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Effect of 940 nm Diode Laser on Pain Level During Local Anesthesia Injection

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Abstract

Background: pain during injection of local anesthesia is one of the most common reasons that makes the patient refrain from visiting the dentist. However topical anesthesia may be used as a solution.

Aim of the study: to develop tools and materials to reduce pain by applying low level laser therapy and compare it with the effect of topical anesthesia.

Methods: This study was carried out at Tikrit University's learning hospital. Group of 18 to 30 years old patients (55 men and 45 women) who would receive dental restorations of their anterior teeth. The patients were divided into 4 groups. Group A takes a laser beam. Group B received treatment by topical anesthetic gel. Group C received both of two therapies at same time. Group D is the control group which does not receive any type of pre-treatment. Analyzing data by using Mintab application program (version 2019) the test which is used in the analysis is a person chi-square under the level of significance 0.01 (P-Value <0.05).

Results: In the current study, a (0,3W, 30sec) 940 nm diode laser used intraoral, according to our analytics after application of low-level laser therapy on the area of injection results in low response to the injection.

Conclusion(s): The administration of local anesthesia using a 940 nm diode laser notably alleviated pain in the anterior maxillary area, demonstrating better outcomes than injections that did not incorporate low-level laser therapy.

Introduction:

Pain is a complicated feeling that results from the body's and mind's reaction to an unpleasant stimulus. Pain is an alert system that keeps an organism safe by making it retreat from dangerous stimuli; it is usually connected to injury or the

possibility of injury (1). Pain can include pricking, tingling, stinging, burning, shooting, aching, or electric sensations. Pain could be felt mild or severe. Even though the causes of pain are similar, no two people experience pain in the same manner. Since pain is a very personal experience, the best indicator is what a person says about their own pain (2). Despite being subjective, most pain has a physiological basis and is linked to injury of tissues (1). Nociceptor, a peripheral nerve fiber in the skin, joints, bones, and muscles, detects when thermal, mechanical, or chemical stimuli reaches a noxious intensity suggestive of injury.

As a result of the damage, numerous factors are released, which activate the nerve endings. Some examples of these factors include globulin, protein kinases, arachidonic acid, histamine, Nerve Growth Factors (NGFs), Substance P (SPs), and Calcitonin Gene-Related Peptides (CGRPs). Among these factors are transducer channels (3) with Transient Receptor Potentials (TRPs). The TRP channels help initiate receptor potentials, which in turn induce action potentials in nerve fibers, much like voltage-gated potassium channels. There are two types of nociceptors: an unmyelinated fiber with a small diameter (C fiber) that transmits a poorly localized, delayed pain, as well as an afferent with a medium diameter (A-delta) that transmits an acute, well-localized, quick pain (4,5).

Pain receptors are nerve fibers found in the skin and other tissues. Their ends can be stimulated by three distinct kinds of stimuli: mechanical, thermal, and chemical. Some endings only react to one kind of stimulation, while other endings can sense all three (1). Two varieties of primary afferent nerve fibers, which carry electrical signals from the tissues to the spinal cord via the ascending nerve tracts, mediate the dual-phase perception of acute pain. Because of their thin myelin coating, the A delta fibers are the bigger and more quickly conducting of the two kinds, and as a result, they are linked to the first, acute, well-localized pain. Mechanical and heat stimulation can activate delta fibers. Smaller, unmyelinated C fibers are responsible for the persistent, poorly localized pain that follows the first, fast feeling. These fibers are sensitive to chemical, mechanical, and thermal stimuli (1,4). Pain during dental visits may be caused by diagnostic procedure (e.g., electrical pulp test, biting test or percussion test). During injection of local anesthesia, an increased risk of intraoperative discomfort has been linked to invasive dental procedures including extractions, crowns and bridges, endodontic therapy, and periodontal/surgical therapy (6). Anesthesia is a medical technique employed to prevent patients from feeling pain during various procedures, including common dental treatments, certain screening and diagnostic examinations, and surgical interventions.

