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The Influence of different Disinfection and Hemostatic Procedures on Post-Operative Pain In Adult Pulpotomy: Clinical Study

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ABSTRACT

Aim: This clinical study aimed to assess the effectiveness of the use of sodium hypochlorite and Diode laser as hemostatic agents, in relieving postoperative pain in pulpotomy procedures for treatment of permanent teeth with symptomatic irreversible pulpitis.

Materials and Methods: Sixty patients, each with a lower first permanent molar diagnosed with symptomatic irreversible pulpitis, were enrolled in this study. The access cavity was prepared followed by coronal pulp tissue extraction. The initial hemorrhage was controlled with a saline-moistened cotton pellet. Patients were divided into 3 groups, (where n=20). Hemostasis and cavity disinfection was attained by the application of either a 2.5% NaOCl solution (Group 1) or a 5% NaOCl solution (Group 2) or diode laser (Group 3). This was followed by the gentle application of Neoputty on the floor of the pulp chamber, followed by the applications of layers of (Fuji Equia) Glass Ionomer Cement. Final permanent restoration using composite Tetric N-Ceram resin was done during the same visit. The patients documented their levels of postoperative pain at the sixth hour, first day, and eighth day. Pain was scored on a Visual Analog Scale (VAS), with scores spanning from 0 mm (no pain-free) to 100 mm (highest level of pain).

Results: At all intervals, NaOCl 2.5% recorded the highest mean score value, while the least mean value was recorded in (Diode laser), with no statistically significant difference between (NaOCl 2.5%) and (NaOCl 5%).

Conclusions: Within the limitation of this study, modern disinfection modalities like Diode laser device, when used as hemostatic agent in pulpotomy of mature molar teeth with IP, exhibits promising results in terms of postoperative pain.

KEYWORDS: Hemostasis, diode laser, pain, sodium hypochlorite

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INTRODUCTION

Carious pulp exposure frequently leads to irreversible pulpitis (IP). [1] For many years, Root Canal Therapy (RCT) was considered the best treatment choice for treating permanent teeth with symptomatic (IP). [2] Meanwhile, RCT has many disadvantages such as being expensive and time consuming. [3] with lower success rate ranging from (24–66%). [4,5] Moreover, pulp removal in RCT leads to decrease in the repair potential of the pulp and loss of the its immune defense mechanism. [6] As reported previously, it was found that, better healing pattern in teeth occurs with irreversible pulpitis, if pulpal inflammation was controlled. [6]

Therefore, a pulpotomy is thought to be an alternative way of treatment to RCT in adult patients. [7] It was proven that, among the treatment modalities of patients with symptomatic IP, pulpotomy was an effective treatment option that helped in pain relief. [8] Pulpotomy can be defined as the removal of the coronal pulp tissues in order to preserve the remaining radicular pulp. [9]

Although, there have been considerable improvements in pain control during root canal treatments (RCT), post-endodontic pain continues to be a major complaint in over 50% of patients. [10]

Nowadays, painless procedures are the main request of patients in dental clinics. Unfortunately, post-endodontic pain is a major complaint in over 50% of patients. [10] Endodontic pain can adversely affect the patient′s overall quality of life, and can be considered, as a main cause contributing to tooth extraction. [11] Full pulpotomy provided faster pain relief compared to RCT; as stated by Galani et al. [2] This may be due to a decrease in local tissue pressure, as well as inflammatory mediators' levels, in addition to severing sensory nerve endings. [12] However, more researches are needed to validate the favorable outcome of this treatment approach. [13, 14]

Previous studies [15,16] investigated the effect of laser application as well as the use of different agents for hemostatis in vital pulp treatments (VPT). The laser minimizes the risk of bleeding, mechanical damage, or bacterial contamination. Thus, it can be effective in pulpotomy treatments. [15]

Among many solutions, sodium hypochlorite (NaOCl) owing a hemostatic and antibacterial effect is considered one of the solutions recommended to be used in vital pulp treatments. [17] Sodium hypochlorite (NaOCl) showed excellent biological compatibility with pulp tissues giving favorable results when used as a hemostatic agent in vital pulp treatments. [17]

This clinical study was conducted to determine the effectiveness of the use of sodium hypochlorite and Diode laser for achieving disinfection and hemostasis, in relieving pain sensation, when pulpotomy was done in permanent teeth diagnosed with symptomatic irreversible pulpitis. Null hypothesis, there is no difference between the effect of diode laser and two different concentrations of NaOCl used as hemostatic agents in pulpotomy in teeth with IP on post-operative pain.

