Research Article
AMERICAN JOURNAL OF PHARMACY AND HEALTH RESEARCH
www.ajphr.com
2026, Volume 14, Issue 08
ISSN: 2321–3647(online)

Comparative Evaluation of Injection Pain During Administration Of Local Anaesthesia After Topical Anaesthetic Gel Versus Cryotherapy Application: A Randomized Controlled Trial

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ABSTRACT

The insertion of local anesthetic solution remains one of the most dreaded events during dental treatment, and discomfort from needle penetration is a recognised source of dental anxiety and treatment avoidance. Topical anesthetic gels and pre-injection cooling (cryotherapy) have both been proposed to reduce this discomfort, yet direct comparisons in adult endodontic patients are limited. To compare pain perception during administration of local anesthesia following a 2% lignocaine topical gel versus a standardized ice-stick cryotherapy protocol. In this two-arm crossover randomized controlled trial, patients aged 18–60 years requiring endodontic treatment in at least two teeth received both protocols at separate sites: 2% lignocaine gel (Group A) for 1 minute and a customized ice stick measuring 5 mm × 10 mm (Group B) for 15 seconds before injection. Injection pain was self-rated on a 10 cm visual analogue scale (VAS), and scores were compared using the Wilcoxon signed-rank test at a 5% level of significance. The mean VAS score was 3.65 ± 1.00 in Group A and 2.53 ± 0.94 in Group B, a statistically significant difference ($z = -2.96$, $p = 0.003$) indicating lower injection pain with cryotherapy. Pre-injection cryotherapy using a standardized ice stick produced significantly less injection pain than 2% lignocaine topical gel. It offers a simple, inexpensive and non-pharmacological chairside adjunct that can be readily incorporated into routine endodontic practice.

Trial Registration: Clinical Trials Registry of India (CTRI/2025/08/092750)

Keywords: Cryotherapy; Injection pain; Local anesthesia; Topical anesthetic; Visual analogue scale; Endodontics.

*Corresponding Author Name: Dr. Sunayana Bidave
Received 10 June 2026, Accepted 13 July 2026

Please cite this article as: Bidave S *et al*., Comparative Evaluation of Injection Pain During Administration Of Local Anaesthesia After Topical Anaesthetic Gel Versus Cryotherapy Application: A Randomized Controlled Trial. American Journal of Pharmacy & Health Research 2026.

INTRODUCTION

The successful management of pain is an essential component of successful endodontic treatment, both during and after. In addition to enhancing the comfort of the patient, good analgesia helps the treatment to be effective and also helps the patient's co-operation and compliance. Therefore, local anesthetics play an essential role in various dental, endodontic and minor surgical procedures [1].

Interestingly, giving a local anesthetic is often said to be one of the most painful aspects of being at the dentist's office. An injection is often perceived as being painful and can help to increase a patient's dental anxiety, avoidance of treatment and create problems with cooperation during treatment. Pain management for the clinician is as crucial as providing excellent anesthesia because both the physiological and the psychological effect of pain plays a role in the ultimate outcome [2].

Local (regional) anesthetic is necessary to keep the treatment painless, but the insertion of the needle and subsequent injection of the anesthetic solution can cause pain. Pain of injection is influenced by a number of procedural factors: needle gauge, injection technique, injection speed, and temperature and pH of the anesthetic [3]. The extent to which dental care is accepted further depends upon patient-related factors like baseline anxiety, individual pain threshold and previous experiences with dental care [4].

Various approaches have been tried to soften injection pain. These include application of topical anaesthetic gels, topical application of ice or refrigerant sprays on the mucosa, reduction of the acidity of the anaesthetic solution by buffering and computer-controlled delivery systems of local anaesthetics [5,6]. Of these, topical anaesthetics and pre-cooling are by far the most popular as they are easy, inexpensive and non-invasive. There are topical anesthetic gels which desensitize the surface mucosa and soften the sensation of the needle being inserted into the tissue, but the effect of the topical anesthetic gel is brief and limited to the outermost layer of tissue [7]. But pre-cooling does the opposite: it slows flow down the sensory nerves, and reduces pain by causing local vasoconstriction, which cools down the tissue.

