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A Clinical And Radiographic Evaluation Of Low-Level Diode Laser Full Pulpotomy In Vital Permanent Teeth

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Abstract:
Background*: The aim of the study was to evaluate the outcome of Pulpotomy in vital permanent teeth using low -level diode laser versus traditional method.*
Materials and Methods*: Forty-six mature permanent molar teeth with carious exposures with symptoms indicative of irreversible pulpitis were randomly allocated equally into two groups according to the pulpotomy technique used* ***Group P1*** *:(Traditional Pulpotomy procedures). And* ***Group P2*** *:(Diode laser Pulpotomy procedures). The tooth was anesthetized, isolated using rubber dam, and disinfected with 2% chlorhexidine before caries excavation. In traditional pulpotomy group, the pulp was amputated to the level of the canal orifices. Haemostasias was achieved by placing a sterile cotton pellet moistened with saline in the access cavity for 6 min.. Retro MTA was used as the pulp capping material. In Diode laser pulpotomy group each pulp stamp was lased for 10 seconds at the preset parameters before placing the capping material. Clinical and radiographic evaluation was done at 6 months, 12 months, and 18 months.*
Results*:* ***At 6- months****: When comparing Diode laser pulpotomy and traditional pulpotomy at 6 months, no significant difference was found (P=.134). The highest success rate at 6 months was found in the low-level diode laser pulpotomy group.* ***At 12- months:*** *When comparing Diode laser pulpotomy and traditional pulpotomy at 12 months, no significant difference was found (P=.527). The highest success rate at 12 months was found in the low-level diode laser pulpotomy group.* ***At 18- months****: When comparing Diode laser pulpotomy and traditional pulpotomy at 18 months, no significant difference was found (P=.456). The highest success rate at 18 months was found in the low-level diode laser pulpotomy.*
Conclusion: *Under the limitations of this study, low-level diode laser therapy in adult pulpotomy didn't affect the success rate.*
Key Word*: full pulpotomy, low-level diode laser, RetroMTA*

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I. Introduction

The ultimate goal of modern restorative procedures is preservation of pulp vitality, especially in restorable young permanent teeth. The teeth with signs and symptoms of irreversible pulpitis were traditionally treated with pulpectomy and root canal treatment. Although this line of treatment is generally successful if well carried out, it is also destructive, expensive, technically challenging, and time-consuming. According to histological studies the entire pulp is rarely totally irreversibly inflamed even in cases with irreversible pulpitis, and it was found that the inflammation and necrotic areas are usually confined to the area adjacent to the carious exposure site while the remaining radicular pulp is still vital and capable of healing if suitable treatment was carried out(1).

Minimally invasive endodontics has recently suggested vital pulp therapy instead of root canal treatment for the management of moderate and even severe pulpitis. These management methods include partial or coronal pulpotomy, depending on the amount of irreversibly inflamed pulp tissue to be removed while leaving the uninflamed radicular pulp tissue to recover(2).

In order to improve the outcome of the pulpotomy procedure, various techniques and materials have been recommended. Among these alternative techniques, low-level diode laser has been described as the most suited laser for pulpotomy with its high absorbance wavelength (970 nm) producing photobiomodulation therapy (PBMT). This therapy may enhance the pulpotomy procedure's outcome since it reduces post-operative pain, modulates inflammation, provides a sterile environment, and promotes biostimulation effects without causing mechanical damage to the remaining radicular pulp tissue(3). Up to date, very few studies have investigated the effects of low-level diode laser in pulpotomy procedures. The null hypothesis of this study was

there would be no difference in the success rate of adult pulpotomy done with or without low-level diode laser biostimulation with RetroMTA capping material.

II. Material And Methods

Ethics approval: The study was approved by the ethics committee of the Faculty of Dental Medicine, Al-Azhar University with Ref No: 153/166.

Study Design: interventional randomized control study

Study Location: Faculty of dental medicine Al-Azhar university, Cairo, Egypt.

Study Duration: October 2020 to March 2023.

Sample size: 46 patients.

Sample size calculation: According to the power analysis of the study the minimum sample size was 15 teeth in each of the two main groups which have a 95 % power to detect a difference between means of 0.099 with a significance level (alpha) of 0.05 (two-tailed).

Patients Examination:
Prior to clinical and radiographic examination, a thorough medical and dental history was taken to aid in case selection and treatment planning.

Clinical Examination.
Extraoral Examination.
The patient's face and neck were examined and any swelling, lymphadenopathy, tender area, or external sinus were noted and recorded.

