



Original Article

Outcome comparison between diode laser pulpotomy and formocresol pulpotomy on human primary molars



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Abstract *Background/purpose:* Diode laser is widely used in dentistry, especially on treating soft tissues. Currently neither the effect of diode laser pulpotomy nor its comparison with formocresol (FC) pulpotomy has been fully investigated. Therefore the purpose of this study was to investigate the clinical and radiographic outcomes of diode laser pulpotomy and formocresol pulpotomy on human primary molars.

Materials and methods: Healthy two-to eight-year-olds were treated with pulpotomies on primary molars as part of their regular dental treatment. The pulpotomy teeth were randomly assigned into one of two groups. The experimental group was treated with diode laser; the control group was treated with 1:5 dilution FC.

Results: Forty-five teeth with diode laser and 45 teeth with FC in 70 healthy children were studied. In 12 months follow-up, the clinical success rates were 92.9%, and 90.9% for laser and FC respectively, and the radiographic success rates were 78.6%, and 72.7% for laser and FC respectively. *Conclusion:* There is no significant difference of clinical and radiographic success rate between diode laser and FC pulpotomy in human primary molars followed for 12 months.

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Introduction

Pulpotomy is a choice of treatment for cariously exposed primary teeth to maintain its function in the oral cavity. Over the past 70 years, formocresol (FC) has been a popular medicament in the primary teeth, mainly because its easiness to use and the outcome of high clinical success rates. In an effort to find a more biologically acceptable and effective alternative to FC, different agents and techniques have been investigated for primary tooth pulpotomy. Nonpharmacologic hemostatic technique for the pulpotomy procedure, such as electrosurgery^{1,2} and laser therapy^{3–6} have been suggested.

Application of laser to dental tissues have shown their potential to increase healing, control hemorrhage, stimulate dentinogenesis and preserve vitality of the dental pulp.⁷ A number of studies using different kinds of laser for primary tooth pulpotomy have been published.^{4,6,8–10} In a review article on human primary teeth by Ansari et al., they reviewed the efficacy of laser pulpotomy over the FC pulpotomy and concluded that higher clinical, radiographic, and histopathological success rates in laser group.¹¹ Meta-analysis also indicated that laser proved better or close results to FC.¹¹ In one similar review article by Coster et al., laser pulpotomy, on the contrary, success rate are found to be lower than conventional pulpotomy procedures.¹² Such inferiority of laser pulpotomy was postulated to be related to its greater technical sensitivity and its lack of bactericidal and fixative effects.¹²

Diode laser has been applied widely in dentistry, especially on soft tissues, such as excision, incision, or ablation. Diode laser emits beam of infrared light and produces well-localized ablation of soft tissues by converting laser energy into heat.¹⁰ This laser is a contact laser; therefore, only soft tissues in immediate contact with the laser tip are affected. This laser energy is relatively poorly absorbed by the tooth structures, therefore has minimal effect on enamel, dentine and cementum. Its other advantages include small size, portability and lower prices.

Up to date, very few studies^{10,13} have investigated the effects of diode laser pulpotomy in comparison with FC pulpotomy. In 2014, Durmus and Tanboga compared the treatment outcomes of diode laser, FC and ferric sulfate (FS) pulpotomy. They found that diode laser pulpotomy offered a high clinical success rate (100%) after 12 months follow-up.¹³ However considering the radiographic success rate (75%), it may not replace traditional FC and FS pulpotomy in primary molars.¹³ Saltzman et al. investigated effects of diode laser pulpotomy with MTA and compared with those of FC pulpotomy with ZOE.¹⁰ They found that laser-MTA and FC-ZOE have similar clinical success rate of 100%. However the laser-MTA showed lower radiographic success rate (71.4%) compared to FC-ZOE (84.6%) at 15.7 months follow-up. But the difference was not statistically significant.¹⁰

The purpose of this study was to investigate the clinical and radiographic outcomes of diode laser pulpotomy on human primary molars and compared the treatment outcomes to formocresol pulpotomy.

Materials and methods

Sample collection

Patients aged between 2 and 8 years and without any medically compromised diseases were selected from a hospital-based dental clinic. Ethical approval for the study was obtained from the institutional review board of TCVGH. Patients were informed of details of the treatment, and informed consent was obtained.

