ORIGINAL RESEARCH

# Comparative Evaluation of Low-level Diode Laser and Electrosurgical Pulpotomy in Primary Molars

Sayani Roy[1], Nishita Garg[2], Lumbini Pathivada[3], Rishika Choudhary[4], Harsimran Kaur[5], Ramakrishna Yeluri[6]

## Abstract

**Aim:** Considering the advantages of the nonpharmacotherapeutic techniques over the disadvantages of the pharmacotherapeutic agents, there is a need to evaluate clinically as well as radiographically various nonpharmacotherapeutic techniques to fortify them as replacements to the traditional pulpotomy. This study was conducted to evaluate and compare the clinical and radiographic outcomes of low-level diode laser (LLDL) and electrosurgical pulpotomy in primary molars.

**Materials and methods:** Seventy primary molars were allocated to group I ($n = 35$) and group II ($n = 35$), which underwent LLDL pulpotomy and electrosurgical pulpotomy, respectively. Clinical and radiographic analysis of all the teeth in the two groups was performed at 1, 3, 6, 9, and 12 months, respectively. Pearson's Chi-squared test was utilized to evaluate the success of both treatment procedures ($p < 0.05$).

**Results:** During the 12-month follow-up period, the differences between the groups pertaining to clinical and radiographical evaluation were statistically nonsignificant, although enhanced results were seen in the laser pulpotomy group. There was no significant difference in the success rate observed between the LLDL pulpotomy and electrosurgical pulpotomy group at the end of the 12-month follow-up period.

**Conclusion:** The two pulpotomy techniques were found to be successful enough in strengthening the concept of a potent and safe nonpharmacotherapeutic approach in the management of pulpally involved primary molars.

**Clinical significance:** This study further establishes nonpharmacological pulpotomy techniques as a favorable alternative to traditional pulpotomy methods.

**Keywords:** Electrosurgery, Low-level diode laser therapy, Pulpotomy.

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## Introduction

Long-standing dental caries lead to the involvement of pulp tissue, which may progress into severe pain and discomfort. Depending on the extent and severity of the insult to the tooth, the pulp shows variable reactions, which are mainly treated by two endodontic therapies, mainly categorized as vital and nonvital pulp therapy. There are various procedures that can be listed under vital pulp therapy—indirect pulp capping, direct pulp capping, and pulpotomy.[1] According to the American Academy of Pediatric Dentistry, "a pulpotomy is performed in a primary tooth with extensive caries but without evidence of radicular pathology when caries removal results in a carious or mechanical pulp exposure."[2] The rationale behind pulpotomy is to surgically amputate the coronal pulp tissue and preserving the remaining pulp which may be healthy or capable of healing by placing a suitable agent which promotes the tissue in the roots to stay vital. The pulpotomy is a success depending on the agent; it should not affect the physiological root resorption process and should be bactericidal and biocompatible.[3]

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There are several techniques for pulpotomy, including pharmacotherapeutic approaches involving dressing the pulp tissue with formocresol,[1,4] glutaraldehyde,[1,5] ferric sulfate,[1,6] calcium hydroxide,[1,7] mineral trioxide aggregate (MTA),[8,9] nanohydroxyapatite,[10] freeze-dried bone,[1,11] Portland cement,[12] bioactive glass,[9,13] Chitra-calcium phosphate cement,[14] reinforced zinc oxide eugenol,[15,16] bone morphogenetic protein,[1,17] collagens,[1,18] or sodium hypochlorite,[1,19] etc. Among these, formocresol was measured as the "gold standard" pulpotomy agent and had been broadly used since its' introduction in 1930 by Sweet.[4] However, because of its potential adverse effects such as carcinogenicity, mutagenicity, cytotoxicity, and presence of cresol, a caustic agent found to be potentially damaging to the succedaneous permanent teeth, it is no longer considered an ideal pulpotomy agent.[20]

Recently, MTA has proved to be a material with properties that meet the requirements of an ideal pulpotomy medicament. Nevertheless, it exhibits short shelf life, difficulty in handling, delayed setting time, and sensitivity to moisture, and it is still too costly.[1,8,9,19] MTA is also known to cause greyish discoloration in primary teeth.[21] To overcome these drawbacks, the use of nonpharmacotherapeutic procedures like electrosurgery and laser ablation were highlighted, which have yielded successful results in previously conducted studies.[19,15,22]

Latest advances in the field of laser technology have made it more lucrative in endodontic applications; it is an accessory or alternative to conventional pulp therapy procedures. Gupta et al.[23] suggested laser as a nonpharmaceutical treatment option due to its ability to control hemorrhage, cell-stimulating properties with only minimal thermal variation to the pulp tissues, and antimicrobial effect. The laser also has the benefit of being noninvasive, economical, transportable, and easily packable with the least setup time.

