

Efficacy of Lasers Treatment of Exposed Pulp to Stimulate Healing: A Systematic Review and Meta-Analysis

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Abstract

Objective: The present systematic review and meta-analysis aimed at evaluating the efficacy of laser's treatment of exposed pulps to stimulate healing. **Material and Methods:** MEDLINE, PubMed, Cochrane Library, Embase, ISI, Google Scholar have been searched as the electronic databases for performing systematic literature between 2005 to 2019. Searches were performed with MESH terms. The quality of the studies included was assessed using the Critical Appraisal Skills Program checklist. For Data extraction, two reviewers blind and independently extracted data from the abstract and full text of the studies included. Moreover, the fixed-effect model's odds ratio for a 95% confidence interval (CI) was calculated. Random effects were used to deal with potential heterogeneity, and I^2 showed heterogeneity. The meta-analysis and forest plots have been evaluated using the Comprehensive Meta-Analysis Stata. **Results:** Five studies (3 RCTs and 2 animal studies) were included in this study. The Odds Ratio was 1.90 (95% CI 1.39-2.42; $p=0.00$); there was a statistically significant difference between the laser and the control groups ($p=0.00$). **Conclusion:** The success rate of laser treatment for exposed pulps is higher than mineral trioxide aggregate, resin, calcium hydroxide and resin-modified glass-ionomer cement. The exact mechanism of this effect has not yet been determined; further research on lasers' impact on exposed pulps treatment is required.

Keywords: Laser Therapy; Dental Pulp Exposure; Dental Pulp Diseases; Study Characteristics.

Introduction

Pulp capping is a method used to dental restorations to prevent necrosis of the dental pulp after being exposed. Pulpal exposure is usually done for routine restorative [1]. Treatment techniques include pulp capping and pulpotomy (pulpectomy). Therefore, it is possible to manage the pulp exposures conservatively through crucial pulp remedy methods, including pulpotomy and pulp capping, that use the pulp regenerative potential [2]. However, to manage the pulpal exposures, it's far standard that pulp capping is the surest therapeutic choices [3,4].

Several medicaments were reported for pulpal exposure with variable success, such as medical portland cement (PC), mineral trioxide aggregate (MTA), resin-modified glass ionomer (RMGI), calcium hydroxide (CH), antibiotics [5-7]. A few studies have shown that dental lasers have significant success in pulp healing after pulp exposure [6,8-10].

The effect of lasers on tissues was first demonstrated in 1967 [11]. Laser therapy has been capable of amplifying the healing process of oral wounds via stimulation of the cell regeneration following injuries, which lessened the pain and modulated the immune system [12-14]. Moreover, it has been capable of inducing the odontoblast for laying down tertiary dentin and forming a dentin bridge to the wall of the exposed pulp [10,15].

Several studies showed the efficacy of lasers to the management of pulp exposures [10,16,17]. One study reported a high success rate to compared the laser therapy group *versus* common pulp-capping material group [17]. Other authors also evaluate the effects of direct pulp capping treatment using super-pulsed CO₂ laser pre-irradiation on the wound healing process of exposed rat pulp on days 1, 3, 7, 14, and 28 postoperatively to compared with self-etching adhesive system and calcium hydroxide. The result showed no significant differences among the experimental groups at any postoperative period [16].

There seems to be a few discussion on the efficiency of the laser applied as one of the accessories to the pulp-capping strategies. Due to the importance of using lasers, the present systematic review and meta-analysis aimed at evaluating the efficacy of laser's treatment of exposed pulps to stimulate healing.

Material and Methods

Search Strategy

From the electronic databases, PubMed, Cochrane Library, Embase, ISI have been used to perform systematic literature between 2010 and 2020. A software program (Endnote X8) has been utilized for managing electronic titles. Searches were performed with mesh terms: (((((((("Lasers/adverse effects"[Mesh] OR "Lasers/methods"[Mesh])) AND ("Dental Pulp"[Mesh] OR "Pulp Capping and Pulpectomy Agents"[Mesh] OR "Dental Pulp Exposure"[Mesh] OR "Dental Pulp Diseases"[Mesh] OR "Dental Pulp Cavity"[Mesh] OR "Dental Pulp Capping"[Mesh])) AND "Health"[Mesh]) AND ("Dental Pulp Capping/adverse effects"[Mesh] OR "Dental Pulp Capping/methods"[Mesh])) AND "acetic acid, calcium hydroxide (Ca(OH)₂, calcium salt (2:1), mercapto-, strontium hydroxide (Sr(OH)₂ drug combination" [Supplementary Concept]) AND "Resin Cements"[Mesh] AND "Glass Ionomer Cements"[Mesh] AND "mineral trioxide aggregate" [Supplementary Concept]) AND "Effectiveness"[Mesh]. This systematic review has been conducted based on the key consideration of the PRISMA Statement–Preferred Reporting Items for the Systematic Review and Meta-analysis [18] and PICO or PECO strategy (Table1).