The inclusion criteria were:

1. Primary molars that required a pulpotomy because of pulp exposure to caries.
2. Teeth with normal mobility.
3. No tenderness to percussion, no swelling or sinus tract
4. Radiographically, teeth had a carious pulpal exposure without furcation or periapical pathology.
5. Root resorption was confined to less than one third of the root.
6. Absence of internal root resorption

The exclusion criteria were:

1. Teeth that cannot be restored with stainless steel crown (SSC).
2. Hemostasis cannot be achieved within 3 min after coronal pulp tissue was removed.

The pulpotomy teeth were randomly assigned into one of two groups. The experimental group was treated with diode laser (Pocket laser, Orotig Med, Verona, Italy). The control group was treated with 1:5 dilution formocresol (Buckley's formocresol, Sultan healthcare, Hackensack, NJ, USA).

Pulpotomy procedures were as follows: after the administration of local anesthesia and tooth isolation using a rubber dam, the caries was excavated and the extent of the lesion determined. If a carious exposure was evident, a high speed bur was used to unroof the pulpal chamber. Coronal pulp tissue was removed with a sterile sharp spoon excavator, followed by sterile saline irrigation. Initial hemorrhage was achieved using a dry sterile cotton pellet. In the study group, complete hemostasis was achieved by exposure to diode laser (915 nm), at 2 W, 100 Hz (Pocket laser, Orotig Med). The laser energy was introduced into the canal orifice through a 300 um optical fiber in a contact mode for 1 second at each orifice for three times to achieve complete hemostasis (Fig. 1). In the control group, after amputation of the pulp and initial control of bleeding with a dry cotton, complete hemostasis was achieved by applying 1:5 dilution FC cotton for 5 min. Intermediate restorative material (IRM, Dentsply Caulk, Milford, DE, USA) was placed over the pulp stumps in both groups, and the tooth was restored with stainless steel crown. Clinical follow-ups were performed every three months after treatment. All pulpotomy procedures were performed by the same pediatric dentist. At each follow-up visit, children and radiographic were evaluated separately by two pediatric dentists.



Figure 1 Complete hemostasis was achieved with diode laser (915 nm) at 2 W, 100 Hz.

Criteria for success of pulpotomy

Clinical success was achieved if there was absence of pain, sinus tract, swelling, and abnormal mobility. Radiographic success was achieved when there was a lack of internal or external root resorption, periapical or furcal radiolucency.

Treatment was considered a failure when one or more of the following signs were present: internal or external root resorption, furcation, or periapical radiolucency, pain, swelling, or sinus tract.

Statistical analysis

The SPSS software (version 19.0, Chicago, IL) was used for all statistical analysis. Chi-square test and t-test were used to compare treatment outcomes of laser and FC pulpotomy. Values of $P < 0.05$ were considered statistical significant.

Intra- and inter-examiner agreements of radiographic assessments were evaluated by Kappa test.

Results

A total of 70 children aged between 2 and 8 years old, participated in this study. Out of 90 primary molars treated, 45 were treated with diode laser. And the remaining 45 primary molars were treated with FC. There is no inter-group difference in terms of age distribution (4.77 ± 1.5 vs. 4.45 ± 1.2 years, t-test, $P = 0.344$). There were 25 first primary molars and 20 secondary primary molars treated with laser, and 26 first primary molars and 19 secondary primary molars treated with FC (Table 1). There was also no

Table 1 Distributions of patients and teeth in laser and formocresol (FC) groups.

	Laser	FC
Patients	41	29
Boys	23	18
Girls	18	11
Total teeth	45	45
Max 1 st molar	11	11
Mand 1 st molar	14	15
Max 2 nd molar	7	6
Mand 2 nd molar	13	13

Max: Maxillary
Mand: Mandibular.

significant difference in terms of tooth distributions between these two groups ($P = 1.00$). The kappa value for intra-examiner reliability is 0.853, and for inter-examiner reliability is 0.774.

