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EVALUATION OF DIRECT PULP CAPPING WITH DIODE LASER ASSISTANCE INFLUENCE ON THE DEVELOPMENT OF DENTIN BRIDGE AGAINST TRADITIONAL APPROACH USING RADIOGRAPHY AND CLINICAL DATA

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Dentin, Direct pulp capping, Diode laser, MTA

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ABSTRACT

Introduction: A novel technique with encouraging outcomes for maintaining pulp vitality and promoting the production of reparative dentin is by using diode laser. Consequently, the current investigation may be beneficial. **Aim:** To evaluate the impact of diode laser with a direct pulp capping (DPC) material on the development of dentin bridge against traditional approach. **Patients and methods:** 32 patients were selected; patients were split into two equal groups at random. A laser-assisted DPC group utilizing a diode laser before applying MTA and a standard group of DPC utilizing MTA only. After 3, 6, and 12 months, dentin bridge thickness was measured and the photographs were analyzed using a digital program called Digora 2.5. **Results:** According to clinical assessment data, 14 cases had clinical success. Radiographically after 3 and 6 months, discernible difference between the two groups in terms of thickness of dentin changes was not shown; however, a year later, the group of lasers had a significant statistically greater median thickness of dentin than the standard group. There was no statistically significant difference between the two groups at 3, 6, and 12 months when comparing the median of the overall dentin thickness. **Conclusions:** On short term check ups, both approaches were successfully equal in preserving vitality of the pulp and promoting the development of dentin bridge from a clinical and radiographic standpoint. Diode laser has enhanced the prognosis of DPC in longer-term follow-ups by virtue of its biostimulating influence on the formation of dentin bridges, sterilization and hemostasis.

INTRODUCTION

One of the most frequent issues that clinicians deal with on a daily basis is deep carious lesions. Although residual dentin thickness and caries depth are difficult to evaluate clinically, radiographic evidence of caries with a pulp exposure risk may be seen [(1)].

The development of restorative materials and dental adhesives, along with the introduction of several conservative techniques to maintain pulp vitality through the application of remineralization and preventive therapies, have enabled dentists to provide patients with minimally invasive, functional, and esthetic treatments [(2)].

The International Caries Consensus Collaboration has provided some recommendations clinically for the treatment of cavities and the elimination of dentin caries; however, treatment choices have altered over time. Before putting a restoration in place, all soft and leathery dentin was removed till hard sound dentin was obtained. The total removal of the soft, leathery dentin may make it impossible to preserve the thin dentin bridge. Such irreversible procedures may require a more forceful method, such as extraction or root canal therapy (3).

Vital pulp therapy (VPT) is a restorative procedure that aims to preserve pulp vitality in deep carious lesions. It can be approached in many ways, including indirect pulp capping, pulpotomy and DPC which was recommended in preserving pulp vitality using a biocompatible material. The prognosis of this procedure is thought to be influenced by a number of factors, including age, exposure site requirements, pulp condition, bleeding, biocompatibility, and the use of an insoluble pulp capping material that promotes reparative dentin formation and stimulates odontoblastic activity. Proper cavity sealing with a restoration is also recommended to prevent bacterial contamination and leakage after the capping material is applied (4).

Since 1994, lasers were utilized in dentistry for managing a variety of dental issues. Among its benefits are decreased discomfort, which eliminates the need for anesthesia, decreased patient anxiety, efficient disinfection, and appropriate hemostasis for the dental area (5). In the context of VPT, a novel use of diode laser-assisted DPC was just unveiled. Diode lasers are helpful in photobiostumulation because they shorten the inflammatory phase of wound healing and accelerate biological cell activities like collagen synthesis and fibroblast mitotic activity (6).

Numerous laser systems have been effectively used in DPC because they offer excellent field sterilization and bleeding control. However, the term “laser-assisted pulp therapy” refers to the sealing process that is necessary for laser treatment, such as calcium hydroxide and mineral trioxide aggregate (MTA). Research has demonstrated that diode lasers can be employed in DPC to provide hemostasis, disinfection, and photobiostimulation, provided that they meet the appropriate parameters as emission mode, radiation exposure, wave length and distance between the surface to be irradiated and the tip (7).