Intraoral Examination.
Percussion Test: Percussion test was done by gently tapping the occlusal surfaces of the target tooth and their adjacent with a blunt mirror handle, starting with the adjacent healthy teeth.
Palpation Test: Palpation test was done by applying firm digital pressure to the buccal and lingual vestibules of the target tooth and their adjacent, starting with adjacent healthy teeth.
Periodontal Probing: The probing depth of the selected tooth was measured and recorded using a calibrated periodontal probe at six positions all around the tooth; mesiobuccal, midbuccal, distobuccal, distolingual, midlingual, and mesiolingual.
Mobility Test: The mobility of the target tooth was examined by applying pressures using the back ends of two mirror handles, in a Bucco-lingual direction, and the tooth mobility was scored as described by Millers as follows[(4)]:
Grade 1: Mobility up to 1mm.
Grade II: Mobility more than 1 up to 2 mm.
Grade III: Mobility over 2 mm.

Pulp Sensibility Testing (Cold test):
Cold testing was done using Endo Ice Ethyl chloride spray (Endo ICE–Coltene/Whaledent, Inc., Cuyahoga Falls, OH, USA). The target tooth and its adjacent teeth were isolated with cotton and air-dried using the 3-way syringe. The adjacent normal tooth was tested first by applying Endo Ice Ethyl chloride spray to a cotton pellet until crystals were formed and then applied to the mid-facial surface of the tooth for 5 sec or until the patient responded. Teeth that demonstrated intense sharp lingering pain that persisted for more than 30 seconds were considered to have irreversible pulpitis[(5)].

Radiographic examination:
A digital periapical radiograph was taken for each target tooth using a 70-Kvp machine (Fona XDC, Via Galilei, Assago, Italy) with a 0.3-second exposure time using a digital a sensor (Vatech EZ Sensor, Humanray Co. Ltd., Korea) with the paralleling technique. The periapical radiographs were used to assess the tooth restorability, extent of caries, its proximity to the pulp, and the presence of periapical pathosis, furcation involvement, or pathological internal and external root resorption.

Exclusion criteria:

After assessment and clinical and radiographic examination, any teeth with any of the following criteria were excluded from the study.

- Non-restorable teeth.
- Teeth with buccal restoration
- Non-vital teeth that were not responsive to thermal stimuli.
- Presence of swelling or sinus tracts.
- Teeth which showed sensitivity to percussion.
- Teeth with grade □ and □ mobility.
- Teeth with immature apices.
- Teeth with internal or external resorption
- Teeth with periapical pathosis.

After patient acceptance, the treatment was then explained to the patient, and was informed about possible complications that may occur during and after the treatment. A written Arabic consent was then signed by the patient.

Grouping of patients:

The patients in the study were randomly allocated into two groups according to the pulpotomy technique used (variable P) Group P1 :(Traditional Pulpotomy procedures). And Group P2 :(Diode laser Pulpotomy procedures).

Pulpotomy procedure.

Anesthesia and rubber dam application.

After clinical and radiographical examination, all patients received a full mouth scaling and 0.12% chlorhexidine mouthwash (Chlorhexidine solution, Mercy HEX, Cairo, Egypt.) for one week before any intervention. Local anesthesia was administrated using (1.8ml of 2% Mepivacaine Hcl with levonordefrin 1:20.000) through a 27-gauge long needle mounted in a metal dental syringe. After profound anesthesia was achieved, isolation was done using a 6"X 6" dental dam sheet (SANCTUARY Dental Dam Medium; Malaysia) which was applied and held in place using a #26 clamp (KSK Dental clamp; Dentech, Tokyo, Japan), then stretched on a plastic frame.

Access cavity preparation and build-up.

The crown of the treated tooth was then disinfected with 2% chlorhexidine (Chlorhexidine mouthwash, Healthpoint, Cairo, Egypt.), and removal of all caries and defective restorations was done using a high-speed size #3 carbide round bur (SS White Burs, Inc., New Jersy; USA) mounted in high-speed handpiece with coolant. After that, the cavity was rinsed with saline solution and if the pulp was exposed, a cotton pellet was placed to stop the bleeding before building up the missing parts of the target tooth using a light-cured resin-modified glass ionomer (Riva Light Cure (SDI, Victoria, Australia) capsules). The pulp chamber was then deroofed using a new size #2 carbide round bur, while complete de-roofing and cavity refinement was done using an Endo Z bur (DENTSPLY MAILLEFER – U.S.A.).