Local Anesthesia (LA) is used when we need to apply a limited area in the body for instance, during dental practice, is used to block pain to a single tooth or multiple teeth. Patients under LA stay conscious and comfort, rather than those under general and regional anesthesia. The most frequent ways to provide local anesthetics are via injection, topical lotion or spray, eye drops, or skin patch. Local anesthetic pain management has grown in importance in many dental offices (7). Research indicates that one of the main causes of people's avoidance of dental care services is their fear of dental injections pain, which can have a negative impact on their oral health (8). The goal of dental treatment is to treat patients without causing them any discomfort (9). Patients experience pain during dental operations since local anesthetic injections are often required. Patients frequently suffer from needle phobia, which is extremely harmful to patients (10,11). The type of anesthetic solution, needle gauge, anesthetic solution temperature, and site pH are some of the variables that affect how painful patients feel (12-14). Dental treatments can be more successful if injection pain is lessened, and anesthesia is administered more effectively.

A variety of approaches have been proposed, including Topical Anesthesia (TA) or vasoconstrictor antagonists, warming the solution and prescription, vibration devices, computer-controlled

injection systems, needle-free injection techniques, and electronic dental anesthesia (15). Generally, topical anesthesia involves applying local anesthetics directly to the skin or mucous membranes to cause a temporary loss of sensation. Reversible nerve conduction is blocked close to the site of administration with TA by targeting free nerve endings in the dermis or mucosa. This results in a brief loss of sensation in a specific area.
Reduced sodium permeability of nerve cell membranes possibly as a result of competition with calcium-binding sites that regulate sodium permeability blocks nerve impulse conduction. This permeability shift raises the excitability threshold and reduces depolarization until the action potential cannot be produced (16). "Light Amplification by the Stimulated Emission of Radiation" is the acronym LASER. Since Miaman dentistry invented laser 1960, the laser has been used in a variety of hard and soft tissue applications in dentistry. The number of studies on laser use has skyrocketed in the past 20 years (17). There are two types of situations: first, there are hard lasers that have restrictions and may be used on both soft and hard tissues. Examples of these include carbon dioxide (CO_2), neodymium yttrium aluminum garnet (Nd: YAG), and erbium-doped yttrium aluminum garnet (Er:YAG) (18,19), due to high costs and a potential for thermal injury to tooth pulp, whereas, However, cool or soft lasers are based on semiconductor diode devices, which are small, inexpensive devices that are mostly utilized for applications. These devices are also referred to as "biostimulation" or Low-Level Laser Treatment (LLLT) (20). Lasers are recommended for many different treatments in dentistry practice because to their simplicity of use, cost-effectiveness, specificity, comfort, and convenience of use compared to traditional modalities (21–24). A broad term used to describe a variety of therapeutic approaches based on photo-bio-modulation a process in which photons interact with atoms or molecules to change an organism's biologically is low-level laser (light) therapy (LLLT) (25). Research has indicated that laser radiation inhibits the transmission of impulses along the axons of nerve fibers A-delta and C. Since these fibers carry nociceptive signals to the spinal cord, it is possible that laser radiation lessens this transmission, which in turn lessens the perception of pain (26). It is still relatively new to utilize LLLT to lessen the discomfort associated with injecting a local anesthetic into the oral cavity. Temporomandibular disorders, chronic facial myalgia, herpes, dentinal hypersensitivity, sinus and gingival inflammation, and inferior alveolar nerve sensory regression have all been treated by LLLT (27,28). However, there is now proof that LLLT can provide topical anesthetic effect. Among its many benefits, low level laser is thought to promote tissue repair, lessen pain, edema, and neurological issues in addition to helping wounds heal and preventing cell death (29). In addition, there is the promising analgesic effects is LLLT, often known as soft laser (30).

Materials and Methods

Study Design, Participants, Sample Size

This study was carried out at Tikrit University's learning hospital. Before receiving any therapy, a group of 18 to 30 patients (100 samples) who would receive dental restorations of their anterior teeth were selected (the age and gender distribution of patients in each group are displayed in Tables (1 and 2), respectively). Each patient signed an informed consent form at the start of the study, and they were free to discontinue participation at any time.

Statical analysis

Analyzing data by using Mintab application program (version 2019) the test which is used in the analysis is a person chi-square under the level of significance 0.01 (P-Value <0.05).

Materials

Use the 940nm diode laser (Biolase EPIC X™ (Epic 10; BIOLASE Inc., Foothill Ranch, USA)) in pulsating mood the

duration of pulse is 20 ms. In rotational motions on dry, healthy, and clean gingiva. And use topical anesthetic 20% benzocaine gel (Ultracare™ Topical Anesthetic Gel). The local anesthetics will be used in this study is 1.8ml of 2% lidocaine 1:80000 epinephrine L.A (Huons Global Pharmaceutical company). The local anesthetic solution is delivered to the injection site by using needle gauge 27(C-K DENTAL IND.CO.LTD.).

