of Efficacy of Lasers on Root Canal Disinfection during Endodontic Treatment: An Original Research

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ABSTRACT:

Background: Microorganisms and their by products are considered to be the major cause of pulp and periradicular pathosis. Root canal infection has multibacterial etiology. The success of the endodontic treatment is directly influenced by the elimination of microorganisms from infected root canals. Many authors have suggested that to eliminate bacteria from the root canals predictably, the adjuvant method or agent is recommended. **Aims:** The present study was conducted to evaluate and compare the efficacy of Er:YAG laser, 2% Chlorhexidine and 3% sodium hypochlorite for disinfection of root canal. **Methodology:** In sixty single rooted teeth, access opening and instrumentation till #25 file was done under rubber dam. The first sample was collected by introducing a sterile paper point for preoperative microbial sampling. Twenty teeth in each group were treated with Er:YAG laser, 2% Chlorhexidine and ultrasonic irrigation 3% sodium hypochlorite using for disinfection of root canal. The second sterile paper point was placed to collect the postoperative sample. Paper points were put in a test tube containing transport medium and sent for microbiology laboratory. **Results:** According to the results of the present study, there was highly significant difference ($P < 0.0001$) in percentage reduction in all the three study groups. There was a statistically highly significant difference ($P < 0.0001$) in pre and post operative colony forming units in samples treated with ultrasonic irrigation with 3% sodium hypochlorite (Group III). **Conclusions:** In the current study, ultrasonic irrigation with 3% sodium hypochlorite was the most effective treatment modality as compared to Er:YAG laser and 2% Chlorhexidine for disinfection of root canal

Key words: 3% sodium hypochlorite, disinfection, Er:YAG laser, 2% Chlorhexidine, ultrasonic irrigation.

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INTRODUCTION

Different anatomy and complexities of the canal, in addition to dentin composition, are key challenges for effective disinfection in endodontics.[1]WD Miller in 1890 was possibly the first to associate disease and inflammation in the jaws with the infected dental pulp canal space.[2] One of the crucial points in endodontic therapy is to disinfect root canal before root filling because of the role of bacteria and their by products in both the initiation and perpetuation of pulpal and periapical disease. Since bacteria are the most important cause of periapical infections, the main objective in endodontic therapy is the disinfection of the root canal and the three-dimensional network of dentinal tubules. The mechanical action of the instruments alone is not effective in cleaning a root canal satisfactorily owing to the complexity of the internal dental anatomy, for example, apical, deltas, lateral canals, and accessory canals.[2] Hence, this process is conventionally carried out by the mechanical action of the endodontic instrument on the canal walls, the chemical action of the irrigating solutions, and the physical action of the irrigation/ aspiration process.[3]In our routine endodontic procedures, many a times, just chemo mechanical therapy is not sufficient to debride the root canals. Therefore, newer modalities or devices must be tried and tested in vivo for complete disinfection of the root canal. Hence, this study evaluates the efficacy of Er:YAG laser, 2% Chlorhexidine, and ultrasonic irrigation using 3% sodium hypochlorite for disinfection of root canal.

AIM

The aim of the study was to evaluate and compare the efficacy of Er:YAG laser, 2% Chlorhexidine and ultrasonic irrigation with 3% sodium hypochlorite for disinfection of root canal.