Group P1 :(Traditional Pulpotomy procedures).

After complete deroofing, the coronal pulp was amputated to the level of the orifice using a high-speed size #2 round bur followed by rinsing the pulp chamber thoroughly with 5ml 0.9% saline solution (Normal Saline solution, Otsuka, Cairo, Egypt.). Following pulpotomy, the pulp stumps were evaluated to ensure that all canals were vital and the teeth with necrotic pulp tissue were also excluded from the study and replaced with another one. Hemostasis was then achieved by placing a sterile cotton pellet moistened with saline in the access cavity for 6 min. After this time any tooth that continued bleeding was excluded from the study and replaced with another one [(6)].

Group P2 :(Diode laser Pulpotomy procedures):

Pulpotomy in this group was done as previously done in traditional group, then after establishing hemostasis, low-level laser energy at (970nm, power .5W, duty cycle 50%, and frequency 5H) was applied to each pulp stump for 10 sec. through 320 microns optical fiber tip (SIROLaser Advance, Bensheim, Germany). Fig 1. The laser was used in pulsed non-contact mode at the level of the occlusal surface of the tooth. Before using the Laser device, all protective measures were taken.

Figure 1: Showing SIROLaser device.

Appling of (Retro MTA capping material:

Retro MTA (Meta Biomed Co, Ltd, Seoul, Korea) was supplied in the form of a cap, a pouch containing 0.3 gm of the powder, and a plastic pipette containing the liquid. The powder from the pouch was poured into the cap, followed by three drops of the liquid, the liquid was allowed to wet the powder gently for 20 sec. until the shiny surface disappeared. The mixed Retro MTA was applied in both groups against the pulp stumps using the Micro apical placement system (MAP) (Produits Dentaires SA, Switzerland) and adapted with a large plugger size # 4 (Dentsply Maillefer, Ballaigues, Switzerland). The floor was then completely covered with a 2-3 mm thickness of Retro MTA. Finally moist cotton pellet was used to better adapt the Retro MTA then the material was allowed to set for 5 min. Prior to restoration, excess material was removed from the cavity walls then the tooth was restored with resin-bonded composite (3M, ESPE, St. Paul, USA) and an immediate postoperative periapical radiograph was taken.

Clinical and radiographic evaluation.

The patients were evaluated clinically and radiographically at intervals of 1 week, 6, 12, and 18 months**.**

The condition of the periapical area was evaluated using the periapical index PAI scoring system as described by Orstavik et al. [(5)]. Table 1.

Table 1: Showing the periapical index system by Ørstavik et al. used for radiographic evaluation of apical area.

Score 1	Normal periapical structures.
Score 2	Small changes in bone structures.
Score 3	Change in bone structure with mineral loss
Score 4	Periodontitis with well-defined radiolucent area.
Score 5	Severe periodontitis with exacerbating features

Assessment of success or failure:

Assessment of success or failure was done using the technique described by Galani et al[(3)]. Each patient was evaluated at different times; (T1): 1 week postoperative, (T2): after 6 months, (T3): after 12 months, and (T4) after 18 months.

- Treatment was considered successful if the patient's final restoration was intact and the patient demonstrated no clinical symptoms (pain (spontaneous or on chewing), swelling, or sinus tract), and had a PAI score of 1.

- Treatment was considered uncertain if the patient's final restoration was intact, and the patient demonstrated no clinical symptoms (pain (spontaneous or on chewing), swelling, or sinus tract), and a PAI score of 2.
- Treatment was considered a failure in the following situations:

1. Any case in which the final restoration was not intact. Irrelevant clinical and radiographic symptoms.
2. Any case in which the final restoration was intact and the patient demonstrated clinical symptoms. Irrelevant of PAI score.
3. Any case in which the final restoration was intact and the patient had a PAI score of 3 or above. Irrelevant of clinical symptoms.

