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Effect of preoperative analgesics and cooled Lidocaine with Epinephrine on the anesthetic efficacy of inferior alveolar nerve block in patients with symptomatic irreversible pulpitis: A single-blind, randomized controlled trial

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Abstract

Background: Treating mandibular molars with symptomatic irreversible pulpitis poses challenges, as achieving anaesthesia in "hot teeth" is difficult. Epinephrine aids anaesthesia by reducing blood absorption through local vasoconstriction. However, when epinephrine is contraindicated, cooling the anaesthetic may provide effective vasoconstriction in cutaneous arteries and inhibit sensory nerve action potentials, enhancing anaesthetic efficacy.
Aim: To evaluate the effectiveness of preoperative analgesics and cooling of 2% lidocaine solution with 1:200,000 Epinephrine on the efficacy of Inferior alveolar nerve block (IANB) during root canal treatment in patients with symptomatic irreversible pulpitis of the mandibular molars.
Materials and methods: This study was conducted on 36 subjects diagnosed with symptomatic irreversible pulpitis. Participants were randomly assigned into one of three groups, each consisting of 12 patients (n=12). The subjects in Group A (Control) received Vitamin E 400 mg tablets as premedication and Local Anaesthetic injection of 2% Lignocaine at room temperature. The subjects in Group B received Piroxicam 20 mg tablets as premedication and local anaesthetic injection of 2% Lignocaine at Room Temperature. The subjects in Group C received Piroxicam 20 mg tablets as premedication and local anaesthetic injection of 2% Lignocaine at 4° Celsius. The patient's preoperative pain levels before and after administering the analgesic, before and after the administration of local anaesthesia and intraoperative pain levels were recorded using the Heft-Parker visual analogue scale. Anaesthetic success was again evaluated after re-initiation of the endodontic treatment. The heart rates of the patients were measured using a finger pulse oximeter.
Results: The patients in group C showed the highest mean difference in pain levels followed by group B and A. However, the Group A patients displayed the highest heart rates followed by Groups B and C. One-way ANOVA showed a significant differences in the pain levels (p=0.0002) and heart rates (p=0.0004) among the groups.
Conclusion: This study showed that Piroxicam effectively achieved IANB in patients with symptomatic irreversible pulpitis of mandibular molars. Cooling 2% lidocaine with 1:200,000 epinephrine to 4°C significantly reduced post-injection heart rate and enhanced anesthetic success.
Keywords: Pulse oximeter, Intraoperative pain, Visual Analogue Scale.

1. Introduction

Mandibular molars experiencing symptomatic irreversible pulpitis present a challenging treatment situation. Dentists often face difficulties in achieving anaesthesia in a hot tooth. Epinephrine decreases the absorption of local anaesthesia in blood by local vasoconstriction [1]. However, in situations where Epinephrine is not advisable,

cooling the dental anaesthetic may be more effective in inducing vasoconstriction in the skin's arteries and preventing sensory nerve action potentials. Research in recent years has explored various strategies to enhance the efficacy of local anaesthesia, particularly in cases of symptomatic irreversible pulpitis, which can be challenging to anaesthetize effectively. Goto et al. [2] demonstrated that cooling induces vasoconstriction in cutaneous arteries via activation of α1-adrenoceptors and α2C-adrenoceptors, which may prolong anaesthetic action by slowing blood flow in treated areas. Supporting this, Butterworth et al. found that cooling lidocaine solutions with ice significantly decreased sensory nerve action potential compared to solutions at room temperature, suggesting an increased numbing effect through cooling.

Similarly, Dabarakis et al. [4] reported that 3% plain mepivacaine solution at 4°C had a notably extended duration of action relative to the same solution at 20°C. Furthermore, Mishra et al. [5] observed that clinical success rates in achieving anaesthesia in patients with symptomatic irreversible pulpitis can be as low as 43-83%, underscoring the difficulty of anaesthetizing "hot" teeth. Given these challenges, nonsteroidal anti-inflammatory drugs (NSAIDs) are frequently prescribed as preoperative analgesics to reduce mild to moderate pain associated with symptomatic irreversible pulpitis. Therefore, the present study investigated and compared the effects of preoperative analgesics and cooling of Lidocaine on the anaesthetic efficacy of inferior alveolar nerve block in patients having symptomatic irreversible pulpitis..

