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# A study to evaluate and compare the onset, duration of action and efficacy of lignocaine and articaine in pediatric dental patients

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## Abstract

Background: Local anaesthetic agents have revolutionized the practise of dentistry and allowed safer pain free surgical experience**.** Because of its potency, safety and effectiveness lignocaine has become the gold standard for comparison among newer agents. Articaine is claimed to be superior to lignocaine owing to its better diffusion through soft tissue and bone, the rapid onset, and the lower degree of toxicity.

Aim: To evaluate and compare onset, duration of action and efficacy of lignocaine and articaine.

Method: Eighty children aged 5-12 years appearing in the outpatient department of Pediatric and Preventive Dentistry were equally divided into two groups for injecting lignocaine and articaine for routine dental procedures.

Result: Time of onset was shorter for articaine while duration of action was longer. Efficacy of articaine is more than lignocaine.

Conclusion: It can be concluded that articaine is a superior alternative to lignocaine specially in pediatric dental patients.

**Key words:** Lignocaine, Articaine, Efficacy, Local anaesthesia

## Introduction

Painless dentistry is the key towards successful management of children and the role of local anaesthesia cannot be overemphasized.[1] Local anaesthetic agents have revolutionized the practise of dentistry and allowed safer pain free surgical experience.[2] Lignocaine was the first non-ester type of local anaesthetic, which was synthesized by Nils Lofgren in 1943 and was introduced into market in 1948, and is the most frequently used anaesthetic agent in dentistry. Because of its potency, safety and effectiveness lignocaine has become the gold standard for comparison among newer agents. [2,3] Articaine was introduced in 1969 by Rusching et al with the name of carticaine and is used clinically in 4% concentration. It is a safe and effective local

anaesthetic for use in clinical dentistry and is the only amide type of local anaesthetic that contains a thiophene ring in its structure instead of benzene ring which increases its liposolubility. [2,4]

Articaine is claimed to be superior to lignocaine owing to its better diffusion through soft tissue and bone, the rapid onset, the excellent quality of the anaesthesia and the lower degree of toxicity. It is 1.5 times as potent as lignocaine, this is why administration uses a smaller volume of solution but a higher concentration of the drug.[5]

Clinical properties such as time of onset, duration of action and efficacy of a local anaesthetic agent are considered as the pivotal factors before making the choice of the anaesthetic agent to be used. [6]

**Materials and Method**

This study was conducted in the Department of Pediatric and Preventive Dentistry.

Inclusion criteria:

1.) Subjects undergoing minor oral surgical procedures, pulpectomies, pulpotomies and root canal treatment.
2.) Subjects in the age group of 5-12 years.
3.) Subjects in good general health and those who comply with the study protocol.

Exclusion criteria:

1.) Subjects with known or suspected allergies or sensitivities to sulphites and/or amide type of local anaesthetics or any ingredient in anaesthetic solution.
2.) Subjects with any concomitant cardiac, neurological, respiratory disease, diabetes or bleeding disorders.
3.) Subjects with evidence of soft tissue infection near proposed injection site.
4.) Children with age less than 5 years and more than 12 years.

Sample selection:

Eighty children appearing in the outpatient department of pediatric and preventive dentistry of our institution were included in the study. Informed consent from the parents was obtained before recruiting the patients for the study. Children in the age group of 5-12 years were selected. Subjects were equally divided into 2 groups based on the choice of anaesthetic agent used:

a) Group i :- Lignocaine 2% was used for local anaesthesia (n=40)
b) Group ii :- Articaine 4% was used for local anaesthesia (n=40)

Ethical approval and consent: Approval to conduct this study was obtained from Ethical Clearance Committee of our institution.

Methodology

Subjects in each group were prepared for the procedure by applying a swab of povidone iodine to disinfect cheeks and lips and topical anaesthesia in form of 2% lignocaine gel was applied at the site of injection for one minute. Then local anaesthetic solution was injected in subjects according to their respective group.

A single researcher injected the local anaesthetic for all the patients. All nerve blocks were given by a breach loading, metallic, cartridge-type, aspirating, non-disposable, syringe equipped with disposable 27 gauze one inch needle. 2 % lignocaine hydrochloride with 1: 80,000 adrenaline solution (Septodont) and 4 % articaine hydrochloride with 1: 200,000 epinephrine (Septodont) was used for nerve blocks.