Selection Criteria

The following inclusion criteria were adopted: 1) Randomized control trials studies, controlled clinical trials, prospective and retrospective studies, experimental studies; 2) Follow-up comparing; 3) Lasers used for direct pulp capping; 4) In English. The following exclusion criteria were established: 1) In vitro studies, case studies, case reports and reviews.

Table 1. PICO OR PECO strategy.

PICO OR PECO Strategy	Description
P	Population/ Patient: exposed pulps treated
E	Exposure/ Intervention: laser therapy
C	Comparison: laser group <i>versus</i> pulp capping procedures without lasers
O	Outcome: the rate of success or failure between Intervention and control groups

Data Extraction and Method of Analysis

The following data were extracted from the research included: study, years, study design, follow-up period, sample size, intervention group, range and mean of age, control group, exposure, outcome, success rate, type of laser, laser wavelength, power of laser, pulse interval duration, frequency, energy fluence, duration of laser application.

The quality of the studies included was assessed using the Critical Appraisal Skills Program (CASP) Checklist [19]. The scale scores range from 0 to 12 (highest grade). For Data extraction, two reviewers blind and independently extracted data from the abstract and full text of studies that included. Moreover, the fixed-effect model's odds ratio for a 95 % confidence interval (CI) was calculated. Random effects were used to deal with potential heterogeneity, and I² showed heterogeneity. The meta-analysis and forest plots have been evaluated using the Comprehensive Meta-Analysis Stata Software, V16 (Biostat, Englewood, NJ, USA).

Results

According to the research design, 63 potentially relevant research abstracts and titles have been discovered in our electronic searches. In the first phase of the study selection, 35 researches have been on the topics and abstracts. Therefore, we thoroughly assessed the complete full-text papers of the rest 22 studies in the second stage to excluded 17 publications due to the lack of the defined inclusion criteria. Then, five articles remained in agreement with our inclusion criteria required (Figure 1).

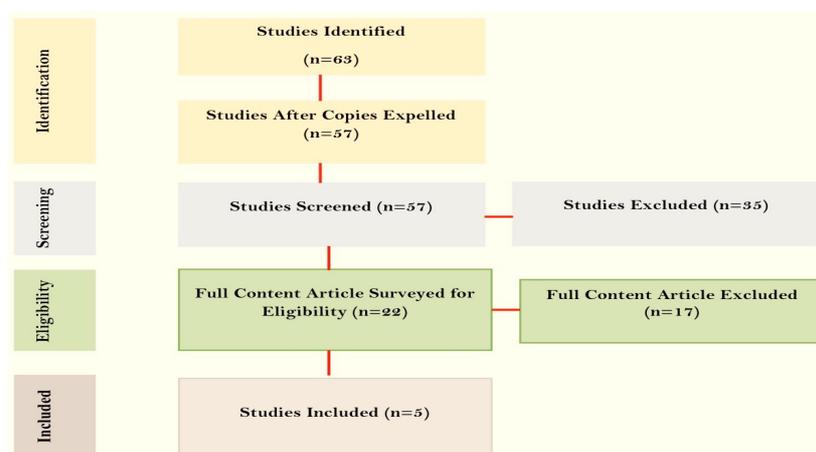


Figure 1. Study attrition diagram.

Sample Size

Five studies (3 RCTs and 2 animal studies) were included; the sample size was 185. The follow-up period has been between 1 and 48 months with a mean: 14.2 months. In the RCT studies in the Intervention group used laser +Ca(OH)₂, laser + resin, laser + RM-GIC, and in Animal studies used laser + resin, laser + MTA, laser +Ca(OH)₂. In two studies [16,20] in the success rate, no difference among test and control groups (Table 2).

Table 2. Studies selected for a systematic review.