Electrosurgical pulpotomy is another nonpharmacological technique that has been proven to have great merits. El-Meligy et al.[24] found that electrosurgery exhibited fewer histopathological reactions compared to the teeth treated with formocresol. Ruemping et al.[25] found that electrosurgery leads to good visualization and hemostasis and is less time-consuming. It is efficient, self-limiting, provides sterilization at the site of application, and has the extra advantage of no systemic effects. It has also become popular due to its simplicity and positive results. Contemplating the advantages of the nonpharmacotherapeutic techniques over the disadvantages of pharmacotherapeutic agents, there is a need to evaluate clinically as well as radiographically various nonpharmacotherapeutic techniques to fortify them as replacements to the traditional pulpotomy clinically as well as radiographically. Since there are few reported studies[6,23] available in the literature comparing the two procedures, hence, this study was done to estimate the success rates of low-level diode laser (LLDL) and electrosurgical pulpotomy in primary molars.

## Materials and Methods

The research protocol was approved by the Ethical Committee of the institute prior to the commencement of this study. The sample size was determined as 70 teeth after power analysis (95%) for this study were included who met the inclusion criteria after screening 183 children in the age range of 4–9 years who visited the Department of Pediatric and Preventive Dentistry. Based on the randomization protocol, the teeth categorized under group I ($n = 35$) underwent LLDL pulpotomy technique, while the teeth categorized under group II ($n = 35$) were treated with electrosurgical pulpotomy technique. Inclusion criteria for this study were the presence of deep carious lesions approximating/involving the pulp of primary molars with at least two-thirds of the root length remaining and if the guardians of the patient approved the participation of their child in the study.[23] Patients with significant behavior management issues, children with any systemic diseases, teeth with spontaneous/nocturnal pain, the occurrence of abscess, swelling, external or internal root resorption, and periapical/periodontal pathology were disqualified from the study.[6,19] Isolation was achieved by rubber dam application of the involved tooth, followed by access cavity preparation, coronal pulp amputation, and after achieving hemostasis within 5 minutes.

Before the LLDL application, the patient, the operating dentist, and the support staff were given protective eye covers. DenLase™ LLDL (China Deheng Grp., Inc, Beijing, China) of wavelength—810 nm, energy—2 J/cm$^2$ under continuous mode, was administered over the radicular stumps in noncontact mode with pulp tissue for not >2–3 seconds. Application of laser was done until pulp tissue ablation and total hemostasis were achieved (Fig. 1).[6,22] In the electrosurgical group, the neutral plate of the electrosurgical unit was first placed on the belly of the patient. The ART-Electrosurge (Bonart Co. Ltd., Taipei Hsien, Taiwan) unit was set at COAG 1 mode at 40% power. The handpiece with the appropriate electrode tip was held 1–2 mm away from the pulp tissue and used to deliver the electric current for not >2–3 seconds, followed by a cooling time of 5 seconds. If required, it was repeated up to a maximum number of applications of three times. After the application of each current, pressure was applied on the pulpal tissue using a large moist, sterilized cotton pellet for absorption of any tissue fluids or blood before the subsequent current application. When completed, the pulp stumps appeared dry and entirely blackened (Fig. 2).[6]

In each group, it was sealed type II glass ionomer cement restorative material after a layer of zinc oxide eugenol dressing was positioned directly over the radicular pulp stumps. The final restoration with stainless steel crown was done either on the same or the consecutive day (Figs 3 and 4). Clinical and radiographical analysis of all the teeth in the two groups was performed at 1, 3, 6, 9, and 12 months to assess the success of treatment procedures clinically and radiographically. The criterion for periodic evaluation was done as suggested by Fuks.[26] The statistical analysis of the data obtained was done using Statistical Package for the Social Sciences software (IBM Corporation, United States of America) version "17." The utilization of Pearson's Chi-squared test was done to calculate the success rates of both procedures with predetermined $p < 0.05$.