Therefore, the goal of this study was to examine, over the course of a year, the effects of diode laser with direct pulp capping on the development of dentin bridge against the standard procedure that did not use laser on both clinical and radiographic levels. The null hypothesis of this study was that there would be no discernible difference in dentin bridge production between the conventional technique and diode laser assisted DPC.

PATIENTS AND METHODS

This research is a clinical trial that is randomized and approved by the Suez Canal University Faculty of Dentistry’s ethical committee for research under IRB number (282/2020). 32 patients, aged 18 to 45, who had extensive caries N in their teeth and might need DPC, were selected. Consents granting permission to take part in the experiment were signed. Cases were classified as either included or excluded based on particular radiological and clinical standards. This clinical trial was reported in accordance with CONSORT criteria to ensure comprehensive and transparent reporting (8).

Calculating the sample size and designing the study

The overall sample size for the comparison between the two groups was ascertained with the aid of a power analysis for a Chi-square test. According to Schmidt et al, (8) results, the computations used the success rate as the first result and anticipated that the laser group would have a good prognosis with a success percentage of 50% [9]. The effect size (w) was 0.75 [10], with a level of 0.05 (5%) using alpha (α) and beta (β) values of 0.10 (10%)., i.e. power = 90%; the smallest estimated sample size was 26 participants. To account for the 20% compensation dropout rate, the sample size was expanded to include 32 participants. There was therefore be 16 subjects in each group. With the G*Power program, sample size.

Selection of Cases

Inclusion criteria:

Patient-related: candidates must be between the ages of 18 and 45, be literate, possess a high caries risk index, be able to sign consent forms, and be open to take part in a 12-month follow-up time frame.

Tooth related: asymptomatic vital permanent molar that is restorable. The x ray should display normal structures without any periapical radiolucency, lamina dura widening, or bone resorption.

Exclusion criteria:

Patient-related: patients with allergies to any kind of restorations, patients with weakened health, pregnant women, and uncooperative patients.

Tooth-related: teeth that had already undergone restorations, as well as those that experienced discomfort during or after vitality tests (such as electrical or cold tests), pain during percussion, inability to isolate teeth, and periapical radiolucencies as well.

Criteria for discontinuing or modifying intervention

The restoration was taken out and root canal therapy was administered if any candidate complained of pain.

Blinding, randomization, and allocation

The outcome assessors were the only people blinded in this experiment, making it single-blinded. The fact that conventional and laser-assisted DPC are two entirely different techniques means that neither the lead investigator nor the subjects were blinded.

During the initial appointment, a computerized distribution was carried out using www.randomizer.org software. Numbers associated with each treatment process were recorded on cards that were placed in successively opaque, correctly numbered and sealed envelopes. 32 patients of both genders were chosen for this study out of the 65 patients who were evaluated for eligibility. Of these, 19 male patients (or 60%) and 13 female patients (or 40%) were chosen.

Grouping of the Sample

Two groups of patients with deep cavities that might be exposed were identified.:

1. Control group (A_0): Standard DPC without a diode laser. Following total caries removal to a pinpoint exposure, resin-modified glass ionomer (Fuji II LC) was used as a temporary restoration for the duration of the follow-up period, after which MTA was applied as a DPC material.
2. Test group (A_1): DPC with a laser. The exposure site was first treated with a diode laser (EPIC X™, BIOLASE) operating at 940 nm and 0.1 W output power. This was followed by the application of MTA and RMGI for optimum sealing.

Preoperative examination

All patients who were recruited had their medical and dental histories obtained by completing a straightforward chart to determine the inclusion criteria. Each patient also had their suitability assessed, their consent form signed, and they were informed of the procedure**.**

The preoperative clinical examination for each chosen tooth comprised a visual assessment of the degree of caries, the health of the gingival tissue, and the state of the surrounding soft tissue. To assess pulp vitality, percussion and cold test were conducted [(11)]. Periapical x-rays were obtained in order to evaluate the extent of caries in the pulp, the periapical condition, and the presence of bone resorption, periapical radiolucency, and lamina dura widening [(12)].

