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COMPARATIVE EVALUATION OF ROOT CANAL DISINFECTION USING 3% SODIUM HYPOCHLORITE, 940NM DIODE LASER AND PHOTODYNAMIC THERAPY IN SINGLE SITTING PULPECTOMY: AN IN-VIVO STUDY

Dental Science

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ABSTRACT

Introduction: Enterococcus faecalis is a common bacterial species in resistant and recurrent infections. It has an active proton pump which prevents its easy inhibition leading to endodontic treatment failure. LASER and photodynamic therapy have been employed lately in improving antimicrobial chemotherapy of localized infections.
Aim: To compare disinfection efficacy of 940nm Diode LASER & Photodynamic therapy(PDT) to Conventional method using 3% Sodium hypochlorite in canals of endodontically treated primary teeth.
Method: Single sitting Pulpectomy was performed on 60 mandibular first primary molars, divided into 3 groups, disinfected using mentioned modalities. Disinfection potential was compared collecting samples at 3 stages using paper points, cultured and incubated for 24hrs to check change in Colony Forming Units of the bacteria.
Results: Data analysis with SPSS version 20 software using Kruskal-Wallis and Mann Whitney-U test.
Conclusion: The three groups showed effective disinfection as revealed by the reduction in the colony forming units of the bacteria at baseline and after intervention. However, diode laser when used in conjunction with sodium hypochlorite as a disinfecting modality was found to be the most effective for the eradication of Enterococcus faecalis from infected root canals.

KEYWORDS

Root canal disinfection, enterococcus faecalis, Sodium hypochlorite, Diode laser, photodynamic therapy

INTRODUCTION

Dental Pulp is the vascular connective tissue contained within rigid dentinal walls that serves functions such as nutritive, protective, formative and sensory for the tooth.[1] Vandalization to the pulp is most frequently brought about by bacteria and its by-products in the form of dental caries. As the carious lesion reaches close to the pulp, an inflammatory response ensues as a reaction of the pulp. If not treated at this stage, repeated insult leads to irreversible damage to the dental pulp.

So, to conserve the natural tooth for function for mastication and/ or esthetics endodontic therapy is the treatment of choice which includes cleaning with complete removal of debris, necrotic tissues, pulp remnants, dentinal shavings and pathologic microrganisms and obturating with a biocompatible material.[2]

Enterococcus faecalis is a facultative anaerobe, possessing the ability to grow in the presence or absence of oxygen. [3] It survives very harsh environments including extreme alkaline pH (9.6), and resist bile salts, detergents, heavy metals, ethanol, azide, and desiccation. [4] It is associated with different forms of periradicular disease including primary and persistent infections endodontic infections.[4] Due to its size (0.5–1 μm in diameter) it can proficiently invade and live within dentinal tubules and has the capacity to endure prolonged periods of starvation until an adequate nutritional supply becomes available.[4]

Due to a highly complex tubular structure of the endodontic system complete removal of microflora is not possible with mechanical instrumentation only. Over the years, a wide variety of irrigants have been used along with mechanical preparation to thoroughly clean the root canals like Sodium Hypochlorite, Saline, Chlorhexidine, Citric acid, Hydrogen peroxide out of which Sodium Hypochlorite forms the main stay.[5]

LASER is one of the most recent development which can be used for the eradication of the deeper-seated microorganisms, especially in lateral dentinal tubules.[6,7] Diode LASER is the most commonly used as an adjunct to root canal therapy to remove smear layer and disinfect the root canals due to its cost effective and user friendly nature.[8]

Another advancement in LASER is the use of Photodynamic Therapy (PDT), also known as Photo activated disinfection which uses non-toxic photoactive dye which is activated by light of specific wavelength in the presence of oxygen.[9] PDT has been employed lately in improving antimicrobial chemotherapy of localized infections.

Thus, this study was done to compare the disinfecting efficacy of Conventional method using 3% Sodium hypochlorite as an irrigant, 940nm diode LASER and Photodynamic Therapy during single sitting pulpectomy of infected roots.

MATERIALS AND METHODOLOGY

The present in-vivo study was performed on 60 Primary Mandibular First Molars requiring pulpectomy. Prior approval of the study was taken by the ethical committee of the institution.

Primary mandibular first molar teeth requiring pulpectomy, with completely formed apex and patients whose parents/guardians have signed informed consent were included in the study. However, ones with presence of large periapical lesion, internal or external root resorption, medically compromised patient and partially erupted tooth were excluded from the study.

