ORIGINAL RESEARCH PAPER

Paediatric Dentistry

EFFECT OF INTRACANAL CRYOTHERAPY ON FRACTURE RESISTANCE OF ENDODONTICALLY TREATED PRIMARY TEETH: AN IN VITRO STUDY

KEY WORDS: intracanal cryotherapy; fracture resistance; primary teeth; pediatric endodontics

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ABSTRACT

This in vitro study evaluated the effect of intracanal cryotherapy on the fracture resistance of primary mandibular incisors following root canal therapy. Thirty extracted teeth were randomly divided into two groups (n = 15). Group A received 20 mL of cold saline (2.5°C) for five minutes, while Group B received saline at room temperature. Fracture resistance was assessed using a universal testing machine (Instron 3345, USA), applying vertical force at 1 mm/min until fracture. Teeth treated with cold saline fractured at a mean force of 108.9 N compared to 121.7 N in the control group reflecting a 10.4% decrease ($p < 0.001$). While cryotherapy is effective for postoperative pain control, it may compromise long-term tooth integrity. Clinicians should weigh these implications in pediatric endodontics.

INTRODUCTION

Management of postoperative discomfort is a frequent concern during root canal procedures in the primary dentition. Children often experience pain following endodontic treatment, influenced by both pre-existing pulp or periapical status and procedural variables(Alí et al., 2016; Arslan et al., 2017; Pak & White, 2017). Among the available pain mitigation strategies, such as long-acting anaesthetics, prophylactic medication, modified access techniques, and occlusal adjustments introduction of intracanal cryotherapy has garnered recent attention.(Keskin et al., 2017; Law et al., 2015; Montero et al., 2015; Parirokh et al., 2012; Sathorn et al., 2008)

Cryotherapy operates through rapid cooling, provoking vasoconstriction, diminishing inflammatory mediator release, and subsequently reducing pain transmission and tissue swelling. In vitro research confirms its ability to decrease tooth surface temperature effectively(Christmas et al., 2018; Tuck et al., n.d.). Although the clinical utility of cryotherapy for pain control is established in permanent teeth, its consequences for the physical integrity, specifically, fracture resistance of primary teeth have not been extensively examined.(Vera et al., 2015)

Pediatric teeth possess thinner dentinal walls, broader pulp spaces, and less mineralised enamel compared to the permanent dentition. These structural features could conceivably render them more vulnerable to temperature-induced microstress and structural damage.

This study investigates whether intracanal cryotherapy modifies the vertical fracture resistance of primary mandibular incisors that have undergone root canal therapy.

MATERIALS AND METHODS

Sample Collection & Preparation

Figure 1: Thirty mandibular incisors randomly divided into Group A (cryotherapy) and Group B (control), with 15 teeth in each group

Thirty freshly extracted, single-rooted primary mandibular incisors free from cracks, caries, or previous restorations were selected. To prevent dehydration, specimens were stored in distilled water at 37°C.

The sample size was determined based on an a priori power analysis targeting a two-group comparison of mean fracture resistance using an independent samples t-test. Assuming an effect size of 10% (based on previous literature and pilot data), a significance level (α) of 0.05, and a statistical power of 0.80, a minimum of 13 samples per group was required to reliably detect a clinically meaningful difference. To accommodate possible data loss or procedural errors, the group size was raised to 15 teeth per group. This sample size aligns with precedent in pediatric endodontic in vitro studies and ensures robust statistical confidence.

Root Canal Preparation

The working length was optimized by inserting a #10 K-file until its tip was just visible at the apical foramen, then shortening by 0.5 mm. Biomechanical shaping was performed up to a size #50 K-file utilising the crown-down technique. Each canal was irrigated with 3% sodium hypochlorite and saline after each instrument. After shaping, a 1-minute final rinse with 17% EDTA was employed, followed by drying with sterile paper points.

Periodontal Ligament Simulation

Before embedding, a layer of silicone was applied along the root up to 2 mm below the cementoenamel junction (CEJ) to mimic the periodontal ligament. Each tooth was set vertically in a block of self-cure acrylic resin up to the same level and left for one hour to fully polymerize.

Experimental Group Allocation

Randomization was performed using the coin toss method:

- Group A (cryotherapy): Received a single final irrigation of 20 mL cold saline (2.5°C) over five minutes.
- Group B (control): Received 20 mL saline at room temperature.

Throughout all procedures, embedded specimens and their acrylic bases were maintained in distilled water at 37°C

Fracture Resistance Testing

Each specimen was placed in a universal testing machine

(Instron 3345, Instron Corp., USA). A compressive force was applied vertically at the centre of the incisal edge with a steel chisel-shaped rod, at a rate of 1 mm/min, continuing until clear fracture or catastrophic failure occurred. Force at failure (in Newtons) was recorded.

Figure 3: Mounted specimen in the universal testing machine (Instron 3345, USA) with vertical load application

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics (Version XX, IBM Corp., Armonk, NY, USA). No additional statistical modules were required beyond the core SPSS package for this dataset.

