**Efficacy of 4% articaine hydrochloride and 2% lignocaine hydrochloride in the extraction of maxillary premolars for orthodontic reasons**

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**ABSTRACT**

**Background:** Articaine is an amide local anesthetic that differs from other agents of its group due to the presence of a thiophene ring instead of a benzene ring, and it is one of the commonly used local anesthetic agents for day care surgeries. Some researches claim that articaine is superior to lidocaine in its biologic profile. **Purpose:** To evaluate the efficacy, time of onset of anesthesia, duration of action and intra- or post-administration complications of articaine in comparison with lignocaine for bilateral extraction of maxillary premolars for orthodontic reasons. **Materials and Methods:** The study was carried out in 20 patients visiting the Department of Oral and Maxillofacial Surgery, Yenepoya Dental College and Hospital, Mangalore, needing bilateral extraction of maxillary premolars for orthodontic purposes. A volume of 0.6–1 ml of 4% articaine hydrochloride (HCl) was injected in the buccal vestibule on one side and 1–2 ml of 2% lignocaine HCl was injected on the other side. After attaining adequate anesthesia, the extraction procedure was carried out under aseptic conditions. **Results:** An onset period of 0.975 ± 0.1118 and 2.950 ± 0.5104 min and duration of anesthesia of 72 ± 17.275 and 49 ± 5.026 min was found for articaine and lignocaine, respectively. Statistically significant differences were noted in the perception of pain using the visual analogue scale. **Conclusion:** Articaine can be used as an alternative to lignocaine, especially in the extraction of maxillary premolars for orthodontic reasons. The clinical advantages including rapid onset, longer duration of action and greater diffusing property over lignocaine and the elimination of the need for a painful palatal injection were demonstrated.

**Keywords:** Articaine, lignocaine, local anesthesia, visual analogue scale

**INTRODUCTION**

Effective control of pain during dental procedures has been one of the most important prerequisite of dentistry.

In 1943, Löfgren synthesized the first modern local anesthetic agent, lidocaine, an amide derivate of diethylamino acetic acid. Lidocaine was marketed in 1948 and is presently the most commonly used local anesthetic in dentistry worldwide. In 1969, articaine was synthesized by the chemist Muschaweck and was approved in 1975 as a local anesthetic in Germany. Articaine differs from the previous amide local anesthetics in that it has a thiophene ring in its molecule instead of the usual benzene ring. It was first named Carticaine, but its generic name was changed to Articaine in 1984. Articaine is the most widely used local anesthetic in a number of countries, including Canada, Norway, Italy, France and the Netherlands. In Germany, more than 90% of the local anesthesia used by dentists is articaine. Patients treated with articaine will be “drug free” more quickly than those who receive other local anesthetics. Articaine is claimed to be superior to lidocaine, owing to its better diffusion through soft tissue and bone, the rapid onset, the excellent quality of the anesthesia and the lower degree of toxicity.
The aim of this study is to evaluate the safety and efficacy of articaine in the bilateral extraction of premolars for orthodontic reasons compared with that of lignocaine.

Purpose
To compare and evaluate the efficacy of articaine HCl anesthesia in the palatal region without palatal injection with lignocaine HCl using a visual analogue scale (VAS) for pain.

1. **Time of onset of anesthesia**
2. **Duration of action**
3. **Intra- or post-administration complications**

### MATERIALS AND METHODS

#### Materials used in this study
1. 0.5–0.6 ml of 4% articaine HCl with 1:100000 adrenaline.
2. 1–2 ml of 2% lignocaine HCl with 1:100000 adrenaline.
3. Disposable syringe with 1.5 inch, 26 gauge needle.
4. Standard extraction instruments.

#### Methods
The study was carried out in 20 patients visiting the Department of Oral and Maxillofacial Surgery, Yenepoya Dental College and Hospital, Mangalore, needing bilateral extraction of the maxillary premolars for orthodontic purposes.