METHODOLOGY

Sixty Patients who enroll at the Outpatient Department requiring root canal treatment in single rooted teeth of maxillary incisors, canine and mandibular incisors, canines, and premolars were identified. A detailed dental and medical history with preoperative radiographs of the patients was taken. In radiographic and clinical examination, all teeth having apical pathosis were selected. Approval was obtained from the Institutional Ethics Review Board with Ref no EC/DYPDCH/CONS/01/2010. Procedure was explained to the patient and informed written consent was taken. **Inclusion criteria:** 1. Single rooted teeth requiring root canal treatment 2. Patient in the age group of 20–45 years 3. Periapical lesion <4 mm. **Exclusion criteria:** 1. Vital teeth 2. Any systemic disorder or antibiotic therapy within previous 2 months 3. Teeth with abnormal anatomy or calcified canals 4. Teeth with periodontal pocket more than 2 mm deep 5. Periapical lesion >4 mm 6. Single rooted teeth with “C-’ shaped canals 7. Roots with multiple canals. Both male and female patients were included in the study. Number was fairly equally distributed in the study groups. Convenience sampling technique was used for patient allocation. Sixty patients were divided into three Groups: a. Group I: Er:YAG Laser (n = 20) b. Group II: 2% Chlorhexidine (n = 20) c. Group III: Ultrasonic irrigation with 3%NaOCl (n = 20). Local anesthesia with 2% lignocaine was administered at the site of disease. Single tooth isolation using rubber dam (Hygienic, Coltene Whaledent) was done. Antisepsis of the operating field was performed with 10% povidone iodine solution (Betadine). A high speed handpiece (NSK, Japan) and sterile round bur BR 46 (Mani, Inc., Dental products, Japan) were used to remove the carious tooth structure or restoration and access to the root canal was achieved. A #10K file (Dentsply) was used to penetrate the apical foramen and to check the patency or any curvatures in root canal. Working length was established using apex locator (iRoot). This was confirmed with an intraoral periapical radiograph. Instrumentation till #25 K file (Dentsply) was done, and irrigation was carried out with saline till no further debris or other particulate matter was visible. Apical gauging was done to size 25 at least. The first sample was collected by introducing a sterile paper point (Dentsply) with a diameter comparable to the full length of the canal and retained in position for 60 s for microbial sampling. If the root canal was dry, a small amount of sterile saline solution was introduced into the canal to ensure viable sample acquisition. The paper point was immediately placed in the test tube containing brain heart infusion (BHI) transport medium (HiMedia) and was sent to the laboratory, for microbiology processing. The bacterial counts were measured for a number of colony forming units (CFUs).

Microbiological procedures

The paper points were transferred into BHI broth for 1 h to obtain samples for the microbiological examination. Then, 10 µl each of pre and post operative samples was inoculated on sheep blood agar plates (HiMedia) using micropipette (Nichipet EX Autoclavable Digital Micropipette) and streaking was done. The agar plates were then placed in incubator (York Scientific Industries Ltd., India) for 24 h. The classic bacterial count technique was used to assess the total number of viable bacteria in CFU per milliliter.

$$\frac{\text{CFU reduction / ml}}{\text{Pre-operative CFU/ ml}} \times 100 = \% \text{ CFU reduction}$$

Each group was treated as follows:

For Group I - Er:YAG Laser

Er:YAG laser of 2940 wavelength with standard settings of 75 mJ, 20 Hz, 1.5W was repeated four cycles for 5s each. A 200U optical fiber 2 mm short of working length was introduced into root canal without activating laser. Then, laser was activated and fiber guided in apical to coronal direction with circular movements and in contact with wet root canal walls.

Canal was moistened with normal saline which was replenished to keep the root canal moist after every laser cycle.

For Group II: 2% Chlorhexidine
In group II 2% Chlorhexidine was used to irrigate root canal with disposable syringe.

For Group III : Ultrasonic irrigation with 3% NaOCl
Ultrasonic irrigation of root canal was done with 3% sodium hypochlorite using endosonic K files (P5, Statelac). Ultrasonically activated #15 K file was used for 3 min at a distance of 1–2 mm short of working length with filing action for 90 s, followed by #20 K file for 60 s in a filing motion and then 30 s circumferential motion.

A total of 50 ml of irrigant solution was used.
Sterile paper point was then placed in root canal for 60 s to collect postoperative sample. Paper point was immediately put in test tube containing transport medium and sent for microbiology laboratory. Microbial processing of samples was done and bacterial counts were measured by CFU in all the three study groups. Temporary dressing was given with zinc oxide eugenol cement till completion of the endodontic treatment. Since sodium hypochlorite is considered gold standard and there is abundant literature showing advantages of ultrasonics as an adjuvant in root canal disinfection, this group was considered as control group. This study group was compared with ozone therapy and Er:YAG lasers for disinfection of root canal. Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 17 (SPSS Inc., Chicago, IL, USA).