The child's age and weight were used to determine the amount of local anaesthesia. This was calculated using Young's formula and Clark's formula of drug dose collection.

Up to one cartridge (1.8 ml) of lidocaine (maximum dose 4mg/kg body weight) and articaine (maximum dose 5mg/kg body weight) was administered.

Study procedure:

1.) Onset of action

The onset time of anaesthesia was recorded as the time elapse between the end of anaesthetic injection and confirmation of anaesthesia through subjective and objective symptoms.

Onset of local anaesthetic agent action was confirmed:- Subjectively by the loss of sensation of the of lip, buccal mucosa, tongue and palate.

Objectively by the presence /absence of pain to prick of sharp dental probe applied about 7 mm from gingival margin on the attached gingiva buccal to the tooth to be tested. A standard digital stop watch was used to calculate the time and it was recorded in minutes.

2.) Duration of action

Duration of anaesthesia was recorded as the time interval between onset of anaesthesia and the return of response through subjective and objective symptoms.

This was determined subjectively as represented by the lack of sensation of mucosa, tongue and lip. Patients recorded the time when anaesthesia had worn off and telephonically informed the operator. Patients who failed to do this were excluded from the study.

3.) Efficacy of anaesthesia

The effectiveness of each anaesthesia technique was assessed by evaluating the presence or absence of pain; during the injection, labial and lingual probing for anaesthesia, placing the rubber dam, during the use of high- and low-speed hand piece and during extraction. A separate

evaluation was made during the removal of the coronal pulp during a pulpotomy procedure. No evaluation was made for the restoration following a pulpotomy. Following the injection, any sign of discomfort indicating pain upon assessment of other evaluation intervals was recorded as a presence of pain, the procedure was discontinued, and the anaesthesia technique was evaluated as inadequate. Efficacy of the anaesthetic solution was determined by recording pain perception during the procedure using Visual Analogue Scale (Fig.1: VAS).

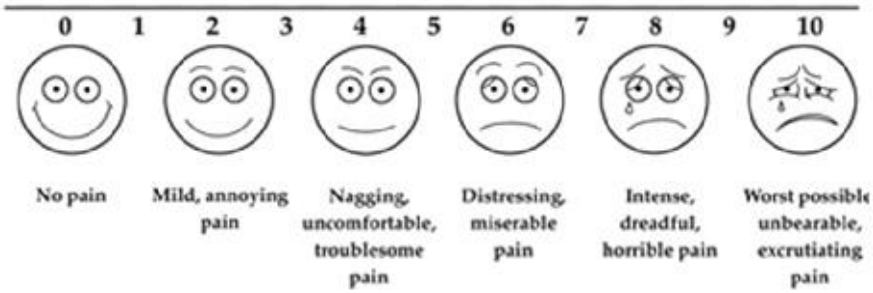


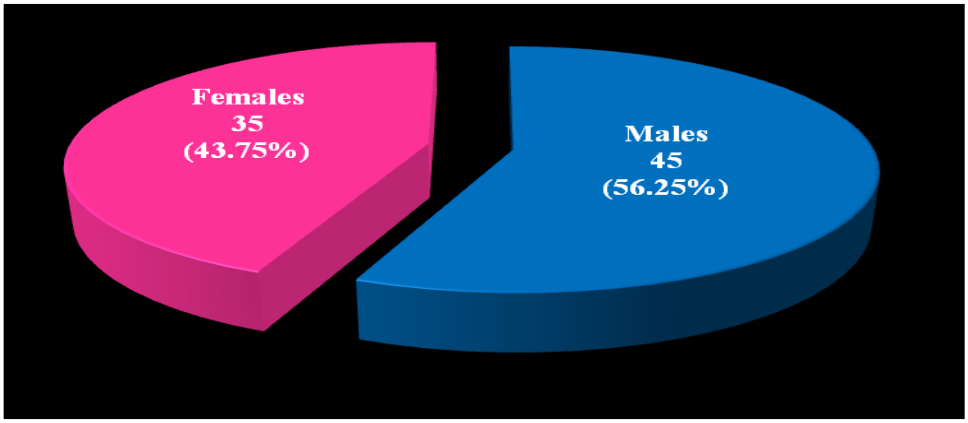

Fig 1: VAS

**Data Analysis**

The results were statistically analysed with SPSS 19 software using independent 't' test for comparing onset and duration of action between articaine and lignocaine. Mann-Whitney U test was used to compare the efficacy of the two anaesthetic agents.