2. Materials and methods

This study was conducted in the Department of Conservative Dentistry and Endodontics at GSL Dental College and Hospital and received approval from the institutional ethics committee (GSLDC/IEC/2023/063).

This randomized, single-blinded trial employed a parallel design and included 36 participants diagnosed with symptomatic irreversible pulpitis. A power analysis determined the necessary sample size, and participants were randomly assigned to one of three groups, with 12 individuals in each group (n = 12). The groups including, group A (Control, Vitamin E 400 mg with 2% Lignocaine at Room temperature), group B (Piroxicam 20 mg with 2% Lignocaine at Room Temperature), and group C (Piroxicam 20 mg with 2% Lignocaine at 4° Celsius).

All 36 participants received a detailed explanation of the study and provided written informed consent. Participants in Groups B and C were given a 20 mg dose of piroxicam one hour before local anaesthetic administration to initiate root canal treatment. To monitor baseline heart rate, a finger pulse oximeter was placed on the index finger of either hand before administering the anaesthetic. A pressure-type syringe was used with anaesthetic cartridges, which were cooled to 4°C to achieve the desired temperature of the local anaesthetic solution. Inferior alveolar nerve block (IANB) injections containing 2% lidocaine at room temperature were administered using a pressure-type syringe (Osung Deosy, Pearland, TX, USA) with 30-gauge short needles (Septojet needles, Septodont). For the preparation of the cooled anaesthetic cartridges, standard anaesthetic cartridges were placed in ice coolant boxes maintained at a temperature of 4°C, verified with a digital thermometer at 4±2°C. Cartridges were kept in the ice bath for 15 minutes before injection.

Patients in Group C were given IANB injections using cooled lignocaine. To maintain blinding, cartridges for the control group were placed in a similar container filled with water at room temperature. After one hour, a standard IANB was carefully administered using the Halsted technique, with 1.8 ml of 2% lidocaine containing epinephrine at a 1:100,000 concentrations, using an aspirating syringe (DentArt Instruments Mfg. Co.) and a long 30-gauge needle (Septodont). Ten minutes following the initial IANB, patients' subjective lip numbness was assessed. Endodontic access was then performed under a rubber dam. The Heft Parker Visual Analogue Scale (HP VAS) was utilized to evaluate patients' pain levels. A dental intern monitored the heart rate every 30 seconds for a total of 5 minutes following the IANB injections, while intraoperative pain levels were simultaneously assessed using the HP VAS. Afterwards, endodontic treatment was resumed under a rubber dam. The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS, version 25.0; IBM Corporation, USA). A one-way analysis of variance (ANOVA) was conducted to assess statistical significance.

3. Results

Patient recruitment began in August 18, 2023 and the study was conducted over a 3-months period. Of the randomly included patients, 53.3% were female and 46.7% were male. Effectiveness of the Preoperative analgesic was determined by the difference in preoperative and intraoperative HP VAS scores.

The differences in pain levels from preoperative to intraoperative stages, alongside changes in heart rate measured before and after IANB injections of Groups A, B and C are presented in Tables 1, 2, and 3, respectively. In Group A, pain differences range from 10 to 31, suggesting variability in patients' pain reduction following the anesthesia. The largest pain reduction is observed in Patients 2 and 9, both with a difference of 31, while the smallest pain reduction is seen in Patients 4 and 7, with a difference of 10 (Table 1). Heart rate differences between pre- and post-injection measurements vary from 16 to 22, indicating slight changes in physiological response to the anesthetic. Most patients show an increase in heart rate, with Patient 12 having the largest increase (22 beats), while Patient 11 shows the smallest increase (16 beats) (Table 1).

In Group B, the difference in pain levels from preoperative to intraoperative ranges from 45 to 70, indicating significant variability in pain relief among the patients. The highest pain reduction is observed in Patient 16, with a difference of 70, while the lowest pain reduction is noted in Patient 22, with a difference of 45. In terms of heart rate changes, the differences range from 14 to 20 beats per minute. Most patients exhibit moderate increases in heart rate post-injection, with Patient 18 showing the highest increase of 20 beats, while Patient 19 shows the smallest increase of 14 beats (Table 2).

