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Clinical Efficacy of Diode Laser for Pulpotomy in Primary Teeth: A Meta-Analysis of Randomized Controlled Trials

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ADMINISTRATIVE INFORMATION

Support - N/A.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 11 April 2025 and was last updated on 11 April 2025.

INTRODUCTION

Review question / Objective To systematically evaluate the efficacy of diode laser for pulpotomy in primary teeth using meta-analysis.

Condition being studied Pulpotomy is a surgical procedure used to treat deep caries exposure, traumatic exposure, or partial pulp infection in primary teeth. When direct pulp capping is not feasible, this surgery involves the removal of coronal pulp tissue under local anesthesia and the application of medication to the pulp wound to preserve the healthy pulp tissue in the root [1, 2]. Commonly used medications include formocresol (FC), ferric sulfate (FS), and mineral trioxide aggregate (MTA). Formocresol was once considered the "gold standard" for pulpotomy in primary teeth [3], but its clinical application is controversial due to the cytotoxicity, teratogenicity, and carcinogenicity of formaldehyde and cresol in its composition [4]. Ferric sulfate solution forms an iron-protein complex upon contact with blood, which mechanically seals the cut vessels, achieving hemostasis and reducing pulp infection and root resorption [5]. However, it has high technical requirements and similar toxicity to formocresol, gradually being replaced by other drugs with better biocompatibility. MTA, due to its excellent marginal adaptation, ability to induce pulp cell proliferation, and formation of high-quality hard tissue barriers, has become the mainstream choice [6]. However, its high cost and strict storage requirements limit its widespread clinical application [7].

In recent years, one of the most innovative and popular advancements in the field of dentistry has been the application of laser technology, including CO2, diode, Nd: YAG, and Erbium lasers, which are commonly used for pulp ablation. Among them, diode laser has received increasing attention in pulpotomy due to its excellent hemostatic effect, strong antibacterial ability, and promotion of wound healing [8, 9]. Diode laser is mainly composed of aluminum, gallium, and arsenic, three excitation elements, and is an efficient laser device. Compared with traditional laser devices,

diode laser instruments have the advantages of small size, high cost-performance ratio, and easy operation, and have been widely used in oral medicine. According to literature review, we have observed the efficacy of various techniques and drugs used in pulp ablation. Previous studies have shown that the success rate of diode laser pulpotomy is significantly higher than that of formocresol pulpotomy [10, 11], but some scholars have also observed contradictory results [12]. Due to inconsistent clinical, radiological, and histopathological results, the clinical efficacy of diode laser pulpotomy still needs further confirmation. Therefore, this study aims to comprehensively evaluate the therapeutic effect and safety of diode laser in pulpotomy of primary teeth through meta-analysis, providing evidence-based medical basis for clinical decision-making.

METHODS

Participant or population All study subjects were children, aged between 2 and 10 years, involving 1018 primary teeth.

Intervention Pulpotomy in primary teeth using diode laser.

Comparator The control group receives conventional treatment without diode laser.

Study designs to be included Following the PRISMA 2020 statement, a systematic search without any filters and limits was conducted in four electronic databases: PubMed, Web of Science, Cochrane Library, and Embase. The search period was from the inception of the database to December 30, 2024. The main search strategy was as follows: ("ablation, laser"[MeSH Terms] OR "laser" OR "diode laser") AND ("pulpotomy"[MeSH Terms] OR "pulpotomy") AND ("primary teeth"[MeSH Terms] OR "deciduous teeth"[MeSH Terms] OR "primary molars"). In addition, target literature was obtained by reviewing the references of the included studies.

Eligibility criteria Inclusion criteria: (1) Studies published in peer-reviewed journals in Chinese and English; (2) Pulpotomy in primary teeth using diode laser; (3) The control group receives conventional treatment without diode laser; (4) Reports on the number of effective and ineffective teeth evaluated by clinical or radiographic examination results; (5) The study design is a randomized controlled trial (RCT). Exclusion criteria: (1) Non-human studies; (2) Observational studies, conference articles, case reports, systematic reviews, and other types of studies; (3) Insufficient outcome information and inability to perform data analysis; (4) Duplicate reporting of literature studies; (5) Studies for which the full text cannot be obtained.

Information sources Following the PRISMA 2020 statement [13], a systematic search without any filters and limits was conducted in four electronic databases: PubMed, Web of Science, Cochrane Library, and Embase. The search period was from the inception of the database to December 30, 2024. The main search strategy was as follows: ("ablation, laser"[MeSH Terms] OR "laser" OR "diode laser") AND ("pulpotomy"[MeSH Terms] OR "pulpotomy") AND ("primary teeth"[MeSH Terms] OR "deciduous teeth"[MeSH Terms] OR "primary molars"). In addition, target literature was obtained by reviewing the references of the included studies.