Clinical success rates for laser group followed up at different times were found to be: 100% (3 months), 96.8% (6 months) and 92.9% (12 months). Similarly, clinical success rates for FC group were 100% (3 months), 97.1% (6 months) and 90.9% (12 months) (Table 2). Radiographic success rates for laser group were 100% (3 months), 90.3% (6 months) and 78.6% (12 months); and for FC group were 100% (3 months), 91.4% (6 months) and 72.7% (12 months) (Fig. 2). There were no significant differences in clinical or radiographic success rates between these two groups in different follow-up interval (Table 3).

Calcification of root canals after pulpotomy occurred around 3–9 months in both groups and the longer the follow up period the more obvious was the calcification of the root canals. There was no significant difference in the occurrence of canal calcification between these two groups. Canal calcification was counted as radiographic success. The radiographic failures were three peri-radicular radiolucency in the laser group (Fig. 3) and one in the FC group, one internal root resorption (Fig. 4) and two external root resorptions in the FC group during six months follow-up.

Discussion

In this study, the clinical success rate for diode laser pulpotomy was 92.9% (at 12 months), and for FC pulpotomy was 90.9%. There was no significant difference between these two groups ($P = 0.265$). The radiographic success rate for diode laser was 78.6% (at 12 months) and 72.7% (at 12 months) for FC. Again, no significant difference was found in radiographic success rate between these two groups ($P = 0.832$). Our results are consistent with Saltzman's study, in which they used split mouth technique to investigate the success rates of diode laser pulpotomy and FC pulpotomy.¹⁰ After an average follow-up period of 15.7 months, they found no significant difference between these two groups. In 2014, Durmus and Tanboga evaluated the treatment outcome of diode laser, FC and FS pulpotomy at 12 months.¹³ They also found no significant difference among these three groups.

In the review article by Ansari et al., it was however concluded that laser pulpotomy is better or comparable to FC pulpotomy, and suggest that laser pulpotomy may be

Table 2 Clinical success rates of laser and FC groups.

Treatment	Teeth	Clinical Success	Rate		
		^a 3M (85)	^b 6M(66)	9M(32)	12M(25)
Laser	45	100%	96.8%	93.8%	92.9%
FC	45	100%	97.1%	93.8%	90.9%
P value		1.00	0.179	0.207	0.265

FC: formocresol

Chi-square test.

^a 3M(85): 3 months follow-up, 85 teeth.

^b 6M(66): 6 months follow-up, 66 teeth.

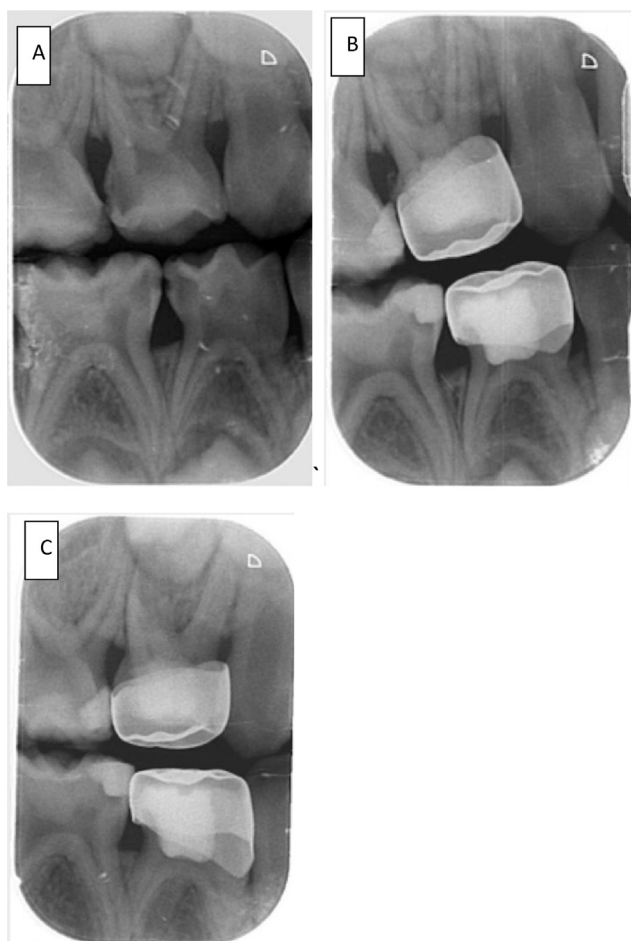


Figure 2 Successful treatment of laser pulpotomy of lower right first primary molar and FC pulpotomy of upper right first primary molar after 12 months follow-up. (A) The preoperative radiograph. (B) The 6 months follow-up. (C) The 12 months follow-up.