RESULTS AND STATISTICAL ANALYSIS

The data obtained were subjected to statistical analysis using "paired t-test." Table 1 shows statistical significance of pre and post operative samples with a mean percentage reduction in CFU among various study groups. The mean percentage reduction in CFU in Group I was 81.44%, Group II was 81.09%, and Group III was 91.65%. There was a statistically significant difference ($P < 0.05$) in preoperative (1700/ml) and postoperative (450/ml) CFU in samples treated with Er:YAG laser (Group I). There was a statistically significant difference ($P < 0.05$) in preoperative (4200/ml) and postoperative (750/ml) CFUs in samples treated with chlorhexidine (Group II). There was a statistically highly significant difference ($P < 0.0001$) in preoperative (10500/ml) and postoperative (250/ml) CFU in samples treated with ultrasonic irrigation with 3% sodium hypochlorite (Group III).

There was highly significant difference ($P < 0.0001$) in percentage reduction in all the three study groups. There was no statistically significant difference ($P > 0.05$) between disinfection carried out by Er:YAG laser (Group I) and chlorhexidine (Group II). There was a highly statistically significant difference ($P < 0.001$) between disinfection carried out by Er:YAG laser (Group I) and ultrasonic irrigation with 3% sodium hypochlorite (Group III). There was a highly statistically significant difference ($P < 0.001$) between disinfection carried out by chlorhexidine (Group II) and ultrasonic irrigation with 3% sodium hypochlorite (Group III). The graphical presentation of comparison of percentage reduction in CFU using Er:YAG laser, chlorhexidine, and ultrasonic irrigation with 3% sodium hypochlorite is shown in Figure 1.

Table 1: Mean percentage reduction in CFU amongst various study groups

Groups	Mean reduction in CFU (%)
Group I (Er: Yag Laser)	81.44
Group II (chlorhexidine)	81.09
Group III (Ultrasonic irrigationwith 3% sodium hypochlorite)	91.65

DISCUSSION

The complete removal of the pathogenic bacteria and their toxic by product is of crucial importance for the successful outcome of therapy. Failures have been documented not only in multirooted teeth but also in single rooted teeth.[4] The difference in the penetration depth of microorganisms and bactericidal irrigating solutions often holds responsible for treatment resistant cases and long term failures which can be observed in conventional endodontics. Literature documents the use of various other adjuvant treatment modalities for disinfection of root canal such as ultrasonics, chlorhexidine, and lasers. In the present study, in Group I, mean preoperative CFU was 1700/ml which was reduced to 450/ml using Er:YAG Laser. In Group II, mean preoperative CFU was 4200/ml which was reduced to 750/ml using chlorhexidine. In Group III, mean preoperative CFU was 10,500/ml which was reduced to 250/ml using ultrasonic irrigation with 3% sodium hypochlorite. Inter and intra group comparison showed statistically significant reduction in microorganism ($P < 0.05$). There was highly significant difference ($P < 0.0001$) in percentage reduction in all the three study groups. There was no statistically significant difference ($P > 0.05$) between disinfection carried out by Er:YAG laser (Group I) and chlorhexidine (Group II). There was a highly statistically significant difference ($P < 0.001$) between disinfection carried out by Er:YAG Laser (Group I) and ultrasonic irrigation with 3% sodium hypochlorite

