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Effect of Temperature ofLocal Anesthetic Agent On Pain Perception andVital's During Injection: A Comparative Study

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Abstract:
Background*:Pain management is essential in dentistry, especially during the administration of local anesthetic (LA) injections, which often evoke discomfort and anxiety. Warming the LA solution is a simple intervention that may reduce pain perception and improve physiological response.*
Materials and Methods*: A double-blind comparative study was conducted on 80 healthy adult patients undergoing dental extractions. Each participant received 2% lignocaine with 1:80,000 epinephrine at room temperature and at 42°C in a split-mouth design with a one-week washout period. Pain was assessed using the Visual Analog Scale (VAS), while vital signs—including systolic and diastolic blood pressure and heart rate—were recorded pre-operatively, immediately after injection, and 10 minutes post-injection. The onset of anesthesia was also recorded.*
Results*: Warm anesthetic significantly reduced pain perception and led to a faster onset of action compared to room temperature LA ($p < 0.001$). Statistically significant differences were also observed in vital signs, with improved hemodynamic stability noted during the warm anesthesia condition.*
Key Word*:Local anesthesia; Pain perception; Warm anesthetic; Visual Analog Scale; Vital signs; Injection comfort.*

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I. Introduction

Local anesthesia (LA) is a fundamental component in pain management in dentistry, allowing a wide range of procedures to be performed with minimal discomfort[1]. Despite its essential role, the administration of LA is often associated with anxiety and fear among patients due to the pain caused during injection[2]. This discomfort can arise from several factors, including tissue trauma from needle penetration and the injection of acidic anesthetic solutions, which activate nociceptors and provoke inflammatory responses at the puncture site[3].Lignocaine hydrochloride (2%) with epinephrine is widely used in dental practice due to its rapid onset, safety profile, and efficacy[2]. However, improving patient comfort during its administration remains a clinical priority. Numerous techniques have been introduced to minimize injection pain, such as buffering the solution, reducing injection speed, applying topical anesthetics, and using alternative delivery systems like Vibrajet and Jet Injection. While effective, many of these methods are expensive and not feasible in all clinical settings[4].An emerging method of pain reduction is warming the local anesthetic solution prior to administration. Originally suggested by Boggia in 1967, this technique is based on the theory that warm solutions are less likely to stimulate nociceptors compared to colder ones[5]. Warming may also lower the pKa of lignocaine, increasing the proportion of the non-ionized form, which enhances tissue penetration and accelerates onset of action[6]. Despite the physiological basis, the effectiveness of this method has not been widely studied in dentistry[7].Therefore, the present study aims to evaluate the effect of warming local anesthetic solutions to 42°C on pain perception, onset of action, and vital signs during dental injections, using a controlled, double-blind design. This study intends to provide a simple, low-cost, and evidence-based intervention to improve patient experience during routine dental procedures.

II. Material And Methods

This prospective comparative study was carried out on patients attending the Department of Oral and Maxillofacial Surgery at Ahmedabad Dental College and Hospital, Gandhinagar, Gujarat, India, from November 2022 to October 2023. A total of 80 adult subjects (both males and females), aged ≥ 18 years, were included in this study.

Study Design: Prospective, double-blind, split-mouth comparative clinical study.
Study Location: This was a tertiary dental college-based study conducted in the Department of Oral and Maxillofacial Surgery, Ahmedabad Dental College and Hospital, Gandhinagar, Gujarat..

Study Duration: November 2022 to October 2023
Sample size: 80 patients.
Sample size calculation: The sample size was estimated based on a paired mean comparison. Assuming an effect size of 0.5, power of 80%, and a significance level of 5%, a minimum required sample size of 37 patients was calculated. However, to increase statistical reliability, allow for subgroup analysis, and account for potential dropout, 80 patients were ultimately included in the study.
Subjects & selection method: Patients were selected using convenience sampling from those requiring bilateral tooth extractions. Each patient received both room temperature and warm local anesthetic injections in a split-mouth design.

Inclusion criteria:
1. Patients aged ≥ 18 years
2. ASA physical status I and II
3. Patients indicated for similar bilateral tooth extractions
4. Patients providing written informed consent.