Comparative studies of ice cones, benzocaine gels and refrigerant sprays have been conducted, largely in paediatric populations [8,10–12]. Although there has been an increase in dentistry utilizing cryotherapy there is limited evidence specifically pertaining to the reduction of injection pain in dental practice [9]. Given this gap, the present randomized controlled trial was undertaken to evaluate and compare pain perception during local anaesthetic administration following the use of a topical anaesthetic gel versus

MATERIALS AND METHOD

Study design and ethical approval

This study was designed as a two-arm crossover randomized controlled trial conducted in accordance with CONSORT guidelines for randomized controlled trials. The study protocol was approved by the Institutional Ethics Committee (approval number IEC/RDDC&RC/PG/Cons/ 184/2025, dated 25/06/25), and the trial was prospectively registered with the Clinical Trials Registry of India (CTRI/2025/08/092750). All subjects were treated at different locations and therefore each patient acted as his/her own control reducing the possible confounding factors of inter-individual variation in anxiety and in pain threshold, and previous dental experience. For each patient, the two pre-injection techniques were administered at two separate appointments one week apart, with the order of the techniques (topical gel versus cryotherapy) randomly allocated. This one-week washout period allowed complete resolution of any anaesthetic and tissue effects from the previous visit, while randomization of the treatment order minimized potential carry-over and order effects. The nature of the study was explained to eligible patients, and written informed consent was obtained before enrolment.

Sample size estimation

"The sample size was calculated using OpenEpi version 3.0", based on data reported by Gurucharan et al. [15]. Using standard deviations of 33.7 and 18.4 for the two groups, a mean difference of 34.5, a two-sided confidence level of 95% ($z_{1-\alpha/2} = 1.96$) and 95% power ($z_{1-\beta} = 2.33$), the estimated requirement was 17 per group. The calculation followed the two-sample means formula described by Rosner (Fundamentals of Biostatistics, 5th ed., equation 8.27).

Eligibility criteria

Healthy patients between 18 and 60 years of age who required endodontic intervention in at least two teeth, in the same or contralateral arch, were eligible for inclusion. Patients were excluded if they had a known allergy to the local anaesthetic agent or to other drugs, reported marked anxiety toward local anaesthesia, had conditions likely to influence pain perception, had taken any premedication before the procedure, presented with acute infection at the injection site, or declined to provide informed consent.

Pre-procedural protocol and group allocation

Prior to anaesthesia, "all patients rinsed with 0.12% chlorhexidine gluconate mouthwash for 30 seconds to reduce microbial load". A pre-anaesthetic assessment was then carried out, comprising review of the medical history, recording of vital signs and confirmation of the relevant anatomical landmarks. For patients requiring treatment in two or more teeth, the two

pre-injection protocols were applied at separate sites, one per assigned group, with the timing of pre-treatment and injection standardized across sites to reduce variability. Group A received the topical anaesthetic gel protocol and Group B received the cryotherapy protocol.

Group A : Topical anaesthetic gel

The cheek was gently retracted with sterile gauze to expose the buccal mucosa at the intended injection site. A cotton applicator tip loaded with 2% lignocaine gel (Wocaine 2% gel, Merind, Mumbai, India) was used to coat the mucosa evenly over the area of needle entry. The gel was left undisturbed for approximately 1 minute to allow diffusion and superficial numbing, during which the patient was asked to keep the area still. Local anesthesia was then administered using a standard technique appropriate to the treatment site.