(Group III). There was highly statistically significant difference ($P < 0.001$) between disinfection carried out by chlorhexidine (Group II) and ultrasonic irrigation with 3% sodium hypochlorite (Group III). Lasers were introduced to dentistry and have some applications in endodontics. Particularly, using a Erbium (Er:YAG) laser, Takeda and Delme et al. found that Er:YAG laser is more effective in removal of debris and smear layer.[5,6] Most lasers are heat producing devices converting electromagnetic energy into thermal. These lasers find uses in oral surgery for cutting or coagulating soft tissues or in the welding of dental prostheses. More recently, new types of lasers have offered non thermal modes of tissue interaction, called photoablation, photo disruption, and photochemical effects. The effect of laser radiation on tissue depends on various properties of the material, for example, specific absorption, chemical structure, and dentistry. On the other hand, the properties of the laser radiation, for example, wavelength, energy density, and pulse duration, must be taken into consideration. The basis of the photochemical effect is the absorption of laser without any thermal change in the chemical and physical properties of atoms and molecules.

Mechanism of action of Er:YAG laser

The wavelengths of the Erbium lasers (Er:YAG, 2940 nm; Er,Cr:YSGG, 2790 nm) are well absorbed in water and hydroxyapatite and are therefore mostly used for the ablation of dental hard and soft tissues. In endodontics, the Erbium lasers are very effective in the removal of the intracanal smear layer[5,7] and have the potential to destroy biofilms on dentine walls[8] . The energy of the Erbium lasers is almost completely absorbed in the first 300 to 400 µm of dentine tissue so that the bactericidal effect is superficial.[9] A study conducted by Pashley et al showed that Er:YAG laser is the most effective device for debris and smear layer removal from root canal walls.[10] In a study on apical cavity preparation by Er:YAG laser and ultrasonic devices without taking into account the substance used for filling, the amount of leakage was lower in the laser group.[11] The study by Harashima et al showed that Er:YAG laser was more effective compared to Er:YAG laser in removal of debris and smear laser.[12]

Mechanism of action of Chlorhexidine

As an antimicrobial agent:

The mechanism of action is found to take place through the cationic ions that are negatively charged. They rapidly get attracted to the inner cell membrane of the bacteria and other microbes and exerts bactericidal effect to eliminate them thus serving as an antiplaque and antimicrobial agent.[13]

Substantivity of Chlorhexidine :

Chlorhexidine offers oral retentivity as its capable to absorb the negativity charged surfaces in tooth , mucosa, pellicle, restorative materials and other oral structures.[14]Recent studies on the substantive nature of chlorhexidine has reported on the inhibition of dentinal proteases thereby prolonging the durability of resin dentin bonds, especially in the absence of collagen.[15,16,17] Due to all above mentioned actions and properties, chlorhexidine can widely be accepted for the purpose of irrigation during root canal treatment. It ensures a microbe and infection free canal on proper application. A clinical study by Siqueira & Sen, Waltimo et al. 2004 has shown that canals that received a final rinse with a 2% chlorhexidine solution were significantly more often free of cultivable microorganisms than controls irrigated with NaOCl alone.[18]

Mechanism of action of ultrasonic irrigation

When a file is placed in the root canal, it causes acoustic streaming effect by mechanical energy, thus dislodging the debris from canal, and by the warming effect, it potentiates the activity of NaOCl. Ultrasonic synergistic system has a significantly superior ability to clean the root canal space when compared to conventional hand filing irrigating technique. NaOCl has tissue dissolving capacity as well as antibacterial properties.[19,20] Hence, with minimal upgradation of existing armamentarium in a dental operatory like endosonic equipment, disinfection of the root canal can be achieved better than conventional method. Use of chlorhexidine and Er:YAG laser is adjuvants. Use of sodium hypochlorite is still being the gold standard in disinfection of root canal system.

CONCLUSIONS

The following are the observations of this in vivo study: 1. Ultrasonic irrigation with 3% sodium hypochlorite was the most effective treatment modality as compared to Er:YAG laser and chlorhexidine for disinfection of root canal. 2. Ultrasonic irrigation with 3% sodium hypochlorite showed 91%, Er:YAG laser 81%, and chlorhexidine 81% reduction in CFU.

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