EUROPEAN ENDODONTIC JOURNAL

ORIGINAL ARTICLE

The Outcome of GaAlAs Diode Laser (980 Nm) Pulpotomy in Patients with Symptomatic Irreversible Pulpitis Assessed Using CBCT – Randomised Controlled Trial with an 18-Month Follow-up

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ABSTRACT

Objective: To evaluate the effect of diode laser (GaAlAs-980 nm) for full coronal pulpotomy (FCP) compared to conventional crown pulpotomy (CCP) in mature teeth with symptomatic irreversible pulpitis (SIP) and assess dentine bridge formation after FCP using CBCT.

Methods: A total of 86 patients (43 per group) with SIP in permanent mandibular molars were included. Access opening and FCP were done, after which haemostasis was achieved with 2.5% NaOCl in the CCP group and a diode laser (GaAlAs-980 nm) in the laser crown pulpotomy group (LCP). Biodentine (Septodont, Saint-Maur-des-Fossés, France) was placed, and the cavity was sealed. Clinical and radiographic follow-ups were done at 6, 12, and 18 months, with additional CBCT evaluation at 18 months. Statistical analysis was performed using the Mann-Whitney U test, and survival rates were assessed using Kaplan-Meier analysis. The Cox proportional model was used to determine the effect of possible covariates on pulpotomy outcomes. $P<0.05$ was considered to be statistically significant.

Results: The overall success rate for CCP and LCP at 18 months was 88.4% and 93% respectively. At the end of 18 months, 8 cases (5 in CCP, 3 in LCP) failed. The postoperative pain score at 48 hours was significantly higher for CCP (mean ± standard deviation: 1.7±1.4; $p<0.001$). CBCT analysis at 18 months revealed thicker dentine bridge formation for LCP (Median & IQR: 0.89, 1.06) compared to CCP ($p=0.0479$). The Kaplan-Meier curve showed a more rapid decline in the survival rate of CCP (0.89) compared to that of LCP (0.93). Postoperative pain at 48 hours, PAI scores at 6, 12, 18 months, and age were found to affect the hazard ratio based on the Cox regression model.

Conclusion: Within the limitations of this trial, there was no significant difference in the outcome between diode laser and conventional pulpotomy. However, LCP resulted in lesser postoperative pain at 48 hours and thicker dentine bridge formation at 18 months, with a longer estimated survival rate.

Keywords: Biodentine, diode laser, full coronal pulpotomy, gallium aluminium arsenide laser, irreversible pulpitis, laser pulpotomy

HIGHLIGHTS

- GaAlAs diode laser-assisted pulpotomy may be a reliable alternative to pulpectomy in mature permanent teeth with vital inflamed pulps.
- Laser-assisted pulpotomy was shown to have lesser postoperative pain.
- Thicker dentine bridge formation following laser-assisted pulpotomy may indicate a better prognosis for such teeth.

Please cite this article as: Swetha D, Ballal S, Sundar S, Vasudevan A, Natanasabapathy V. The Outcome of GaAlAs Diode Laser (980 Nm) Pulpotomy in Patients with Symptomatic Irreversible Pulpitis Assessed Using CBCT – Randomised Controlled Trial with an 18-Month Follow-Up. Eur Endod J 2024; 9: 35-43

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Received January 27, 2023,
Revised July 01, 2023,
Accepted August 01, 2023

Published online: December 26, 2023
DOI 10.14744/eej.2023.72687

INTRODUCTION

The preservation of pulp vitality is essential for maintaining tooth functionality and immuno-competency (1). There is a resurgence of vital pulp therapy (VPT) procedures for managing cariously exposed pulp (2). Recent systematic reviews and meta-analyses suggest that full coronal pulpotomy (FCP) has success rates similar to conventional root canal therapy (92% – 94%) in mature teeth with symptomatic irreversible pulpitis (SIP) at the end of 12 months and can thus be considered as an effective alternative treatment (3–5).

Sodium hypochlorite (NaOCl) (2.5% – 5.25%) is commonly used as a haemostatic and disinfecting agent during FCP (3, 6). However, NaOCl may have adverse effects, such as cytotoxicity to the superficial layers of the pulp tissue (7) and a deproteinising effect on dentine (8). On the other hand, diode lasers exhibit good haemostasis and other advantages, such as bio-stimulation and antimicrobial properties with minimal alteration to the pulp tissue (9, 10). Diode lasers are near-infrared lasers operating at wavelengths of 810 – 980 nm (9, 10), and being a contact-type laser, only tissues in the immediate subjacent area are affected in a selective, precise manner (11), consequently preserving the remaining radicular tissue (12, 13).