METHODOLOGY

Sample Size Calculation

We calculated the sample size to identify the differences in postoperative pain levels measured using a 100-mm Visual Analog Scale (VAS) across three experimental groups: 2.5% NaOCl, 5% NaOCl, and Diode laser. Based on previous studies [18,19] in vital pulp therapy reporting standard deviations between 15–20 mm, we assumed a pooled standard deviation of 18 mm and a clinically meaningful difference of 15 mm. Using one-way ANOVA with a significance level of 0.05 and a power of 80%, the estimated sample size was 28 per group. However, due to clinical feasibility and ethical considerations in recruiting patients undergoing acute endodontic care, we adjusted the sample size to 20 patients per group (total n=60). This provides approximately 65–70% power to detect the predefined effect size. Sample size calculation was determined using G*Power version 3.1.9.7.

Research Ethics Committee Approval

This study obtained the ethical approval from the Research Ethics Committee, Faculty of Dentistry, Cairo University (35-4-24).

Study Design

The subjects of the study were recruited from the endodontic clinic at the National Research Centre, Cairo, Egypt. Sixty patients with lower first permanent molar diagnosed with symptomatic irreversible pulpitis participated in this study. All procedures were part of routine care, and patients were given information about their treatment verbally. Patients were treated with pulpotomy using either NaOCl 2.5 %, NaOCl 5% concentration or diode laser for disinfection and hemostasis according to the allocation in the experimental groups.

The inclusion criteria

- Patients in good health aged 20- 45 years old,
- Treatment of one tooth for each patient,
- The patient was presented with pain triggered by thermal stimuli that lasted for several minutes after removing of the stimulus, confirming the diagnosis of IP.
- Restorability of the tooth,
- No periapical radiolucency
- Normal limits of probing pocket depth (3 mm)

The exclusion criteria

- Patients with systemic disorders, pregnant females,
- The existence of allergies, patients suffering from pain in more than one molar on the same side
- Presence of intraoral or extraoral sinus tractor fistula.
- Analgesics used within the past 12 hours.
- The patient has received antibiotics during the week before the procedure.

Randomization, subject allocation and blinding

Randomized sequences of integers ranging from 1 to 60 were established using RANDOM.ORG-Sequence Generator (http://www.random.org) and distributed into three lists on an Excel sheet representing the three groups, according to the type of hemostatic agent that would be used. Each patient picked a number, and then the patient was allocated in a group according to this number. The three operators were randomly assigned to the patients of each group, so that each operator had an equal number of patients from the three lists. This study is considered as single blind study (Subject Blinding), as the type of hemostatic agent that was used was unrevealed to the patient.

Clinical Procedure

Local anasthesia was administrated (articaine 4% solution with Epinephrine 1/100,000 (Septodont, France). Rubber-dam was applied for isolation, then disinfection of the tooth crown using a 5% NaOCl solution. Access cavity preparation followed by the removal of necrotic and infected dentin manually by an excavator and/or by a low-speed hand piece using a round bur. Thoroughly cleaning of the cavity was done by cotton pellet moistened with a 5% NaOCl solution. Another rubber dam sheet was placed over the existing one. Subsequently, with a sterile bur, the roof of the pulp chamber was carefully removed, exposing the underlying pulp. The removal of the coronal pulp tissue was done with a sterile round bur, in a high-speed handpiece with the presence of

copious amount of coolant. The initial hemorrhage was controlled by applying a saline moistened cotton pellet. The achievement of complete hemostasis and cavity disinfection was attained through the application of either a 2.5% NaOCl solution (Group 1) or a 5% NaOCl solution (Group 2) or diode laser (Group 3).

Group 1: Cavity disinfection and hemostasis with 2.5% NaOCl solution (n =20)
NaOCl 2.5% served as a disinfectant for the cavity, as well as a hemostatic agent. A cotton pellet saturated with a 2.5% NaOCl solution was positioned within the pulp chamber. The cotton pellet was inspected every two-minute until the six-minute mark, then the duration of hemostasis was recorded.

Group 2: Cavity disinfection and hemostasis with 5% NaOCl (n =20)
Same procedure was done as in group 1 but with using 5% NaOCl solution.