## Results

In this study, the mean age of the children was observed to be 6.63 ± 1.54 years. The distribution of teeth at different follow-ups of 1, 3, 6, 9, and 12 months, respectively, is shown in Flowchart 1. Tables 1 to 3

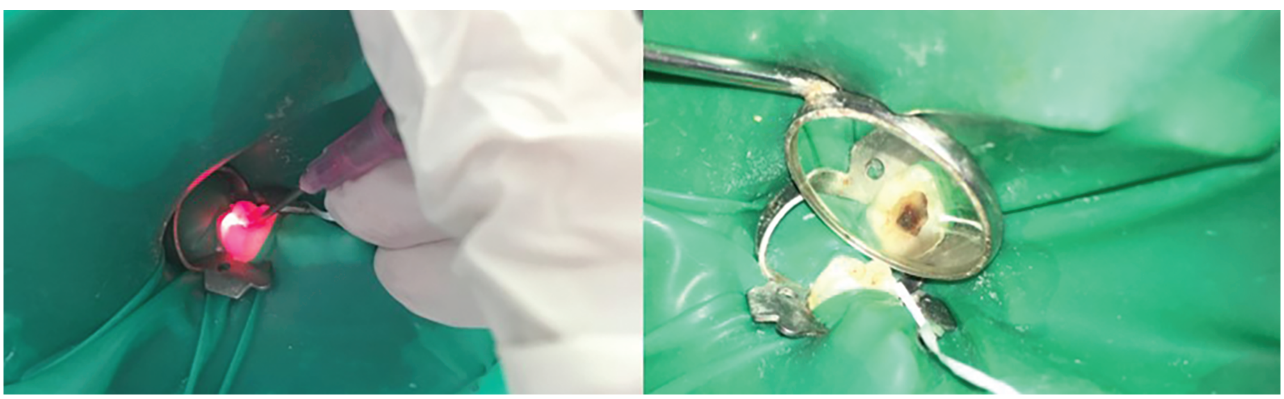


**Fig. 1:** Application of laser over the radicular stumps in noncontact mode and pulp ablation with complete hemostasis achieved

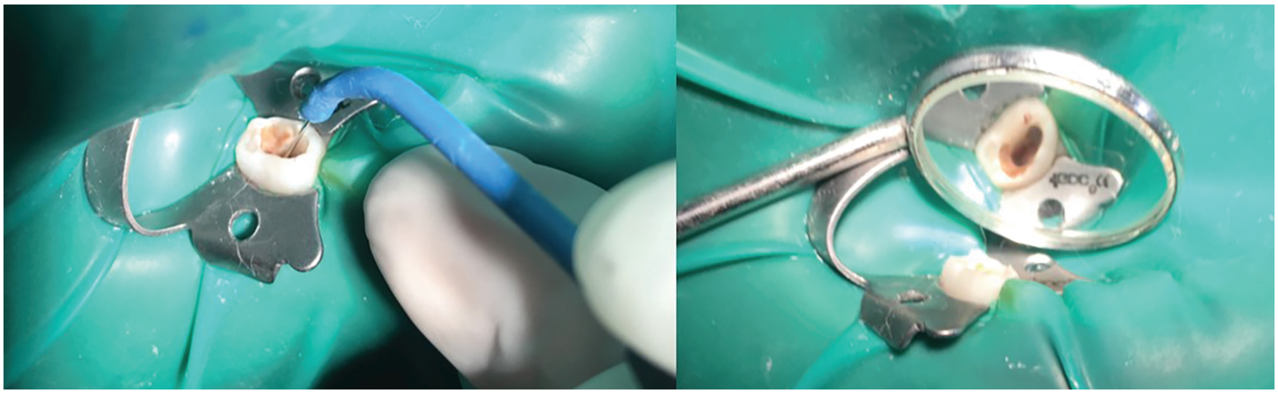


**Fig. 2:** Application of electric current through electrode tip over the radicular stumps in noncontact mode; the pulp stumps appeared dry and entirely blackened after application

