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EFFICACY OF BUFFERED VERSUS NON-BUFFERED LOCAL ANESTHETIC SOLUTION IN DENTAL EXTRACTION CASES (A CLINICAL STUDY)

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ABSTRACT

Aim: This study was performed to evaluate the efficacy of Articaine 4% 1:100000 epinephrine buffered with sodium bicarbonate ($NaHCO_3$) 8.4% solution versus conventional non-buffered Articaine 4% 1:100000 epinephrine in dental extractions of maxillary premolar teeth in terms of pain on injection, onset of action and duration of anesthesia.

Materials and Methods: Nineteen female patients requiring bilateral extractions of maxillary first premolar teeth for orthodontic treatment were selected from the outpatient clinic of Oral and Maxillofacial Surgery, Faculty of Dentistry, Cairo University. This study was designed as a split mouth method where extractions of bilateral first premolars were carried out over a single visit. One side was infiltrated by conventional Articaine 4% with 1:100000 epinephrine (Control group) and the other side was infiltrated with Articaine 4% with 1:100000 epinephrine freshly buffered with 8.4% $NaHCO_3$ solution in a ratio of 9:1 (Study group).

Results: Non-buffered group showed statistically significant higher pain score, slower onset time and shorter anesthetic duration when compared to the buffered group.

Conclusion: Buffering the local anesthetic solution Articaine 4% 1:100000 epinephrine with 8.4% $NaHCO_3$ in a ratio of 9:1 is a simple procedure resulted in a significant decrease of pain during injection, rapid onset and longer duration of anesthesia when compared to conventional Articaine 4% 1:100000 epinephrine.

KEYWORDS: Buffering, Local anesthesia, Pain, Onset, Duration

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INTRODUCTION

Local anesthetics are considered the most important aspect of pain control in dentistry.[1] Over many years, different types of local anesthetics have been developed allowing for a wide range of selection according to the patient need and the procedure to be performed. [2, 3]

Local anesthetics are formed of hydrophilic molecules which are unable to penetrate the neurons and must be converted to a lipophilic structure to be able to diffuse through the tissues at a normal pH of 7.4. Vasoconstrictors are usually added to the local anesthetic solutions to provide vasoconstriction of the blood vessels on injection site leading to decrease in absorption of the solution and prolonging the duration of anesthesia.[4-6]

Vasoconstrictors are unstable components which require the addition of an antioxidant preservative such as sodium metabisulphite. However, adding vasoconstrictors with the preservative to the local anesthetic solution increases its acidity by lowering the pH to around 3.4 which leads to pain on injection, burning sensation and slower onset of anesthesia. [7-9]

Buffering of the local anesthetic solutions is a simple procedure that was widely reported with many advantages such as decreasing pain and burning sensation on injection, rapid onset and prolonged duration of the local anesthetic. The most common drug used to buffer local anesthetic solutions is 8.4% sodium bicarbonate ($NaHCO_3$) in a ratio of 9:1. [10-14]

Articaine is a local anesthetic containing both ester and amide links ensuring profound anesthetic effect. Different studies reported that buffered Articaine with 8.4% sodium bicarbonate had more rapid onset and decreased pain when compared to buffered lidocaine solutions. [15-17]

This study was performed to evaluate the efficacy of the local anesthetic solution Articane 4% 1:100000 epinephrine buffered with 8.4% $NaHCO_3$ versus conventional non-buffered Articane 4% 1:100000 epinephrine in dental extractions of maxillary premolar teeth concerning pain during injection, onset of action as well as the duration of anesthesia.

MATERIALS AND METHODS:

Nineteen female patients in need of bilateral extractions of maxillary first premolar teeth for orthodontic treatment were selected from the outpatient clinic of Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Cairo University. Healthy individuals with an age range of 21-50 years were included in the study. Medically compromised patients with bleeding disorders, history of allergic reactions, psychological disorders or any systemic disease interfering with dental extraction were excluded from the study. This study was approved by the Research Ethics Committee of Faculty of Dentistry, Cairo University.

Sample size calculation :

This power analysis utilized pain as the primary outcome. Pertaining to the results of Valiulla et al [18], the mean and standard deviation (SD) for the pain score values were 2.4 (1.51) and 3.9 (1.54), respectively. Using alpha (α) level of (5%), β level of 0.8 (Power = 80%); the effect size (d) for Mann-Whitney U test was 0.984 and the minimum estimated sample size was 19 cases per group. Sample size calculation was carried out using G*Power Version 3.1.9.2.

This study was designed as a split mouth method where bilateral first premolar extractions were performed over a single visit. One side was infiltrated by conventional Articaine 4% with 1:100000 epinephrine (Control group) and the other side was infiltrated with Articaine 4% with 1:100000 epinephrine freshly buffered with sodium bicarbonate 8.4% solution in a ratio of 9:1 (Study group).

Buffering of the local anesthetic was performed with a conventional hand mixing protocol. A 1ml sterile syringe was used to withdraw 0.18 ml of local anesthetic solution from the 1.8 ml carpule followed by injection of 0.18 ml of sodium bicarbonate 8.4% solution (Otsuka Pharmaceuticals, Egypt) into the carpule obtaining a ratio of 9:1 between the local anesthetic solution and the sodium bicarbonate (Fig.1, 2).