All clinical procedures were carried out under strict aseptic conditions and rubber dam isolation

Table 1: Procedure for pulpectomy before allocation in various groups

Administration of local anaesthesia and application of rubber dam
↓
Decay and unsupported tooth structure was removed; canal orifices localized after access cavity preparation using Mani diamond bur for entry for extension of cavity.
↓
Patency of the canals was checked with no. 15 K file.
↓
Sterile paper points were used to collect samples from the root canal that were transferred to tubes containing glucose broth.
↓
Working length determination
↓
All root canals were prepared using rotary file system (Kedo S) using 3% NaOCl as an irrigant.
↓
Recapitulation with 15 number K file, followed by randomly dividing the samples into three groups with 20 teeth each: Group I, Group II, Group III.

Group I: Control group
No further intervention was done in the root canals before obturation

Group II: LASER root canal disinfection
Irradiation of the root canals was performed using 940 nm Diode LASER after biomechanical preparation at 0.5-Watt power in continuous and non-contact mode with 200-micron diameter fiber tip. Sodium hypochlorite was delivered inside each root canal till the canal opening followed by insertion of activated LASER fiber into the apical area moving it in a retrieving circular motion from apical to coronal third at the rate of 1mm/s. Three cycles of irradiation were given per root canal

Group III: Photodynamic therapy
Irradiation of the root canals was performed using 940 nm Diode LASER after biomechanical preparation at 0.2-watt power in continuous and non-contact mode with 200-micron diameter fiber tip. 0.5 ml Methylene blue dye (100mM concentration diluted in distilled water) [27] was delivered inside each root and left undisturbed for 2 minutes followed by insertion of activated LASER fiber into the coronal area. Three cycles (3 cycles of 10 seconds each) of irradiation were given per root canal.

All teeth were obturated with metapex.

MICROBIOLOGICALANALYSIS:
Microbiological sample using sterile paper point was taken from apical and middle third and transferred to glucose broth for analysis for presence of E. faecalis.

The samples were seeded on petri dish containing Rapid Enterococci ChromoSelect Agar followed by incubation of the samples for 48 hours at 37°C to count the CFUs. Grown colonies were identified using standard methods and colony forming units were calculated using digital colony counter.

STATISTICALANALYSIS:
The data will be analysed using SPSS version 20 software. For non-parametric data Kruskal-Wallis test and Mann Whitney-U test was used. For intra-group comparison Wilcoxon rank sum test, was used. The level of significance and C.I will be 5% and 95% respectively.

RESULTS
After statistical analysis, the results of the present study showed maximum root canal disinfection and reduction in enterococcus faecalis counts in group II (Diode laser group), followed by group I (control group) and group III (PDT group), although the difference between the three groups was not statistically significant (Table 3).

DISCUSSION
The dental pulp is sensitive to external factors such as microbial infections from dental caries and/or mechanical and chemical irritations during dental procedures.[10] The pulp undergoes various morphologic and histologic changes as the carious lesion approaches the pulp. [11]

Treatment of the tooth with root canal therapy is dictated by the vitality of the tooth, the patient's symptoms, and the radiographic presentation. Enterococcus faecalis is a microorganism commonly detected in symptomatic/asymptomatic persistent endodontic infections. Its prevalence in such infections ranges from 24-77%.[4]

Removal of microorganisms from contaminated root canals is a complex job which requires efficient antimicrobial solutions for disinfection. Irrigation paired with instrumentation provide support in the elimination of pulp tissue and microorganisms. [12] Various irrigating solutions such as EDTA, normal saline, chlorhexidine, hydrogen peroxide and Iodine have been used over the years, however, Sodium hypochlorite (NaOCl) is considered to be the gold standard. It is an organic solvent (pH>11) which cause amino acid degradation and hydrolysis through the production of chlorine. [12]

But, in view of the highly complex tubular structure of the root canals, Sodium hypochlorite alone is not enough to bring about root canal disinfection.

A comparatively newer treatment modality involves the use of diode laser along with sodium hypochlorite. Bactericidal effect of laser is attained by causing changes in bacterial cell wall. [13] A number of large, vesicle formations of different sizes can be observed called as membrane blebbing which covers the bacteria totally or partly. The blebbing phenomenon is the result of the inner layer of the membrane splitting from the two outer layers. [13] This change of the cell membrane impacts upon the barrier function, and thus, a slight restructuring of the membrane disturbs the cell metabolism substantially.[13] So, in the present study, diode laser was used as an adjunct to sodium hypochlorite.