Table 1. Preoperative and Intraoperative Pain, and Heart Rate Differences for Patients Undergoing IANB Treatment in Group A (Vitamin E 400 mg, 2% Lignocaine at room temperature)

S. No.	Patients	Difference between Preoperative and Intra-operative pain	Difference between Pre injection and Post injection Heart rates
1	Patient 1	18	19
2	Patient 2	31	21
3	Patient 3	13	17
4	Patient 4	10	20
5	Patient 5	18	18
6	Patient 6	13	19
7	Patient 7	10	18
8	Patient 8	24	20
9	Patient 9	31	17
10	Patient 10	21	21
11	Patient 11	18	16
12	Patient 12	15	22

Table 2. Preoperative and Intra-operative Pain, and Heart Rate Differences for Patients Undergoing IANB Treatment in Group B (Piroxicam 20 mg, 2% Lignocaine at room temperature)

S. No	Patients	Difference between Preoperative and Intra-operative pain	Difference between Pre injection and Post injection Heart rates
1	Patient 13	58	17
2	Patient 14	49	19
3	Patient 15	62	15
4	Patient 16	70	18
5	Patient 17	51	16
6	Patient 18	58	20
7	Patient 19	67	14
8	Patient 20	49	17
9	Patient 21	62	15
10	Patient 22	45	19
11	Patient 23	63	16
12	Patient 24	62	18

In Group C, the differences in pain levels range from 10 to 31, indicating variability in pain relief among the patients. The greatest reduction in pain is seen in Patients 2 and 9, both showing a difference of 31, while the least pain relief is noted in Patients 4 and 7, with a difference of 10. Regarding heart rate changes, the differences range from 4 to 10 beats per minute. Patient 34 shows the smallest change in heart rate with a difference of 4, indicating minimal physiological response to the treatment. Patient 35 exhibits the largest change in heart rate with a difference of 10, suggesting a more significant physiological reaction to the injection (Table 3).

The patients in group C showed the highest mean difference in pain levels followed by group B and A. One-way ANOVA demonstrated a significant difference in the pain levels among the groups (p=0.0002) (Table 4). However, the Group A patients displayed the highest heart rates followed by Groups B and C. One-way ANOVA showed a significant difference among the groups (p=0.0004) (Table 4).

Table 3: Preoperative and Intraoperative Pain, and Heart Rate Differences for Patients Undergoing IANB Treatment in C (Piroxicam 20 mg, 2% Lignocaine at 4° Celsius)

S. No.	Patients	Difference between Preoperative and Intra-operative pain	Difference between Pre injection and Post injection Heart rates
1	Patient 25	18	7
2	Patient 26	31	5
3	Patient 27	13	9
4	Patient 28	10	7
5	Patient 29	18	8
6	Patient 30	13	6
7	Patient 31	10	9
8	Patient 32	24	5
9	Patient 33	31	7
10	Patient 34	21	4
11	Patient 35	18	10
12	Patient 36	15	7

Table 4. Comparison between the groups (One-way Analysis of Variance)

Groups		Mean Difference	Standard Deviation	Significance
Pain levels	A	18.5	7.17	0.0002
	B	58	7.85	
	C	70	10.31	
Heart rates	A	19	1.85	0.0004
	B	17	1.90	
	C	7	1.81	

4. Discussion

Pain is a common and distressing experience for dental patients, particularly during invasive treatments such as root canal therapy. By investigating the effects of preoperative analgesics and the cooling of local anaesthetics, this study addresses a critical gap in dental anesthesiology. The results may contribute to better pain management strategies, thus increasing patient comfort and decreasing anxiety during dental treatments. Furthermore, understanding the interplay between preoperative medications and the temperature of local anaesthetics may help clinicians make informed decisions that optimize pain control, ultimately contributing to better clinical outcomes and patient satisfaction. Therefore, the present study investigated the effects of preoperative analgesics and cooling of lidocaine on the anaesthetic efficacy of inferior alveolar nerve block in patients having symptomatic irreversible pulpitis.

In this study, blinding of the participants was implemented to eliminate any potential bias. The dosage of 20 mg of Piroxicam was selected based on findings from Pulikottil *et al.* (2018), which demonstrated that pre-anaesthetic analgesics significantly enhanced anaesthetic success [6]. Additionally, previous research by Kim *et al.* (2016) indicated that Vitamin E helps mitigate the systemic side effects of lidocaine [7]. Pain levels were recorded using the Heft-Parker Visual Analogue Scale due to its proven reliability in endodontic studies. Piroxicam's anti-inflammatory action, which inhibits the synthesis of arachidonic acid, cyclooxygenase, lipoxygenase,

prostaglandins, and leukotrienes, likely contributed to the observed improvement in anaesthetic efficacy.

