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Evaluation of Diode Laser Effectiveness in The Disinfection of Necrotic Primary Teeth

(An in vivo study)

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Background: In recent years, diode laser has been utilized for canal disinfection, however more clinical studies are needed to examine its effect.
Aim: This in vivo study was done to assess diode laser effectiveness in the disinfection of necrotic deciduous teeth root canal system.
Materials and methods: A Total of 40 lower primary molars in (4-6 years old) patients need root canal therapy were selected, randomly divided into two groups (A, B). In both groups samples from root canal were collected to full working length with the help of sterile paper point for subsequent microbiological examination, then irrigation was done with 5.25% sodium hypochlorite (NaOCl) in group A, while in group B NaOCl irrigation was followed by laser irradiation with zolar diode LASER (810 nm), at output power 1watt. Following canal disinfection in both groups, samples were collected and cases were followed up radiographically and clinically.
Results: using 1watt 810nm Diode LASER in combination with 5.25% NaOCl did not show statistically significant difference in E. Faecalis count. Also, both groups showed successful clinical and radiographic results after 6months follow up.
Conclusions: 5.25% of "NaOCl" effectively reduces E. faecalis count, and no different results was obtained when combined with 810nm, 1watt diode laser.

Keywords: Root canal, primary teeth, disinfection, diode laser

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Introduction

The successful endodontic therapy mainly relies on eradication of bacteria and irritants from root canal before obturation.[1] Mechanical approach alone is insufficient to completely clean the complex canal system.[2] Disinfection of root dentin became a challenge specially when bacteria enters deep into the dentinal tubules.[3] Most of the existing root canal irrigants work throughout direct action with microorganisms and so cannot reach deep into to clean the dentinal tubules.[4,5] Many investigations proved Sodium hypochlorite efficacy. Accordingly, it is the most widely used canal irrigating solution.[6] However, due to its tissue toxicity[7] and weak penetration into the dentinal tubules[8] the need to search for other modalities became a must.

Enterococcus faecalis is a resistant bacterial strain to different endodontic irrigations which causes recurrent infections leading to failures in endodontic treatment.[9] To improve the efficacy of irrigation systems, different types of laser have been tested for their disinfecting abilities alone or in combination with other irrigants.[10] Diode laser is one of the most preferable laser types because of its high penetration power into the dentinal tubules, bactericidal effect,[11,12] reasonable size and price. Hence, the current study was carried out to assess the antibacterial effectiveness of diode laser 810 nm, 1 watt in combination with 5.25% NaOCl.

Materials and methods

A total of 40 mandibular primary molars, patients between (4-6year- (mean 4.8±0.69) were selected randomly from the Outpatient Clinic of the Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Ain shams University.

Criteria of inclusion:

•Decayed first or second primary molars (D, E) with abscess or history of swelling.
•Patients age between 4-6 years.
•Presence of periapical radiolucency in PA radiograph.

Criteria of exclusion:

•Non restorable tooth.
•Teeth having internal or external resorption.

Ethical considerations

Ethical approval was granted from the Research Ethical Committee of Faculty of Dentistry, Ain Shams University on September \21, 2017 with approval code FDASU-REC IM 091734.

Consent and Assent:

The study was explained to all the parents' participants, and they signed informed consent included their agreement to participate in this study. Verbal assent from the children was obtained according to the rules of the ethical committee.

Allocation

Study participants were randomly allocated using a computer softwareprogram "www.random.org" that generated the random sequence into one of the two groups.

Group A:

•Local anesthesia was administered (LIGNOSPAN standard, Lidocaine HCl 2% and Epinephrine 1: 100,000 Injection, septodont inc., France)
•Isolation of the teeth using rubber dam
•A sterilized high-speed handpiece and round bur for access opening, then canal walls were shaped with safe ended diamond stone.

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•The root canal was entered with K-file[1] size 10.
•Irrigation with sterile saline using hypodermic syringe 27-gauge needle, with push-pull action, canal walls were debrided.
A pretreatment sample was collected from the root canals by placing two sterilized paper points for 60 s in the canal, then transferred them to sterilized tube of 2 ml BHI broth (brain heart infusion broth).
•Cleaning and shaping till size 30 manual k-files was done.
•Irrigation between files with 5 ml of 5.25% NaOCl using hypodermic syringe and 27-gauge, beveled needle.
•Canal was then flushed by sterile saline, then second sample was taken by the same steps as mentioned before.