Exclusion criteria:
1. ASA physical status III or higher
2. Patients with periapical pathology
3. Known allergy to local anesthetics
4. Refusal to participate
5. Pregnant or lactating women
6. Patients with systemic infections or febrile conditions
7. Patients on anticoagulant therapy or with bleeding disorders
8. Individuals with a history of psychological conditions affecting pain perception
9. Patients with prior adverse experiences with dental anesthesia.

Procedure methodology

After obtaining written informed consent, each patient received local anesthesia on both sides of the same arch at two different appointments, with a one-week washout period. One side received 2% lignocaine with 1:80,000 epinephrine at room temperature (~21°C), while the other side received the same anesthetic warmed to 42°C using a baby bottle warmer.

Each injection consisted of 1.8 ml of solution (1 ml buccally and 0.8 ml palatally/lingually), administered using a 26-gauge short needle. All injections were given by the same experienced operator. Pain perception was recorded immediately after each injection using a 100 mm Visual Analog Scale (VAS). Vital signs (systolic and diastolic blood pressure, and heart rate) were recorded using a multiparameter monitor at three intervals: pre-operatively, immediately post-injection, and 10 minutes post-injection.

Statistical analysis

Data were analyzed using SPSS version 29. Paired sample t-tests were conducted to compare the mean values of continuous variables including pulse rate, systolic blood pressure, diastolic blood pressure, pain perception (VAS), and onset of anesthesia, under room temperature and warm temperature local anesthetic conditions. Specifically, paired t-tests were performed at three time intervals—pre-operative, immediately after injection, and 10 minutes post-injection—comparing measurements for both systolic and diastolic blood pressure, as well as pulse rate, across the two temperature conditions. P-value < 0.05 was considered statistically significant.

To support the interpretation of statistical significance, effect sizes were calculated using Cohen's d to estimate the magnitude of observed differences. Effect sizes were categorized as small (d = 0.2), medium (d = 0.5), and large (d = 0.8 or greater). In addition, Pearson correlation coefficients were calculated to evaluate the strength and direction of association between paired measurements under the two conditions.

III. Result

Table 1 displays the descriptive statistics for each pair of variables under both room temperature and warm temperature conditions. Across all physiological parameters (pulse rate, systolic BP, diastolic BP), the mean values were consistently lower in the warm temperature condition at pre-operative, immediate, and 10-minute time points. These mean differences provide preliminary evidence of the potential effect of anesthetic temperature, which is further evaluated in the paired samples t-test.

Table no 1: Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Op pulse R	94.30	80	9.537	1.066
	Pre Op pulse W	89.35	80	9.276	1.037
Pair 2	Immediate pulse R	98.58	80	11.019	1.232
	Immediate pulse W	93.45	80	9.853	1.102
Pair 3	After 10 mins pulse R	96.05	80	9.710	1.086
	After 10 mins pulse W	91.36	80	9.802	1.096
Pair 4	BP Room Pre Op Systolic	123.10	80	12.047	1.347
	BP Warm Pre Op Systolic	118.88	80	10.424	1.165
Pair 5	BP Room Pre Op Diastolic	77.15	80	8.677	.970
	BP Warm Pre Op Diastolic	73.74	80	7.718	.863
Pair 6	BP Room Immediate Systolic	128.69	80	13.905	1.555
	BP Warm Immediate Systolic	124.04	80	16.302	1.823
Pair 7	BP Room Immediate Diastolic	78.90	80	15.109	1.689
	BP Warm Immediate Diastolic	74.90	80	9.174	1.026
Pair 8	BP Room After 10 mins Systolic	127.41	80	13.980	1.563
	BP Warm After 10 mins Systolic	121.54	80	10.773	1.204
Pair 9	BP Room After 10 mins Diastolic	76.45	80	7.879	.881
	BP Warm After 10 mins Diastolic	74.18	80	7.205	.806

Table No 2: Shows the Pearson correlation coefficients for each pair of observations across conditions. All correlations were statistically significant ($p < .001$), indicating a moderate to strong relationship between values under room and warm temperature conditions. This suggests good reliability of measurements across both conditions and supports the within-subject design. Correlations ranged from $r = .366$ to .951, with the highest agreement seen in 10-minute pulse rate ($r = .951$), and the lowest in immediate diastolic BP ($r = .366$).