#### Criteria for selection of patients for the study

**Inclusion criteria**
- Age group of 16–26 years
- Both males and females
- ASA Grade 1 patients were selected for the study

**Exclusion criteria**
- Medically compromised patients
- Hypertensive patients
- Diabetic patients
- Pregnancy

Patients needing to undergo bilateral extraction of the maxillary premolars for orthodontic reasons were selected. A volume of 0.6–1 ml of 4% articaine HCl was injected in the buccal vestibule on one side and 1–2 ml of 2% lignocaine HCl was injected on the other side. After attaining adequate anesthesia, the extraction procedure was carried out under aseptic conditions.

**Techniques used in the administration of local anesthesia**

**Local infiltration**
In the local infiltration technique (submucosal), small nerve endings in the area of the dental treatment are flooded with the local anesthetic solution, preventing them from becoming stimulated and creating an impulse. The local infiltration technique is commonly used in anesthesia of the maxillary teeth.

Volume of the drug, 4% articaine HCl with 1:100000 adrenaline, for anesthetizing the maxillary premolar in our study used was 0.5–0.6 ml in the buccal vestibule (submucosal) only. Palatal anesthesia was achieved without palatal infiltration, when objective symptoms were checked before the extraction procedure.

Volume of 0.5–1 ml of 2% lignocaine HCl with 1:100000 adrenaline was injected in the buccal vestibule (submucosal) for anesthetizing the premolar (control side) in our study. Palatal anesthesia was not achieved when the objective symptoms were checked and, therefore, an additional palatal infiltration was given to anesthetise the palatal mucosa before carrying out the extraction procedure.

After achieving complete anesthesia, the normal extraction procedure was carried out. During the extraction procedure, the patients were periodically questioned about pain. Each patient was evaluated using a 100-mm VAS during and after the extraction.

### RESULTS

The study group consisted of 20 patients who underwent extraction of the bilateral maxillary premolars for orthodontic purposes. All subjects were evaluated pre-operatively. All of them received 4% articaine with 1:100000 epinephrine and 2% lignocaine with 1:100000 epinephrine bilaterally.

The amount of anesthetic injected, the time of injection, the onset and duration of anesthesia and the post-injection complications were recorded for all patients. Pain experience is analyzed with a VAS. The values were compared and statistically analyzed (T, Test drug volume [ml]; paired samples statistics; T, Test time of onset of anesthesia [min]; T, Test duration of anesthesia [min]; Wilcoxon Signed Ranks Test – pain score). The results are tabulated in the tables and are depicted in the graphs.

**Demographics**
Twenty (20) patients were treated with 4% articaine hydrochloride (HCl) (study group) and 2% lignocaine hydrochloride (HCl) (control group).

Five male and 15 female patients with a mean age of 21 years were included in the study.

**Drug Volume [Figure 1]**
The study compared the amount of local anesthetic solution that was injected to achieve adequate anesthesia. The mean volume of articaine administered was 0.710 ± 0.1252 ml and the mean volume of lignocaine was 1.880 ± 0.2042 ml. The volume used is less in the articaine group, which is statistically significant ($P < 0.0005$).

The volume of anesthetic administered is summarized in Table 1a and 1b.

The drug volume in lignocaine is significantly higher than articaine ($P < 0.0005$).

**Time of Onset [Figure 2]**
The study showed the onset period ranging between 0.5 and 1 min in the articaine group and between 2 and 4 min in the lignocaine group. The mean onset time of anesthesia in the study group was 0.975 ± 0.1118 min and it was 2.950 ± 0.5104 min in the test group, as shown in Tables 2a and 2b. The time of onset of anesthesia in lignocaine is significantly higher than that in articane ($P < 0.0005$).
**Duration of Anesthesia [Figure 3]**
A mean duration of 72 ± 17.275 min was seen with the articaine group and 49 ± 5.026 min was seen with the lignocaine group. The difference is statistically significant (P < 0.0005), giving an inference that articaine has a longer duration of anesthesia compared with that of the control group. The values are depicted in Tables 3a and 3b.

The duration of anesthesia in articaine (P < 0.0005) is higher compared with that of lignocaine.

**Pain Ratings [Figure 4]**
We included VAS evaluation for the efficacy analysis. We found no significant difference in pain score in the articaine–palatal buccal group (P = 0.564), but a significant difference was noted in pain score in the lignocaine–palatal buccal group (P < 0.0005).