**Results**

A total 80 study subjects (40 – Articaine, 40 – Lignocaine) between the age of 5 – 12 years were taken in the study, out of which 45 (56.25%) were males and 35 (43.75%) were females (Graph 1). Mean age of study subjects was 8.48 years. Mean time interval for onset of anesthesia in articaine group was 1.380 minutes and for lignocaine it was 2.938 minutes (Table 1). Onset of anesthesia was found to be early in articaine group as compared to lignocaine group and difference of time in onset of anesthesia was found to be statistically very highly significant ($p < 0.001$). Mean duration of action in articaine group was 244.05 minutes and for lignocaine group it was 168.80 min. Duration of action was found to be more in articaine group as compared to lignocaine group and difference of time in duration of action was found to be statistically very highly significant (Graph 2). Mean score on visual analogue scale for articaine group was 1.40 and for lignocaine group it was 2.25. Efficacy of articaine group was found to be better as compared to lignocaine group and difference of efficacy (Visual Analogue Score) was found to be statistically highly significant (Table 2).

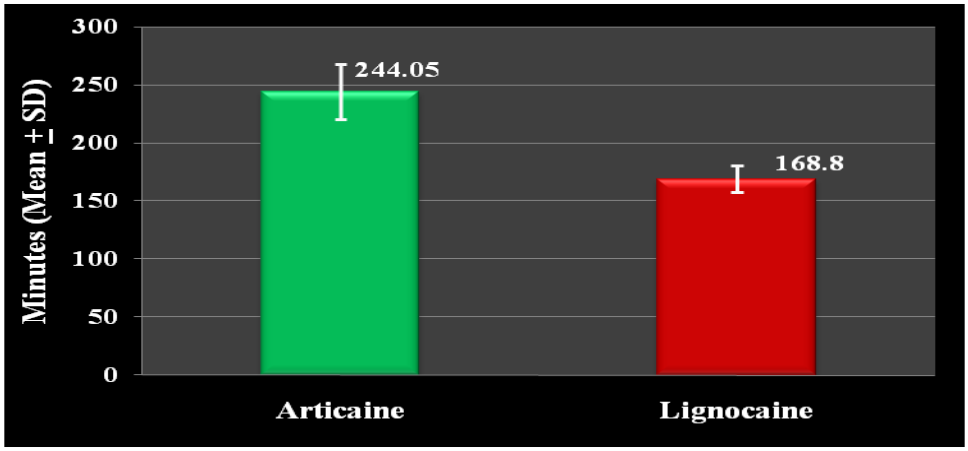



Graph 1: Description of study subjects

Table 1: Comparison of onset of anaesthesia between articaine and lignocaine groups.

| Groups | Onset of Anaesthesia (in minutes) | | Independent 't' test | p - value |
|---|---|---|---|---|
| | Mean | SD | | |
| Articaine | 1.380 | 0.4316 | 16.525 | **< 0.001 (VHS)** |
| Lignocaine | 2.938 | 0.4112 | | |

SD – Standard Deviation, VHS – Very Highly Significant




Graph 2: Duration of Action

Table 2: Comparison of efficacy (Visual Analogue Score) between articaine and lignocaine groups.

| Groups | Visual Analogue Score (VAS) | | | Mann Whitney U test | p - value |
|---|---|---|---|---|---|
| | Mean | SD | Mean Rank | | |
| Articaine | 1.40 | 1.033 | 34.04 | 541.50 | **0.004 (HS)** |
| Lignocaine | 2.25 | 1.373 | 46.96 | | |