Restorative procedures

Following the administration of local anesthia and rubber dam application, the caries removal procedure was carried out. To provide appropriate accessibility and visibility, all occlusal undermined enamel was first removed using high-speed fissure carbide burs. Texture was taken into account rather than discolouration when evaluating the carious dentin. After that, the floor and walls were cleared of any soft, diseased dentin using a spoon excavator. Using a sterile big low-speed carbide round bur, discolored, leathery and carious dentin that was difficult to excavate was removed. Additionally, minimal bleeding was accomplished after removal of soft caries from the floor and mechanical pinpoint exposure encircled by sound dentin of no more than 1 mm [(13)]. After pinpoint exposure, bleeding was promptly stopped by using a cotton pellet soaked in water on the exposure that is visible. After utilizing an air-water syringe to air dry the field, a dry cotton pellet was used to apply very little pressure [(14)].

In the laser group, warning signs were posted at the experimental room's doors and windows to discourage anyone from entering during the treatment, and the patient, operator, and other staff members were all wearing safety eyewear. A laser was applied with all the settings given in Table (1) to the exposure site. MTA (Powder: Calcium sulphate dehydrate, distilled water, tetracalcium alumino ferrite, dicalcium silicate, bismuth oxide, and tricalcium silicate) was mixed using a spatula on a glass slab (CERKAMED Medical Company, Poland) [(15)] and was immediately applied to the site of exposure utilizing an amalgam carrier. The cavity was then restored using an RMGI mixed for 8 seconds in an amalgamator, then it was applied and light cured (Fuji IITM LC, GC, Japan) according to the instructions of the manufacturer. The conventional group was given MTA alone, then RMGI without the use of a laser.

Table (1) *Diode lasers parameters*

Parameters	Description
Type	Diode laser (EPIC™ , BIOLASE) 940 nm
Output power	0.1 watt
Tip	400 non initiated
Mode	Non-contact
Distance	About 2 mm
Time	5 sec/mm^2
Motion	Sweeping circular
Laser density	27.7 W/cm^2
Irradiated spot size	0.68 mm

Follow up and post-operative instructions

During the follow-up phase, each patient received information on oral hygiene measures and postoperative instructions. We followed up after 3, 6, and 12 months. A binary system evaluation chart was used to determine the success criteria [(16)].

Clinical assessment

After 3, 6, and 12 months, patients were called back. The restored tooth's vitality was assessed during the follow-up period using a binary variable that was employed in previous studies. No postoperative discomfort, a positive outcome of cold pulp test using a cold spray (HygenicR Endo-IceR; Coltene, OH, USA), absence of sensitivity on percussion as well as a negative or positive visual inspection for sinus, fistula, or swelling were used to determine the success of the procedure [17].

Radiographic evaluation

Every visit included a radiographic assessment using the extension cone paralleling technique (XCP) [18], and periapical radiographs taken digitally were collected to examine the produced dentin bridge thickness at each follow-up session. Digora for Windows 2.5, a digital imaging tool, was utilized to analyze digital images of periapical radiolucency (positive/negative) and to measure the thickness of the dentin bridge one micrometer under the temporary restoration [19]. Two defined tangential lines were drawn in the third month, passing through two defined repeating spots (A and B), where A is the point where the restorative material is the deepest. and B represents the formed dentin bridge thickness. These measurements and calculations were made using Digora 2.5. The two spots were joined by a third line that was drawn and measured in millimeters. The formed dentin thickness is represented by this line, which was measured in follow-up radiographs at 3, 6, and 12 months. The recently produced dentin thickness per each follow-up interval was calculated by subtracting the numbers, which displays the change in dentin thickness per each interval of time [18].