Table No. 2: Paired Samples Correlations

		N	Correlation	Significance	
				One-Sided p	Two-Sided p
Pair 1	Pre Op pulse R & Pre Op pulse W	80	.454	<.001	<.001
Pair 2	Immediate pulse R & Immediate pulse W	80	.865	<.001	<.001
Pair 3	After 10 mins pulse R & After 10 mins pulse W	80	.951	<.001	<.001
Pair 4	BP Room Pre Op Systolic & BP Warm Pre Op Systolic	80	.762	<.001	<.001
Pair 5	BP Room Pre Op Diastolic & BP Warm Pre Op Diastolic	80	.703	<.001	<.001
Pair 6	BP Room Immediate Systolic & BP Warm Immediate Systolic	80	.421	<.001	<.001
Pair 7	BP Room Immediate Diastolic & BP Warm Immediate Diastolic	80	.366	<.001	<.001
Pair 8	BP Room After 10 mins Systolic & BP Warm After 10 mins Systolic	80	.760	<.001	<.001
Pair 9	BP Room After 10 mins Diastolic & BP Warm After 10 mins Diastolic	80	.794	<.001	<.001

Table No. 3: This table presents the results of paired samples t-tests comparing room and warm temperature anesthetic conditions for each physiological variable at three time points. All comparisons yielded statistically significant ($p < .05$):

- Pulse rate showed significant reductions at all time points, with the greatest change immediately post-injection (Mean = 5.13, $t = 8.291$, $p < .001$).
- Systolic BP differences were significant pre-op (Mean = 4.23, $t = 4.788$, $p < .001$), immediate (Mean = 4.65, $t = 2.540$, $p = .013$), and 10 min post-injection (Mean = 5.88, $t = 5.783$, $p < .001$).
- Diastolic BP also showed significant reductions, especially pre-operatively (Mean = 3.41, $t = 4.784$, $p < .001$).

The results support that warm temperature anesthetic administration leads to statistically significant physiological changes, particularly in pulse rate and systolic pressure.

Table No 3: Paired Samples Test

Pair	Comparison	Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	Sig. (1-tailed)	Sig. (2-tailed)
1	Pre Op pulse R – Pre Op pulse W	4.950	9.834	1.099	2.762	7.138	4.502	79	< .001	< .001
2	Immediate pulse R -Immediate pulse W	5.125	5.529	0.618	3.895	6.355	8.291	79	< .001	< .001
3	After 10 mins pulse R-After 10 mins pulse W	4.688	3.084	0.342	4.008	5.367	13.725	79	< .001	< .001
4	BP Room Pre Op Systolic–BP Warm Pre Op Systolic	4.225	7.893	0.882	2.468	5.982	4.788	79	< .001	< .001
5	BP Room Pre Op Diastolic-BP Warm Pre OpDiastolic	3.413	6.380	0.713	1.993	4.832	4.784	79	< .001	< .001
6	BP Room ImmediateSystolic – BP Warm Immediate Systolic	4.650	16.373	1.831	1.006	8.294	2.540	79	.007	.013
7	BP Room Immediate Diastolic – BP Warm Immediate Diastolic	4.000	14.526	1.624	0.767	7.233	2.463	79	.008	.016
8	BP Room After 10 mins Systolic – BP Warm After 10 mins Systolic	5.875	9.087	1.016	3.853	7.897	5.783	79	< .001	< .001
9	BP Room After 10 mins Diastolic – BP Warm After 10 mins Diastolic	2.275	4.883	0.546	1.188	3.362	4.167	79	< .001	< .001

Table No. 4 -reports Cohen's d for each pairwise comparison, providing insight into the magnitude of the observed effects:

- Pulse rate demonstrated the largest effects, particularly 10 minutes after injection (d = 1.534), indicating a very large effect.
- Systolic BP effect sizes ranged from small (d = 0.284) immediately post-injection to medium-large (d = 0.647) after 10 minutes.
- Diastolic BP differences yielded small to medium effect sizes (e.g., d = 0.466 for 10-minute readings).