SD – Standard Deviation, HS – Highly Significant

**Discussions**

Local anaesthesia is an essential need of modern dentistry. During pedodontic treatment, effective pain control is extremely important to reduce patient's discomfort and operator's stress. These agents primarily aim at controlling pain efficiently. A successful pediatric dentistry can only be practised by delivering a painless dental procedure to a child and inflicting a positive dental behaviour towards that procedure without causing any adverse psychological impact on the child. Local anaesthesia gives that opportunity to the dental surgeons by offering its pharmacological property of blocking pain sensation. The choice of anaesthetic solution should be based on three main clinical considerations: time of onset of anaesthesia, duration of the anaesthetic effect and anaesthetic efficacy. Literature reports state that 90–95% of articaine is metabolized in the blood and only 5–10% is broken down in the liver. The plasma half-life has been reported to be as low as 20 min. Both articaine and lidocaine have the same maximum milligram dose of 500 mg (recommended dose of 6.6–7 mg/kg) for the adult patient. [3]

In the present study we compared articaine and lignocaine in terms of onset of anaesthesia, duration of action and efficacy by giving nerve blocks with both the solutions in different individuals. In this study, these two local anaesthetic solutions (articaine and lignocaine) were chosen because they are the most commonly used preparations in the pediatric dental practise for the management of pain.

Onset of anaesthesia:

In the literature, some controversies have been reported related to calculation of time period of onset of anaesthesia. Some authors[13] considered the onset period to begin at the time of injection. However, in the present study, we considered the onset period to begin from the completion of injection until anaesthesia is confirmed which is in agreement with most of the published studies.[6,7,8]

An ideal anaesthetic agent should have a short onset of anaesthesia. Onset of anaesthesia, depends on a number of factors, such as the intrinsic properties of the drug substance used, and the anaesthetic technique employed. Latency (time of onset) is also directly influenced by the corresponding pKa value. Smaller pKa values being associated to shorter latency. Accordingly, 4 % Articaine (pKa = 7.8) would present a shorter time of onset of anaesthesia than 2 % Lidocaine

(pKa = 7.9).[9] In the present study, mean time for onset of articaine was 1.380 minutes and for lignocaine 2.938 minutes which was statistically very highly significant. The results of the present study are in accordance with study conducted by Kalia et al[2] (2011) where they reported that mean time duration for onset of articaine was 1.08 minutes and for lignocaine was 1.88 minutes when nerve blocks were administered for both the solutions and the result was significant statistically. The faster onset of articaine was may be due to high lipophilicity and 4% concentration, because of which its ability to diffuse through nerve membranes, soft tissue, and bone is enhanced.

Similarly, Sripathi Rao et al[10] also reported that onset of anaesthesia with articaine was between 0.5-1 minute and between 2-4 minutes with lignocaine which was statistically significant. They concluded that onset of anaesthesia is faster in the articaine group. In accordance with our study, Saraf SP[7] et al also reported that onset of anaesthesia was faster in articaine group as compared to lignocaine group. They concluded that articaine was 1.5 times more potent than lignocaine.

However, in contrast to our study, Kambalimath DH et al[9] (2013) reported that articaine and lignocaine have similar onset of action .Mean time for onset of articaine was 1.35 min and for lignocaine was 1.40 min which was statistically not significant.

Vahatalo K et al (1994)[11] compared articaine and lignocaine for onset of action using infiltration for both the anaesthetic agents and concluded that the result was not significant statistically.

Duration of action:

Duration of anaesthesia is proportional to its degree of protein binding. However, the duration of the effect of the local anaesthetic is also dependent on the injection site or concentration of vasoconstrictor present in the anaesthetic solution, among other factors. As local anaesthetic solutions are believed to act binding to a protein receptor in the sodium channel, the greater protein binding of a specific agent presumably results in a longer period of sodium channel blockade and a longer duration of anaesthesia. The reported protein-binding values for lidocaine and articaine are 65% and 95%, respectively.[12] Articaine presents one of the greatest protein binding percentages of all amide local anaesthetics, comparable only to ultra-long action substances such as Bupivacaine, Ropivacaine and Etidocaine. This in turn implies a longer duration of the anaesthetic effect.[9] In the present study duration of action for articaine was 244.05 minutes while for lignocaine it was 168.80 minutes and the result was very highly significant statistically. Thus, it can inferred that articaine has a longer duration of action than lignocaine. Similarly, Ram D and Amir E[12] (2006) also reported that duration of numbness for articaine was more (205.8 minutes) than lignocaine (180.6 minutes). The result was statistically significant. In agreement with our study Costa CG et al[13] also found the similar results when they compared the two solutions for maxillary infiltration. They reported that mean duration of action for articaine infiltration was 56.7 minutes while for lignocaine infiltration was 39.2 minutes.