The use of diode lasers in endodontics has witnessed varying waves of interest. It was initially studied for root canal disinfection either directly or as an irrigant activation method (14). However, interest shifted to mid-infrared lasers such as Er:YAG for irrigant activation systems like photon-initiated photoacoustic streaming (PIPS) due to their higher absorption in water-based solutions (14, 15). Meanwhile, diode laser retained interest in other modalities, such as controlling postoperative pain (16, 17), and VPT. Clinical studies on using laser as an adjunct for pulpotomy in primary teeth have been successful (13, 18). However, literature regarding the same is scarce in permanent teeth, warranting the need for research on this topic.

Pulpal regenerative materials that can avoid re-infection and aid in radicular pulp healing are essential for the long-term clinical success of pulpotomy (19). Hydraulic calcium silicate-based cements (HCSCs) have been suggested for VPT as they induce faster, thicker and non-porous hard tissue barrier (20). Mineral Trioxide Aggregate (MTA) has been used in earlier studies to induce calcific barrier formation (6, 20). However, the longer setting time (>2 hours), poor handling properties and dyschromia are some shortcomings of MTA (19). BiodentineTM (Septodont, Saint-Maur-des-Fossés, France) claims to have a faster set and better seal, with osteogenic and bioactive properties (20, 21). Furthermore, it has shown promising results for VPT procedures in mature teeth by promoting tertiary dentinogenesis (21–23).

Most studies have evaluated pulpotomy outcomes using clinical and 2-dimensional (2D) radiographic criteria (3, 4, 6, 22). Nonetheless, 2D radiographs do not provide an accurate evaluation of periapical health (3). Cone-beam computed tomography (CBCT) is highly sensitive in detecting early periapical lesions (24) and can also aid in qualitative and quantitative assessment of reparative dentine formed after VPT (25, 26).

Hence, this randomised controlled trial (RCT) aimed to evaluate the efficacy of diode laser (GaAlAs-980 nm) for FCP compared with conventional pulpotomy in mature teeth with SIP using CBCT. The null hypothesis (H0) tested was that there is no significant difference between the outcomes of conventional crown pulpotomy (CCP) or laser crown pulpotomy (LCP) in mature teeth with SIP.

MATERIALS AND METHODS

This study was designed as a single-blind, prospective, non-inferiority, parallel-arm RCT and conducted following the Declaration of Helsinki. It was approved by the Institutional Ethics Committee (MADC/IRB-XVII/2017/317) and registered with the Clinical Trial Registry of India (CTRI/2019/09/021443). All patients were informed of the risks and benefits of the procedure, and consent was obtained before treatment. The Consolidated Standards of Reporting Trials (CONSORT) 2010 guidelines were adhered to during the trial (Fig. 1). Intraoral periapical (IOPA) radiographs were taken using film holders and paralleling technique. Pain intensity was scored before and after treatment using the Visual Analog Scale (VAS) in cm.

Selection of Patients

Patients who presented with a deep carious lesion with spontaneous pain on clinical examination were subjected to pulp sensibility testing using an electric pulp test (EPT), cold testing using Endo Ice (Coltene/Whaledent Inc., Cuyahoga Falls, OH, USA), and preoperative IOPA radiographs. The presence of lingering pain on pulp testing and radiographic involvement of the pulp confirmed a diagnosis of SIP.

Inclusion Criteria

Healthy adult patients (ASA Class I) between 18–40 years were included (27). Mature permanent mandibular molars with SIP having a preoperative pain (VAS) score of 0–4 and radiographic periapical index (PAI) score of 0–1 were chosen. The tooth was selected only if it was restorable and the probing pocket depth and mobility were within normal limits.

Exclusion Criteria

Medically compromised patients, pregnant and lactating mothers, were excluded from the trial. Teeth with gross decay, necrotic pulp, resorption, subgingival caries, and uncontrolled bleeding following pulpotomy were also excluded. Patients who did not respond to inferior alveolar nerve block (IANB) after local anaesthesia were excluded. Patients not eligible to be enrolled in the study received the appropriate treatment according to ethical regulations.

Procedure

All procedures were carried out by a senior postgraduate student trained to perform the pulpotomy. An IANB with 2% lignocaine in 1:80000 adrenaline (Indoco Remedies Ltd. Mumbai, India) was used to anaesthetise the tooth being treated.

Following rubber dam isolation, the tooth was disinfected using 2.5% NaOCl (Parcan Septodont, New Delhi, India). In teeth with proximal lesions, caries was excavated, and a pre-endodontic build-up was done using Tetric N-Ceram resin com-