Study	Study Design	Follow-Up (Months)	Sample Size	Mean of Age (Years)	Intervention Group	Control Group	Success Rate (%)
Cengiz et al. [17]	RCT	6	60 Test 1: 15 Test 2: 15 Control 1: 15 Control 2: 15	28 (18-41)	Laser+Ca(OH) ₂ Laser+Resin	Ca(OH) ₂ Resin	T 1: 100% T 2: 100% C 1: 73% C 2: 67%
Yazdanfar et al. [10]	RCT	12	10 Test: 5 Control: 5	26 (14-40)	Laser+RM-GIC	RM-GIC	T: 100% C: 60%
Suzuki et al. [16]	Animal	1	42 Rats 75 Teeth	8-9 Weeks	Laser + Resin	Ca(OH) ₂ Resin	ND
Hasheminia et al. [20]	Animal	4	9 Cats 36 Teeth	NA	Laser+MTA Laser+Ca(OH) ₂	MTA	ND
Olivi et al. [21]	RCT	48	64 Test 1: 34 Test 2: 30	Test 1: 14.5 (11-18) Test 2: NA (19-40)	a, 2a, Laser+Ca(OH) ₂ 1b,2b, Laser+Ca(OH) ₂	1c, 2c, Ca(OH) ₂	T1a: 80% T2a: 80% T 1b: 75% T 2b: 70% C 1c: 63% C2c: 50%

RCT: Randomize Control Trials; T: test; C: control; ND: No Difference; NA: No Information Provided by the Authors.

Two studies [17,21] used chromium-doped yttrium, erbium, gallium, scandium, and the garnet laser. Moreover, low-level diode lasers have been utilized in one study [10]. Suzuki et al. used a CO₂ laser [16], and Hasheminia et al. used YAG [20]. The optic fiber diameter in two studies was not reported [17,21], and this range was between 400 to 740 μm. In one study [17], laser wavelength did not report; the range of this parameter was 808 to 10,600 nm. Hasheminia et al. did not report the power of laser [20], but in the other four studies, the range was 0.5 to 5 W, and pulse interval duration was not reported in two studies [10,21], the range of this in three studies was 20 to 700 μs. The frequency reported in three studies [17,20,21] between 3 to 20 Hz. Energy fluence reported in two studies [16,20] and duration of laser application in one study [10] not reported (Table 3).

Table 3. Parameters of laser.

Study	Type of Laser	DOF (μm)	LW (nm)	P (W)	PID (μs)	F (Hz)	EF (J/cm ²)	DL
Cengiz et al. [17]	Er, Cr: YSGG	-	-	0.5	140	20	-	10
Yazdanfar et al. [10]	Diode	400	808	1.5	-	-	-	-
Suzuki et al. [16]	CO ₂ laser	740	10,600	0.5	200	-	0.698	1.5
Hasheminia et al. [20]	Er: YAG	600	2940	-	700	3	71	15
Olivi et al. [21]	Er, Cr: YSGG	-	2780	3-5	20	20	-	60
Olivi et al. [21]	Er: YAG	-	2940	1.5-2	-	3	-	60

DOF: Diameter of Optic Fiber; LW: Laser Wavelength; P: Power; PID: Pulse Interval Duration; F: Frequency; EF: Energy Fluence; DL: Duration of Laser Application.

Bias Assessment

According to the Critical Appraisal Skills Program (CASP) Checklist, one study had a total score of 10/12 [10], one study had an overall rating of 9/12 [17], and three studies had a total score of 8/12 [16,20,21]. This outcome showed a moderate risk of bias in all (Table 4).

Success Rate

After data extraction, three studies of five studies were included in the meta-analysis. The odds ratio was 1.90 (95% CI 1.39-2.42; p=0.00) among 3 studies and heterogeneity found (I² = 90.52%; p=0.00). This result showed a statistically significant difference between the laser and control groups (p=0.00) (Figure 2).

Table 4. Quality assessment.

Criteria	Cengiz et al. [17]	Yazdanfar et al. 10]	Suzuki et al. [16]	Hasheminia et al. [20]	Olivi et al. [21]
Focused	Y	Y	Y	Y	Y
The cohort has been recruited in an acceptable way	Y	Y	Y	Y	Y
Exposure has been accurately measured	Y	Y	Y	Y	Y
Outcome	Y	Y	Y	Y	Y
Confounding factors have been addressed	N	N	N	N	N
Follow-up has been extended and complete	N	Y	N	N	Y
Results have been clear	Y	Y	Y	Y	N
Results have been precise	Y	Y	Y	Y	Y
Results have been credible	Y	Y	Y	Y	Y
Results could be applied to the local population	Y	Y	N	N	Y
Results fitted with available evidence	CT	CT	CT	CT	CT
The important clinical implications	Y	Y	Y	Y	Y
Quality Score	9	10	8	8	8

Y: Yes; N: No; CT: Cannot Tell.