Group B:
Same steps were done as group 1 then,
•Canal was dried with paper point size 30
•Intracanal irradiation was done with Diode laser (Zolar Technology & Mfg. Co. Inc, Canada), having wavelength of 810 nm. The settings used were, noninitiated Fiber optic tip with power of 1 Watt, interval 20 sec and duration of 30 secs in a repeat mode.
•Fiber optic tip (200 µm) was removed from the canal in helicoidal movements at 2 mm/s speed, this was repeated for 4 times at intervals of 20 s. After completion of irradiation, sterile saline was placed in the canal and second sample was taken as described before.
•Collected samples were then sent to Dr. Ali Zaki laboratory- Professor of medical microbiology and immunology, Ain Shams University- for bacterial culturing and count.
Obturation:
•Canals then were dried by using sterile paper points and filled with premixed calcium hydroxide iodoform paste (Metapex (Meta Biomed Co. Ltd, Cheongju, Korea).
•Pulp chambers were then filled by reinforced zinc oxide and eugenol (IRM, Dentsply Sirona, Australia), covered with stainless steel crown.
•Follow up after 1month, 3months and 6months was done.

Statistical Analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Logarithmic transformation of bacterial count data was performed due to the high range of bacterial counts; however, Log_{10} Colony Forming Unit (Log_{10} CFU) of bacterial count data showed non-parametric distribution while percentage reduction in bacterial counts data showed parametric distribution. Data were presented as median, range, mean and standard deviation (SD) values. For non-parametric data, Mann-Whitney U test was used to compare between the two groups. Wilcoxon signed-rank test was used to study the changes by time within each group. Dunn's test was used for pair-wise comparisons. For parametric data, Student's t-test was used to compare between the two groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

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Results

1.Bacterial counts

a. Comparison between the two groups

At base line as well as following one week, there was no statistically significant difference between Log_{10} CFU of bacterial counts in the two groups (*P*-value = 0.052,

Effect size = 0.657) and (*P*-value = 0.089, Effect size = 0.555), respectively.

Table 1: Descriptive statistics and results of Mann-Whitney U test for comparison between Log_{10} CFU of bacterial counts in the two groups

Time	Laser + NaOCl (n = 20)	NaOCl (n = 20)	*P*-value	*Effect size (d)*
Base line			0.052 *(ns)*	0.657
Median (Range)	5.1 (4.9 – 6)	5 (4.9 – 5.2)		
Mean (SD)	5.1 (0.2)	5 (0.1)		
1 week			0.089 *(ns)*	0.555
Median (Range)	3 (0 – 3.9)	3.7 (0 – 4.3)		
Mean (SD)	2.8 (1.3)	3 (1.6)		

** : Significant at P ≤ 0.05*

(ns): Non significant at P > 0.05

a. Changes by time within each group

In each group, there was a statistically significant reduction in Log_{10} CFU of bacterial counts after 1 week (*P*-value <0.001, Effect size = 0.877) and (*P*-value <0.001, Effect size = 0.877), respectively.

Table 2: Descriptive statistics and results of Wilcoxon signed-rank test for comparison between Log_{10} CFU of bacterial counts at different time periods within each group

Time	Laser + NaOCl (n = 20)	NaOCl (n = 20)
Base line		
Median (Range)	5.1 (4.9 – 6)	5 (4.9 – 5.2)
Mean (SD)	5.1 (0.2)	5 (0.1)
1 week		
Median (Range)	3 (0 – 3.9)	3.7 (0 – 4.3)
Mean (SD)	2.8 (1.3)	3 (1.6)
P-value	<0.001*	<0.001*
Effect size (r)	0.877	0.877

**: Significant at P ≤ 0.05*

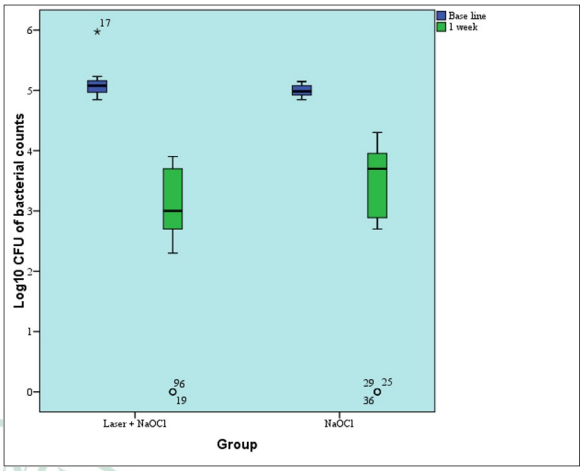

Figure 1: Box plot representing median and range values for Log_{10} CFU of bacterial counts in the two groups (Star and circles represent outliers)

a. Comparison between percentage reduction in bacterial counts in the two groups

After 1 week, there was no statistical significant difference between mean percentage of bacterial reduction in the two groups (*P*-value = 0.053, Effect size = 0.642).