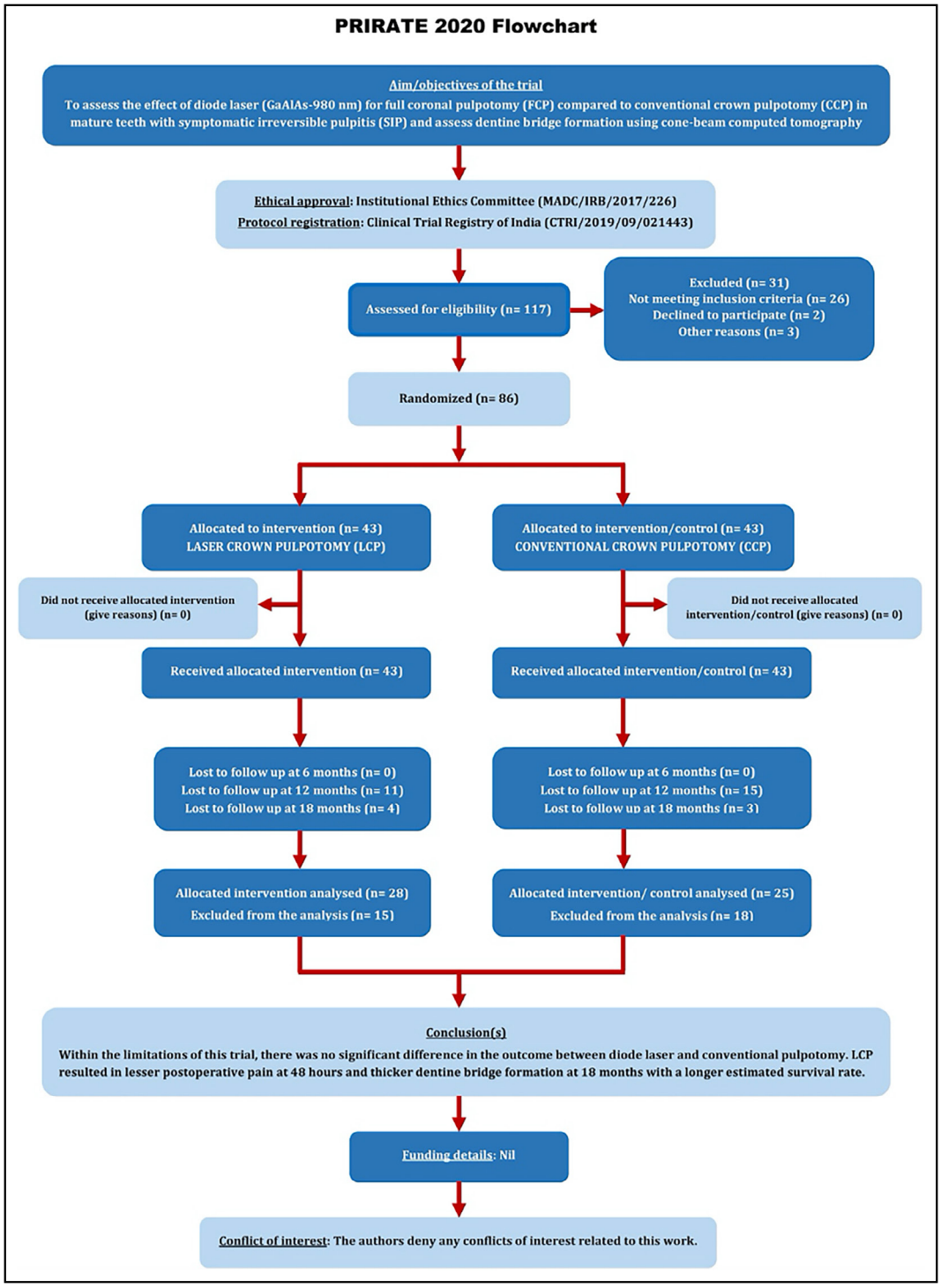

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) flowchart

posite (Ivoclar Vivadent AG, Schaan, Liechtenstein). Access opening was performed under the dental operating microscope (Labomed Prima DNT, Haryana, India) with a high-speed handpiece and #2 sterile round bur (Prime Dental, Mumbai, India). The exposed coronal pulp was amputated gently using a slow-speed handpiece with sterile round bur #2 and water coolant up to the level of the root canal orifices (3).

The tooth was randomised to the CCP or LCP group using a computer-generated simple block randomisation (www.randomizer.org). Allocation concealment was done using sequentially numbered opaque sealed envelopes (SNOSE). An assessor not involved in the trial recorded details of the allocated group. It was possible to blind only the outcome assessor, as neither the patient nor the operator could be blinded due to the nature of the interventions. A total of 86 patients were included in the study, with 43 allocated to each intervention group.

CCP: Haemostasis was achieved using a small moist cotton pellet dipped in 2.5% NaOCl placed on the exposed pulp with gentle pressure for 5 to 10 minutes until the arrest of bleeding (3) (Fig. 2).