The inclusion criteria and The Exclusion criteria

The patients had to be between the ages of 18 and 30 (the age and gender distribution of patients in each group are displayed in Tables 1 and 2, respectively), have normal maxillary incisors or canine tooth restorations, and have a Visual Analog Scale (VAS) score of greater than 115 before receiving any treatment. Any oral lesions such as aphthous stomatitis at the injection site, any periodontal disease in the upper jaw, the use of analgesics or corticosteroids 48 hours prior to the study, failure to cooperate with the patient for injection(shaking during injection, etc.), light sensitivity (photosensitivity), lidocaine and epinephrine, pregnant women, and any underlying chronic disease were among the exclusion criteria.

The study groups

This study will apply diode laser 940nm LLLT and topical anesthetic gel on maxillary anterior teeth for 100 patients they divide into 4 groups each group have 25 patients each of them involved male and female from 18 to 30 years of old. Group A takes a laser beam at 0.3 watt in interment mood for 30 sec. by bleaching tip and the distance between the gingiva and tip of laser probe is 1mm. Group B received treatment by topical anesthetic gel (Ultracare™ Topical Anesthetic Gel). Group C received both of two therapies at same time. Group D is the control group which does not receive any type of pre-treatment) placebo (only giving local anesthesia).

Procedure

Patients were asked for medical and dental history before the first treatment session. All patients were diagnosed and treated by the same operators. They were divided into four treatment sequences, based on their four pre-anesthesia procedures.

Group A took laser beam in pulsating mode after the injection site was dried, the LLLT was accomplished by applying a 940 nm diode laser perpendicular on the injection site
(placed for 30 seconds in the maxillary anterior teeth's buccal vestibule). It was applied as gently as possible in circular motions
(an average of 11– 12 circular motions in 20 s)
, and as soon as the operation was completed, L.A. was administered.

The tip of laser handpiece was placed 1 mm from the target area, perpendicular to the mucosal surface. The tip of laser handpiece was circumscribed by a silicone piece (hollow in the middle) to maintain the distance. The application of the laser energy was at a power of 0.3 W for a duration of 30 s. The patient wore protective glasses (goggles) in both groups.
A 45° angle was formed between the needle and the bone at the location of maxillary teeth apex during the injection, and the anesthetic agent was at a rate of 1 milliliter per minute (31).
To guarantee the best quality and consistency and to remove the potential influence
of interindividual variations in experience and skill
, the same operators carried out each injection.

Group B takes a topical anesthetic gel applied on injection site by cotton tip applicator for 60 sec. and administrates L.A immediately injected with the same procedure mentioned previously.

Group C Is the topical anesthesia + LLLT condition, LLLT was applied after topical anesthesia.

Group D They did not receive any treatment before L.A.

Immediately following the injection, patients' pain levels were assessed using a Visual Analog Scale (VAS) as shown in Figure (1) with a range of 0 to 3. The individuals were asked to use a (VAS) to rate their level of pain prior to injection. Four classifications were created using the VAS scores. There are three types of pain: no pain = 0, mild =1, moderate = 2, and severe = 3. Two operators evaluated the patients' discomfort levels.

Results

In the current study, a (0,3W, 30sec) 940 nm diode laser used intraorally, according to our analytics after application of LLLT on the area of injection results are calculated by use person chi-square test as shown in Table (3) and Figure (2) the group A show a significant reduction of pain level during needle insertion more than group D with mean and standard division (SD) 22.36 ± 1.29, 26.30 ± 2.08 respectively while in group B(topical) and group C (topical and LLLT) there is not any significancy in reduction of pain with Mean ± SD 24.44 ± 1.77, 24.16 ± 1.36 respectively.

Discussion

Injectable anesthesia is a necessary component of most dental procedures (32). Dental patients frequently worry about the pain associated with anesthetic injections (33). Injections of LA without pain can improve patient comfort and cooperation, enhance treatment quality, and foster patient confidence (32).

This study assessed the impact of LLLT on the pain associated with dental anesthetic injections, considering the beneficial biological effects of LLLT, such as its analgesic action (34). According to the study's findings, applying LLLT to the oral mucosa before receiving a LA injection considerably lessens pain and topical anesthetic. Similarly, applying LLLT with TA has the same effect, with no discernible difference in the two groups' pain reduction levels.