Group B : Cryotherapy

At cryotherapy allocated sites, injection area was pre-cooled with customized ice stick prior to anaesthesia. Ice sticks were made with sterile distilled water, which was frozen into special polypropylene moulds with standardized dimensions (5 mm/10 mm) to provide uniformity between patients. The ice stick was followed with light and steady pressure for 15 seconds, as suggested by earlier studies reporting a reduction in nerve conduction and tissue sensitivity at this exposure time, following a retraction of the cheek. It was important to not apply too much pressure or sustained contact that could cause damage to the tissue. This site was then dried with sterile gauze and local anaesthesia was then administered using a standard technique appropriate to the treatment site.

Pain assessment

The amount of pain at injection was assessed on a visual analogue scale (VAS) of 10 cm with "no pain" at the "minimal" end and "worst imaginable pain" at the "highest" end. All patients were given an explanation of the scale beforehand. The patient indicated the spot on the drawing that most closely reflected the pain, and the distance away from the painless spot (the zero point) was measured to get a score from 0 to 10. The correct procedure was standardized for all participants in order to ensure consistency of rating.

Statistical analysis

The data were analyzed using SPSS version 26.0 (IBM Corporation, USA) at 5% level of significance. Normality of the distribution of pain score was tested using Shapiro–Wilk test. Data were not normally distributed and therefore non-parametric descriptive data were used and the Wilcoxon signed-rank test was used to compare the paired scores, as each patient received both techniques (crossover design).

RESULTS AND DISCUSSION

The Shapiro–Wilk test indicated that the pain scores in both groups deviated significantly from a normal distribution. In Group A (topical anaesthetic gel) the test statistic was 0.885 (p = 0.039), and in Group B (cryotherapy) it was 0.886 (p = 0.040); as both p-values were below 0.05, the assumption of normality was rejected and non-parametric analysis was adopted (Table 1).

Table 1 : Shapiro–Wilk test of normality for pain scores in the two groups

Group	Statistic	df	Sig. (p)
Group A (Topical Anaesthetic Gel)	0.885	17	0.039
Group B (Cryotherapy)	0.886	17	0.040

The mean VAS pain score was 3.65 ± 1.00 in Group A, with a median (IQR) of 4.00 (1.50), compared with 2.53 ± 0.94 and a median (IQR) of 2.00 (1.00) in Group B. "The Wilcoxon signed-rank test showed a statistically significant difference between the groups (z = −2.96, p = 0.003)", the negative z-value reflecting lower median scores in the cryotherapy group. Cryotherapy therefore provided more effective control of injection pain than the topical anaesthetic gel (Table 2).

Table 2 : Comparison of pain scores between the two groups (Wilcoxon signed-rank test)

Group	Mean ± SD	Median (IQR)	z-value	p-value
Group A (Topical Anaesthetic Gel)	3.65 ± 1.00	4.00 (1.50)	−2.96	0.003*
Group B (Cryotherapy)	2.53 ± 0.94	2.00 (1.00)	−2.96	0.003*

**Significant difference at p ≤ 0.05*

DISCUSSION

This trial compared injection pain after two simple pre-injection measures a 2% lignocaine topical gel and a standardized ice-stick cryotherapy protocol in adults undergoing endodontic treatment. This crossover design meant that each patient could serve as his or her own control which further minimized the variance of individual's pain threshold, anxiety state, and prior experiences known to affect the perception of an injection [2,3]. The results show that the pain scores in the cryotherapy group are significantly lower than the scores in the topical gel group (2.53 ± 0.94, 3.65 ± 1.00 respectively) with the Wilcoxon signed-rank test demonstrating statistical significance (z = −2.96; p = 0.003). The null hypothesis was thus rejected: Difference was found between 15 second application of ice stick and 2% lignocaine gel to blunt the pain associated with the insertion of needles and anesthetic deposition.

Topical lignocaine acts by penetration of the mucous epithelium, to cause the sodium channels of the free nerve endings to become more difficult to activate, at the site where the needling is occurring [7]. However, its influence is superficial (2/3 mm into the mucosa) and requires good

contact time and sufficient field area and dryness. The gel is numbing in the area where the needle is injected only, and not the deeper submucosal and periosteal tissues that the needle passes through, so there is frequently discomfort when the solution is being placed. This limitation is a possible explanation for the higher scores recorded in Group A.