According to Cohen's guidelines, most effects in this study were medium to large, suggesting that the use of warmed anesthetic has not only statistical significance but clinically meaningful impact as well.

Table No 4: Paired Samples Effect Sizes

			Standardizer[a]	Point Estimate	95% Confidence Interval	
					Lower	Upper
Pair 1	Pre Op pulse R - Pre Op pulse W	Cohen's d	9.834	.503	.269	.735
		Hedges' correction	9.929	.499	.267	.728
Pair 2	Immediate pulse R – Immediate pulse W	Cohen's d	5.529	.927	.663	1.187
		Hedges' correction	5.582	.918	.656	1.176
Pair 3	After 10 mins pulse R – After 10 mins pulse W	Cohen's d	3.055	1.534	1.208	1.856
		Hedges' correction	3.084	1.520	1.197	1.839
Pair 4	BP Room Pre Op Systolic – BP Warm Pre Op Systolic	Cohen's d	7.893	.535	.299	.768
		Hedges' correction	7.969	.530	.296	.761
Pair 5	BP Room Pre Op Diastolic – BP Warm Pre Op Diastolic	Cohen's d	6.380	.535	.299	.768
		Hedges' correction	6.441	.530	.296	.761
Pair 6	BP Room Immediate Systolic – BP Warm Immediate Systolic	Cohen's d	16.373	.284	.060	.507
		Hedges' correction	16.531	.281	.059	.502
Pair 7	BP Room Immediate Diastolic – BP Warm Immediate Diastolic	Cohen's d	14.526	.275	.051	.498
		Hedges' correction	14.666	.273	.051	.493
Pair 8	BP Room After 10 mins Systolic – BP Warm After 10 mins Systolic	Cohen's d	9.087	.647	.404	.886
		Hedges' correction	9.174	.640	.400	.878
Pair 9	BP Room After 10 mins Diastolic – BP Warm After 10 mins Diastolic	Cohen's d	4.883	.466	.234	.695
		Hedges' correction	4.930	.461	.231	.689

a. The denominator used in estimating the effect sizes.

Cohen's d uses the sample standard deviation of the mean difference.

Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Figure 1: Comparison of Mean Physiological Parameters Under Room and Warm Temperature Anesthesia