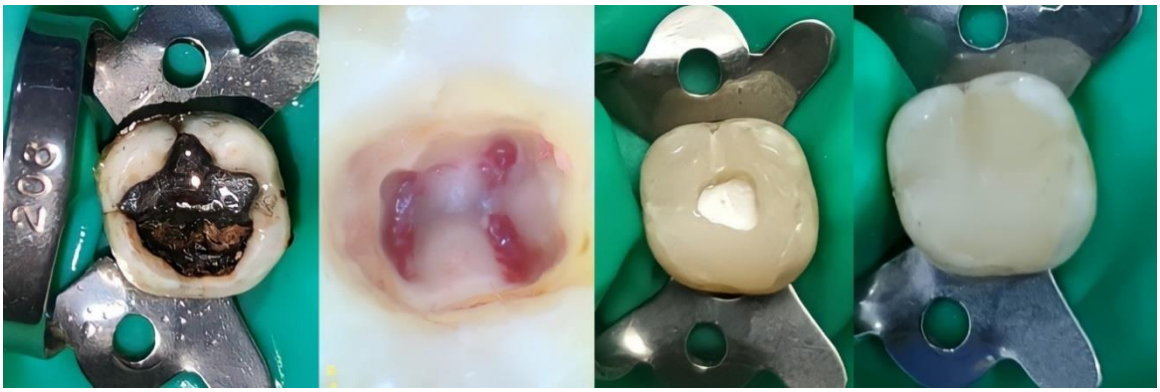

Figure 2: Showing photographs of pulpotomy steps of lower 2nd molar.

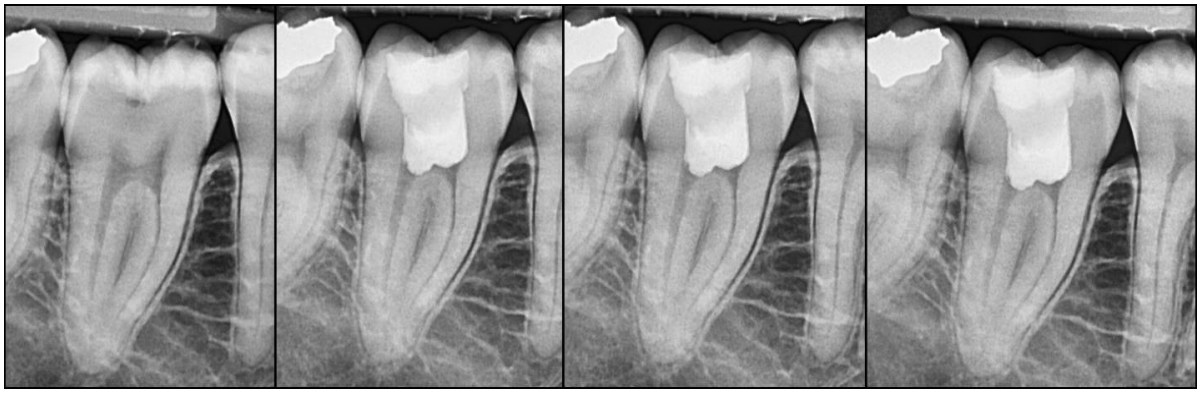

Figure 3: Radiographs of lower 2nd molar A) preoperative B) after 6 months C) after 12 months D) after 18 months.

Data management and analysis:

Data were collected, tabulated, and statistically analyzed using independent sample T to compare the two groups. The mean and SD values were calculated for each group in each test. The significance level was set at $P \leq 0.05$. Statistical analysis was performed using SPSS for Windows 25 software.

III. Result

A total of 46 cases were treated with adult pulpotomy during the course of the study. During the pulpotomy procedure, 6 cases had bleeding time of more than 6 min. and were excluded. Furthermore, one case did not attend during 6-month follow-up period. Therefore, only 39 cases were included in the statistics of the current study.

Comparison between evaluation time intervals*:*

A. low-level diode laser pulpotomy tech. The success rate in Low-level diode laser pulpotomy group was 95% at 6 months, 94% at 12 months, and 89% at 18 months. There was no significant difference between the success rate in the low-level diode laser pulpotomy group between 6,12 and 18 months (P=.264).

B. Traditional pulpotomy tech. The success rate in the traditional pulpotomy group was 78% at 6 months, 72% at 12 months, and 70% at 18 months. There was no significant difference between the success rate in the traditional pulpotomy group between 6,12 and 18 months (P=.093) (table 2).

Comparison between different groups:

Data in this section was statistically analyzed using Fischer exact test, Chi-Square test, and McNemar test.

A. *At 6- months*: When comparing Diode laser pulpotomy and traditional pulpotomy at 6 months, no significant difference was found between them (P=.134). the highest success rate at 6 months was found in the low-level diode laser pulpotomy group 95% while the lowest was found in the traditional pulpotomy group 78%.