Table 3 Radiographic success rates of laser and FC groups.

Treatment	Teeth	Radiographic	Success	Rate
		^a 3M (85)	^b 6M(66)	9M(32) 12M(25)
Laser	45	100%	90.3%	81.3% 78.6%
FC	45	100%	91.4%	87.5% 72.7%
P value		1.00	0.964	0.647 0.832

FC: formocresol

Chi-square test.

^a 3M(85): 3 months follow-up, 85 teeth.

^b 6M(66): 6 months follow-up, 66 teeth.

considered as an alternative for vital pulp therapy on human primary teeth.¹¹ However in another review article by Coster et al., Nd:YAG, CO₂ and diode laser pulpotomy were compared with the conventional pulpotomy, and they concluded that laser pulpotomy is less successful than the conventional pulpotomy.¹² In 2014, Lin's review article concluded that after 18–24 months, FC, ferric sulfate and MTA showed significantly better clinical and radiographic

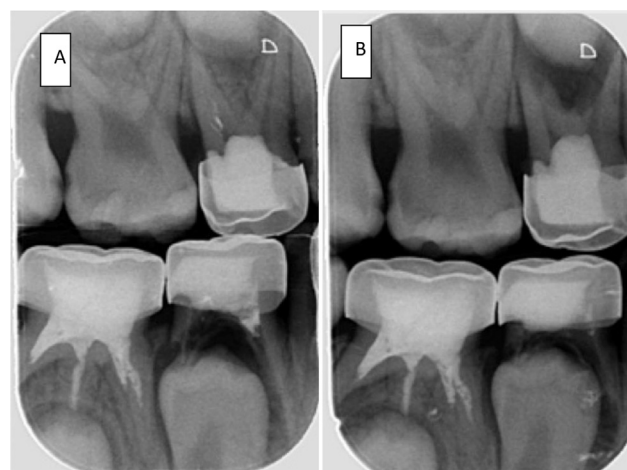


Figure 3 Radiographic failure of laser pulpotomy on upper right first primary molar with furcation lesion. (A) Immediately after pulpotomy. (B) The 6 months follow-up.



Figure 4 Radiographic failure of FC pulpotomy on upper left first primary molar with internal root resorption. (A) Preoperative radiograph. (B) The 6 months follow-up. (C) The 9 months follow-up.

outcomes than calcium hydroxide and laser therapies in primary molar pulpotomy.¹⁴ But in that review article, drop-out rates were regarded as failure in the final meta-

analysis. This may affect the final results, leading to conclusions different from other review articles.

In Yadav's study, they found higher clinical success rates of diode laser than FS nine months after treatment.¹⁵ However the radiographic success rate was the same between diode laser and FS pulpotomy. They concluded that diode laser appears to be an acceptable alternative to pharmacotherapeutic pulpotomy agents.

A study by Uloopi et al., comparing the diode laser and MTA pulpotomy found that the success rate of diode laser is comparable to MTA pulpotomy.⁸ Although the success rate of diode laser was lower than MTA (85% vs. 94.7%), the difference was not statistically significant difference.

In the present study the most common failure of diode laser was furcal and/or periradicular radiolucency. In Saltzman's study, furcal and/or periradicular radiolucency was also the most common failure in diode laser group.¹⁰ However, in Yadav's study, the most common failure was internal root resorption in diode laser group.¹⁵

Thermal damage of the proximal pulp tissue exerted by laser application might raise hyperemia in the pulp tissue and may affect the treatment outcome.¹⁶ Therefore in our present study; a sharp excavator was used to remove coronal pulp tissue instead of diode laser to prevent excessive laser heat damage to the remaining pulp tissue. In the present study, diode laser was used for pulpotomy technique. Because pulp tissue has a very high water content, and high absorbance of the wavelength (980 nm) of diode laser was expected. Furthermore, diode laser is a contact laser, only soft tissues in immediate contact are affected, and have no effects on hard tissue. Therefore diode laser is well suited for primary tooth pulpotomy technique. In conclusion, there is no significant difference of clinical and radiographic success rate between diode laser pulpotomy and FC pulpotomy in human primary molars. Diode laser pulpotomy can be considered for use as a pulpotomy technique in clinical practice.