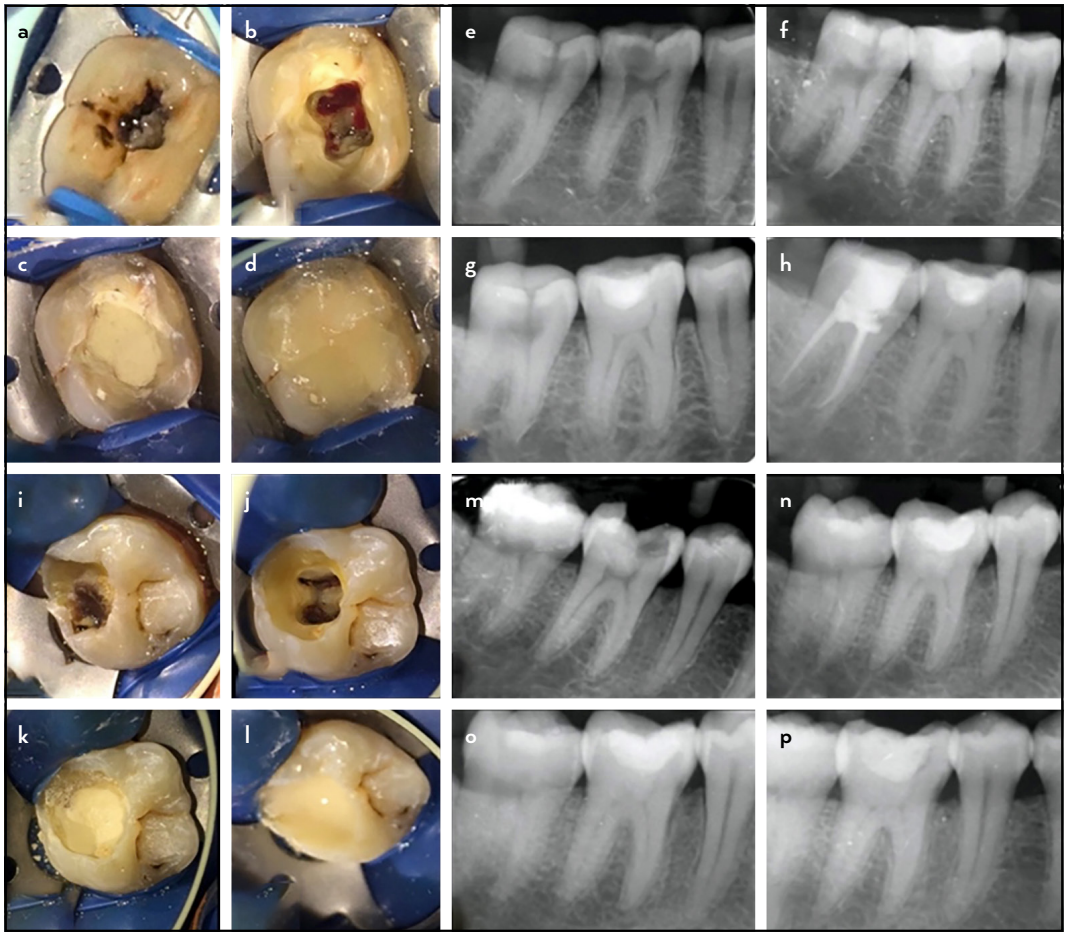

Figure 2. Representative clinical pictures and radiographs of treatment done in conventional CCP group (a-h) and LCP group (i-p); (a, i) Preoperative image of a permanent mandibular molar, (b) Haemostasis with 2.5% sodium hypochlorite in CCP group, (j) Haemostasis with GaAlAs diode laser (980 nm) in LCP group, (c, k) Biodentine placement, (d, l) Layering with GIC followed by resin composite restoration; (e, m) Preoperative radiograph, (f, n) Immediate postoperative radiograph, (g, o) 6 month follow-up, (h, p) 18 month follow-up

CCP: Conventional crown pulpotomy, LCP: Laser crown pulpotomy, GIC: Glass Ionomer Cement

LCP: Laser protective eyewear was provided for the patient, operator, and assistant. Initially, the cavity was dried with a small moist cotton pellet, and haemostasis was achieved using the 980 nm, 1.5 Watt GaAlAs diode laser for 4 seconds on each root orifice using a 200-micron fibre tip (28). Following the laser application, a thin, sterile char was observed over the exposed pulp tissue (Fig. 2).

In both groups, once haemostasis was achieved, 3–4 mm of BiodentineTM was gently packed over the exposed pulp, and this was confirmed radiographically (3). This was followed by layering with Fuji IX Glass Ionomer Cement (GIC) (GC Corporation, Tokyo, Japan) and permanent restoration with Tetric N-Ceram resin composite. Postoperative pain scores were recorded at 48 hours using VAS (rating: 1 to 10). The patients were recalled and asked to point to their pain score on a VAS diagram. This consisted of a 10 cm ruler with two labels of 'no pain' and 'most intense or worst pain' on the scale's extreme left and right ends (29). VAS was chosen as it is simple to apply and is more sensitive to small changes (30). It is considered the most reliable and valid tool for self-reporting of pain (29). It quantifies pain as mean scores among patients with similar conditions (29, 30). If the patient presented with severe pain (VAS≥7), root canal therapy was initiated at the follow-up visit, and the case was recorded as a failure in this trial.