Table 3: Mean, standard deviation (SD) values and results of Student's t-test for comparison between percentage reduction in bacterial counts in the two groups

Laser + NaOCl (n = 20)	NaOCl (n = 20)	*P*-value	*Effect size (d)*
97.4 (2.8)	**94.1 (6.6)**	**0.053**	**0.642**

**: Significant at P ≤ 0.05*

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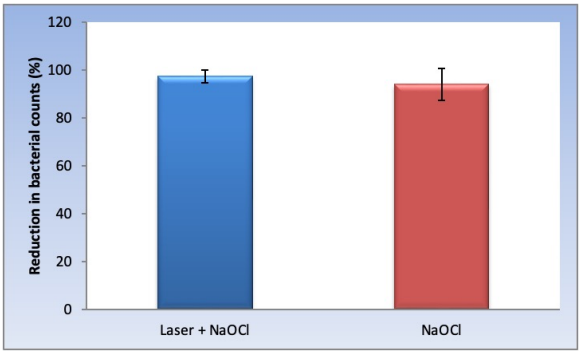

Figure 2: Bar chart representing mean and standard deviation values for percentage reduction in bacterial counts in the two groups

2.Clinical results

Regarding clinical signs and symptoms and radiographic evaluation, there was no differences between both groups after 1,3 and 6 months follow up. Both groups showed absence of pain on percussion in follow up appointments, abscess resolution and healing of sinus tracts. Radiographically, periapical lesions started to heal in both groups.

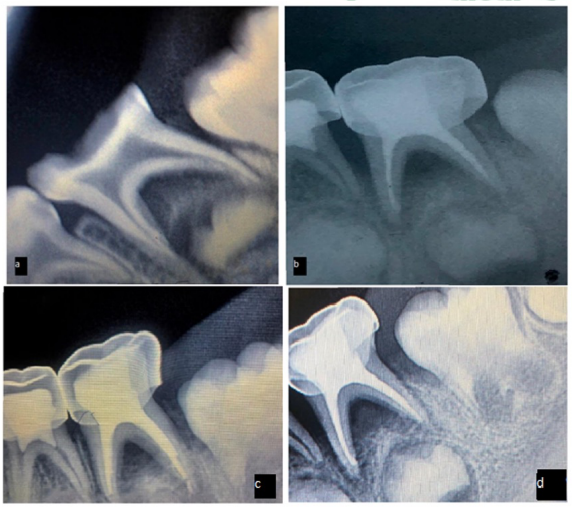

Figure (3): Radiographic outcome of group A: (a) preoperative, (b) one-month follow-up, (c) three months follow-up, and (d) six months follow-up

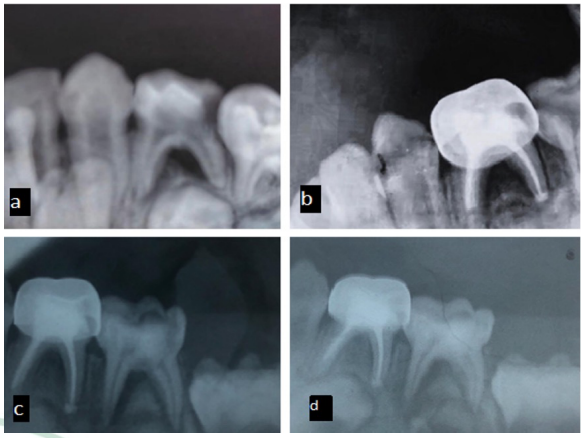

Figure (4): Radiographic outcome of group B: at (a) preoperative, (b) one-month follow-up, (c)three-month follow-up, and (d) six-month follow-up

Discussion

Varying concentrations of NaOCl is the most widely used root canal irrigant due to its bactericidal effect, ability to destroy bacterial biofilms, and dissolve necrotic and vital tissues.[13] However CBCT scans showed that about 35% of the root canal system consists of canal curvatures and isthmi, which remained uninstrumented, regardless of the instrumentation technique used.[14] Despite part of the infected pulp tissue and the superficial layers of dentin are removed during root canal preparation, the chemical irrigants effect remains limited to the root canal superficial dentin layers.[2,4,5]

Recently, there had been a new approach in root canal treatment ways especially in deciduous teeth due to their complicated root canal system that made mechanical instrumentation only not enough to achieve complete disinfection, one of these recent approaches was diode laser.[15]

The purpose of this study was to determine the potency of 810nm diode laser in conjunction with sodium hypochlorite 5.25% concentration, at 1watt output power in disinfection of contaminated root canals.

