International Journal of Clinical Trials
Rao AS et al. Int J Clin Trials. 2026 Nov;13(4):377-384
https://www.ijclinicaltrials.com
pISSN 2349-3240 | eISSN 2349-3259
DOI: https://dx.doi.org/10.18203/2349-3259.ijct20263253

Original Research Article

Evaluating the effect of cryotherapy on injection pain and onset of action of precooled and warmed local anesthetic agent in symptomatic irreversible pulpitis patients: an *in vivo* study

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Received: 05 August 2026
Revised: 17 August 2026
Accepted: 20 August 2026

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ABSTRACT

Background: Pain is one of the main reasons for patients seeking dental treatment, but fear of pain attributed to injection is cited as an obstacle in providing appropriate dental care. Achieving profound pulpal anesthesia is challenging due to several factors but it is mandatory for successful completion of root canal treatment. To enhance the success rate of inferior alveolar nerve block (IANB) in mandibular teeth with SIP several approaches have been considered. Cryotherapy approach has been routinely employed in clinical settings. Therefore, the study aims to assess the pain at site, onset of action of temperature-controlled anesthetics with intraoral cryotherapy in patients with symptomatic irreversible pulpitis.

Methods: In this double-blind, randomized clinical trial, 45 patients with deep carious lesions having moderate-to-severe pain in the mandibular first molar teeth were selected. Subjects were allocated randomly into various groups based on precooling agent and temperature of local anesthesia (LA): Group I-Normal LA with Lignocaine spray-control group, Group II: Prewarmed LA with Endo ice, Group III: Prewarmed LA with Ice cubes, Group IV: Precooled LA with Endo ice, Group V: Precooled LA with Ice cubes. All participants underwent an IANB, after which the pain at the site and onset of action were compared and evaluated.

Results: Statistical assessment of the data revealed a marked decrease in pain at the site with faster onset of action in Group V.

Conclusions: Cryotherapy application boosted the efficacy of IANB in anesthetizing mandibular molars with SIP.

Keywords: Local anesthesia, Cryotherapy, Symptomatic irreversible pulpitis, VAS

INTRODUCTION

The mandibular first molar is affected by carious lesions more than any other tooth mainly because it is the first permanent tooth to erupt.[1] Symptomatic irreversible pulpitis is an inflammatory disease of pulp implying that the inflamed pulp is unable to heal. Teeth with SIP present with occasional or spontaneous pain that may be throbbing or vague, localized, generalized or transferred to another site, traditionally accompanied by lingering periods of pain after thermal, specifically cold stimulus.[2]

So inferior alveolar nerve block (IANB) is most commonly used nerve block in endodontics to anesthetize mandibular molars for root canal treatment.[1] IANB using lignocaine in mandibular posterior teeth had a failure rate of 44-81%. There are number of causes, including local tissue acidosis brought on by the production of lactic acid and its by products, hyperalgesia offered on by inflamed

pulp, and the most widely recognized explanation is there is increased prevalence of sodium channels that do not respond to tetradotoxin.[3]

Effective pain control during root canal therapy reduces patient fear and anxiety.[4]Although local anesthetics are the most effective drugs in management of pain, this unpleasant may worsen due fear and anxiety caused by the sight of needle and has been referred to as needle phobia.[5] Various methods have been suggested to reduce pain during injections which can be pharmacologic and non-pharmacologic such as application of topical anesthetics, buffering the local anesthetics, adjusting the rate of infiltration, application of heat and cold acupuncture while administering injection and use of mechanical delivery systems.[6]

The term cryotherapy comes from Greek word “cryos”, “cold”. Cryotherapy is widely used as curative treatment in medicine and dentistry and is believed to be effective in reducing edema, bleeding and inflammation. It inhibits the transmission of neural impulses and limits the production of chemical mediators that contribute to pain signaling. Cryotherapy can be used during vital pulp therapy, nerve block, periradicular surgeries, root canal treatment to minimize preoperative and post-op pain.[7]

Topical anesthetic is commonly used before injection to control initial needle penetration pain but the drawbacks are limited duration of effect, unpleasant taste and possible diffusion of anesthetic to unintended areas.[8] Another method for minimizing pain perception is to precool the injection site.[7] Research conducted by Ghaderi et al showed that cooling the injection site for one minute before administering local anesthetic significantly reduced discomfort during infiltration.[9]

Cryoanesthesia is the application of cold to the localized part of body in order to block the local nerve conduction of painful nerve impulses. It can be induced by agents such as refrigerant sprays or with the help of ice. It affects not only the nerve cells but also all cells in applied area, unlike other topical anesthetics and analgesics. Although it affects lasts only briefly, it is adequate to minimize the discomfort experienced during needle insertion.[5] So, the objective of this study is to assess the pain at site, onset of action of temperature-regulated anesthetics combined with intra oral cryotherapy in patients suffering from symptomatic irreversible pulpitis.