Fig. (1) Showing 25ml 8.4% sodium bicarbonate solution (Otsuka Pharmaceuticals, Egypt)

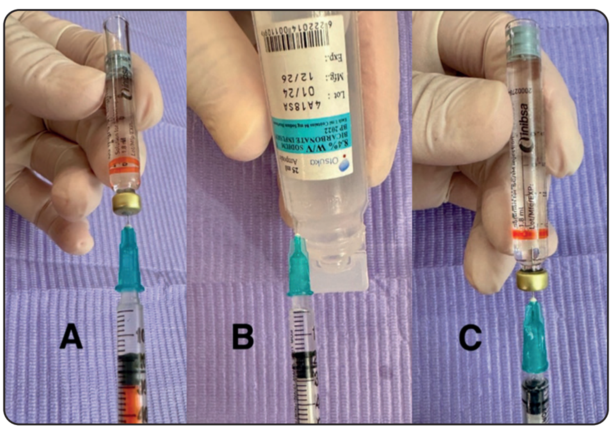

Fig. (2) Showing the procedure of the buffering technique starting with withdrawal of 0.18 ml from the local anesthetic carpule (A).Withdrawal of 0.18 ml of 8.4 % $NaHCO_3$ (B). Injection of 0.18 ml of 8.4 % $NaHCO_3$ into the local anesthetic carpule (C).

After buffering the local anesthetic solution, both the patient and the operator were blinded from the type of the solution used during injection. Buccal infiltration with a flow rate of 1.8 ml/min with blinded solution was performed on one side followed by the other solution to the opposite side. Pain during injection, onset of action and the duration of anesthesia were the parameters used to compare the two groups.

Pain on injection was measured according to the visual analogue scale of pain (VAS) from 0 to 10 where a zero score indicates no pain and a score of 10 indicates worst pain ever. Patients were asked to evaluate the pain intensity from 0-10 immediately after injection of each side.

The onset of action is the time required for the anesthetic solution to act and was measured by probing the buccal mucosa starting 30 seconds after the injection then at an interval of 10 seconds until the patient reports negative feeling for probing.

Finally, the duration of anesthesia was measured as the time elapsed between the end of injection to the time at which the patient started to experience little pain.

Statistical Analysis

The numerical data were explored for normality by evaluating the distribution of data and utilizing tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Onset and duration of anesthesia data revealed normal (parametric) distribution while the pain scores are non-parametric data. Data were presented as mean, standard deviation (SD), median and Inter-Quartile Range (IQR) values. For parametric data, Student's t-test was used compare between the two groups. For non-parametric data, Mann-Whitney U test was used for comparison between the two groups. The significance level was set at $P \leq 0.05$. Statistical analysis was carried out with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

RESULTS

Pain (VAS score)

Control group showed statistically significant higher pain score than the study group (P-value <0.001, Effect size = 1.663) (Table 1) (Fig. 3).

TABLE (1) Descriptive statistics and results of Mann-Whitney U test for comparison between pain scores in the two groups

Control (n = 19)		Study (n = 19)		*P*-value	*Effect size (d)*
Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)		
4 (4, 5)	4.53 (1.07)	3 (2, 3)	2.74 (1.19)	<0.001*	1.663

**: Significant at P ≤ 0.05*

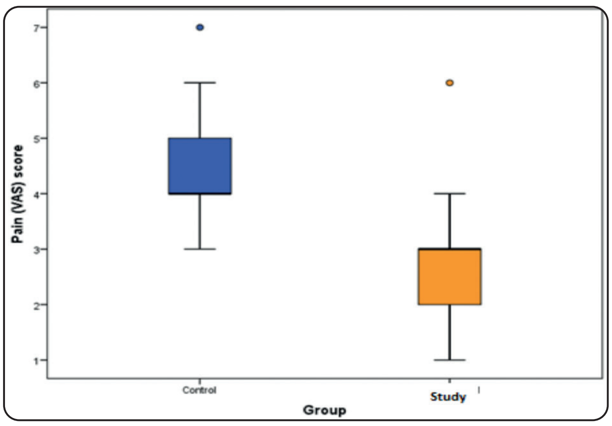

Fig. (3) Box plot representing median and Inter-Quartile Range (IQR) of pain scores in the control and study groups (Circles representing outliers)

Onset time (seconds)

Control group showed statistically significant slower onset of anesthesia than the study group (P-value <0.001, Effect size = 5.206) (Table 2) (Fig.4).