Declaration of Competing Interest

The authors deny any conflicts of interest related to this study.

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References

1. Dean JA, Mack RB, Fulkerson BT, Sanders BJ. Comparison of electrosurgical and formocresol pulpotomy procedures in children. *Int J Paediatr Dent* 2002;12:177–82.
2. Fishman SA, Udin RD. Success of electrofulguration pulpoto- mies covered by zinc oxide and eugenol or calcium hydroxide: a clinical study. *Pediatr Dent* 1989;18:385–90.
3. Wilkerson M, Hill S, Arcoria C. Effects of the argon laser on primary tooth pulpoto- mies in swine. *J Clin Laser Med Surg* 1996;14:37–42.
4. Odabas ME, Bodur H, Baris E, Demir C. Clinical, radiographic, and histopathologic evaluation of Nd:YAG laser pulpotomy on human primary teeth. *J Endod* 2007;33:415–21.
5. Elliott RD, Roberts MW, Burkes J, Philips C. Evaluation of the carbon dioxide laser on vital human primary pulp tissue. *Pediatr Dent* 1999;21:327–31.
6. Liu J. Effects of Nd: YAG laser pulpotomy on human primary molars. *J Endod* 2006;32:404–7.
7. Gonzalez C, Zakariasen KL, Dederich DN, Pruhs RJ. Potential preventive and therapeutic hard tissue applications of CO2 laser, Nd:YAG laser and argon lasers in dentistry: a review. *J Dent Child* 1996;63:196–206.
8. Uloopi K, Vinay C, Ratnaditya A, Gopal AS, Mrudula K, Rao RC. Clinical evaluation of low level diode laser application for primary teeth pulpotomy. *J Clin Diagn Res* 2016;10:ZC67–70.
9. Marques N, Neto N, Rodini CO, Fernandes A, Sakai V, Machado M. Low-level laser therapy as an alternative for pulpotomy in human primary teeth. *Lasers Med Sci* 2015;30:1815–22.
10. Saltzman B, Sigal M, Clokie C, Rukavina J, Titley K, Kulkarni G. Assessment of a novel alternative to conventional formocresol- zinc oxide eugenol pulpotomy for the treatment of pulpally involved human primary teeth: diode laser-mineral trioxide aggregate pulpotomy. *Int J Paediatr Dent* 2005;15:437–47.
11. Ansari G, Aghdam HS, Taheri P, Ahsaie MG. Laser pulpotomy— an effective alternative to conventional techniques—a sys- tematic review of literature and meta-analysis. *Laser Med Sci* 2018;33:1621–9.
12. De Coster P, Rajasekharan S, Martens L. Laser-assisted pul- potomy in primary teeth: a systematic review. *Int J Paediatr Dent* 2013;23:389–99.
13. Durmus B, Tanboga I. In vivo evaluation of the treatment outcome of pulpotomy in primary molars using diode laser, formocresol and ferric sulphate. *Photomed Laser Surg* 2014;32: 289–95.
14. Lin PY, Chen HS, Wang YH, Tu YK. Primary molar pulpotomy: a systematic review and network meta-analysis. *J Dent* 2014;42: 1060–77.
15. Yadav P, Indushekar K, Saraf B, Sheoran N, Sardana D. Comparative evaluation of ferric sulfate, electrosurgical and diode laser on human primary molars pulpotomy: an in-vivo study. *Laser Ther* 2014;23:41–7.
16. de Freitas PM, Soares-Geraldo D, Biella-Silva AC, Silva AV, da Silveira BL, Eduardo CP. Intrapulpal temperature variation during Er,Cr: YSGG enamel irradiation on caries prevention. *J Appl Oral Sci* 2008;16:95–9.