All data were initially assessed for normality using the Shapiro-Wilk test. Group comparisons employed independent samples t-tests, with significance set at $p<0.05$. Outlier detection was performed using boxplots and standardized residuals (z-scores ±3.0). No data points were excluded as no outliers or missing values were identified in the final analysis.

Power and sample size calculations were performed as described by Jain S et al. ("Effect of intracanal cryotherapy on fracture resistance of teeth that have undergone endodontic treatment-An in vitro study," n.d.)(2021), using effect size estimates from their published findings to determine that 15 samples per group would provide adequate power (0.80) at = 0.05 for detecting clinically relevant differences in fracture resistance.

RESULTS

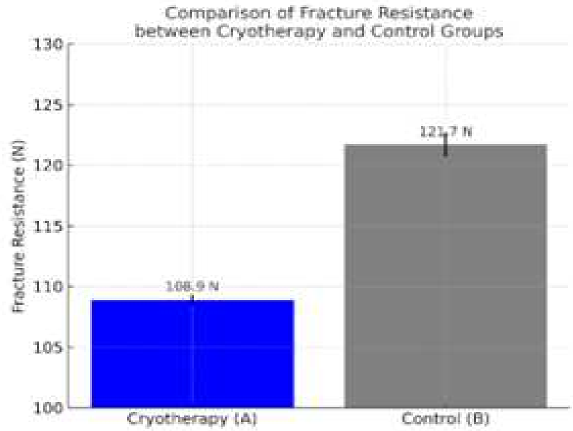
All data points were available for analysis; no values were missing or excluded as outliers.

Cryotherapy exposure resulted in a mean fracture resistance of 108.9 ± 0.4 N (experimental group), while the control group's mean was 121.7 ± 1.0 N. The mean difference was 12.7 N; results were statistically significant ($p < 0.001$).

Table 1. Fracture Resistance Values

Group	N	Mean (N)	SD	95% CI (N)	Mean Diff	p-Value
Cryotherapy (A)	15	108.9	0.4	108.69–109.11	12.7	<.001
Control (B)	15	121.7	1.0	121.16–122.24		

In addition to means and standard deviations, 95% confidence intervals (CIs) were calculated for each group to indicate the precision of the estimated fracture resistance means



Graph 1. Bar chart comparing the mean fracture resistance (N) between Group A (Cold Saline) and Group B (Room Temperature Saline).

DISCUSSION

Our findings indicate that application of cold saline as a final root canal irrigant led to a marked reduction in fracture resistance in primary mandibular incisors compared to irrigation at room temperature. This implies that while cryotherapy may be beneficial for immediate post-treatment comfort, it potentially compromises the long-term mechanical robustness of pediatric teeth.

Primary teeth are inherently more susceptible to damage due to thinner structural walls and larger pulpal spaces. Rapid cooling likely causes differential contraction between enamel and dentin, given their distinct thermal expansion coefficients. Such stresses could initiate or propagate microcracks, increasing the risk of fracture under normal oral function or future restorative procedures.

While statistical analysis confirmed a highly significant reduction in fracture resistance in the cryotherapy group, it is essential to interpret this finding within a clinical context. The observed mean difference of approximately 10% suggests that intracanal cryotherapy, although effective for pain control, could compromise the mechanical durability of primary incisors. This magnitude of reduction may be clinically relevant for pediatric patients whose teeth are already vulnerable due to naturally thinner dentin and enamel structures. Pediatric dentists should therefore weigh the benefits of cryotherapy against the potential for increased fracture risk, particularly in situations where long-term tooth integrity is vital.

These results align with thermal contraction hypotheses and existing data suggesting that excessive temperature changes can diminish the strength of dentin, especially in delicate, developing teeth. Nevertheless, while prior literature highlights the pain-relieving effects of intracanal cryotherapy, clinicians must weigh these benefits against potential risks to tooth survival and function in pediatric populations.(Al-Nahlawi et al., 2016)

A limitation of the present study is its in vitro design, which cannot fully simulate the thermal, mechanical, and biological variability of in vivo oral conditions (e.g., presence of the periodontal ligament, continual hydration, and variable masticatory forces). It is also possible that modifying temperature or duration parameters of cryotherapy could attenuate adverse effects while preserving benefits. Future research must clarify this balance. Advanced imaging techniques such as micro-computed tomography (micro-CT) or finite element analysis may provide further insight into subclinical damage not visible macroscopically.(Al Bast & Abiad, 2024)

Maintaining the integrity of primary teeth is essential for speech, mastication, and preserving space for permanent successors. Thus, interventions potentially increasing fracture risk demand careful consideration and conservative clinical application.

CONCLUSION

In this study, intracanal cryotherapy significantly decreased the vertical fracture resistance of endodontically treated primary mandibular incisors. Dental practitioners should exercise caution when applying cryotherapy as a final irrigant in pediatric endodontic protocols, and further research in actual clinical settings and with varied protocols is recommended.

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