Analytical statistics

With numerical data, the Shapiro-Wilk and Kolmogorov-Smirnov tests were used to explore the numerical information. When dentin thickness and data distribution were examined, a non-parametric distribution was revealed, whereas parametric distribution was found when age data was examined. The data's mean, median, range, and standard deviation (SD) were shown. Mann-Whitney to compare the two groups with non-parametric data, the U test was employed. Using Friedman's test, the variations over time within each group were examined. When Friedman's test is significant, Dunn's test was employed to make pairwise comparisons. For non-parametric data, the student's t-test was employed. and for parametric data to compare the two groups. The gender data was presented using frequencies and percentages. The two groups were compared using the chi-square test. A significant threshold of $P < 0.05$ was established. Using Version 23.0 of IBM SPSS Statistics for Windows. IBM Corp., Armonk, NY; statistical analysis was carried out.

RESULTS

Clinical assessment results

The lack of discomfort during percussion, any swelling, postoperative pain and any fistula or sinus during follow-up suggest clinical success for all groups that responded positively to the cold pulp test. Each group had two patients that were dropped out from the study; as a result, the results were identical in both groups, and a statistical comparison was not possible.

Results of radiographic assessment

Base line characteristics

The mean age values of the two groups did not differ in a way that was statistically significant. Table (2) indicates that in the two groups, there was no statistically significant difference in the gender distributions.

Table (2) *Descriptive data and the findings of the Chi-square and Student's t-tests used to compare the two groups' baseline characteristics*

	Laser (n = 14)	Conventional (n = 14)	*P*-value
Age (Years)			
Mean (SD)	30.9 (4.1)	28.1 (5.2)	0.127
Gender [n (%)]			
Male	8 (57.1%)	7 (50%)	0.705
Female	6 (42.9%)	7 (50%)	

**: Significant at P ≤ 0.05*

Comparison between the two groups

1. **The dentin thickness (the percentage rise in dentin thickness over 3, 6, and 12 months)**

The dentin thickness change in the two groups did not differ statistically significantly after 3 or 6 months (P-value=0.629, effect size 0.183; p-value=0.135, effect size 0.588); however, the laser group had a statistically significant higher median dentin thickness than the conventional group after 12 months (P-value=0.046, effect size 0.816) as indicated in Table (3).

2. **The total thickness of the dentin (the absolute total measurement of the thickness of the dentin over 3, 6, and 12 months)**

As indicated in Table (4), there was no statistically significant difference in mean dentin thickness after 3, 6, and 12 months for either group (P-value = 0.748, Effect size 0.122), (P-value = 0.945, Effect size 0.026), and (P-value = 0.232, Effect size 0.463).

Table (3): *Descriptive statistics and the Mann-Whitney U test results to compare the changes in dentin thickness (mm) between the two groups.*

Time	Laser (n = 14)	Conventional (n = 14)	*P*-value	*Effect size (d)*
3 months				
Median (Range)	0.272 (0.089-0.387)	0.241 (0.189-0.439)	0.629	0.183
Mean (SD)	0.258 (0.1)	0.289 (0.085)		
6 months				
Median (Range)	0.091 (0.015-0.158)	0.122 (0.011-0.174)	0.135	0.588
Mean (SD)	0.083 (0.044)	0.107 (0.05)		
12 months				
Median (Range)	0.03 (0.002-0.089)	0.013 (0.002-0.064)	0.046*	0.816
Mean (SD)	0.034 (0.026)	0.017 (0.016)		

**: Significant at P ≤ 0.05*

Table (4) *Mann-Whitney U test findings and descriptive statistics are used to compare the two groups' absolute dentin thicknesses (mm).*

Time	Laser (n = 14)	Conventional (n = 14)	*P*-value	*Effect size (d)*
3 months				
Median (Range)	0.294 (0.178-0.387)	0.241 (0.189-0.439)	0.748	0.122
Mean (SD)	0.288 (0.065)	0.289 (0.085)		
6 months				
Median (Range)	0.377 (0.293-0.491)	0.368 (0.26-0.578)	0.945	0.026
Mean (SD)	0.393 (0.063)	0.395 (0.095)		
12 months				
Median (Range)	0.438 (0.357-0.574)	0.382 (0.264-0.588)	0.232	0.463
Mean (SD)	0.443 (0.074)	0.411 (0.097)		

**: Significant at $P \leq 0.05$*

Changes within each group

Dentin thickness changed statistically significantly over time in the laser group (P-value <0.001, Effect size = 1). Pairwise comparisons between time periods revealed a statistically significant increase in dentin thickness from 3 to 6 months and from 6 to 12 months.