The impact of LLLT on pain from dental anesthetic injections was assessed by Ghaderi et al. in 2016. They found that patients who received topical anesthetic gel plus LLLT before receiving anesthetic injections reported significantly lower VAS pain scores than those who received topical anesthetic gel alone, though this difference was not clinically significant (35). Deferent results were obtained in the present study. According to vivo research on LLLT's effects on oral mucosal innervation, LLLT raises the stimulation threshold of nerve fibers and reduces the frequency at which pain signals are transmitted by them (36).

Lasers suppress neurogenic inflammation, lower action potentials, and lessen the transmission of pain signals by blocking A-delta and C fibers (37). This study suggests that the reduction of pain on the laser side is due to changes in the peripheral nerve system's synthesis, release, and metabolism of the chemical mediators of pain (38).

In their study on 84 patients (41 females and 43 males) who required bilateral restoration of their maxillary central incisors Sharifi et al. evaluate the effect of a LLLT on pain of local anesthetic injection. They concluded moderate pain is decreased by laser therapy, whereas mild pain is unaffected (32). According to Shapiro et al., using a low-level Er: YAG laser in a laser anesthetic device in conjunction with lidocaine significantly reduced the pain associated with inserting needles during intramuscular injections (39). Based on research by Jagtap et al., administering LLLTs before receiving anesthetic injections for tooth extraction significantly decreased the amount of pain felt during the procedure (40). Also, Ghabraei et al. evaluated the pain response for fifty-six patients between 18 − 60 years old after treated with LLLT by diode laser with a wavelength of 980 nm on maxillary anterior mucosa. And they concluded that the severity of pain is significantly decreased in the laser group (41). Uçar et al. conclude topical anesthesia + LLLT with an 810-nm diode laser did not influence anesthesia efficacy and duration in children also notably, the level of pain in the patient treated with

laser did not exceed “mild pain (42). Afkhami et al. found the use of semiconductor diode laser with wavelength 940nm for 60s on the maxillary anterior teeth at 200 mW of power on a 30 patient between 22 and 30 years of age. The level of pain in the laser group was significantly lower than in the control group (43). On other hand Elbay et al. evaluate the level of pain on 160 children aged 6 to 12 years old when they give local anesthesia after applying 940nm diode laser and divided them into four groups as well as to our study they found the application of LLLT for 40s reduced the level of pain more than LLLT for 30s or topical alone (44). The effectiveness of LLLT in pain management can be influenced by several aspects, including laser optical characteristics, tissue type, exposure duration, wavelength, and radiation dosage (40,45). Furthermore, variations in treatment regimens may account for discrepancies in study outcomes. In this blind clinical trial study featured a split-mouth design, which removed the potential for interindividual variances to cause confusion.

Furthermore, the design minimized the carry-over effect, a fundamental limitation of split-mouth research, by blinding participants to the laser side and randomly allocating the laser and control sides (46). The design of this study was single-blind. The LLLT was administered by the same dentist who administered the anesthetic injections and who also served as the examiner who documented the pain scores. In this randomized clinical trial study, we try to use similar parameters to previous studies but with decrease the time of exposure from 60s to 30s, eliminate some adverse effects vasodilation and accelerated collateral circulation (43). Therefore, when LLLT is done prior to injection, one should take the potential for hematoma formation into account. Additionally, both the control and laser of handpiece light were turned on. Moreover, laser radiation had no vibration, no heat production, and no visual or auditory stimulation. The patients did not know which side got LLLT as a result. In the present study, VAS was used to measure the level of pain. The ease and adaptability of this scale to various demographics and research types led to its utilization. Its application may be finished quickly in less than a minute and does not require a training session. Furthermore, research has shown that VAS is responsive to shifts in the experience of pain.

Conclusion

1. Compared to injections without LLLT, the 940 nm diode laser considerably decreased the pain associated with local anesthetic injections in the anterior maxillary region.
2. Also, the LLLT with topical anesthesia does not have any significant effects in comparison to the effect of topical anesthesia alone.

Recommendations

Uses of different laser parameters.

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This research was self-funded.

Conflicts of interest:

The authors claim to have no conflicting interests.