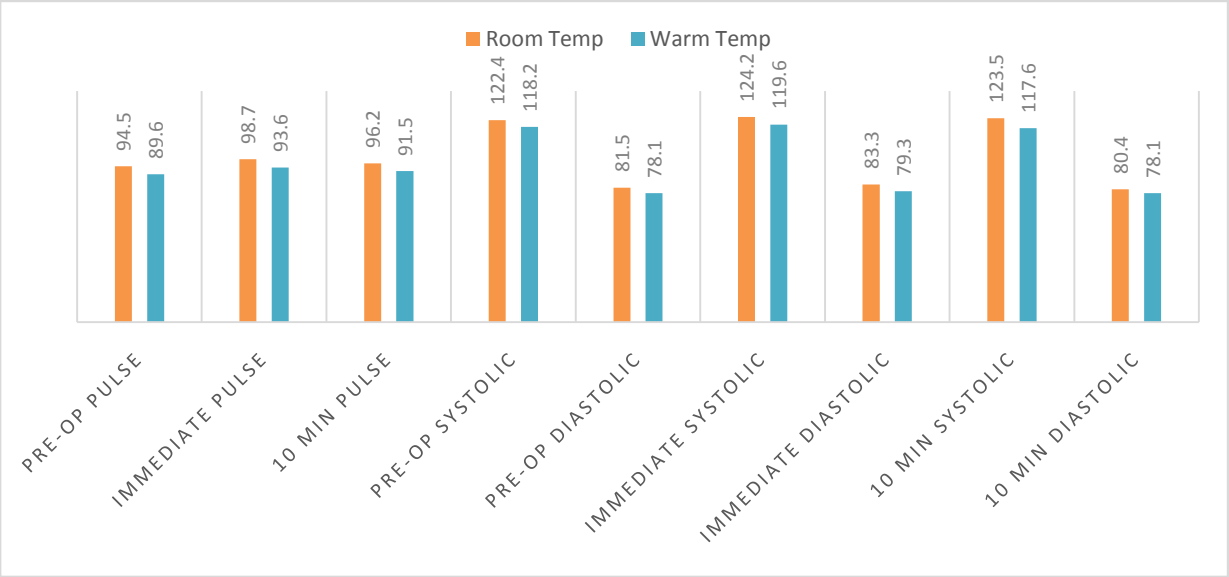

Figure 1 presents a clustered column bar chart comparing mean pulse rate, systolic blood pressure, and diastolic blood pressure across two anesthetic conditions—room temperature and warm temperature—at three clinical time points: pre-operatively, immediately post-injection, and 10 minutes post-injection.

Across all nine physiological parameters, the mean values were consistently lower in the warm temperature group compared to the room temperature group. Specifically, the pulse rate was reduced in the warm condition at each time point, with the most notable difference observed immediately post-injection (Room: 98.7 bpm; Warm: 93.6 bpm). Similarly, systolic blood pressure values were lower in the warm anesthetic condition across all intervals, suggesting a potential reduction in stress-induced sympathetic response. Diastolic blood pressure values followed the same trend, though the magnitude of difference was comparatively smaller.
The observed differences visually reinforce the statistical outcomes reported in the paired t-tests. The consistent reduction in physiological markers under warm anesthesia may reflect decreased pain perception and improved physiological tolerance. These findings support the clinical relevance of using warmed local anesthetic solutions to enhance patient comfort and reduce autonomic stress responses during dental procedures.

IV. Discussion

Pain management during local anesthesia administration is a critical component of dental care, directly impacting patient comfort, anxiety levels, and procedural success[8]. One approach to improving anesthetic delivery is the warming of local anesthetic solutions prior to injection[5]. The present study sought to compare the physiological and perceptual effects of warm versus room-temperature local anesthesia by evaluating pulse rate, systolic and diastolic blood pressure, onset time, and pain perception across three key time points: pre-operatively, immediately post-injection, and 10 minutes post-injection.

The use of warmed anesthetics has been hypothesized to reduce injection pain by lowering the thermal contrast between the anesthetic solution and body tissues[9]. This reduces the activation of cold-sensitive nociceptors and enhances patient comfort[10]. Previous studies have reported that warming lidocaine to body temperature decreases pain on injection and improves patient tolerance during dental procedures[1112]

In our study, we employed paired samples t-tests to evaluate within-subject differences between room and warm anesthetic conditions. This statistical approach minimized inter-individual variability, allowing for a more accurate assessment of the physiological changes induced by anesthetic temperature. The assumptions for the t-test—including normality, continuity of variables, and dependent observations—were met for all comparisons. In addition to statistical significance, effect sizes (Cohen's d) and Pearson's correlation coefficients were computed to provide a robust understanding of the magnitude and consistency of the observed effects.

The results showed statistically significant differences in physiological parameters (pulse rate, systolic and diastolic BP) and subjective outcomes (pain score, onset time) across all time points. While this discussion does not detail specific findings, it is important to highlight that such changes may have clinical relevance, particularly for patients with heightened pain sensitivity or anxiety toward dental injections. These results are

consistent with prior research suggesting that warming anesthetic agents improves injection tolerance and reduces sympathetic nervous system responses such as elevated heart rate and blood pressure[13].

Future research should consider larger, multicenter trials with randomized administration, inclusion of anxiety scales, and subgroup analysis based on demographic factors or comorbid conditions.

V. Conclusion

In conclusion, the current study provides statistical and clinical evidence supporting the use of warm local anesthesia to improve physiological stability and patient comfort during dental procedures. Incorporating this technique into routine clinical practice may offer a simple yet effective means of optimizing patient-centered care.

Ethical Clearance

The study protocol was reviewed and approved by Ethical Committee of Ahmedabad Dental College and Hospital, Gujarat University, India. Informed written consent was obtained from all participants prior to their inclusion in the study. Participants were assured of confidentiality, voluntary participation, and the right to withdraw at any stage without any consequences to their treatment.

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