The ratings are tabulated in Tables 4a and 4b.

There was no significant difference in pain score in the articane–palatal buccal group (P = 0.564).

A significant difference in pain score in the lignocaine–palatal buccal group (P < 0.0005) was noted.

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**Table 1a: Drug volume (ml)**

| Drug volume (ml) | Group I (articaine) | Group II (lignocaine) |
|------------------|---------------------|-----------------------|
| 0.6              | 2                   |
| 0.7              | 1.5                 |
| 0.7              | 2                   |
| 0.8              | 2                   |
| 0.6              | 2                   |
| 0.7              | 1.8                 |
| 0.6              | 2                   |
| 0.7              | 2                   |
| 0.6              | 1.5                 |
| 0.7              | 2                   |
| 0.8              | 2                   |
| 0.7              | 2                   |
| 0.6              | 1.8                 |
| 1                | 2                   |
| 0.6              | 1.5                 |
| 1                | 2                   |
| 0.6              | 2                   |
| 0.8              | 1.5                 |
| 0.6              | 2                   |
| 0.8              | 2                   |

**Table 1b: Paired samples statistics**

| N   | Mean | Std. deviation | t     | P value |
|-----|------|----------------|-------|---------|
| Pair 1 Group I (articaine) | 20 | 0.710 | 0.1252 | <0.0005*** |
| Pair 1 Group II (lignocaine) | 20 | 1.880 | 0.2042 | -24.015 |

***Highly significant

**Table 2a: Time of onset of anesthesia (minutes)**

| Group I (articaine) | Group II (lignocaine) |
|---------------------|-----------------------|
| 1                   | 3                     |
| 1                   | 4                     |
| 1                   | 4                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 0.5                 | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 2                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |
| 1                   | 3                     |

**Table 2b: Paired samples statistics**

| N   | Mean | Std. deviation | t     | P value |
|-----|------|----------------|-------|---------|
| Pair 1 Group I (articaine) | 20 | 0.975 | 0.1118 | -16.823 <0.0005*** |
| Pair 1 Group II (lignocaine) | 20 | 2.950 | 0.5104 | -2.950 |

***Highly significant
Post-Injection Complications
We did not find any complications either in the articaine group or in the lignocaine group.

DISCUSSION
Articaine, unlike other amide local anesthetics, undergoes biotransformation in both liver and plasma and is thus cleared more quickly from the body. The available literature indicates that articaine is equally effective when statistically compared with other local anesthetics.[5]

It is essential to standardize the procedure when comparing the
efficacy of two anesthetic drugs. In this study, we compared the
efficacy of articaine hydrochloride (HCl) 4% with lignocaine hydrochloride (HCl) 2% both with vasoconstrictors during the extraction of maxillary premolars bilaterally. The volume of 0.5–1 ml of 4% articaine HCl was deposited buccally on one side and, on the other side, 1–1.5 ml of 2% lignocaine HCl was deposited. Parameters including the time of onset of anesthesia and the duration of anesthesia were studied. It was observed that on the side where lignocaine was injected, an additional palatal infiltration was required in order to perform painless extraction and where articaine was used, palatal infiltration was not required.

Table 3a: Duration of anesthesia (minutes)

| Group I (lignocaine) | Group II (articaine) |
|----------------------|----------------------|
| 45                   | 60                   |
| 45                   | 90                   |
| 50                   | 60                   |
| 45                   | 60                   |
| 40                   | 90                   |
| 50                   | 90                   |
| 55                   | 90                   |
| 60                   | 60                   |
| 45                   | 90                   |
| 50                   | 90                   |
| 55                   | 60                   |
| 60                   | 60                   |
| 45                   | 60                   |
| 50                   | 90                   |
| 55                   | 50                   |
| 60                   | 45                   |
| 45                   | 60                   |
| 45                   | 45                   |
| 50                   | 60                   |
| 55                   | 90                   |
| 50                   | 90                   |
| 45                   | 45                   |
| 45                   | 60                   |
| 50                   | 60                   |
| 55                   | 90                   |
| 50                   | 60                   |

