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Efficacy of buffered vs. conventional Lignocaine in bilateral maxillary premolar extractions: A randomized trial

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Abstract

Background: Local anaesthesia is essential for pain control in cases requiring bilateral maxillary Premolar Orthodontic extraction. However, conventional lignocaine with adrenaline is acidic (pH- 3.5), which often causes burning on injection, delayed onset, and shorter duration of anaesthesia. Buffering lignocaine with sodium bicarbonate increases pH closer to physiological levels, potentially improving aesthetic performance.

Aim: To evaluate and compare the efficacy of 8.4% sodium bicarbonate–buffered lignocaine with conventional lignocaine in cases requiring bilateral maxillary Premolar Orthodontic extraction.

Materials and Methods: A prospective, randomized, split-mouth clinical trial was conducted on children above 18 years and adults indicated for bilateral maxillary premolar orthodontic extractions. On one side, conventional 2% lignocaine with 1:80,000 adrenaline was administered (control group), and on the contralateral side, freshly prepared sodium bicarbonate–buffered lignocaine (10:1 ratio) was used (study group). Pain on injection was assessed using Visual Analog Scale (VAS), onset of anaesthesia (in seconds) was recorded, and duration of anaesthesia (in minutes) was measured. Data were analysed using Mann–Whitney U test; $p < 0.05$ was considered statistically significant.

Results: Buffered lignocaine significantly reduced pain on injection (mean VAS 2.70 vs. 4.10; $p < 0.001$), demonstrated faster onset of anaesthesia (mean 89.64 seconds earlier; $p < 0.001$), and prolonged duration (mean 215.34 vs. 190.07 minutes; $p < 0.001$) compared with conventional lignocaine.

Conclusion: Buffering lignocaine with sodium bicarbonate enhances patient comfort by reducing injection pain, accelerates onset, and prolongs anaesthesia duration in bilateral maxillary Premolar Orthodontic extraction procedures. Given its simplicity and clinical benefits, buffered local anaesthesia may be considered as a valuable adjunct in dentistry, although wider adoption requires resolution of stability and availability concerns.

Keywords: Buffered local anaesthesia, 8.4% sodium bicarbonate, lignocaine, bilateral maxillary Premolar Orthodontic extraction

Introduction

Local anesthesia has revolutionized modern dental practice, by facilitating painless and effective treatment. Lignocaine, introduced in 1943, remains the most widely used amide-type local anesthetic agent due to its safety, reliability, and low allergenicity. However, patients often report a burning or stinging sensation during injection, which can lead to anxiety, negative behavior, and compromised cooperation in adult as well as children [1].

The discomfort associated with lignocaine infiltration is attributed to its acidic pH (approximately 3.5 with adrenaline), which ensures stability and prolongs shelf life. Several strategies have been suggested to reduce this injection pain, including the use of topical anesthetics, slow injection techniques, warming of solutions, and buffering [2, 3].

Buffering lignocaine with 8.4% sodium bicarbonate increases the solution's pH closer to physiological levels, reducing pain on injection, enhancing the proportion of unionized base form, and thereby accelerating onset and improving quality of anesthesia [4, 5]. Studies in adults and children have demonstrated that buffered lignocaine can reduce injection discomfort and shorten onset time, although evidence remains limited in pediatric dentistry [6, 7]. Hence, this clinical study was undertaken to evaluate and compare the efficacy of 8.4% sodium bicarbonate–buffered lignocaine and conventional lignocaine solution in cases requiring bilateral maxillary Premolar Orthodontic extraction, in terms of pain perception, onset, and duration of anesthesia.

Aim

To evaluate and compare the efficacy of 8.4% sodium bicarbonate–buffered and conventional local anesthetic solutions in in cases requiring bilateral maxillary Premolar Orthodontic extraction.

Materials and Methodology

Study Design: A prospective, randomized, controlled, split-mouth clinical study.