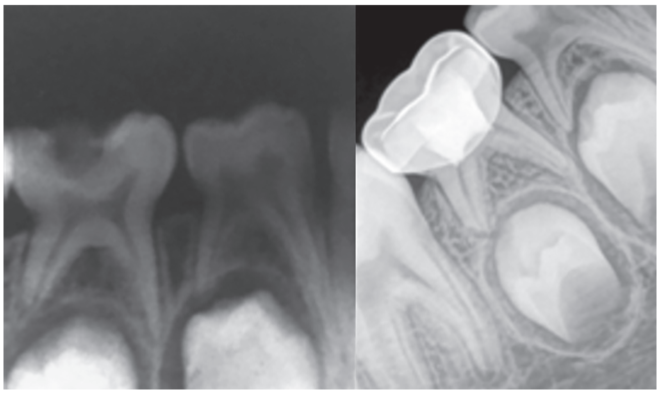


**Fig. 3:** Preoperative and postoperative radiographs of low-level laser pulpotomy group

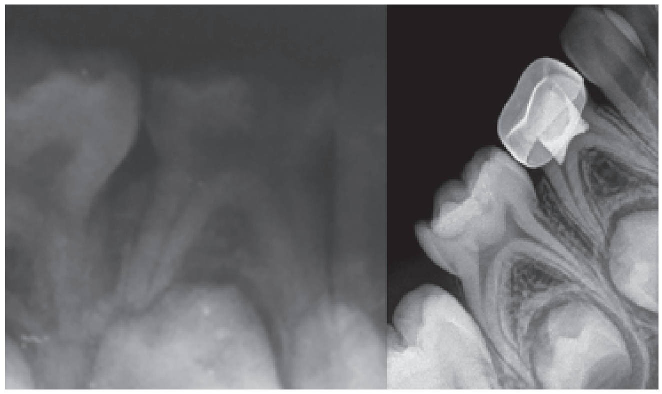


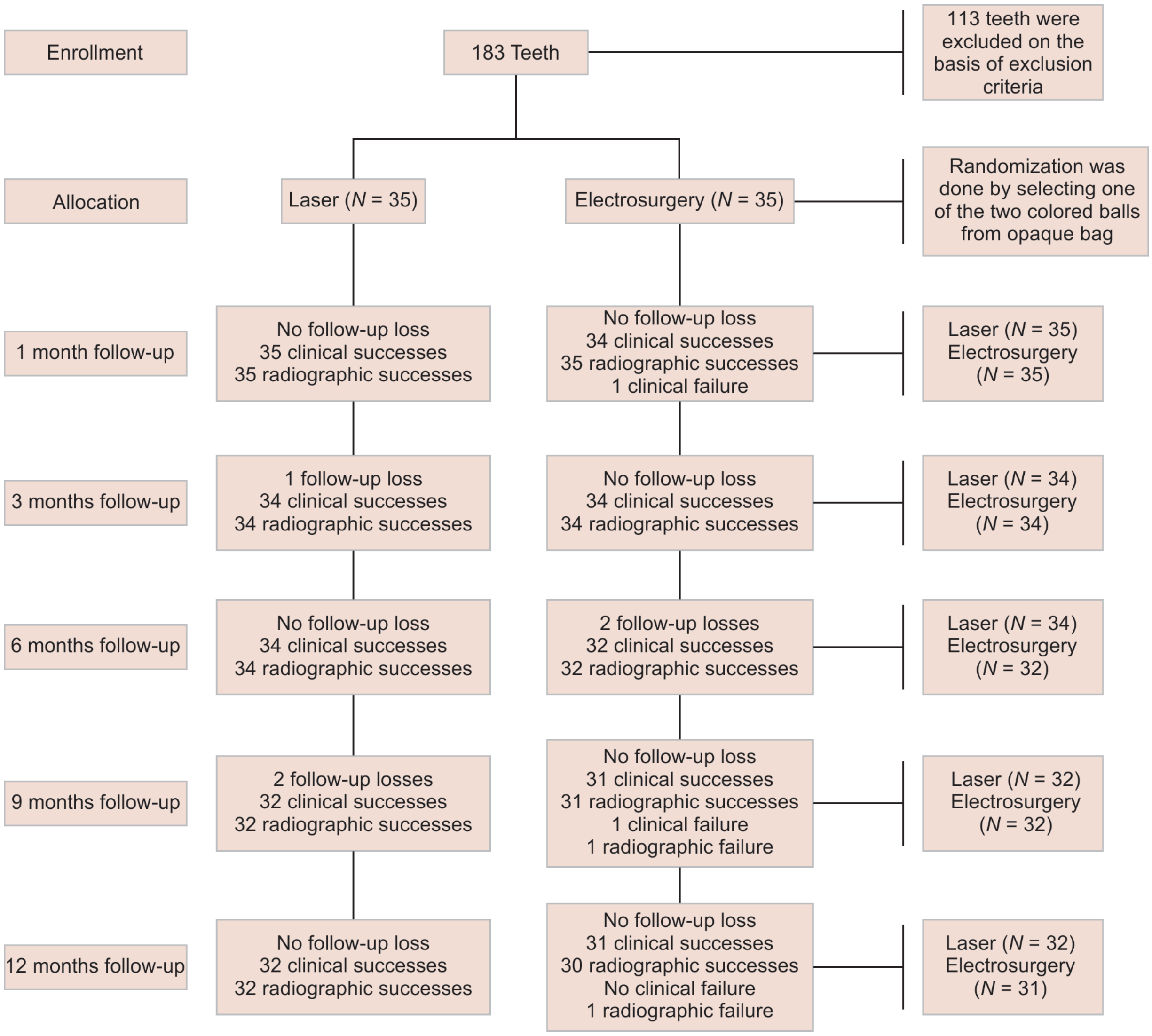
**Fig. 4:** Preoperative and postoperative radiographs of electrosurgical pulpotomy group