Kalia V et al[2] (2011) also reported that mean duration of action for articaine was 232.8 minutes and for lignocaine was 160.8 minutes. The results were significant and they concluded that articaine has more duration of action as compared to lignocaine. In accordance with our study, Sripathi Rao BH et al[10] also reported that a mean duration of 72 min was seen with articaine infiltration and 49 min with lignocaine infiltration which was significant statistically. They concluded that articaine has a longer duration of anaesthesia as compared to lignocaine. However, in contrast to our study, Arali V and Mytri P (2015)[6] reported that duration of anaesthesia was 160 min for articaine infiltration and 200 minutes with lignocaine nerve block and the result was statistically not significant. Vahatalo K et al (1994)[11] and Kambalimath DH et al (2013)[9] also reported that there was no significant difference between duration of action when the two solutions were infiltrated. In the study conducted by Jaikaria A et al (2018)[14] they reported a shorter duration of anaesthesia with articaine as compared to lignocaine where they used articaine for infiltration and lignocaine for nerve block.

Efficacy:

Objective quantification, standardization and measurement of pain among different individuals is difficult to establish because its perception and intensity are multifactorial in compassing sensorial and affective factors.[15] In the present study, efficacy of local anaesthetic agents was evaluated by assessing the pain experienced by the individuals using visual analogue scale. Visual analogue scale (VAS) chosen because it is methodologically sound, theoretically simple, easy to run and unassuming to the respondent. [4] Profoundness of anaesthesia was made and by means of visual analogue scale (VAS) in which the patient was instructed to score intraoperative pain intensity[9]. In the present study intraoperative VAS of 1–10 for articaine was 1.40 while for Lidocaine it was 2.25 and these results are statistically highly significant and it was found that articaine was more efficacious than lignocaine. The intra operative analgesia evoked by articaine may be explained by its ability to readily diffuse through tissues due to the presence of thiophene group in the molecule, which increases liposolubility. Articaine is unique among amide local anaesthetics, in that it contains a thiopentone group instead of the benzene ring found in lidocaine and other amide local anaesthetics. The thiopentone ring contains a methyl ester side linkage that contributes to articaine's rapid conversion to articainic acid, its primary metabolite. Thiopentone ring increases liposolubility, higher the potency and diffusion through the epineurium.[7,9] The results of the present study are in accordance with study conducted by Kambalimath DH[11] (2013) who reported that VAS score for articaine was 1.88 and for lignocaine was 2.45 and the results were statistically significant. They concluded that articaine is more efficacious than lignocaine. Arali & Mytri[5] (2015) and Ghadimi S et al[17] (2018) also reported that buccal infiltration with 4% articaine was more effective than 2% lignocaine Inferior Alveolar nerve block in achieving pulpal anaesthesia in 5-8 year old children. Similarly, Mauthingal S et al[3] (2015) also reported that 4% articaine produced greater changes from the base line pulp tester readings than 2% lignocaine when administered as buccal infiltration in the mandible. They concluded that articaine is more efficacious than lignocaine. However, in

contrast with our study, Chopra R et al[1] (2016) reported that IANB with lignocaine and articaine have similar efficacy and articaine achieves better anaesthesia than lignocaine infiltration.

In the study conducted by Vahatalo K et al[11] (1994), Malamed SF et al[16] (2000), Oliveira PC[15] (2004) and Jaikaria A et al[14] (2018) they also reported that articaine and lignocaine are equally efficacious as the result was not significant statistically.

## Conclusion

The present study was undertaken to compare the onset, duration of action and efficacy of 2% lignocaine with 4% articiane. Based on the results of this study, it can be concluded that articaine is a superior alternative to lignocaine specially in pediatric dental patients. Local anaesthesia is a unprecedented component of any dental practise. Therefore, use of a superior anaesthetic agent is always desirable.

## Limitations and Future Studies

The studies comparing articaine and lignocaine in terms of onset, duration of action and efficacy in pediatric dental patients are less. Further studies can be undertaken in this regard so as to reach a more conclusive evidence.

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