The mechanisms of action of cryotherapy seem to be operating through a few complementary means. Local cooling results in a constriction of blood vessels, a short-term decrease in tissue metabolism and decreases the conduction of A-delta and C fibres [5,9]. Another possible mechanism that cold stimuli can selectively increase the activity of large A-beta fibres, which in accordance with the gate control theory of pain, can inhibit the transmission of nociceptive signals to the dorsal horn [5]. Cryotherapy might have an enhanced analgesic effect, and this peripheral and central modulation is a reasonable explanation for the effects observed in the current study.

Results are consistent with other recent evidence. Using pre-injection cryotherapy, Ravindran et al. reported significantly lower pain scores than topical benzocaine gel used [13]; similarly, Abbasi et al. compared ethyl chloride spray with 5% lidocaine gel prior to buccal infiltration and also reported less injection pain in the pre-injection cryotherapy arm [14]. When the data for pre-cooling were obtained for calculation of the present sample size from Gurucharan et al., authors noted that in patients with symptomatic irreversible pulpitis, pre-cooling of the injection site not only decreased the level of injection pain in the patient but also shrank the duration of the onset of pulpal anaesthesia [15]. Of particular interest, a superiority of surface cooling was particularly noted by Rai et al., for greater palatine nerve block injections, where the mucosa is thin, densely adhering to the bone and quite less vascular [16].

This is confirmed by systematic reviews. Saeedi et al. [17] performed a meta-analysis of studies which revealed that cooling resulted in greater pain relief than topical anesthetic method alone, but the mode, duration and location of the injection were highly varied between the studies. A more recent review, which focused only on adult populations, concluded in the same direction, stating that there should be standardized protocols for delivering cryotherapy to allow meaningful comparisons between trials [18]. To help achieve the methodological goal of good reproducibility, the dimensions of the ice-stick (5 mm × 10 mm) and the application time (15 seconds) were fixed.

The strengths of this study are the use of a validated 10 cm VAS as well as the crossover design. To the best of our knowledge, there are a few limitations of this study that should be acknowledged: The sample was modest but well powered and was restricted to just one center

which implies limited transferability. This allowed no blinding as there is a noticeable difference between the feeling of the ice and the gel, so there could be a source of performance bias. No more than one cooling duration was tested and anesthetic onset and depth and postoperative pain were not measured or evaluated. The findings likewise are not susceptible to being directly extrapolated to pediatric, elderly and very anxious patients, which is a crucial demographic for which non-pharmacological pain control could prove beneficial.

From a practical perspective, the capacity for cryotherapy to be quite straightforward, readily reproduced, not add to application procedures or add to the allergy risk of topical agents, and to offer better pain relief when administered during anesthetic, makes it a low cost, high benefit treatment. The use of it in routine endodontic practice, especially for nervous patients or in demanding clinical situations seems to be warranted. It would be advantageous to undertake multicenter trials including larger, more diverse patient cohorts, with optimal cooling parameters and the determination of the additional effect of cryotherapy when combined with topical anesthetic, as this will help shape the future of cryotherapy treatment.

CONCLUSION

Pre-injection cryotherapy using a standardized ice stick was more effective in decreasing pain during local anesthetic administration in adult endodontic patients within the limitations of this RCT, compared to the 2% lignocaine topical anesthetic gel. The concept of cryotherapy is simple and reliable therapeutic technique which is of low cost and can be easily utilized in daily clinical activities as an adjunct for enhanced comfort while performing injection.

DECLARATIONS

“Conflict of interest:

The author declares no conflict of interest.

Funding:

This study received no specific grant from any funding agency.

Ethical approval:

The study was approved by the Institutional Ethics Committee, (approval number IEC/RDDC&RC/PG/Cons/184/2025), and was prospectively registered with the Clinical Trials Registry of India (CTRI/2025/08/092750). Written informed consent was obtained from all participants”.

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