A statistically significant decrease in dentin thickness over time was seen in the conventional group (P-value <0.001, Effect size = 1). Table (5) shows that based on pairwise comparisons between time periods, there was a statistically significant increase in dentin thickness from three to six months, followed by a non-statistically significant change in dentin thickness from six to twelve months.

Table (5) *Results of Friedman's test and descriptive statistics are used to compare dentin thicknesses (mm) at various intervals within each group.*

Time	Laser (n = 14)	Conventional (n = 14)
3 months		
Median (Range)	0.294 (0.178-0.387) ^{C}	0.241 (0.189-0.439) ^{B}
Mean (SD)	0.288 (0.065)	0.289 (0.085)
6 months		
Median (Range)	0.377 (0.293-0.491) ^{B}	0.368 (0.26-0.578) ^{A}
Mean (SD)	0.393 (0.063)	0.395 (0.095)
12 months		
Median (Range)	0.438 (0.357-0.574) ^{A}	0.382 (0.264-0.588) ^{A}
Mean (SD)	0.443 (0.074)	0.411 (0.097)
P-value	<0.001*	<0.001*
Effect size (w)	1	1

** Statistically significant change by time is shown by different superscripts in the same column, with significance set at $P < 0.05$.*

DISCUSSION

This work's primary goal was to evaluate the impact of diode laser with a direct pulp capping (DPC) material on the development of dentin bridge against traditional approach regarding clinical findings and radiographs taken at 3, 6, and 12 months.

Vital pulp therapy (VPT), according to the American Association of Endodontists, is a treatment that attempts to maintain the vitality of the pulp that has been affected by trauma, caries, or restorative operations. This approach includes, for example, pulpotomy (partial or full), direct pulp capping, and in direct pulp capping [20]. When there is no microbiological contamination and the patient is young and has a strong pulp tissue healing potential, preservation of the permanent tooth that is pulpally implicated should be given careful consideration [21]. When compared to a tooth with a root canal filled, the protective resistance to mastication pressures (proprioception) is another significant advantage for the preservation of pulp.

The three primary factors that lead to exposure of the pulp are mechanical factors, caries and trauma. DPC is the handling of the exposure by appropriate covering it using a material that is biocompatible and directly applied on the exposure to enhance the development of the reparative dentin and preserve the vitality of the pulp. Differentiation of progenitor cells in the vital pulp is required to produce reparative dentin [22].

Cases that were unsuitable for rubber dam isolation were eliminated from the current study because it was a deal breaker. Microorganisms appear to play a major role in the DPC's result. Infection brought on by lingering germs or fresh bacteria that seeps through filling margins can have unfavorable effects. Therefore, in addition to using rubber dams and maintaining circumstances for aseptic treatment, the cavity needs to be filled right away using a well-sealed restoration [23].

Since MTA is regarded as the gold standard for biologically treating pulp, it was chosen. Adhesive resins, calcium silicate, calcium hydroxide (CH), calcium-enriched mixture, and enamel matrix derivative are some other materials used in DPC. In spite of CH's lengthy history, the results of a long term study have proven inconsistent [24]. The high toxicity of CH to tissue culture cells, its disintegration and degradation under the restorations, and the porous dentin bridges under CH that could cause microleakage are the drawbacks of using CH for DPC [25].

MTA encourages the undifferentiated cells to divide and undergo odontoblast differentiation. According to reports, pulp cells that come into direct touch with MTA are activated at a higher level, which may facilitate dentin bridge development and pulpal healing more effectively. According to histological reports, the dentin bridge that forms in close proximity to MTA is denser than that of CH[26].