TABLE (2) The mean, standard deviation (SD) values and results of Student's t-test for comparison between onset of anesthesia (seconds) in both groups

Control (n = 19)		Study (n = 19)		*P*-value	*Effect size (d)*
Mean	SD	Mean	SD		
152.6	18.8	68.4	13	<0.001*	5.206

**: Significant at P ≤ 0.05*

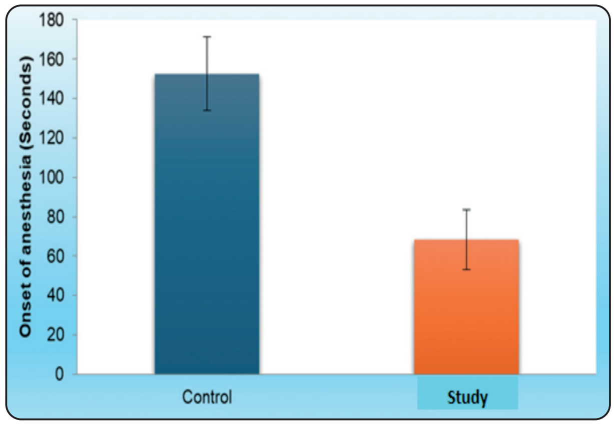

Fig. (4) Bar chart showing the mean and standard deviation values for onset of anesthesia in the control and study groups

Duration of anesthesia (minutes)

Control group showed statistically significant shorter duration of anesthesia than the study group (P-value <0.001, Effect size = 3.103) (Table 3) (Fig.5).

TABLE (3) The mean, standard deviation (SD) values and results of Student's t-test for comparison between duration of anesthesia (minutes) in both groups

Control (n = 19)		Study (n = 19)		*P*-value	*Effect size (d)*
Mean	SD	Mean	SD		
185.6	15.1	228.3	12.3	<0.001*	3.103

****: Significant at P ≤ 0.05***

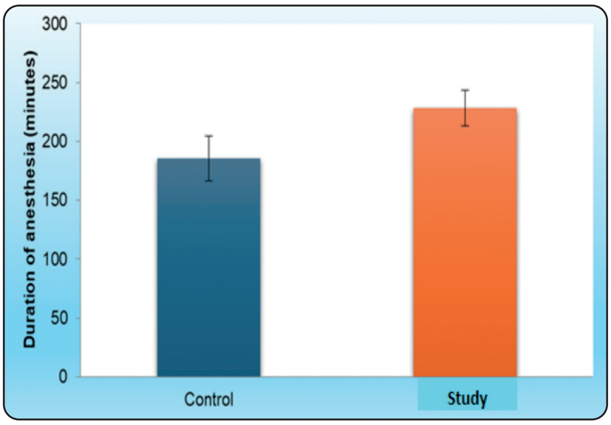

Fig. (5) Bar chart showing the mean and standard deviation values for duration of anesthesia in the control and study groups

DISCUSSION

In the present study, the non-buffered group (Control group) showed a statistically significant higher pain score than the buffered group (Study group) according to the visual analogue scale of pain. This result coincides with the findings of Malamed[19] and Brandis [20] who explained that increasing the shelf life and stability of a local anesthetic solution with vasoconstrictor require the addition of a preservative which significantly decrease the pH of the solution and increase its acidity which is considered the main reason for the burning sensation during injection.

In addition, buffering of the local anesthetic solution using sodium bicarbonate 8.4% decrease its acidity and increase its pH to a value near that of normal tissues of 7.4. Hence, decreasing the pain and burning sensation during injection. This finding supports the results of other authors [19-24] who concluded that alkalization of local anesthetic solution has many benefits including decrease in pain and stinging sensation due to the increase in the solution's pH and decreased acidity.

In this study, a statistically significant faster onset of anesthesia was found in the buffered group in comparison with the non-buffered group. This could be explained on the basis that buffering of the local anesthetic solution increases its pH thus, increasing the RN free molecules which are responsible for the diffusion through the nerve sheath. This coincides with the findings of other authors [25-28] who reported that in more acidic solutions, equilibrium shifts towards the charged RNH+ molecules which are found in more amounts than the uncharged RN molecules. When the pKa of the solution is equal to the pH which can be achieved by alkalization of local anesthetic solution, the charged RNH+ molecules and uncharged RN molecules are distributed equally. Hence, this increase in the amount of RN molecules leads to more diffusion into the nerve sheath and faster onset of anesthesia.

In the present study, longer duration of anesthesia was achieved in the buffered group compared to the non-buffered group. This could be explained on the basis that when local anesthetic solution is injected into the tissues, some molecules diffuse into the nerve sheath and others diffuse into the surrounding tissues and absorbed into the blood vessels. Buffering of local anesthetic solution increases the amount of RN molecules responsible for diffusion into the nerve sheath. Therefore, more solution will diffuse into the sheath and re-equilibrate to RNH+ forms which is responsible for conduction blockage on receptor sites. This is found to be in agreement with Agarwal et al [29], Lingaraj & Vijayakumar [30] and Afolabi et al [31] who reported that increased diffusion of local anesthetic molecules into the nerve sheath lead to increase in conduction blockage at the receptor sites thus, increasing the duration of the local anesthesia at the injection site.

CONCLUSION

Buffering the local anesthetic solution Articaine 4% 1:100000 epinephrine with 8.4% $NaHCO_3$ in a ratio of 9:1 is a simple procedure resulted in a significant decrease of pain during injection, rapid onset and longer duration of anesthesia when compared to conventional Articaine 4% 1:100000 epinephrine.

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