Group 3: Cavity disinfection and hemostasis with Diode Laser (n =20)
The patient, operator, and assistant were requested to wear Laser protective eyewear. At the start, a small moist cotton pellet was used to dry the cavity. Complete hemostasis as well as cavity disinfection was established using Elexxion diode laser of 808 nm wavelength. The laser was operated at a power of 1W, applied with a contact tip on exposed pulp tissue for short bursts, for two seconds. A 300 µm diameter optical fiber was used for up to three laser applications as needed. The thin, flexible nature of the fiber is crucial for accessing the complex and constrained anatomy of root canals in endodontics. After bleeding was successfully controlled, laser technology was used with the same parameters to disinfect the cavity. A non-contact circular motion technique was used for five seconds to achieve this result.

Subsequently, in all groups, Neoputty was gently applied all over the pulp chamber floor. This was followed by the application of layers of (Fuji Equia) Glass Ionomer Cement. Final permanent restoration using composite Tetric N-Ceram resin was done during the same visit. All treatment procedures were performed by two expert endodontists.

Evaluation of pain
Each patient received a VAS form to evaluate postoperative pain. Only one of the endodontists who performed the treatment explained to all the patients, how to record their pain level using VAS. Pain was scored by each patient on a Visual Analog Scale (VAS), with scores spanning from 0 mm (no pain-free) to 100 mm (intense level of pain), highlighting the level of the pain experienced. The patients were asked to make a mark on the straight line to express the pain intensity and record the post-operative pain levels they experienced on VAS scale at 6 hours, 1 day, and 8 days.

Statistical Analysis
The mean and standard deviation values were generated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, pain data showed non-parametric (not-normal) distribution (Scores).
Friedman was applied for comparison between more than two groups in related samples. Wilcoxon was applied for comparison of two groups in related samples. The Kruskal Wallis test was used to compare between more than two groups in non-related samples. The Mann Whitney test was used to compare two groups in non-related samples. Statistical analysis was conducted using IBM SPSS Statistics (Version 20 for Windows), with the significance level set at $P \leq 0.05$

RESULTS

A) Regarding the effect of time intervals,
In NaOCl 2.5%, the value recorded (After 6hrs) was statistically significant different with (After 1st day) and (After 8 days), where (p=0.046) and (p=0.023) and same significant difference was found in **Diode Laser,** where (p=0.023) and (p=0.026) respectively.

In NaOCl 2.5%, the value recorded with (After 1st day) was statistically significant different with (After 8 days), where (p=0.014); and significant difference was found in **Diode Laser** where (p=0.023).

In NaOCl 5%, the value recorded with (After 8 days) was statistically significant different with (After 6hrs) and (After 1st day), where (p=0.023), **Where,** no statistically significant difference was noted between (After 6hrs) and (After 1st day) where (p=1).
In all groups, the highest mean score was observed at (After 6hrs), whereas the lowest was recorded at (After 8 days).

B) Regarding the effect of different groups,
At the three times intervals, there was a statistically significant difference between (NaOCl 2.5%), (NaOCl 5%) and (Diode laser), where (*p*=0.009) **After 6 hours**, and (*p*=0.001) at **1st day and** (*p*=0.026) **After 8 days.**

It was noted the presence of a statistically significant difference between (Diode laser) and each of (NaOCl 2.5%) and (NaOCl 5%), where (*p*=0.014) and (p=0.019) respectively **after 6 hours**; While (*p*=0.003) and (p=0.002) at **1st day.**
(NaOCl 2.5%) group recorded no statistically significant difference with (NaOCl 5%) a**fter 6 hours** and **After 1st day,** where (*p*=0.138).

After 8 days, no statistically significant difference was noted between (NaOCl 2.5%) and each of (NaOCl 5%) and (Diode laser) where (*p*=0.056) and (p=0.269); while, (NaOCl 5%) recorded a significant difference with (Diode laser) where (*p*=0.014).

In all time intervals, the highest mean score was observed in (NaOCl 2.5%), whereas the lowest was recorded in (Diode laser).

Table (1): The mean, standard deviation (SD) values of Pain of different groups.