METHODS

This study was designed as a prospective, randomized clinical trial with double-blind methodology and initiation of the research took place post approval from the institutional ethics committee (EC/IRB NO: MDC-R-088484) in Department of Conservative Dentistry and Endodontics, Mamata Dental College, Khammam, Telangana between the period of January 2025-March 2025. All participants received comprehensive information regarding the procedure and provided both oral and written consent prior to inclusion in the study.

Inclusion criteria

The study included individuals who presented with deep carious lesions resulting in mild to moderate pain in mandibular molars, were between 18 and 60 years old, and classified as ASA physical status I or II.

Exclusion criteria

Patients excluded from the study were those anxious about treatment, with allergies to lignocaine, a fear of injections, a history of recent cardiac events, those who were pregnant/breastfeeding, had received premedication, or had necrotic teeth with sinus tracts, advanced periodontal disease, poor oral hygiene, dental fractures, or extensive periapical radiolucency exceeding 2 mm.

Randomization and blinding

After clinical and radiographic assessment and confirmation of a positive EPT response for SIP, 45 participants were recruited. To strengthen the validity of results, the study design incorporated a double-blind approach, ensuring that both outcome assessors and participants were unaware of group allocations.

Participants were randomly assigned to five groups using computer-generated sequences, with each group receiving an equal number of allocations (1:1:1:1:1).

Temperature controlled LA

LA was administered at carefully regulated temperatures: pre-cooled solutions were achieved by refrigerating the anesthetic at 4-6°C, while warm solutions were prepared by placing five milliliters of 2% lignocaine in a thermostatic water bath set at 42°C. A separate vial containing the same anesthetic solution was also heated to 42°C. Its temperature was checked with a thermometer to confirm it matched the required level just before administration for the nerve block.

Group I: Normal LA with lignocaine spray-control group

A topical anesthetic agent (Lignocaine) was applied on dried mucosa for one minute using a cotton applicator. Subsequently, a standard IANB was performed utilizing a 27-gauge, 1.5-inch needle with 1.8 mL of 2% lignocaine containing 1:80,000 epinephrine. The anesthetic was slowly administered over two minutes, targeting the mandibular foramen via the coronoid notch (Figure 1).

Group II: Prewarmed LA with Endo ice

Endo ice (1,1,1,2 tetrafluoroethene) was sprayed on to a cotton applicator and applied at injection site for two

minutes followed by injecting prewarmed LA after it has reached body temperature (37°C) (Figure 2).

Group III: Prewarmed LA with ice cubes

Patients in this group received an ice pretreatment of the soft tissue at injection site for 2 minutes using a tube of ice which were made by filling the small finger of a latex glove with water; knotting the open end and then cutting away the rest of the glove and placing the water filled portion in the freezer followed by injecting prewarmed LA after it attained body temperature (37°C) (Figure 3).

Group IV: Precooled LA with Endo ice

As in group 2 Endo ice was used as precooling agent at the site of injection followed by injecting precooled LA (Figure 4).

Group V: Precooled LA with ice cubes

As in group 3 after pretreatment with ice precooled LA was injected (Figure 5).

The initial operator provided local anesthetic solutions and handled group allocation and concealment. A second operator, unaware of the group assignments, evaluated post-injection pain at the injection area using a 100 mm visual analog scale (VAS) right after administration.

Temperature at the injection region was checked both prior to and following the use of the cooling agent via a digital thermometer.

EPT was performed for every 2 minutes until two consecutive negative responses conformed the onset of anesthesia (Figure 6).