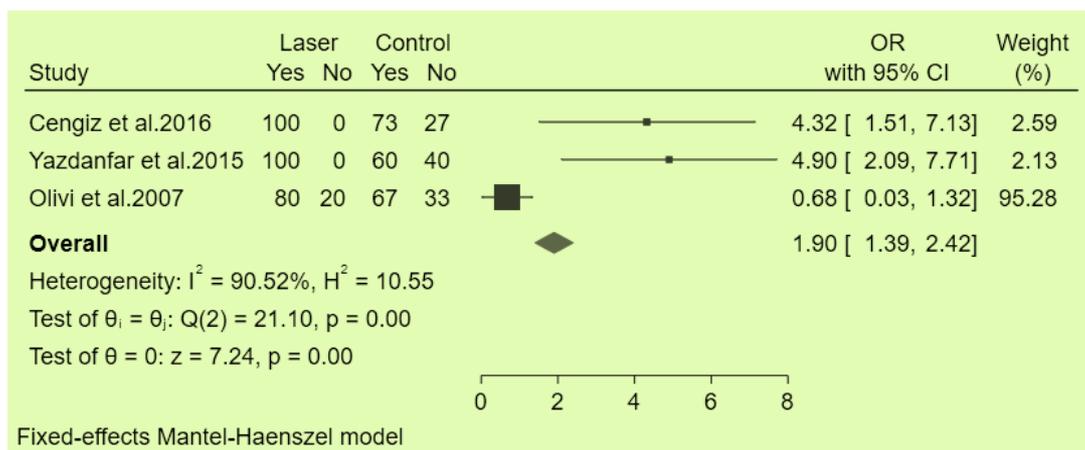


Figure 2. Forest plots showed a success rate between the laser group and control groups.

Discussion

The present systematic review and meta-analysis findings show the success rate in the laser group is higher than the control group (OR = 1.90; 95% CI 1.39-2.42; p=0.00). Lasers in dentistry are considered to be a new era that is being utilized in medical and dentistry to overcome a number of the drawbacks posed with the aid of the conventional dental processes [17,22,23].

A previous systematic review and meta-analysis showed that OR was 1.737 (95 % CI) [24], and these results are similar to the present study. The difference between the two studies is that one of them used old studies. In the Cengiz et al. [17] study, the Racal and Er, Cr: YSGG laser-irradiated CH groups the Er, Cr: YSGG laser-irradiated indicated a greater rate of success in comparison to just Racal and CH groups only. Researchers also confirmed that laser-assisted procedures had higher effectiveness than traditional techniques to improve the pulp-capping therapies' outputs in carious exposure [10,25].

It was previously demonstrated that laser + MTA provided more acceptable healings; moreover, Er: YAG laser might be utilized in the direct pulp-capping treatment when combining with the two popular substances [20]. According to this systematic review and meta-analysis, laser therapy had greater effectiveness in retaining the pulp vitality as compared to the conventional therapies. Furthermore, the rate of success considerably differed between the conventional therapies (60%) and the diode 808-nm, laser-assisted (100%) groups following a one-year follow-up ($p > 0.05$) [10]. Previous authors investigate the group of the pulps given treatment with CO₂ laser in the final recall examination at the month 12 suggested vitality of 89 teeth, reflecting the 89% rate of success [26]. However, the rate of success in the control group notably declined (68%). Findings showed the approximate similarity of the intervention group and the control group in terms of the patient's mean age and the exposure size. This was demonstrated by Moritz et al. [27]. Additionally, CO₂ laser seemingly is one of the worthwhile aids in the direct pulp-capping, and it could be possible to increase the effectiveness of the laser treatments using a pulsed CO₂ laser. Healing the pulp could be highly predicted with a shorter exposure in the younger groups [28,29]. Information from current meta-analysis [24], laser therapy of the exposed pulps could promote outcomes of the direct pulp-capping processes.

The present study results can help dentists expose pulps treated with laser therapy better than common methods. Few RCT has been performed in this area; it is recommended that further functional studies be performed in the future with larger sample size and comparison of all conventional *versus* laser treatment methods. A systematic review and meta-analysis studies that compare all parameters of laser with the control group for exposed pulps treatment.

Conclusion

It seems the success rate of laser treatment for exposed pulps is higher and even close to 100% compared to conventional methods such as mineral trioxide aggregate, resin, calcium hydroxide and Resin-modified glass-ionomer cement. But since this effect's exact mechanism has not yet been determined, further research on the impact of lasers on exposed pulps treatment is required.

Authors' Contributions

SP	 0000-0001-7177-4407	Writing - Original Draft Preparation and Writing - Review and Editing.
SJ	 0000-0003-3803-1235	Conceptualization, Methodology, Investigation, Formal Analysis, Writing - Original Draft Preparation, Writing - Review and Editing and Supervision.
GJ	 0000-0002-5527-9817	Methodology, Writing - Original Draft Preparation and Writing - Review and Editing.
AJ	 0000-0001-9895-7457	Writing - Original Draft Preparation and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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None.

Conflict of Interest

The authors declare no conflicts of interest.

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