Variables	Pain												
	NaOCl 2.5%				NaOCl 5%				Diode laser				p-value
	Mean	SD	Median	Range	Mean	SD	Median	Range	Mean	SD	Median	Range	
After 6hrs	7.33 ^{aA}	0.52	7.00	1.00	7.00 ^{aA}	0.00	7.00	0.00	6.33 ^{aB}	0.52	6.00	1.00	0.009*
After 1st day	6.67 ^{bA}	0.52	7.00	1.00	7.00 ^{aA}	0.00	7.00	0.00	4.00 ^{bB}	0.89	4.00	2.00	0.001*
After 8 days	2.67 ^{cAB}	0.52	3.00	1.00	3.33 ^{bA}	0.52	3.00	1.00	2.33 ^{cB}	0.52	2.00	1.00	0.026*
p-value	0.004*				0.002*				0.002*				

Means with different small letters indicates significant difference in the same column, means with different capital letters indicates significant difference in the same row.
*; significant ($p<0.05$)

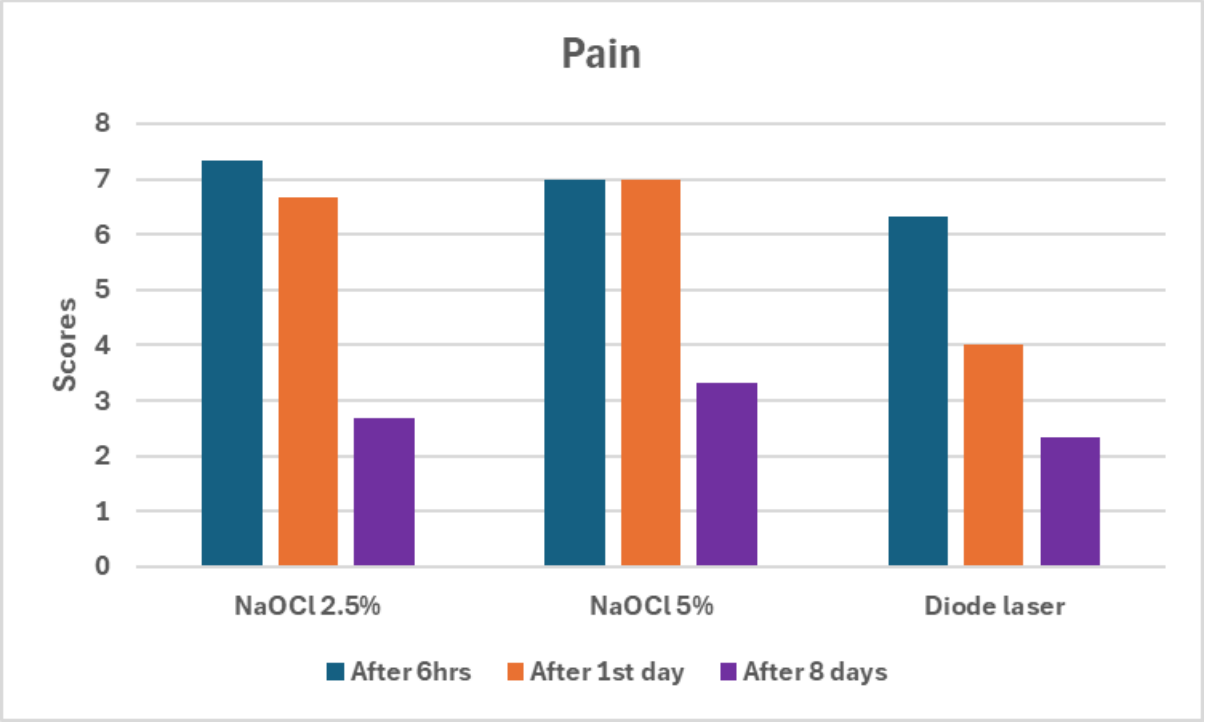

Figure (1): Bar chart representing Pain for different groups at different time intervals

DISCUSSION

Previously, it was thought that the pulp of teeth diagnosed with IP was unable to heal and that the only choice should be RCT. Based on Ricucci et al., histologic study There was no correlation between clinical signs and symptoms of patient with the existing inflammatory condition of the exposed pulp. [20]

That′ s why, RCT should not be considered as the only line of treatment chosen to deal with teeth with IP; pulpotomy can be considered as an accepted treatment for such cases.

A randomized clinical trial that compared the outcomes and postoperative pain of full pulpotomy (FP) and RCT in mature molar teeth with irreversible pulpitis (IP) have shown that, regarding the time and cost, the Full Pulpotomy (FP) group showed clinical and radiographic success rates of 97.3% and 93.3%, respectively, compared to the RCT group's 98.6% and 94.6%. [21] These findings were in accordance to those of several previous studies, [7, 18, 22, 23] showing that FP can be considered as a more preferred choice than RCT in mature teeth with IP. It was concluded in a systematic review published in 2021, that VPTs, especially FP, was considered as a very successful line of treatment in cases with IP. [24] FP was the treatment of choice, rather than pulp capping or partial pulpotomy. [25,26]

Based on these promising results, our study was conducted to assess the efficacy of the use of sodium hypochlorite and Diode laser as disinfectant and hemostatic agents, in acheiving postoperative pain reduction after pulpotomy of permanent teeth with

symptomatic IP. In our study, cavity disinfection and hemostasis in pulpotomy of mature teeth with IP was done either using different concentrations of sodium hypochlorite (2.5% and 5%) or with Diode laser.