Laser therapy has just entered a new age, with numerous studies examining the use of lasers for direct pulp capping. Researchers have discovered reparative dentin production as a result of laser radiation, after a report regarding the repair of critical pulp wounds by laser. In comparison to the previously published results, it is hypothesized that careful direct pulp capping using microscopes and lasers would enhance working conditions, boost the efficiency of the capping material and raise long-term success rates [27].

Different tests with different DPC parameters employed diode lasers. Better reparative dentin development than that produced by conventional procedures is the result of its reduction of inflammation and improvement of calcification through the creation of more calcified nodules. Because the diode laser seal that is produced on the soft tissue during pulp capping is insufficient, pulp capping agent is required following diode laser irradiation in order to improve prognosis. **Afkhami F *et al,*** **[28]** agreed on this.

Diode lasers have a number of benefits for DPC, including rapid field dryness and robust hemostasis. The diode additionally offers deeper tissue penetration. According to Yazdanfar, the areas of hemostasis created by diode laser comprise a small layer of necrosis beneath which is a reversible damage area. This provides a space for fibroblasts and inflammatory cell migration, which aid in the creation of the dentin bridge [29].

In DPC, the biostimulation effect was successfully used, resulting in a decrease in inflammation, stimulation, and cell proliferation. Low level laser therapy (LLLT) is an alternative to pulpotomy that has been reported by **Marques *et al,*****[30]**. Fernandes et al. reported clinical and radiological evaluations at 6, 12, and 18 months follow up [31]. These investigations show that LLLT applied prior to MTA treatment yields good results for pulp repair. These findings are consistent with those of **Alsofi L *et al,*** **[6]** who discovered that LLLT applied for pulp capping decreases the inflammatory period and aids in repair. Following laser therapy, numerous human and animal studies have demonstrated effective reparative dentin production [32].

Deynek *et al,* **[33]** concluded that the diode laser utilized in the current investigation, (EPIC™, BIOLASE) had an optimal wavelength of 940 nm for biostimulation of the pulpal cells' mitochondria, with an output power of 0.1 watt. Bahgat et al., who focused on the microbiological and disinfection aspects of their work, employed diode lasers with the same output power and wavelength as this study [34]. Cavity irradiation was carried out in a noncontact mode (2 mm distance) using a 400 non-initiated tip to spread power across the tip and 5 sec/ mm^2 to lower the temperature; **Serap** **[35]** established these parameters.

Clinical evaluation and radiography were the methods of assessment. It was suggested by **Fernandes *et al,*** **[31]**. In terms of the radiographic evaluation, the extension cone paralleling technique (XCP) was employed to guarantee that the patient's bite would remain consistent over the duration of the follow-up. Digora 2.5 [19] was utilized for digital image processing, and digital periapical radiographs were obtained to assess the thickness of the produced dentin bridge. Together with the examination of the residual dentin bridge thickness under the restoration, the radiographic evaluation also included any anomalies such as periapical radiolucencies and widening in the lamina dura (positive or negative). **El Chaghaby *et al,*** **[18]** agreed to use Digora 2.5 and the XCP technique for radiographic evaluation of produced dentin bridge thickness.

In relation to the findings of the clinical assessment, it is possible that the 14 cases in each group that were reported as successful were the consequence of an accurate diagnosis and the use of a resin-modified glass ionomer repair to seal the demineralized dentin and aid in achieving a satisfactory coronal seal. Hence, providing adequate time for pulp healing and aiding in the suppression of the caries development [36]. According to **Patro *et al,*** **[37]** the primary methods for evaluating the combined binary outcome (success/failure) employed for clinical assessment were the visual inspection of sinuses, fistulas, or edema, the percussion test, and the cold vitality test.

In every group, there were two dropout cases. In reference to traditional group dropout instances, one case underwent root canal therapy following a follow-up examination that revealed pulpitis. This could be the result of clinical errors in case selection and diagnosis, where some studies found that failure might be linked to a large exposure site that lowers prognosis [38]. Radiological monitoring of dentin bridge formation was hampered in the other case due to full coverage restoration during follow-up. While both dropout cases in the laser-assisted group later underwent root canal therapy and displayed spontaneous pain.