Main outcome(s) After searching public electronic databases, a total of 1392 studies were included in the literature review process, and the literature screening process is shown in Figure 1. After excluding 701 duplicate studies and 590 irrelevant studies, 101 studies were reviewed in full, and ultimately, this study included 17 qualified studies.We evaluated the clinical success rate of diode laser pulpotomy based on different follow-up times. The heterogeneity assessment showed good homogeneity among the included studies (total: I2=0%; ≤3 months: I2=0%; 6 months: I2=0%; 9 months: I2=0%; ≥12 months: I2=0%), and a fixed-effect model was used for meta-analysis. The overall analysis suggested that diode laser pulpotomy had a similar clinical success rate compared to the control group (RR: 1.01; 95% CI: 0.99-1.03). For different follow-up times, diode laser pulpotomy showed similar clinical success rates compared to the control group at ≤3 months (n=672; RR: 1.01; 95% CI: 0.98-1.05), 6 months (n=822; RR: 1.01; 95% CI: 0.98-1.04), 9 months (n=449; RR: 1.02; 95% CI: 0.97-1.06), and ≥12 months (n=847; RR: 1.01; 95% CI: 0.98-1.05), indicating similar short-term, medium-term, and long-term clinical success rates for diode laser pulpotomy.The heterogeneity assessment showed low heterogeneity among the included studies, suggesting the use of a fixed-effect model for efficacy evaluation (total: I2=0%; ≤3 months: I2=0%; 6 months: I2=0%; 9 months: I2=48%; ≥12 months: I2=47%). Overall, there was no statistically significant difference in radiographic success rates between diode laser pulpotomy and the control group (RR: 0.99; 95% CI: 0.97-1.02). Subgroup analysis by different follow-up times found that compared to the control group, diode laser pulpotomy had similar radiographic success rates at ≤3 months (n=714; RR: 1.01; 95% CI:

0.97-1.05), 6 months (n=889; RR: 0.99; 95% CI: 0.95-1.03), 9 months (n=470; RR: 1.06; 95% CI: 0.98-1.15), and ≥12 months (n=950; RR: 0.95; 95% CI: 0.90-1.01).

Quality assessment / Risk of bias analysis The quality of the RCT studies was assessed using the Cochrane Collaboration Risk of Bias tool. The results showed that the included studies had certain biases in allocation concealment and blinding implementation, while they had lower biases in randomization implementation, completeness of outcome data, selective reporting of study results, and other biases.

Strategy of data synthesis Revman5.3 software was used for statistical analysis. The effect size of the count data was represented by relative risk (RR), and the 95% confidence interval (CI) was used to estimate the range of the effect size. Heterogeneity was judged by I^2 statistics and Q test, with I^20.1 considered to have homogeneity among the included studies, and a fixed-effect model was used for analysis; if I^2>50% or P≤0.1, it was considered that the homogeneity among the included studies was poor, and a random-effect model was used for analysis. Subgroup analysis was conducted based on different follow-up times and different control groups. Funnel plots were used to determine whether there was publication bias among the included studies. If heterogeneity was large, sensitivity analysis was conducted to explore the source of heterogeneity. Unless otherwise specified, the test level was set to 0.05.

Subgroup analysis Due to the differences in control groups used in the included studies, subgroup analyses were conducted based on different control groups to further determine whether there were significant differences in efficacy between diode laser pulpotomy and different controls.
Regarding clinical success rate, the heterogeneity assessment showed low heterogeneity among the included studies, and a fixed-effect model was used for efficacy evaluation (total: I2=0%; FC-ZOE: I2=0%; FS-ZOE: I2=0%; MTA-ZOE: I2=0%; SG-REGIC: I2=0%). Compared to FC-ZOE (n=1590; RR: 1.00; 95% CI: 0.98-1.02), MTA-ZOE (n=389; RR: 1.01; 95% CI: 0.94-1.09), and SG-REGIC (n=200; RR: 0.99; 95% CI: 0.83-1.17), diode laser pulpotomy had similar clinical success rates. Compared to FS-ZOE, diode laser pulpotomy was more likely to achieve clinical success (n=758; RR: 1.04; 95% CI: 1.01-1.07).
Regarding radiographic success rate, the heterogeneity assessment showed low heterogeneity among the included studies, and a fixed-effect model was used for efficacy evaluation (total: I2=0%; FC-ZOE: I2=29%; FS-ZOE: I2=0%; MTA-ZOE: I2=0%; SG-REGIC: I2=0%). Compared to FC-ZOE (n=1590; RR: 0.99; 95% CI: 0.96-1.02), FS-ZOE (n=758; RR: 1.03; 95% CI: 0.99-1.08), MTA-ZOE (n=509; RR: 0.99; 95% CI: 0.92-1.07), and SG-REGIC (n=200; RR: 0.85; 95% CI: 0.66-1.10).

Sensitivity analysis We assessed the presence of significant publication bias among the included studies using funnel plots. The results showed that the included studies were evenly distributed in the upper part of the funnel, with no significant publication bias detected.We found that only four studies had a high risk of blinding implementation. All included studies had a low risk of bias in random allocation, allocation concealment, completeness of outcome data, selective reporting of study results, and other sources of bias.Additionally, the heterogeneity of included studies was evaluated using I2 statistics, and all results indicated the heterogeneity was modest, with I2 ranging from 0% to 48% (most results were 0%). Therefore, we considered the included studies to have an acceptable quality in risk of bias assessment.

Country(ies) involved China - Shaoxing Stomatological Hospital.

Keywords Diode laser; Formocresol, Pulpotomy; Meta-analysis; Randomized controlled trials.

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