**Table 1:** Clinical success and failure rate in both the groups at follow-up intervals of 1, 3, 6, 9, and 12 months

| *Time interval* | *Clinical evaluation* | *Group I* | *Group II* | *Chi-square value* | *p-value* |
|---|---|---|---|---|---|
| 1 month | Success | 35 | 34 | 1.014 | 0.314 |
| | | 100.0% | 97.1% | | NS |
| | Failure | 0 | 1 | | |
| | | 0.0% | 2.9% | | |
| 3 months | Success | 34 | 34 | 0.000 | 1.000 |
| | | 100.0% | 100.0% | | NS |
| | Failure | 0 | 0 | | |
| | | 0.0% | 0.0% | | |
| 6 months | Success | 34 | 32 | 0.000 | 1.000 |
| | | 100.0% | 100.0% | | NS |
| | Failure | 0 | 0 | | |
| | | 0.0% | 0.0% | | |
| 9 months | Success | 32 | 31 | 1.014 | 0.314 |
| | | 100.0% | 96.9% | | NS |
| | Failure | 0 | 1 | | |
| | | 0.0% | 3.1% | | |
| 12 months | Success | 32 | 31 | 0.000 | 1.000 |
| | | 100.0% | 100.0% | | NS |
| | Failure | 0 | 0 | | |
| | | 0.0% | 0.0% | | |

NS, not significant

**Flowchart 1:** Distribution of teeth available at various follow-up intervals (1, 3, 6, 9, and 12 months)




represent the clinical, radiographical, and overall success and failure rates in both groups at follow-up intervals of 1, 3, 6, 9, and 12 months, respectively. The intergroup comparison revealed statistical nonsignificant differences pertaining to clinical, radiographical, and overall success and failure rates at 1, 3, 6, 9, and 12 months follow-up intervals ($p > 0.05$), indicating that LLDL or electrosurgical pulpotomy can be utilized as viable nonpharmacological pulpotomy techniques.

## Discussion

Varying rates of success, disadvantages, and concerns regarding the safe application of pharmacological agents made it clear that further research on the utilization of nonpharmacological techniques is necessary. Neodymium-doped yttrium aluminium garnet laser, $CO_2$, or LLDLs have been recommended for pulpotomy, amongst which LLDL was used in this study. Diode lasers lead to the formation of a tubular dentin bridge which is important as it creates a “barrier effect” against the percolation of harmful agents.[27,28] Few researchers have suggested that the initial formation of a tubular dentin/osteodentin can become gradually lined with tubules forming tubular dentin with time.[29–32] LLDL have biostimulative light energy activating cells and accelerates the healing of the wound by altering the expression of platelet-derived growth factor, transforming growth factor β, and blood-derived fibroblast growth factor genes that are accountable for stimulating cellular proliferation and development of fibroblast.[33,34]

In the present study, wavelength—810 nm, energy—2 J/cm$^2$ under the continuous mode, was administered over the radicular stumps in noncontact mode with pulp tissue which is similar to the study done by Uloopi et al.[22] except for the time of contact. The time for contact is 2–3 seconds, as in the study done by Yadav et al.[6] to reduce the injury to the pulp by thermal insults, which depends on the exposure time of the laser rather than the power output of the device.