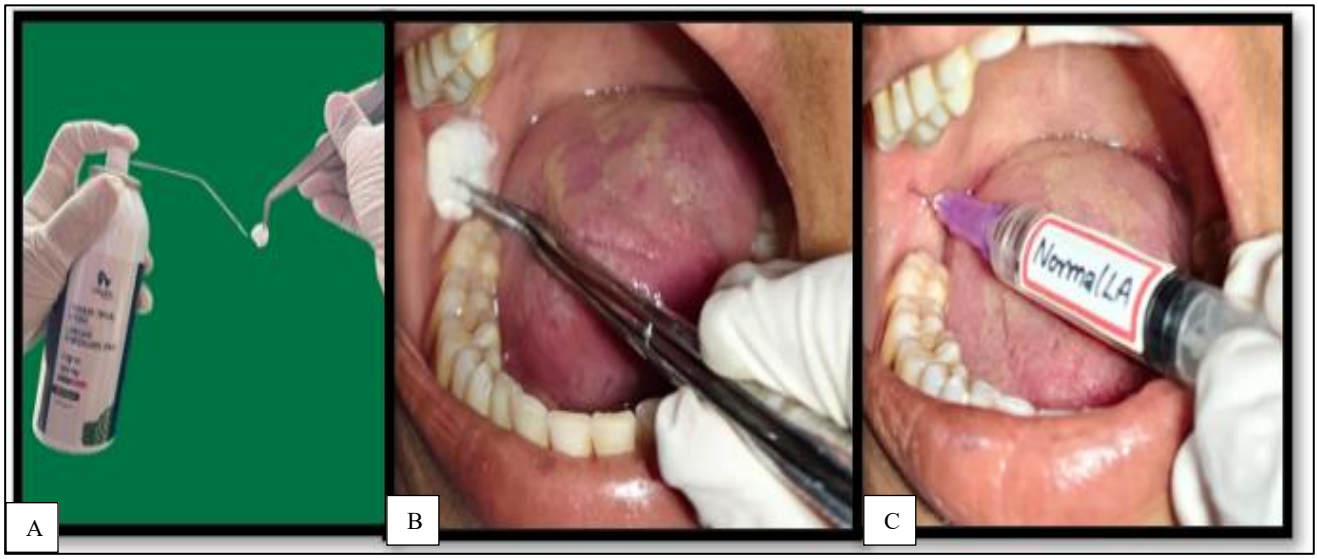


Figure 1 (A-C): Group 1: Topical lignocaine spray is applied to cotton pellet followed by placement at injection site and injection of normal temperature LA.



Figure 2 (A-C): Group 2: Endo frost is sprayed on a cotton pellet and applied at site of injection followed by injecting pre warmed LA.

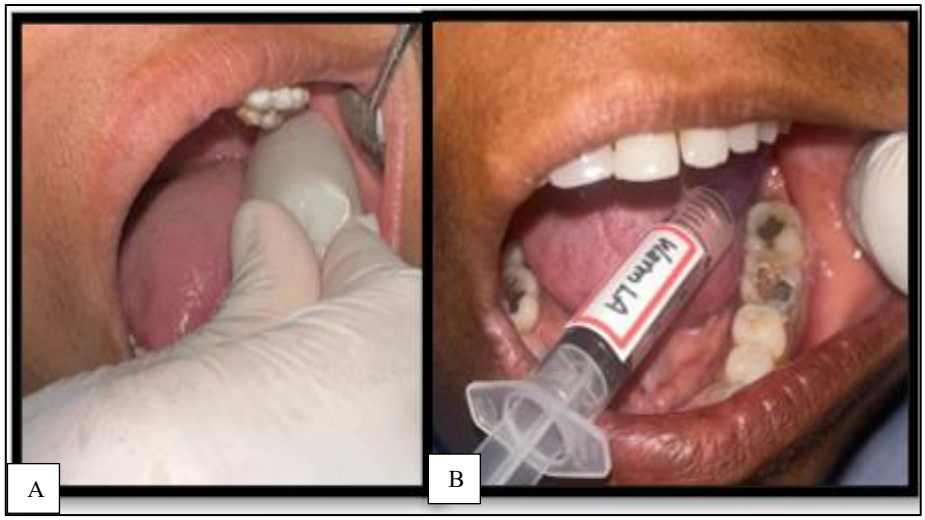


Figure 3 (A and B): Group 3: Ice cubes are placed at the site of injection as precooling agent followed by injecting pre warmed LA.



Figure 4 (A-C): Group 4: Endo frost is sprayed on a cotton pellet and applied at site of injection followed by injecting pre cooled LA.