Outcome Assessment

Postoperative follow-up evaluation was performed in the 6th, 12th and 18th month. Post-treatment sensibility testing (EPT and cold test) was done at each follow-up visit. At the end of 18 months, a limited volume CBCT (Planmeca Promax 3D Proface, Helsinki, Finland) was taken with the settings 90 kVp, 10 mA, 5×5 cm, voxel size of 75 µm to evaluate the thickness of calcific barrier formation as well as the periapical status. Orstavik's periapical index (PAI) was used to evaluate the periapical status on IOPA radiographs, while Estrela's criteria was used for CBCT assessment of the periapical status at 18 months (CBCTPAI). Dentine bridge thickness was assessed using the upper and lower limit of pulp density in each section where Biodentine was placed (31).

The evaluation using IOPA and CBCT was performed by 2 pre-calibrated, blinded endodontists. The digital images were viewed on a 23-inch monitor (Dell, Texas, USA) with a resolution

TABLE 1. Pain score at 48 hours postoperative follow-up using Mann-Whitney U test

Group	n	Mean	SD	p
CCP	43	1.67	1.43	<0.001**
LCP	43	0.40	1.23	

**: Statistically highly significant. n: number, SD: Standard deviation, CCP: Conventional crown pulpotomy, LCP: Laser crown pulpotomy

of 1920×1080 in a darkroom. Interoperator reliability scores were calculated using Cohen-Kappa statistics. Any disagreements were clarified by discussion with a senior endodontist.

Outcome Measures

The treatment was successful when clinical and radiographical success was present (32). An intact coronal seal on the treated tooth with no pain, swelling, sinus tract and tenderness to percussion was considered a clinical success. The case was considered radiographically successful when there was no widening of PDL space, external or internal root resorption, formation of a new periapical lesion or increase in the size of pre-existing radiolucencies.

Statistical Analysis

Statistical analysis was performed using Stata/SE 17.0 statistical software (StataCorp., Texas, USA). The intergroup comparison for postoperative pain at 48 hours between the CCP and LCP groups was performed using the Mann-Whitney U test. The normality assumption for 'dentine bridge thickness' was rejected as per the results of the Shapiro-Wilk test. Thus, intergroup comparison for this variable was also performed using the Mann-Whitney U test. 'Hedge's g' after applying "Hedge's and Olkin's bias correction factor" was used to quantify the effect measure pertaining to the study variable 'dentine bridge thickness'.

A Kaplan-Meier graph was generated to visually represent the mean survival rates at a certain time interval for both groups (33). The 'survival table' or 'lifetable' was generated to calculate the survival rate and its 95% confidence interval during different time intervals (2 days, 6, 12 and 18 months) defined within the overall study period (33). 'Exponentially extended survival function' was performed to compute an 'Ad-hoc approximation' of the mean survival time for both groups.

The Cox proportional hazards model was used to determine the effect of possible covariates such as age, gender, postoperative pain after 48 hours and PAI score at different periods (6, 12 and 18 months) on the overall hazards ratio (33). S(t)-curve function was used to generate the estimated failure or survivor function plot for both groups pertaining to a particular covariate after fitting the Cox proportional hazards model.

RESULTS

A total of 117 patients presenting with deep caries were screened, out of which 86 patients (48 female and 38 male) with a mean age of 29.6 years were included after meeting the eligibility criteria. At the end of 18 months, only 53 patients were evaluated due to considerable loss to follow-up (Fig. 1).

TABLE 2. Comparative evaluation of dentine bridge thickness in CBCT at 18 months using Mann-Whitney U test

Group	Median	IQR	Effect size	p
CCP	0.51	1.01	–0.46 (95% CI; –1.04, 0.127)	0.0479*
LCP	0.89	1.06	–0.44 (95% CI; –1.03, 0.14)	

*: Statistically significant. IQR: Interquartile range, CI: Confidence interval

The overall success rate at 18 months was 88.4% for the CCP and 93% for the LCP groups. Pulp sensibility testing was positive in 79% of teeth in CCP and 88% of teeth in LCP. At the end of 18 months, 8 cases (5 in CCP and 3 in LCP) were considered failures requiring root canal therapy or extraction. Among these, 2 failed at 1 week and 1 month due to tooth fracture, swelling and pus discharge (1 in each group), while the other 6 failures occurred between the 12 and 18-month review period.

The mean preoperative VAS score was 3.2. A statistically significant difference was noted between CCP and LCP ($p<0.001$) for postoperative pain scores at 48 hours, with higher scores for CCP (Table 1).

The inter-observer reliability was 0.91 for the IOPA radiographic assessment and 0.89 for the CBCT assessment. No new periapical radiolucencies were noted in either of the groups ($p>0.05$) on IOPA radiographs at 18 months, with PAI>3 recorded only in the 8 failed cases. CBCT assessment of periapical status at 18 months did not reveal any newly developing or expanding apical radiolucencies in any patients. No root resorption or pulp canal obliteration was detected in both groups for all the patients.