B. *At 12- months*: When comparing Diode laser pulpotomy and traditional pulpotomy at 12 months, no significant difference was found between them (P=.527). the highest success rate at 12 months was found in the low-level diode laser pulpotomy group 94% while the lowest was found in the traditional pulpotomy group 72%.

C. *At 18- months*: When comparing Diode laser pulpotomy and traditional pulpotomy at 18 months, no significant difference was found between them (P=.456). the highest success rate at 18 months was found in the low-level diode laser pulpotomy group 89% while the lowest was found in the traditional pulpotomy group 70%.

Table 2: Comparison of the success in pulpotomy tech. at 6, 12, 18 months.

	Outcome at 6 m.		**Outcome at 12 m**		**Outcome at 18 m.**		**test of sig.**
	Success 34out 39		**Success 31 out 37**		**Success 29 out 36**		
P. tech	N	%	N	%	N	%	
Laser	19 out of 20	95%	18 out of 19	94%	17out of 19	89 %	P=.264
Traditional	15 out of 19	78%	13 out of 18	72%	12 out of 17	70%	P=.093
test of sig.	P=.134		P=527		P=.456		

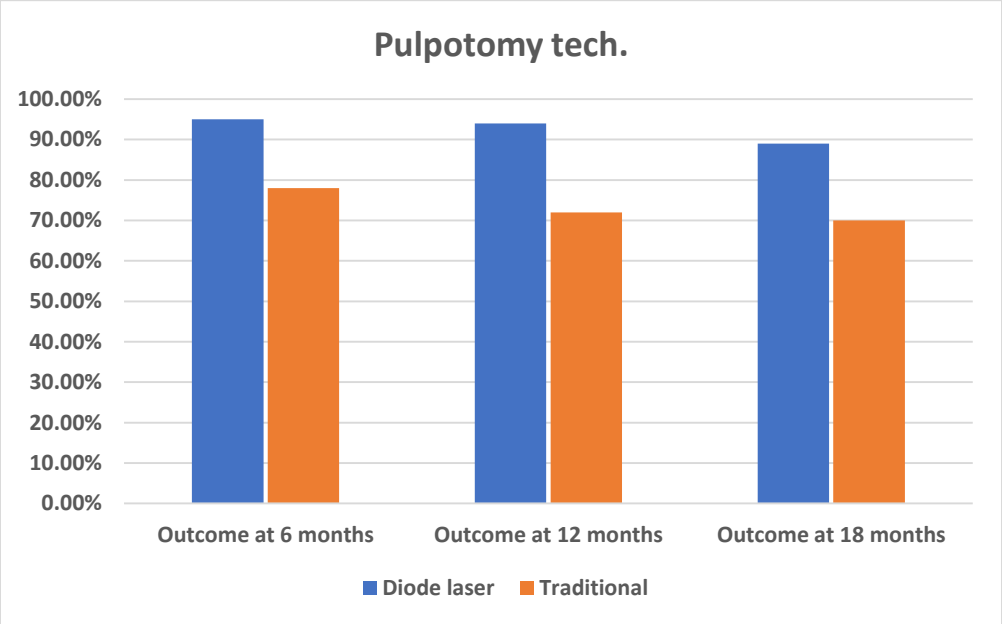

Figure 4: A bar chart representing a comparison between the success and failure of Diode laser and traditional pulpotomy at 6, 12 & 18 months**.**

IV. Discussion

Recently coronal pulpotomy has been advocated as a less invasive treatment for mature adult teeth with irreversible pulpitis as it has the potential to change the way we do endodontics [(7)]. A lot of research has been done to evaluate the short- and long-term success of pulpotomy treatment[(8)].

Furthermore, low-level diode lasers have been used in many different dental branches such as implantology, operative dentistry, prosthetic dentistry, and oral surgery. It has the advantage of being minimally invasive and has been shown to decrease post-operative pain and improve tissue healing and regeneration[(9)]. Its use in adult pulpotomy procedures has not been investigated thoroughly. This study aimed to compare the outcome of full pulpotomy in permanent teeth using low-level diode laser biostimulation in comparison to the traditional method.

The null hypothesis of this study was there would be no difference in the success rate of adult pulpotomy done with or without low-level diode laser biostimulation with RetroMTA capping material. The null hypothesis was accepted with regards to the effect of low-level diode laser in pulpotomy success rate.

A total of 39 patients were evaluated for 6 months while 37 patients were evaluated for 12 months and 36 patients were evaluated for 18 months which was comparable to other research done in this field [(10)].