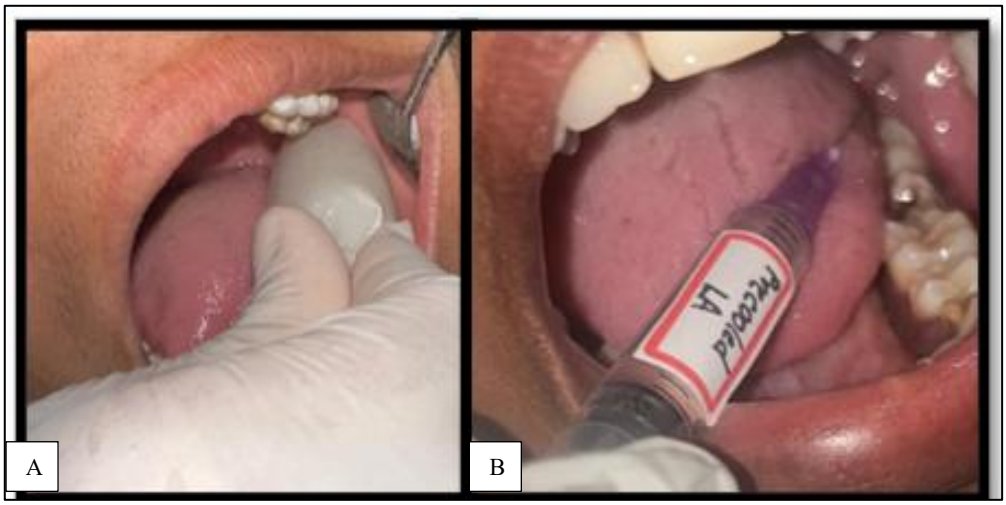


Figure 5 (A and B): Group 5-Ice cubes are placed at the site of injection as precooling agent followed by injecting pre cooled LA.



Figure 6 (A-C): VAS assessment, EPT, measuring temperature at site.

Statistical analysis

All gathered data was recorded in a Microsoft excel spreadsheet and analyzed using SPSS software v23.0. Pairwise comparison was done using Mann-Whitney U test, Post hoc Tukey's test. Comparison among groups was done using One way ANOVA, Kruskal Wallis test. P value below 0.05 was regarded as statistically significant.

RESULTS

Table 1 shows demographic data of the patients.

Table 2 shows comparison of five groups with onset time in minutes Group V-precooled LA with Endo ice has shown lower values representing faster onset of time when compared to other groups, and this difference reached statistical significance.

Table 3 shows comparison of five groups with VAS scores shows Group V-Precooled LA with Endo ice has shown lower VAS scores representing less pain perception by patients in these groups when compared to other groups.

Table 4 shows comparison of five groups with changes in temperature from before to after treatment shows Group V-Precooled LA with Endo ice has shown highest change in the temperature which was statistically significant.

Table 1: Demographic data.

Parameters	N	Percentage
Sex		
Male	25	55.5%
Female	20	44.5%
Age (in years)		
18-39	22	48.8%
40-60	23	51.1%

Among 45 patients in present study 25 are male (55.5%) and 20 are female (44.5%). 22 patients within age group of 18-39 and 23 patients within age group of 40-60.

Table 2: Comparison of 5 groups with onset time in minutes.

Groups	Mean	SD	Mean rank
Normal LA with lignocaine spray	4.89	1.05	35.61
Prewarmed LA with endo ice	3.56	1.33	25.44
Prewarmed LA with ice cubes	3.33	1.41	23.33
Precooled LA with endo ice	2.67	1.41	17.00
Precooled LA with ice cubes	2.22	0.67	13.61
F value	18.0780		
P value	0.0010		

Table 3: Comparison of five groups with VAS scores.

Groups	Mean	SD	Mean rank
Normal LA with lignocaine spray	3.33	1.22	24.61
Prewarmed LA with endo ice	2.33	1.32	32.50
Prewarmed LA with ice cubes	2.22	2.11	22.28
Precooled LA with endo ice	2.11	1.36	21.83
Precooled LA with ice cubes	1.11	1.36	13.78
H value	9.9040		
P value	0.0420		

Table 4: Comparison of five groups with changes in temperature from before to after treatment.

Groups	Mean	SD	Std. err.
Normal LA with lignocaine spray	0.70	0.72	0.24
Prewarmed LA with endo ice	2.78	1.85	0.62
Prewarmed LA with ice cubes	3.86	2.26	0.75
Precooled LA with endo ice	5.33	2.92	0.97
Precooled LA with ice cubes	5.98	6.15	2.05
F value	3.6051		
P value	0.0133		

DISCUSSION

This study evaluated whether using precooling agent and controlling injecting temperature improved LA. It is found that precooling with ice cubes produced better results Endo ice, including faster onset of and greater reduction in pain.