In pulpotomy procedures for mature teeth with irreversible pulpitis (IP), both sodium hypochlorite (NaOCl) and laser irradiation (particularly diode lasers) are used for disinfection and hemostasis. NaOCl is a commonly used irrigant known for its antimicrobial and tissue dissolving properties, while lasers offer advantages like improved hemostasis, bio-stimulation, and potentially less alteration to the pulp tissue. [27]

Sodium hypochlorite (NaOCl) has been widely used since (1920) in endodontics. It is an effective organic solvent that is used as antimicrobial irrigant. [28] Upon interaction between NaOCl and dentin surface, oxidation process in the dentin matrix occurs, producing sodium chloride and oxygen. [29] The cytotoxicity effects of sodium hypochlorite in cell cultures was also proven. [30]

On the other hand, an increased pulpal inflammatory response after the use of NaOCl was reported by Hilton [31] in a review concerning the success of pulp-capping. Furthermore, NaOCl was not recommended by Pascon et al. to be used as a cavity disinfecting agent. [32]

In disagreement to these findings, the biocompatibility of NaOCl had been proved [33]; promoting pulpal repair, [34] w**ith Inflammatory effects limited to the surface cells, with no impact on the deep pulp tissues.** [35]

Since 1960s, numerous types of lasers were introduced in the dental practice [36]; they were very useful in many purposes. [37] In endodontics, neodymium: yttriumaluminium-garnet (Nd:YAG) and carbon dioxide (CO2) lasers were among the most widely used laser systems. They proved their efficiency in the disinfection and cleaning of the root canal and lateral dentinal tubules. [38] Among the different types of lasers used in dentistry, the compact size and the low cost of the diode laser are the main reasons of their increasing popularity in dental practice. [39] Diode lasers have several advantages: simple setting-up, ease of operation, affordability and small size. [40] The diode lasers additionally offers deeper tissue penetration, rapid field dryness and effective hemostasis. [41] Diode wavelengths have little absorption in dental hard tissue, with high absorption ability in hemoglobin and melanin. Being highly absorbed by water, [42] enables it to act selectively and precisely. [40]

In this study, we used Elexxion diode laser with a wavelength of 808 nm, operated at a power of 1W, and applied with a contact tip on exposed pulp tissue for short bursts, for two seconds. A 300 µm diameter optical fiber was used for up to three laser applications as needed. The thin, flexible nature of the fiber is crucial for accessing the complex and constrained anatomy of root canals in endodontics.

In this present study, pain measurement was assessed using Visual Analogue Scale (VAS). Among different pain scale measurement, VAS proved to be the most valid, reliable and providing clear records. After explanation, patients usually succeed to use it easily. [43]

At all intervals, the highest mean score value was achieved by (NaOCl 2.5%), and the lowest by (Diode laser). NaOCl 5% was not statistically different from NaOCl 2.5%.

The severity of the associated pain decreased significantly with NaOCl 2.5% and diode laser group after1 day following treatment and significantly decreased in all groups after 8 days following treatment.

These results are in agreement with the clinical study, [2] that demonstrated a stronger pain reduction with FP, resulting in no or mild pain for most patients by the second day. This could be attributed to the decreases of local tissue pressure and inflammatory mediators levels, which is possibly because of the disruption of the peripherals of nociceptive sensory neurons.

In a trial conducted by Swetha et al. [27], at 48 hrs, the postoperative pain score was significantly higher for conventional crown pulpotomy (CCP) group in which haemostasis was achieved with 2.5% NaOCl than in laser crown pulpotomy (LCP) group.

Reduced postoperative pain can be linked to the anti-inflammatory effects of the diode laser, which leads to a decrease in chemical mediators such as prostaglandins and substance P. [44, 45]

CONCLUSION

Within the limitation of this present work, modern disinfection modalities like Diode laser device, when used as hemostatic agent in pulpotomy of mature molar teeth with IP, exhibits promising results in terms of postoperative pain relief.

RECOMMENDATION

More clinical studies should be carried on to test the effect of new modalities for hemostsis in pulpotomy of teeth with IP and its impact on postoperative pain.

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