The other technique used in this study is electrosurgery which denatures the pulp and bacterial infectivity by carbonization.[35] The advantage of electrosurgical pulpotomy is that its pulpal penetration is self-limiting and crosses only a few cell layers providing hemostasis and superior visualization without systemic involvement or chemical coagulation.[35] Srinivasan et al.[36] commented that it can be measured as a “gold standard” in

**Table 2:** Radiographic success and failure rate in both the groups at follow-up intervals of 1, 3, 6, 9, and 12 months

| *Time interval* | *Radiographic evaluation* | *Group I* | *Group II* | *Chi-square value* | *p-value* |
|---|---|---|---|---|---|
| 1 month | Success | 35 | 35 | 0.000 | 1.000 |
| | | 100.0% | 100.0% | | NS |
| | Failure | 0 | 0 | | |
| | | 0.0% | 0.0% | | |
| 3 months | Success | 34 | 34 | 0.000 | 1.000 |
| | | 100.0% | 100.0% | | NS |
| | Failure | 0 | 0 | | |
| | | 0.0% | 0.0% | | |
| 6 months | Success | 34 | 32 | 0.000 | 1.000 |
| | | 100.0% | 100.0% | | NS |
| | Failure | 0 | 0 | | |
| | | 0.0% | 0.0% | | |
| 9 months | Success | 32 | 31 | 1.014 | 0.314 |
| | | 100.0% | 96.9% | | NS |
| | Failure | 0 | 1 | | |
| | | 0.0% | 3.1% | | |
| 12 months | Success | 32 | 30 | 1.014 | 0.314 |
| | | 100.0% | 96.8% | | NS |
| | Failure | 0 | 1 | | |
| | | 0.0% | 3.2% | | |

NS, not significant

**Table 3:** Overall rates of success and failure in both the pulpotomy groups at follow-up intervals of 1, 3, 6, 9, and 12 months

| *Time interval* | *Overall success and failure* | *Group I* | *Group II* | *Chi-square value* | *p-value* |
|---|---|---|---|---|---|
| After the 12-month follow-up | Success | 32 | 30 | 3.050 | 0.081 |
| | | 100.0% | 90.9% | | NS |
| | Failure | 0 | 3 | | |
| | | 0.0% | 9.1% | | |

NS, not significant

the pulpotomy of deciduous teeth in their review. The main consideration in electrosurgical pulpotomy is lateral heat production, an interval time between applications that allows cooling of pulp tissues as the heat build-up might lead to side effects.[25] In this study, the electric current was delivered for not >2–3 seconds, followed by a cool time of 5 seconds, as done by Yadav et al.[6] in their study. The tip was placed 1–2 mm away from the radicular pulp stumps to minimize the heat and electrical transfer to pulpal tissue and structure of the tooth and would still allow the occurrence of electrical arcing. The repetition of the procedure was done utmost three times at each pulpal stump for 2–3 seconds to reduce heat build-up in any single area of the tooth. The procedure followed was similar to the studies performed earlier and found to be successful.[6,23,25,35]

This study has revealed 100 and 90.9% overall success rates after a 12-month follow-up in LLDL and electrosurgical pulpotomy groups, respectively, with no significant difference between the two techniques. The results can be correlated with a previous study done by Yadav et al.,[6] where they found no significant difference between the laser and electrosurgical pulpotomy groups. The results, when compared with the previous studies, prove both techniques as successful alternatives to pharmacological pulpotomy techniques.[6,22,23,25,36–40] The LLDL therapy has shown 100% clinical success, which is similar to the results found by Gupta et al.,[23] Yadav et al.,[6] and Durmus and Tabonga[41] in their studies. A total of 100% radiographic success in the laser pulpotomy group was seen in this study which is comparable to the study done earlier by Gupta et al.[23] but does not follow the same pattern as observed by Durmus and Tabonga[41] and Yadav et al.[6] who found 75 and 80% radiographic success respectively. When the success rate is compared to the previous studies, they reveal that LLDL can be an effective alternative to pharmacological pulpotomy techniques.[9,22,23] Electrosurgical pulpotomy has shown 97.1% clinical and 96.8% radiographic success, which corresponds with previous studies done by Bahrololoomi et al.[39] and Dean et al.[38] who have found it as an effective alternative to pharmacological pulpotomies. In the study done by Dean et al.,[38] with postprocedural observation time of 5 months, the success rates were clinically—96% and radiographically—84% for the electrosurgical groups. Similar results were observed by Bahrololoomi et al.[39] in the electrosurgical group at 9 months of the follow-up period.