IANB may not be successful because of anatomical differences, additional nerve supply, psychological influences, and sodium channels that are less responsive. Modifying the pH and temperature of local anesthetics can enhance their efficacy and minimize discomfort during injection.[10]

Warming the anesthetic solution before injection has been found to lower the level of pain that patients experience. Since nerve endings respond to cold, heating the anesthetic solution may lessen nerve stimulation and accelerate the onset of anesthesia, stopping pain signals before they are fully processed. This approach leads to more rapid closure of the sodium channels. An alternative reason is that the pKa of local anesthetics varies with temperature, and heating lowers it to a greater proportion as the active non-ionized anesthetic can enter the nerve membrane. In the present study, the local anesthetic was heated to 42°C in a thermostatically regulated water bath, following the procedure outlined by Sarah and colleagues.[11]

Applying cryotherapy increases lignocaine's pKa, resulting in a higher ratio of cationic molecules, which are responsible for anesthesia, thus improving its effectiveness. Additionally, reduced temperatures facilitate stronger attachment of the anesthetic to nerve membrane proteins, enhancing the duration and quality of anesthesia. Cooling further modifies membrane protein structures involved in sodium channel regulation, thereby increasing the anesthetic's efficacy. Exposure to lower temperatures can inactivate A-delta fibers, which play a key role in transmitting sharp pain associated with injections. Minimizing tissue nociceptor stimulation and speed of painful signal propagation.[12]

According to Dabarakis et al reducing the temperature of local anesthetic agents can expedite the onset of anesthesia, consistent with the findings of the current investigation.[13] Precooling the area before injection was found to substantially decrease pain levels compared to the use of topical anesthetic gel, aligning with results reported by Nikhitha et al.[5] According to Vera et al the ideal cryotherapy time required is determined by the characteristics of soft tissue around it. When the thickness is lesser, a 5 minute cryotherapy session is satisfactory.[14] According to Gupta et al precooling the injection with ice cubes has shown more pain reduction than using Endo ice which was is accordance with the present study.[1] Karunakar et al concluded that Administering cryotherapy together with cooled local anesthetic solutions is highly effective in diminishing injection discomfort relative to standard anesthetics, which supports the results of the present study.[10]

Ram et al comparison of VAS scores between room temperature and warmed local anesthetic solutions yielded differing results from those observed in the current research.[11] According to Powell et al pKa of lignocaine is 7.57 at 40^0C and 7.92 at 25^0C-warming increases speed of onset.[15] This study found a notable decrease in pain when warm local anesthetic was administered to areas that had been precooled, as opposed to using standard local anesthetic, which aligns with the results reported by Chittora et al.[9]

The current research demonstrates that pain was diminished when using precooled anesthetic compared to prewarmed anesthetic, potentially due to cooling effects such as reduced nerve conduction speed, increased endorphin release, and changes to nociceptor activation thresholds. The elevated pain scores observed with the warmed anesthetic may be attributed to prompt vasodilation, which improves blood flow and promotes the movement of leukocytes and plasma proteins out of blood vessels, possibly causing increased inflammatory responses.[16]

Pain levels in this study were assessed using the VAS, which is recognized for its robust psychometric qualities. The VAS is straightforward to use in clinical settings, demonstrating high reliability between observers, consistent results on repeated tests, good acceptability and responsiveness, and strong validity. Furthermore, it can detect even small fluctuations in pain intensity.[17-20]

To establish when LA commenced, an electric pulp tester was employed, as it offers a more precise method for evaluating pulpal anesthesia than relying solely on patients' subjective and objective responses after anesthesia administration.[10]

Limitations of the present study are that this study primarily evaluated injection-site pain and the onset of pulpal anesthesia after administration. Long-term outcomes, including duration and depth of anesthesia, intraoperative pain during root canal treatment, and postoperative pain, were not assessed. Individual differences in soft-tissue thickness, local blood flow, and sensitivity may have influenced the degree of cooling achieved at the injection site. Although temperature was measured, complete standardization of the actual tissue temperature may not have been possible.

CONCLUSION

Cryotherapy application boosted the efficacy of IANB in anesthetizing mandibular molars with SIP. Within the limitations of the present study. Applying precooling to the injection area notably diminishes pain. Those receiving local anesthetic that had been precooled with ice cubes experienced the lowest levels of pain and the quickest anesthetic effect in comparison to prewarmed and standard local anesthetic.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Rao AS, Reddy AV, Reddy MJ, Gayathri SSD, Jahnavi K, Sri LM, et al. Evaluating the effect of cryotherapy on injection pain and onset of action of precooled and warmed local anesthetic agent in symptomatic irreversible pulpitis patients: an *in vivo* study. Int J Clin Trials 2026;13(4):377-84.