Table 3b: Paired samples statistics

|               | N  | Mean | Std. deviation | t   | P value |
|---------------|----|------|----------------|-----|---------|
| Pair 1 Group I (lignocaine) | 20 | 49.00 | 5.026          | -5.954 | <0.0005*** |
| Pair 2 Group II (articaine)  | 20 | 72.00 | 17.275         |     |         |

Table 4a: Pain ratings

|               | buccal | palatal |
|---------------|--------|---------|
| Group I (articaine) | 0      | 100     |
| Group I (articaine) | 0      | 100     |
| Group II (lignocaine) | 0      | 100     |
| Group II (lignocaine) | 0      | 100     |
| Group II (lignocaine) | 0      | 100     |

Table 4b: Wilcoxon signed ranks test – Pain score

|               | Mean | Std. deviation | P value |
|---------------|------|----------------|---------|
| Pair 1 Group I articaine–buccal | 1.00 | 3.078          | 0.564   |
| Group I articaine–palatal | 1.50 | 3.663          |         |
| Pair 2 Group II lignocaine–buccal | 0.20 | 0.616          | <0.0005*** |
| Group II lignocaine–palatal | 0.85 | 0.489          |         |

***Highly significant
Articaine is an amide derivative with a “thiophene ring” in its molecular structure instead of the usual benzene ring, making it more lipophilic and thus accounting for its diffusion properties within tissues and bones, resulting in faster onset of action compared with lignocaine.[6] This is the reason that we could achieve anesthesia on the palatal side only, with infiltration of 4% articaine HCl on the buccal side.

In comparison with other amide-type local anesthetics, articaine contains a carboxylic ester group. Thus, articaine is inactivated in the liver as well as by hydrolyzation in the tissue and blood. Articaine is the only local anesthetic agent that is inactivated in both ways. Because the hydrolyzation is very fast and starts immediately after injection, about 85–90% of the administered articaine is inactivated in this way. The main metabolic product is articainic acid (or more accurately, articainic carboxylic acid), which is non-toxic and inactive as a local anesthetic.

When articaine is injected, the concentration of active drug at the site of injection is nearly twice that obtained when lignocaine is used; hence, half the volume of articaine was sufficient to achieve similar anesthesia.

In our study, the mean volume of articaine administered was 0.710 ± 0.1252 ml and the mean volume of lignocaine was 1.880 ± 0.2042 ml. We found that a lesser amount of articaine was required to achieve profound anesthesia when compared with lignocaine.

It is well documented that palatal injection is a painful experience to the patients even though surface anesthesia does allow for atraumatic needle penetration. Because of the density of palatal tissues and their firm adherence to the underlying bone, palatal injection is still painful.

Our study showed no significant difference in pain score in the articaine group, while there was a significant difference in pain score in the lignocaine group. An additional palatal infiltration was required for the lignocaine group to perform painless extraction of maxillary premolars. Pain measurement is difficult to establish because its perception and intensity are multifactorial, encompassing sensorial and affective factors.

In our study of 20 patients, there were no adverse effects or complications observed. Keeping the efficacy in mind, articaine is a safer local anesthetic agent similar to other groups of local anesthetic agents.

A study was carried out to examine an interaction of lidocaine, articaine and mepivacaine with some antihypertensive drugs such as clonidine and reserpine on pentylentetrazole-induced seizures, and the conclusion drawn was that articaine is the most safe local anesthetic and can be used in epileptic patients.[6]

For the efficacy of local anesthesia, multiple variable factors exist, like technique variability, anatomic variations, complexity of the procedure and reporting error. Pain itself is multifactorial; perception and pain reaction greatly vary among individuals. Further, controlled clinical trials, comparative studies with similar local anesthetic agents in other areas of the oral cavity in the form of infiltration and nerve block are necessary to evaluate the safety and efficacy of articaine.

**CONCLUSION**

Articaine can be used as an alternative to lignocaine in the extraction of maxillary premolars for orthodontic reasons avoiding palatal injections that are painful. Reports of toxicity reactions are extremely rare with the use of articaine. Rapid inactivation of plasma esterases may explain the apparent lack of overdose reactions, even though it is marketed as 4%.[7] Clinical advantages like a shorter time of onset, longer duration of action and greater diffusing property over lignocaine could be proved.

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