There was one clinical failure observed in this study where the patient reported pain and mobility at the 1-month follow-up in the electrosurgical pulpotomy group, which can be accredited to a variety of reasons. The reason could be an error in case selection or misdiagnosis of the extent of pulpal pathology, as many authors, after their studies, provided a statement that electrosurgical pulpotomy requires a more sensitive analysis.[38,42–44] The other reasons where failure can also be attributed due to the operator's error or poor fitting stainless steel crown, which is believed to be causing marginal leakage and gingival irritation. This failed tooth was excluded from the study and received treatment according to the necessity of the tooth. A similar finding was also present in the study done by Dean et al.,[38] which was excluded and treated as needed.

Another failure in the electrosurgical group was observed at the 9-month follow-up, where both clinical and radiographical signs of failure were observed. The tooth presented with pain periodontal space widening and with furcal radiolucency. Though the patient's guardian gave a history of pain caused by chewing hard food, other reasons cannot be ruled out, including the ones mentioned above. In the study done by El-Meligy et al.,[24] after a period of 2 weeks, an acellular periodontal ligament was observed. They assumed that it might have been from the accumulation of excessive lateral heat causing resorption and necrosis. This was affirmed by Shulman et al.[44] as a comparable response observed in their research. They also predicted that the accessory canals transferred heat to the pulp floor of the molars may have been accountable for the widening of the periodontal ligament.

At the follow-up of 12 months, one radiographic failure was seen in the electrosurgical group. There was radiographic finding showing external and internal root resorption without any clinical failures. According to the research conducted by Ranly,[45] internal resorption might occur due to injury to the residual tissue caused by inflammation of the residual pulp. Shulman et al.[44] concluded that the affected radicular pulp present close to the site of amputation is responsible for internal resorption. The authors acknowledged that the main culprit was the electric currents traveling down the canal and the necrotic pulp tissue altering the metabolism of cementoclasts and dentinoclasts. This phenomenon can be explained by the fact that electrical current follows through the root canal, which is the path of least resistance. Based on the radiographic finding, the pulpotomy of the tooth was accounted for as a failure. Severe infiltration of the inflammatory cell was also observed by Law[46] and Shulman et al.[44] in the coronal one-third portion of the radicular pulp following electrosurgical pulpotomy, indicating incomplete healing despite the achievement of dentinal bridge formation.

The noninvasive and nonpharmaceutical nature of laser pulpotomy can be accredited for 100% clinical success in this study as they do not have side effects. It leads to decontamination and sterilization of the radicular pulp simultaneously with its preservation, controlling hemorrhage efficiently and faster pulpal wound healing.[9,29] In spite of failures encountered in the electrosurgical pulpotomy group, the technique resulted in a comparable number of successes with no significant difference from the LLDL group. The overall clinical and radiographic success of both groups is appreciable and provides a direction towards the utilization of nonpharmacological pulpotomy in regular clinical practice. These techniques not only provide a faster treatment approach, but the use of the equipment adds an additional interest in the treatment amongst the children of higher age groups though the opposite was anticipated at the beginning of the study. Although younger patients presented with initial apprehension towards treatment but the use of appropriate euphemisms led to better patient compliance was observed in the study with few deviations from the regular observation.

Future studies can also include histopathological changes observed in both the groups and success and failure evaluated on the additional criteria. Moreover, the initial high cost of setting up of laser unit and electrosurgical equipment is a drawback. Although, that can be compensated as it is a one-time investment and can be used for various other purposes.

## Conclusion

On the basis of observations of the present study, the conclusion can be drawn that either LLDL or electrosurgical pulpotomy can be utilized as viable nonpharmacological pulpotomy techniques in day-to-day pediatric dental practice.

### Clinical Significance

This study further establishes nonpharmacotherapeutic pulpotomy techniques as a better alternative to traditional pharmacological methods with a high success rate and minimal risk factors.

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