The clinical outcomes of this study indicated that Piroxicam served as an effective preoperative analgesic, significantly enhancing both clinical and statistical success rates of IANB compared to the control group. These findings are consistent with prior studies by Wali *et al*. (2012) [8] and Deepankar Shukla *et al*. (2022) [9], which reported Piroxicam's 90% efficacy in IANB. Additionally, this study found Piroxicam to be clinically effective with minimal adverse effects; no side effects were reported, likely due to the single preoperative dosage. Future research may investigate variables like age, ethnicity, and body weight that could influence Piroxicam's efficacy in IANB applications.

Local Anaesthetic failure may be due to various reasons. In Clinically normal teeth, there is a 75%-90% success rate of anaesthesia, whereas, in the case of inflamed tissue (irreversible pulpitis), anaesthesia is ineffective in 30%-80% of patients. According to Hargreaves *et al*. (2001) [10] in Irreversible pulpitis, there is an 8-fold higher failure of local anaesthetic injections. Tetrodotoxin-resistant receptors get activated by the presence of inflammatory mediators, and exhibit resistance to the local anaesthetic solutions. As the local anaesthetic solution is subjected to rapid uptake by blood circulation, it is absorbed in the blood circulation, thus decreasing the concentration and the amount of the anaesthetic solution.

Individuals receiving IANB injections without a vasoconstrictor reported either no anaesthesia or only brief anaesthesia lasting just 1 to 2 minutes. Epinephrine, which activates both alpha and beta-adrenergic receptors, can pose certain complications due to beta-receptor stimulation. As a natural hormone from the adrenal medulla, epinephrine is secreted at a basal rate of approximately 0.17 to 0.54 µg/min in a healthy adult weighing 70 kg, a standard still applicable today. When administered with a single dose of lidocaine, the risk of adverse reactions remains low, though it increases with multiple lidocaine-epinephrine injections. To reduce the uptake of local anaesthetic in IANB injections without increasing epinephrine levels, cooling the anaesthetic solution offers a practical solution by inducing local vasoconstriction, thus inhibiting sensory nerve fibres. Butterworth et al. [3] found that cooling the anaesthetic delays its uptake by peripheral circulation. Lowering the temperature of lidocaine increases its pKa, ionic strength, and buffering capacity, as shown by Sanchez *et al*. [11]. Rosenberg and Havener [12] also noted that cooling lidocaine extended anaesthesia duration in rat sciatic nerves, while Dabarakis et al. [4] observed a significantly prolonged anaesthetic effect in maxillary premolars with 3% mepivacaine at 4°C versus 20°C (22.3 minutes vs. 17.3 minutes). Since cooling the anaesthetic solution may extend its duration and potency, this study assessed the efficacy of 2% lidocaine with 1:200,000 epinephrine cooled to 4°C in inferior alveolar nerve blocks. Results revealed an improved anaesthetic success rate with cooling, consistent with studies by Aggarwal *et al*. (2023) [13] and Riaz *et al*. (2023) [14].

This study focused on a randomly selected patient group rather than targeting individuals with cardiac health concerns, where epinephrine use in local anaesthesia is often restricted. Future research could involve patients with systemic conditions that contraindicate epinephrine to provide a clearer understanding of the benefits of cooling anaesthetic solutions before administration. These findings could ultimately help improve local anaesthesia effectiveness, allowing dental practitioners to manage "hot teeth" cases more effectively and reduce instances of anaesthesia failure.

5. Conclusion

In conclusion, cooling 2% lidocaine with 1:200,000 epinephrine to 4°C reduced post-injection heart rates and improved anaesthetic success rates. Additionally, preoperative Piroxicam was highly effective for achieving IANB in patients with symptomatic irreversible pulpitis in mandibular molars. Using a cooled anaesthetic combined with Piroxicam as a premedication offer a promising approach to enhance the efficacy of local anaesthesia, particularly for difficult cases like "hot teeth." This approach may lead to better pain management and improved patient satisfaction during root canal treatments.

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