Study Population: children above 18 years age and adults were recruited from the Department of Oral and Maxillofacial surgery.

Inclusion Criteria

- Children above 18 years age and adults

- Indicated for bilateral orthodontic extraction of maxillary premolars
- Cooperative behavior (Frankl's rating 3 and 4)
- No systemic illness (ASA I patients)

Exclusion Criteria
- History of allergy to lignocaine or sodium bicarbonate
- Acute odontogenic infection at the site of injection
- Medically compromised patients
- Children or adult on analgesics or sedatives within 24 hours

Sample Size: Based on previous literature and power analysis, a minimum of 50 patients were recruited (final number inserted after statistical calculation).

Randomization: Split-mouth design ensured that each patient served as their own control. One side received conventional lignocaine (control) and the contralateral side received buffered lignocaine (study). The sequence was randomized using computer-generated random allocation.

Intervention
Control group: 2% lignocaine with 1:80,000 adrenaline (non-buffered)

Study group: 2% lignocaine with 1:80,000 adrenaline buffered with 8.4% sodium bicarbonate in 10:1 ratio, freshly prepared prior to injection.

Procedure: All extractions were performed in a single appointment. Infraorbital nerve block and Greater Palatine nerve block was administered bilaterally using a standardized technique by the same operator. A 27-gauge short needle was used. Injection was given slowly over 60 seconds.

Outcome Measures
1. **Pain on injection:** Assessed using Visual Analog Scale (VAS, 0–10).

2. **Onset of anesthesia:** Time (in seconds) from injection to subjective numbness and absence of response to probing.

3. **Duration of anesthesia:** Time (in minutes) from onset until the first subjective sensation of recovery.

Statistical Analysis: Data was tabulated and analyzed using SPSS (version SPSS version 28). Mean and standard deviation were calculated. Independent t-test and paired t-test were used to compare intergroup differences. p-value <0.05 was considered statistically significant.

Results

Table 1: Descriptive statistics of pain (mean VAS score)

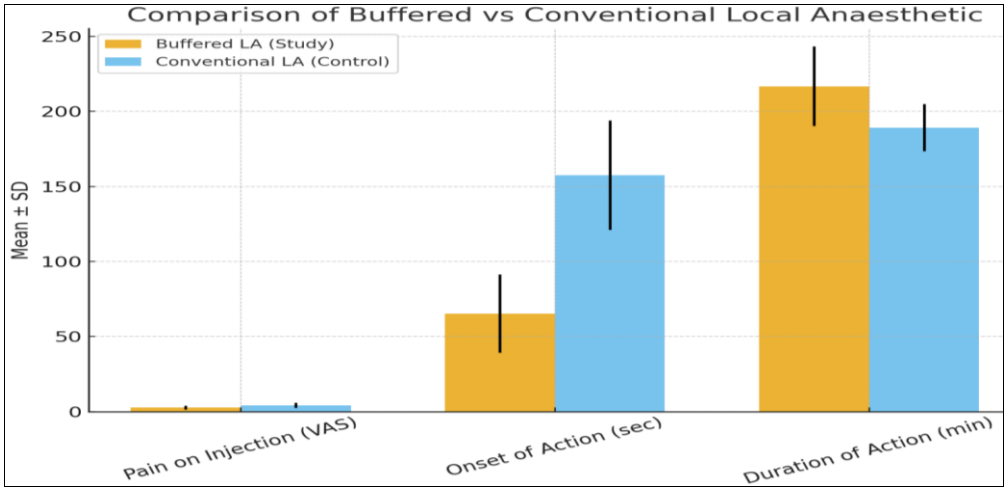
Group	Minimum	Maximum	Mean	SD
Study	0.00	7.00	2.60	1.30
Control	1.00	8.00	4.20	1.70

Table 2: Comparison of duration of anesthesia (in minutes) between Study and Control groups

Group	Minimum	Maximum	Mean	SD
Study	110	280	216.8	26.50
Control	160	265	189.30	15.70