CBCT evaluation for calcific barrier formation at 18 months revealed that dentine bridge formation was evident in 97% of the cases (Fig. 3). Intergroup comparison showed higher dentine bridge thickness values for LCP ($p=0.0479$) (Table 2, Appendix 1).

A greater survival rate was noted for LCP compared to CCP at the end of the study period (Table 3). The restricted mean survival function "rmean" showed a mean survival rate of 494 days for CCP and 519.35 days for LCP (Appendix 2). The exponentially extended survivor function "emean" estimated the approximate mean survival time for CCP to be 4354.48 days and for LCP to be 7465.16 days (Appendix 3).

The Kaplan-Meier survival analysis showed a more rapid decline in survival rate (0.89) for the CCP group during the 6-month review, following which the curve remained flat for the rest of the study period. The LCP group showed a slight decline in survival rate (0.93) only during the 12-month review (Fig. 4).

Cox regression using the Breslow method showed that postoperative pain at 48 hours and PAI scores at 6, 12, and 18 months and age affected the hazard ratio significantly (Table 4, Appendix 4). For these covariates, a decreasing trend in survival rates was observed for both groups with time. With respect to gender, males had a better survival rate for both groups, though not a significant covariate ($p=0.278$).

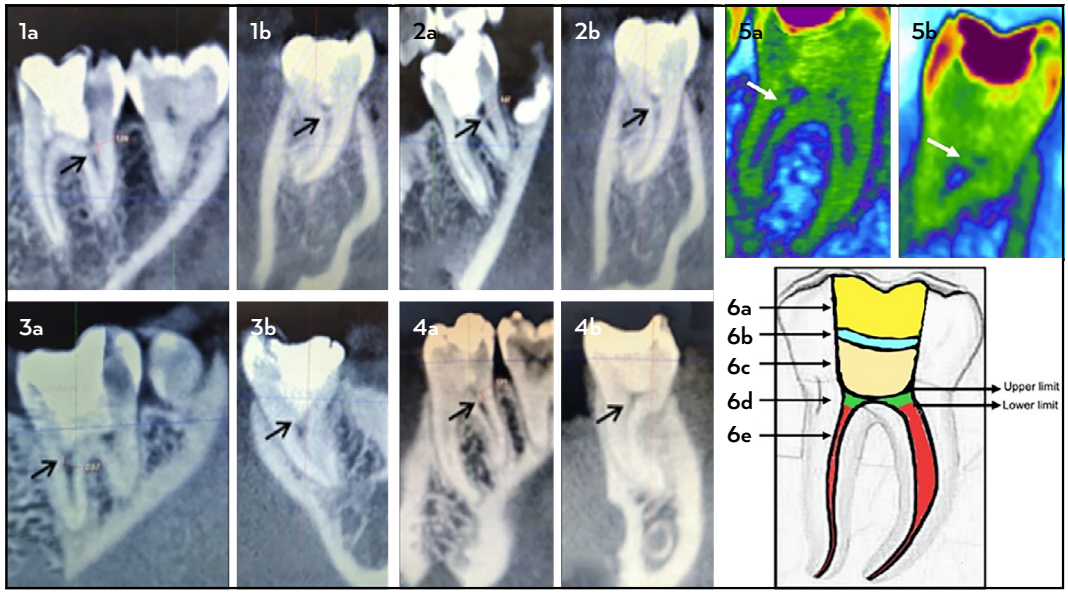

Figure 3. CBCT assessment of periapical status and dentine bridge thickness at 18 months each in the (a) sagittal and (b) coronal sections; CCP group: (1a, 1b and 2a, 2b) and LCP group: (3a, 3b and 4a, b); (5a,b): Contrast image of CBCT showing continuous bridge of mineralisation in green colour beneath the Biodentine in sagittal and coronal sections respectively. Diagrammatic representation for measurement of dentine bridge in CBCT (6a) resin composite (6b) glass ionomer cement, (6c) Biodentine, (6d) dentine bridge, (6e) radicular pulp

CBCT: Cone-beam computed tomography

DISCUSSION

This randomised clinical trial assessed the influence of GaAlAs diode laser (980 nm) on FCP compared to conventional pulpotomy using NaOCl in human permanent mandibular molars with SIP. Apart from clinical and 2D radiographic assessment for the success of pulpotomy, a limited volume CBCT was also used to assess radiographic success and the thickness of dentine bridge formation. A robust methodology with simple block randomisation, 1:1 allocation and SNOSE was used to reduce selection bias.

The overall clinical and radiographic success rate of pulpotomy was found to be 90.7% at 18 months, which is comparable to the results of Tan et al. (23). The success rate in this study was slightly higher than previous studies reporting 87.3% (34) and 89.8% (35) success using MTA, and 87% success using Biodentine (22) at 1 year. However, the success rates of this trial were slightly lower than that reported by Taha & Abdulkhader (3) and Rechithra et al. (12). The marginal variation in results between these studies could be due to differences in materials used, techniques followed, site of the carious lesion, operators' efficiency and the type of teeth selected (3, 12, 22, 34, 35).