The results demonstrated that following the clinical treatments, the remaining dentin thickness was significantly enhanced in both groups, with non-significant inter-group difference throughout the first 3 and 6 months. This outcome was consistent with that of **Bidar *et al,*** [32] and **Kermanshah *et al,*** [39]. This may be because the undifferentiated cells were stimulated by MTA to multiply and undergo odontoblast differentiation. This might possibly be because both groups used glass ionomer modified with resin, which aided in creating an appropriate marginal seal.

Other research, like **Zhang *et al,*** [40] which showed that using diode laser with DPC promotes better prognosis through more efficient biostimulation and sterilization, disagreed with this finding and found a statistically significant difference between both groups in the first 3 and 6 months of DPC of carious teeth. This might be the result of employing parameters that were not employed in this investigation.

The laser group outperformed the traditional group in terms of dentin thickness increase after a year, according to the results. This aligned with the findings of **Nammour *et al,*** [27] who employed direct pulp capping assisted by diode laser at the same wavelength as our study. According to **Yazdnfar *et al,*** [29] the laser decontaminates teeth more effectively than the traditional method because it has a wavelength that can penetrate deep into dentin and disperse bacteria, both of which are necessary in cases where teeth are cariously exposed and the surrounding tissues are contaminated. Hemostasis is particularly crucial because excessive bleeding may be a sign of pulp inflammation, which lowers the pulp's ability to heal. Additionally, bleeding moisture contamination of the surrounding dentin may compromise the ability to achieve a sufficient seal.

Komabayashi *et al,* [41] results confirmed the change within each group. The advantage that lasers provide over conventional DPC is principally biostimulation, which promotes odontoblast and fibroblast cell proliferation and results in the continuous production of extracellular dentin matrix and reparative dentin over a longer length of time (12 months).

This was further highlighted by **Wang *et al,*** [42] who discovered that a longer run follow-up period is necessary for a better prognosis due to the biostimulating effect of the laser-assisted DPC, which is a long-term process. At 12 months, it was discovered that the success rates in the conventional and laser-assisted groups were, respectively, 68.2% and 91.7%. Abdel Gawad L concurred as well [43].

About the clinical findings, 14 cases in each of the two groups showed no signs of swelling, sinus formation, fistula formation, positive results on the cold test, and negative results on the percussion test. Each group had two patients that were dropped out from the study; as a result, the results were identical in both groups, and a statistical comparison was not possible. This was in accordance with **Gunaydın & Çakıcı** [44]**.** However, **Bidar *et al,*** [32] disapproved of this study because their histological analysis of the animals revealed that the study groups' dentinal bridge formation varied. More often, there was severe inflammation and necrosis.

In order to examine the role of laser irradiation in direct pulp capping techniques, several systematic reviews and metaanalyses of the literature were carried out. **Javed F *et al,*** [45] assessed the data regarding the effects of laser irradiation as a follow-up procedure to promote healing following pulp exposure. **Payahoo *et al,*** [46] who also aimed to assess the effectiveness of treating exposed pulps with lasers in order to promote healing.

The results of this study may support the use of a diode laser with an output power of 0.1 watt at a wavelength of 940 nm in direct pulp capping therapy due to its effectiveness in biostimulating the development of dentin bridges and disinfecting materials, both of which may improve patient outcomes. Larger sample numbers and longer follow-up periods are advised for additional clinical research.

CONCLUSIONS

The current study's limitations allow for the potential derivation of the following conclusions:

1- On short-term follow-ups, both approaches were successful equally in preserving the vitality of the pulp and promoting the development of dentin bridge from a clinical and radiographic standpoint

2- Diode laser intervention has enhanced the prognosis of DPC in longer-term follow-ups by virtue of its biostimulating influence on the formation of dentin bridges, hemostasis, and field sterilization.

CLINICAL RECOMMENDATION

Diode laser-assisted DPC is advised for the care of deep carious lesions due to its effectiveness in biostimulation and disinfection, which may improve prognosis.

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