Table 3: Comparison between study and control groups using Mann-Whitney U test

Parameter	Mean Difference	Mann-Whitney U test	Z-value	p-value
Onset of anaesthesia (in seconds)	-89.64	429.00	7.194	0.000*
Duration of action (in minutes)	25.27	1362.00	10.862	0.000*
Pain (Mean VAS Score)	-1.40	2487.00	5.922	0.000*



Graph 1: Comparison of pain (VAS), duration of action (MIN), onset of action (SEC) between Study and Control groups

Discussion
The present study compared the efficacy of sodium bicarbonate–buffered lignocaine with conventional lignocaine in children above 18 years and adults undergoing bilateral maxillary premolar orthodontic extractions. The findings revealed that buffered lignocaine significantly reduced pain on injection, demonstrated a faster onset, and provided longer duration of anaesthesia compared to the conventional formulation.
The reduction in injection pain observed in this study can be attributed to the alkalinization of lignocaine. The conventional formulation of lignocaine with adrenaline has

an acidic pH (approximately 3.5), which ensures stability but contributes to the burning or stinging sensation during injection [1]. Buffering with sodium bicarbonate increases the solution's pH closer to physiological levels, thereby reducing injection discomfort [2]. Christoph *et al*. [3], demonstrated that buffered lignocaine significantly decreased pain scores in emergency settings, while similar results were confirmed in dental studies by Kashyap *et al*. [4], and Balasubramanian *et al* [5].

In terms of onset, our study demonstrated that buffered lignocaine acted more rapidly than the conventional solution. The pharmacological explanation lies in the increased proportion of the non-ionized base form of lignocaine in buffered solutions, which facilitates faster diffusion across the nerve sheath and accelerates the onset of anesthesia [6]. Davies [7], in a systematic review, highlighted that buffering consistently shortens the latency period across different clinical contexts. More recent dental studies [4, 5, 8, 12] have reaffirmed these results, reporting faster onset with buffered anaesthetics. A meta-analysis by Guo *et al* [13]. also confirmed significantly shorter onset times with buffered solutions in infraorbital and greater palatine nerve block procedures.

The present study also demonstrated a prolonged duration of anaesthesia with buffered lignocaine. This may be attributed to both enhanced diffusion and the additive analgesic effect of carbon dioxide generated during the buffering reaction, which further potentiates local anaesthetic action [6, 9]. Clinical studies in children and adults have reported similar findings, with buffered lignocaine showing superior anaesthetic efficacy and extended duration compared to conventional solutions [4, 5, 10, 14, 15].

The clinical significance of these results in dentistry is considerable. Pain and discomfort during local anaesthetic administration are major contributors to dental anxiety, negative behaviour, and poor cooperation in children and adults [2, 11]. By reducing injection pain, improving onset, and prolonging duration, buffered anaesthetic solutions can enhance cooperation, efficiency, and overall patient experience during dental treatment. Recent split-mouth studies have highlighted that buffered solutions improve acceptance of injections in orthodontic extractions[16] and minor oral surgical procedures [17]. However, despite these benefits, routine clinical adoption remains limited due to concerns about solution stability, the need for fresh preparation, and the lack of commercially available pre-buffered cartridges [7, 12, 18]. Nevertheless, ongoing clinical trials and systematic reviews suggest that buffering may soon be recognized as a standard adjunct for paediatric and adult dental anaesthesia [13, 19, 20].

Conclusion

Sodium bicarbonate–buffered lignocaine significantly reduced injection pain, provided a faster onset, and prolonged the duration of anesthesia compared with conventional lignocaine in children above 18 years and adults undergoing bilateral maxillary premolar orthodontic extractions. These findings highlight the potential of buffered local anesthesia to enhance comfort, cooperation, and treatment efficiency in adult as well as pediatric dentistry. Although practical concerns such as stability and commercial availability remain, buffering appears to be a simple and effective modification with promising clinical applications.

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