Since E. faecalis is highly resistant to wide range of disinfectants and is the most

common cause of persistent endodontic infections and unsuccessful root canal therapy, many studies have used it to determine the efficacy of various antibacterial agents. Furthermore, E. faecalis is very heat-resistant, and it was proved that the main mechanism for laser antibacterial action is primarily a result of heating effect, so it was recommended to use E.faecalis in the evaluation of heat-independent antimicrobial effect of laser.[16]

Different types of Lasers showed promising antimicrobial properties. Many research have been conducted to evaluate various laser types and wavelengths for root canal disinfection.[17]

Diode laser proved its antibacterial action which may be due to its higher penetration depth (1000 µm into dentinal tubules) in comparison to NaOCl, which penetrates to 100 µm.[11,12]

Most of the studies that proved laser antibacterial efficacy recommended that laser should not be used alolne as a substitute to NaOCl, however using it as an auxiliary technique to the traditional disinfection and debridement protocols might be beneficial.[18]

By reviewing literature further clinical trials is needed to evaluate diode laser root canal disinfection in primary teeth. The following study is to evaluate the Antibacterial Activity of Diode Laser 810 nm in combination with Sodium Hypochlorite (5.25%) and Sodium Hypochlorite alone in canal disinfection after pulpectomy in primary molars.

In the present study, 5.25% NaOCl has shown significant reduction in CFU of E Faecalis These findings were in consonance with the findings of Snehal S. Sonarkar et al (2018).[19]

The effect of -810 nm diode laser 1 watt- in conjunction with 5% sodium hypochlorite, was slightly higher than using NaOCl alone, but with no statistical significance. This could be attributed to the relatively low power output (1W) of laser used in our study, these findings were in accordance with Mahima Tilakchand et al (2018), where they compared 3% NaOCl in conjunction with 980 nm diode laser with different outputs, only diode laser with 1.5watt and 1.95 watt shows statistical significant reduction in bacterial count when compared with irrigation by 3% NaOCl alone, while using 1.05 watt diode laser in combination with 3% NaOCl showed no statistical significant bacterial reduction.[20]

Also, in accordance with Snehal S. Sonarkar et al (2018), when used 810 nm ,0.8-watt diode laser alone in canal disinfection, results showed that it was less effective than 5% NaOCl especially against anaerobic bacteria, the researchers attributed that to the low laser output used in the study.[19]

Our findings differ than the findings of Shanshan Dai et al (2018) findings where diode-NaOCl showed satisfactory bactericidal effects in experimentally contaminated root canals of primary teeth.[21]

The reason for this could be attributed to the lower laser output power used in the current disinfection protocol, while higher laser power was used in Shanshan Dai et al (2018) study.

Again differs with R.A.Sarda et al (2019), results of that study showed significant reduction in the E. faecalis count when NaOCl was used in combination with diode laser in comparison to using NaOCl alone, this could be due to the lower NaOCl concentration 3% and higher laser power 1.5 used in that study in comparison to our study.[18]

Results also differs than Nikhil Jambagi et al (2021), where diode laser disinfection showed higher reduction of microbial count compared 2.5% NaOCl, this could be attributed to the lower NaOCl concentration used in this study compared to our study.[22]

Subsequently, laser-assisted endodontics is recommended however more research is needed to determine the antibacterial efficacy of 810-nm diode laser.

Moreover, to enhance the efficacy of the 810-nm diode laser, adjusting the power output (more than 1watt) is recommended.

Also, more clinical studies are needed regarding diode laser effect in healing of periapical lesions.

Conclusion

5.25% NaOCl has strong antibacterial action which was not enhanced by using 1watt, 810nm diode laser.

Recommendations

More in-vivo studies are needed to determine the antimicrobial effect of lasers and their role in the healing of periapical lesions by using Combination therapy of NaOCl irrigation and LASER irradiation with different laser power, with long term clinical and radiographic evaluation.

To enhance the efficacy of the 810-nm diode laser, adjusting the power output (more than 1watt) is recommended.

Using lower NaOCl concentrations (less than 5.25%) in combination with diode laser root canal disinfection protocol can take advantage of laser use without harming surrounding vital tissues by high NaOCl concentration.

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