A recent study showed 95.5% success at 12 months when a combination of laser and MTA was used for partial pulpotomy in immature permanent molars (5). In our study, LCP showed a higher percentage of success (93%) than CCP (88.4%), but this was not significant. The higher success rate of LCP can be attributed to the diode laser's ability to enhance cellular motility and mesenchymal cell proliferation, thereby promoting the healing of inflamed pulp tissue (18, 36). Literature regarding the use of

TABLE 3. Survival table by type of pulpotomy

Interval		Beg. total	Deaths	Lost	Survival	SE	95% CI	
							Lower bound	Upper bound
Conventional Crown Pulpotomy (CCP)								
2	3	43	1	0	0.97	0.23	0.84	0.99
180	181	42	4	0	0.88	0.48	0.74	0.94
540	541	38	0	38	0.88	0.48	0.74	0.94
Laser Crown Pulpotomy (LCP)								
2	3	43	1	0	0.97	0.23	0.84	0.99
365	366	42	2	0	0.93	0.38	0.79	0.97
540	541	40	0	40	0.93	0.38	0.79	0.97

Beg: Beginning, SE: Standard error

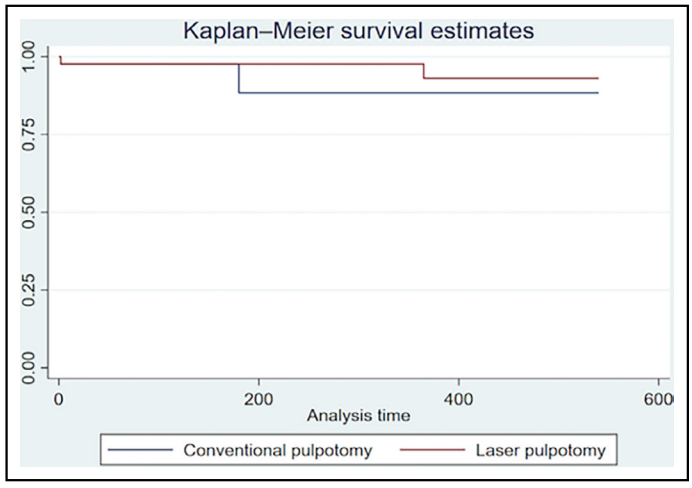

Figure 4. Kaplan-Meier survival analysis

diode laser as a haemostatic agent in human permanent teeth pulpotomy is scarce, and the duration of exposure to a laser for FCP has not been standardised. However, previous studies suggest that odontoblasts undergo regressive changes if exposed to a laser for more than 5 seconds (28, 31). Hence, in this study, the diode laser was used in continuous mode for 4 seconds at each root orifice (3-Watt power with 50% duty cycle).

Regarding postoperative pain scores at 48 hours, 75% of patients in the LCP group experienced lesser pain than the CCP group (25%) in this trial. The reduction in postoperative pain may be attributed to the diode laser's anti-inflammatory effect, which decreases chemical mediators like prostaglandins, substance P and others (36, 37). Pulp sensibility was also recorded at each follow-up visit in this study, with variable results in both groups. However, pulp testing may result in false responses and may be considered unreliable (1, 38), highlighting the need for continued review (39).

The long-term maintenance of pulp vitality following pulpotomy depends on the final restoration's quality and seal (23). The loss of coronal restoration leading to pulpotomy failure was noted in 6 of the 8 failed cases in this trial. Failures can be divided into early or immediate, and late or delayed (23). In this study, 2 cases had early failures, which eventually required an endodontic intervention within the first month of FCP. Additionally, 6 had late failures, with loss of coronal restoration being the only cause. These results agree with long-term outcomes assessed over a 5-year period by Tan et al. (23), who noted that loss of the definitive coronal restoration was a crucial factor contributing to a delayed failure in pulpotomy cases.

The site of the carious lesion may also influence the degree of pulpal inflammation and postoperative contamination (40). In this study, amongst the failed cases, 6 were proximo-occlusal. Thus, as reported in previous studies (3, 12), the site of caries could have contributed to the treatment failure.

The 3-dimensional (3D) assessment of dentine bridge formation and periapical status using CBCT as an adjunct may be more relevant and accurate (21), justifying its use in the current study. In this trial, there was no significant difference with regard to periapical scores between the CCP and LCP groups on both IOPA and CBCT evaluation at 18 months. A periapical lesion was seen in the 8 failed cases, while no new or expanding lesions were evident in the other cases, thereby deeming them successful (39).

In our study, the 18-month CBCT assessment revealed the presence of a calcific barrier in 97% of the cases. The newly formed column of the dentine bridge appeared to be continuous with no evidence of pulp calcifications. On quantitative assessment, it was found that the average thickness of the dentine bridge formed in the LCP group (0.89 mm) was higher than CCP (0.51 mm). Thus, using a diode laser exhibited a positive influence on biomineralisation. Nevertheless, histopathologic evaluation can illuminate the nature of the mineralised tissue formed, as it remains the gold standard for assessing dentine bridges (21).