Among the new technologies, photodynamic therapy (PDT), also known as photoactivated disinfection or photochemotherapy, has demonstrated to be a great ally to conventional endodontic treatment in eliminating microorganisms that remain viable in root canal system.[14] The mechanism of action of PDT occurs when dye, acting as a photosensitizing agent, absorbs photons from the light source, and their electrons enter an excited state, also known as triplet state. In the presence of a substrate, such as oxygen, the photosensitizer, when return to its basic state, transfers the energy to substrate, forming free radicals of high cytotoxicity, such as superoxides and singlet oxygen.[15] These highly reactive species can cause serious damage to microorganisms through irreversible oxidation of cellular components, causing damage to the cell membrane, mitochondria, nucleus, and other microbial cell components.[15]

In the present study, sixty teeth were randomly allocated into the three study groups, the non-significant difference at baseline (Table 2) indicates prevention of bias in the study.

The results of the present study suggested that the maximum reduction in the bacterial count was seen in the Diode laser group (Group II), followed by control group (NaOCl) (Group I) and PDT group (Group III). These differences were however, not statistically significant. Failure to get statistically significant results can be attributed to sample size being small.

Similar results were observed in a study conducted by Mathew A et al which compared the disinfecting potential of the chemical method with laser alone and combination of laser photodynamic therapy with chemical method after rotary method of bio mechanical preparation and suggested that application of diode laser combined with Sodium hypochlorite was the most effective in eradication of microorganisms from the root canals.[16]

De Souza EB et al also evaluated the disinfection degree of dentine caused by the use of diode laser after biomechanical procedures and suggested that high power Diode laser irradiation was able to provide increased disinfection of deeper radicular dentin. [17]

Castelo-Baz P et al evaluated the bactericidal efficacy of 940nm diode laser alone or in combination with 5% sodium hypochlorite against mature biofilms of E. faecalis and suggested that combination of sodium hypochlorite and Diode laser has a synergistic effect, hence intensifying the bactericidal action.[18]

Kaiwar A et al verified the disinfection of diode laser, following chemo-mechanical procedures against Enterococcus fecalis and reported that 980nm Diode laser can eliminate bacteria that have immigrated into the dentin, thus being able to increase the success rate in endodontic therapy. [19]

The effectiveness of Diode laser could be attributed to the following reasons:
As the laser light is directed through an optical fibre, it can act as an accessory to enhance the effectiveness of the treatment. This is due to the capacity of the optical fibre to distribute light evenly 360° around the root canal, with minimal losses, and compatible with the dimensions of the root canal.[88] With the aid of the fibre, the effect of Laser can be extended to areas with difficult access and can easily reach the apical third, even in the curvatures of molars, as well as to external biofilm of the root apex.[20]

The lower penetration effect of Sodium hypochlorite solution into the intra canal dentinal tubules could be suggestive of its lesser effectivenesss. Similarly, the lower effectiveness with photodynamic therapy could be because of the lower wattage of diode laser used, and that the irradiation was done only in the coronal area of the pulp chamber.

However, contradictory results were seen in study done by **Bago I et al** who evaluated the antimicrobial effect of a diode laser irradiation, photo-activated disinfection (PAD), conventional and sonic activated irrigation with 2.5% sodium hypochlorite (NaOCl) on Enterococcus faecalis and suggested that Photoactivated disinfection was more successful in reducing the root canal infection than diode laser and NaOCl syringe irrigation alone, which could be due to the 3D EndoProbe of the Helbo laser would achieve greater antimicrobial effects than the 2D Spot Probe of LaserHF.[21]

Although, there is literature available for disinfection potential for the three treatment modalities used in the study, however, there is still paucity of research with respect to standardized protocol of use of different kinds of laser units. Further studies are required for the use of appropriate wattage and mode of laser to be used with different procedures.

CONCLUSION

It was observed that all the three groups showed effective disinfection as revealed by the reduction in the colony forming units of the bacteria at baseline and after intervention. However, diode laser when used in conjunction with sodium hypochlorite as a disinfecting modality was found to be the most effective for the eradication of Enterococcus faecalis from infected root canals.

CLINICAL IMPLICATION: Use of laser along with sodium hypochlorite can be suggested to be an effective method of root canal disinfection in day to day clinical practice.

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