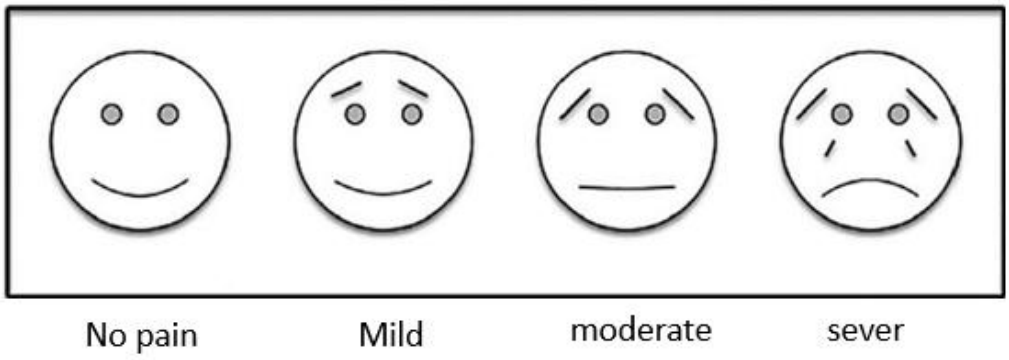

Figure 1: The modified visual analog scale

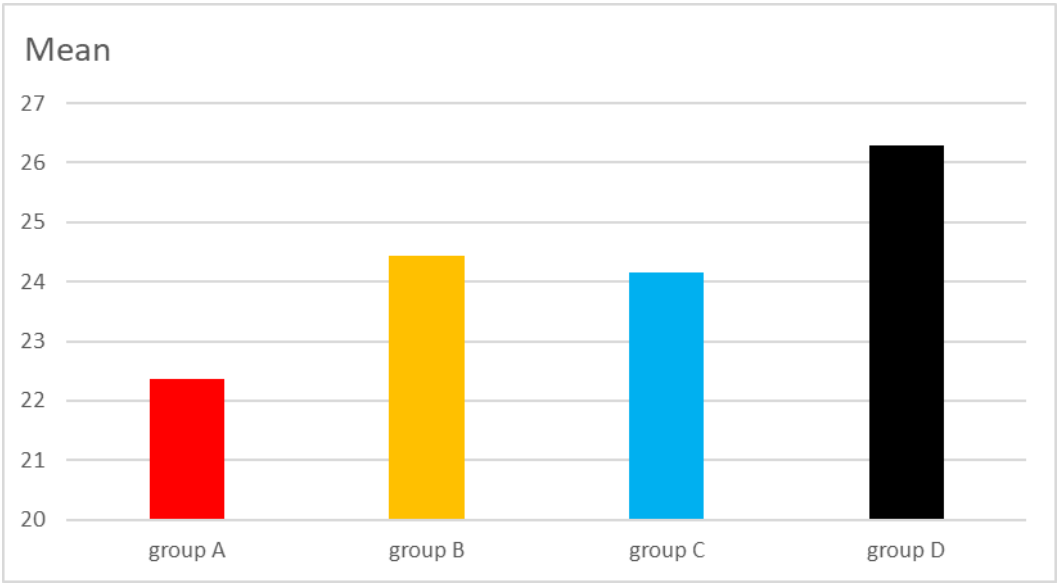

Figure 2**:** As shown in the graph the pain in the group A (laser group) decreases in the level in the pain level of group D (control group) also there is no significant difference between levels of pain in the group B (topical group) and group C (topical plus Low-level laser therapy).

Table 1: Distribution of ages by research group.

Groups	Number	Mean+SD
Group A	**25**	**21.36 ± 1.35**
Group B	**25**	**26.90 ± 1.66**
Group C	**25**	**23.9 ± 1.54**
Group D	**25**	**28.40 ± 2.50**
Total	**100**	
P - Value		**0.037 * Significant under level 0.05**

Table 2: Distribution of genders by study group.

Groups	Male			Female			Total
	No.	%	Mean ±SD	No.	%	Mean ±SD	
Group A	**13**	**52.0 %**	**13.75±0.957**	**12**	**48.0 %**	**11.25±0.923**	**25**
Group B	**13**	**52.0 %**		**12**	**48.0 %**		**25**
Group C	**14**	**56.0 %**		**11**	**44.0 %**		**25**
Group D	**15**	**60.0 %**		**10**	**40.0 %**		**25**
Total	**55**	**55.0 %**		**45**	**45.0 %**		**100**
	ns **Pearson Chi-Square = 0.444 P-Value = 0.931** **Not Significant**						

Table 3: The level of the pain on each group with mean and standard deviation (SD)

Groups	Number	Mean ± SD
Group A	25	22.36 ± 1.29
Group B	25	24.44 ± 1.77
Group C	25	24.16 ± 1.36
Group D	25	26.30 ± 2.08
Total	100	

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