In this study, only maxillary and mandibular molars with irreversible pulpitis in patients aged between 25-35 were selected as these are the most common teeth and age for carious exposure. [(11)]. Furthermore, it has been previously established that the type of teeth and age of the patient does not appear to be a significant factor in the outcomes of pulpotomy[(12)].

As the definition of irreversible pulpitis is qualitative in nature, different classifications were used to define irreversible pulpitis as Wolter's classification that classifies pulpitis into initial, mild, moderate, and severe pulpitis[(13)]. Hashim classification also classifies pulpitis into mild reversible, severe reversible, and irreversible pulpitis[(14)]. In this study diagnosis of irreversible pulpitis was determined according to the diagnostic terminology approved by The American Association of Endodontists, as it used in similar research [(15)].

In this study during pulpotomy procedures, hemostasis was achieved using a sterile cotton pellet moistened with saline which is similar to other studies. Although several studies have used hemostatic agents such as sodium hypochlorite[(11)] and ferric sulfate[(16)]. In this study, saline was used to allow the ability to evaluate hemostasis without any intervention of other chemicals[(17)]. With regards to hemostasis time, there is no current standard on the definite time of hemostasis in adult pulpotomy. In this study, bleeding of the pulp for more than 6 min was excluded similar to other studies that have been done on this topic[(18)].

With regards to the pulpotomy technique, a Diode laser with 970 nm wavelength was used in this study as it is the most appropriate laser for photobiomodulation protocols as it's highly absorbed by pigmented vascularized chromophores making it suitable for pulp [(19)]. Each pulp stump was lased in a non-contact mode with parameters (power .5W, duty cycle 50%, and frequency 5H) to give time for thermal release to produce a photochemical rather than photothermal effect preventing excessive heating and charring with subsequent thermal damage [(20)].

Regarding the choice of capping material, Retro MTA was used as it is considered a modification of the standard MTA material with better handling properties and shorter setting time[(21)].

Assessment of success or failure was done using a combined clinical and radiographic examination described by Galani M. et al 2017[(10)]. as detailed in section 3.7. proposed simple evaluation criteria for pulpotomy and has been used in another similar research[(22)].

With regards to success and failure, the overall success rate in this study was 87.2 % after 6 months, 83.7 % after 12 months, and 80.5% after 18 months with no significant difference in the success rate between the evaluation periods. Previous research has established that the success rate of adult pulpotomy ranges between 78.1 % to 98, the result of this study falls within this range [(8, 11)]. This variability in outcomes may be attributed to the different criteria used to evaluate success and failure as well as the length of follow-up time of the different studies.

With regards to the pattern of failure, the first case failed immediately after the 3rd week, four cases after 6 months, three cases after 12 months, and two cases after 18 months with no significant difference between evaluation times. This pattern is similar to the other research done in this field [(23)].

Low-level diode laser has been used successfully in orthodontics to improve alveolar bone remodeling and reduce pain during the orthodontic procedure. Additionally, it was used in oral medicine, to reduce the time needed to treat lesions and reduce pain. In the other hand it was used in oral surgery to improve wound healing and reduce the severity and duration of pain and swelling. [(24, 25)]. Under the condition of this study, there was no significant difference in success rate between traditional pulpotomy and Low-level diode laser pulpotomy groups after 18 months (89%, and 70%) (P=.456). No research has been done to date evaluating the effect of low-level diode laser in adult pulpotomy. In the field of pediatric dentistry, it has been researched extensively and these results are similar to the results of this study [(26-29)]. In contrast, Liu et al, [(30)] compared traditional and Nd: YAG laser pulpotomy and found that laser pulpotomy groups had a significantly higher success rate. This may be attributed to the use of different types of lasers (Nd: YAG laser versus low level diode laser), laser parameters (2 W, 20 Hz, 124 J/cm2 versus 970nm .5W, duty cycle 50%, 5H), and evaluation periods (ranged from 9 months to 66 months versus 18 months).

The current research in adult pulpotomy is focused on establishing a baseline outcome percentage of success so that clinicians can make better decisions for their patients in clinical practice. A lot of available research has been directed to evaluate preoperative conditions as a predetermining factor of the success of adult pulpotomies. The use of adjuvants as lasers and topical medications may become more widespread if more research is done to evaluate their effect on adult pulpotomy success.

V. Conclusion

Under the limitations of this study, low-level diode laser therapy in adult pulpotomy didn't affect the success rate.

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