In this trial, we performed a survival analysis to determine the estimated time to failure by using a robust statistical analysis model (33, 41). Based on this analysis, the likelihood of LCP having a better survival probability than CCP was higher. The Cox regression analysis showed that age, postoperative pain at 48 hours and PAI scores at 6, 12, and 18 months affected the hazard ratio. Similar to the results reported by Anta et al. (22), a decreasing trend in survival rate was observed as the patient's age increased. However, the influence of these covariates on the outcome of pulpotomy needs to be verified in future studies.

TABLE 4. Cox proportional hazard regression model

Covariate assessed	Hazard ratio	Z	p> |Z|	95% CI	
				Lower bound	Upper bound
Pulpotomy	0.37	–1.20	0.23	0.07	1.86
Age	1.17	3.10	0.002**	1.06	1.30
Gender	0.41	–1.08	0.28	0.08	2.04
Postoperative pain at 48 hours	1.65	4.16	<0.001**	1.30	2.10
PAI score at 6 months	5.19	4.61	<0.001**	2.57	10.48
PAI score at 12 months	4.58	4.87	<0.001**	2.48	8.46
PAI score at 18 months	3.99	4.41	<0.001**	2.16	7.39

*: Statistically significant, **: Statistically highly significant. PAI: Periapical index

This is the first study to have evaluated the efficacy of GaAlAs diode lasers for FCP in permanent teeth with SIP using CBCT. In accordance with other RCTs, a 30% dropout rate was observed at 12 months, remaining consistent up to 18 months in this trial. The dropout rate must be considered when considering the current study's results. When patients are lost to follow-up, the interval-censored observation between the initial visit and the review cannot be determined, which may affect the outcomes assessed and the generalisability of the results (33). The relatively high dropout rate of participants in this trial may have been due to their attitude towards dental care, relief from pain (22) and inability to report for follow-up due to the COVID-19 pandemic (42). In such an event, the cumulative survival probability as a function of time and influential covariates can be predicted using the Kaplan-Meier and Cox regression survival analysis models (41). This study is the first of its kind survival analysis to be undertaken for the evaluation of pulpotomy outcomes in endodontic literature. It is also interesting to note that the results obtained in this trial used a 980 nm GaAlAs diode laser (200-micron fibre tip) at a power setting of 1.5 watts for 4 seconds on each root orifice. Varying the laser parameters may provide different results, which need to be investigated in future studies.

Future Perspectives

Laser pulpotomy could be an alternative to pulpectomy with reliable outcomes in mature permanent teeth with vital inflamed pulps. 3D imaging with CBCT may help evaluate dentine bridge formation and the periapical health status following pulpotomy. Future studies should thus consider using a limited volume CBCT as a routine diagnostic aid for the long-term outcome assessment of pulpotomy procedures.

A recent histologic study noted that as the depth of the carious lesion increased (deep versus extremely deep), the level of bacterial penetration and intensity of pulpal inflammation was correspondingly higher (43). Thus, the judicious selection of cases with standardised clinical and radiographic criteria is crucial for the long-term success of VPT procedures (38, 44). Furthermore, the timing of the permanent restoration (44), maintenance of a good coronal seal and periodic recall and review of teeth receiving pulpotomy (39) is also warranted.

CONCLUSION

Within the limitations of this randomised controlled trial using CBCT assessment in mature permanent teeth with SIP, the results for laser-assisted and conventional pulpotomy were comparable. Nevertheless, LCP resulted in less postoperative pain at 48 hours and thicker dentine bridge formation. The estimated survival at the end of 18 months was also higher for LCP.

Disclosures

Online Appendix Files: https://jag.journalagent.com/eurendodj/abs_files/EEJ-72687/EEJ-72687_(0)_EEJ-2023-01-011_Online_Appendix_Files.pdf

Conflict of interest: The authors deny any conflict of interest.

Ethics Committee Approval: This study was approved by The Meenakshi Academy of Higher Education and Research Ethics Committee (Date: 14/03/2018, Number: MADC/IRB-XVII/2017/317) and registered with the Clinical Trial Registry of India (CTRI/2019/09/021443).

Peer-review: Externally peer-reviewed.

Financial Disclosure: This study did not receive any financial support.

Authorship contributions: Concept – S.B., S.S., V.N.; Design – S.B., S.S., V.N.; Supervision – S.B., S.S., V.N.; Funding - D.S., A.V., S.B., S.S., V.N.; Materials - D.S., A.V.; Data collection and/or processing – D.S., A.V.; Analysis and/or interpretation – D.S., A.V., S.S.; Literature search – D.S., A.V., S.S.; Writing – D.S., A.V., S.B., S.S., V.N.; Critical Review – D.S., A.V., S.B., S.S., V.N.

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