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The Efficacy of 4% Articaine Infiltration Anesthesia in the Extraction of Mandibular Molars: A Randomized Controlled Study

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ABSTRACT

Introduction: Articaine was developed in 1969, with reported advantages which are increased potency, increased duration of its anesthetic effect and superior diffusion through bony tissue. The effectiveness of using 4% articaine infiltration for extraction of mandibular molar teeth in comparison to 2% lidocaine inferior alveolar nerve block is not settled yet.

Aim: The aim of this study was to evaluate the effectiveness of using 4% articaine infiltration for extraction of mandibular molars by comparing it to the use of 2% lidocaine inferior alveolar nerve block in terms of success, the volume of local anesthetic agents and the pain experienced during the procedure.

Materials and methods: A prospective randomized controlled study included 210 patients indicated for extraction of unrestorable mandibular molars, they were randomly assigned into 2 groups; a control group in which the extraction was carried out under inferior alveolar nerve block with 1.8 ml 2% lidocaine with 1:80,000 epinephrine and a study group in which the extraction proceeded under infiltration with 1.8 ml articaine with 1:100,000 epinephrine. The variables investigated included; the success and failure of extraction, the volume of local anesthetic required completing the extraction 1.8 or 3.2 ml and the degree of pain experienced during extraction assessed by pain numerical rating scale.

Results and discussion: Both groups showed a statistically non-significant difference in providing local anesthesia although the control group had a higher success rate. With respect to the volume of anesthesia required to complete the extraction the study group required 3.6 ml anesthesia more often than the control group with a statistically significant difference, also the study group demonstrated statistically higher scores of pain than the control group.

Conclusion: 4% Articaine infiltration demonstrated fewer efficacies than 2% lidocaine inferior alveolar nerve block in the extraction of mandibular molars.

Key words: Articaine, Lidocaine, Mandibular infiltration

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INTRODUCTION

Local anesthesia is an essential part of pain control in dentistry and most of the local anesthetic solutions, currently in use, are safe with negligible soft tissue irritation and minimal concerns for allergic reactions [1]. Lidocaine is the first amide type local anesthetic that has been in use since 1948 and it is considered as the gold standard against which all other local anesthetics are compared [2,3].

Articaine was developed in 1969 and was first marketed in Germany in 1976 and was FDA approved in 2000, its molecular structure contains a thiophene ring and an ester side chain [4]. Its lower systemic toxicity allows it to be used in higher concentration (4%) than other amide type anesthetic solutions [5]. Other reported advantages of articaine are increased potency, increased duration of its anesthetic effect and superior diffusion through bony tissue [2].

In most maxillary surgical procedures field anesthesia achieved by infiltration is sufficient because of the thin and porous cortex of the alveolar bone whereas surgery in the mandible often times require conduction anesthesia

provided by nerve blocks because of the thick buccal cortical bone [1, 6], of which the inferior alveolar nerve block (IANB) described by Halsted, et al. is the most widely used [7], other techniques include the indirect technique, the anterior injection technique, the Gow-Gates and the Akinosi-Vazirani techniques [8]. Infiltration anesthesia of the mandible has been used as supplementary technique to IANB and as primary technique of anesthesia for mandibular deciduous teeth and for pulpal anesthesia in the incisor canine region in adults whereas in the molar region success seems to be dependent on the choice of local anesthetic solution [6].

Many studies have evaluated the effectiveness of articaine and compared it to that of lidocaine; Katyal, et al. [9] demonstrated that articaine provides superior anesthetic effect than lidocaine for maxillary and mandibular infiltrations and block anesthesia in routine dental procedures, also Brandt et al. [10] in a review of 13 studies found that articaine was better than lidocaine after infiltration anesthesia but no difference was observed after mandibular block anesthesia. Bartlett, et al. [11] in their review of studies that compared 2% lidocaine IANB with 4% articaine buccal infiltration in providing pulpal anesthesia in mandibular molars in adults, identified only 2 studies and they concluded that there was no significant difference between the 2 methods, they also observed that studies present a number of weaknesses in their design that make their level of evidence inconclusive. In a recent review, the authors compared 4% articaine with lidocaine for inferior alveolar nerve block in extraction of mandibular third molars, 9 studies were included in their systematic review and they found that articaine demonstrated superior anesthetic effect [12].

It seems that the effectiveness of using 4% articaine infiltration for extraction of mandibular molar teeth in comparison to 2% lidocaine inferior alveolar nerve block is not settled yet. Therefore the aim of this study was to evaluate the effectiveness of using 4% articaine infiltration for extraction of mandibular molars by comparing it to the use of 2% lidocaine inferior alveolar nerve block in terms of success of anesthesia, the volume of local anesthetic agents required and the pain experienced during the procedure.

MATERIALS AND METHODS

This study was designed and implemented as a prospective randomized controlled study. It included 210 patients who were indicated for extraction of unrestorable mandibular molars and was conducted at the Department of Oral and Maxillofacial Surgery, College of Dentistry, University Of Baghdad during the period extending from January to April 2019. The inclusion criteria were patient's ≥ 18 years of age who were willing to participate in this study. Patients were excluded from this study if they had an acute infection at the extraction site, mobile teeth, completely impacted teeth, allergy to the local anesthetic agents used in this study, uncontrolled systemic diseases or those taking medications affecting pain assessment and pregnant female patients. The patients were randomly assigned into 2 groups: A control group in which the extraction of the mandibular molars was carried out under IANB with 1.8 ml 2% lidocaine hydrochloride with 1:80,000 epinephrine (Lignospan Special, Septodont, Saint-Maur-des-Fosse's Cedex, France) and a study group in which the extraction of the mandibular molars proceeded under infiltration with 1.8 ml articaine hydrochloride with 1:100,000 epinephrine (Ubistesin™ forte, 3M ESPE, Neuss, Germany,). Block randomization was used to prepare the randomization tables, to avoid the imbalance in distribution of the patients between the two groups. Assignment was performed using Microsoft Excel (2016). Participants were informed about the different treatments, but blinded to the assignment.

The study sample size was determined using a free software (G*power 3.1.9.4 for Windows). The required data for sample size calculation were obtained from relevant literature. A sample size of 206 participants was found enough to reject the null hypothesis between test and control groups at probability power of 0.8 and 0.05 types I error probability. To overcome any possible statistical error and drop out, a total sample 210 patients was considered in this study.

The Research Ethics Committee at the College of Dentistry, University of Baghdad approved the protocol of this study (protocol reference number 038118) and each patient signed an informed consent to participate in the study.

Prior to the surgical procedure, the patients were informed about the nature of the procedure and the possible complications that may arise and they were assigned into one of the 2 groups of the study according to their sequence in the randomization table prepared.

For the control group, the patients received 1.8 ml of 2% lidocaine hydrochloride with 1:80,000 epinephrine using the conventional IANB technique, about 1.5 ml of local anesthetic solution was slowly deposited to anesthetize the inferior alveolar and the lingual nerves, and when the patient reported numbness of the ipsilateral lower lip and tongue the remaining 0.3 ml was injected in the buccal vestibule corresponding to the accused tooth to anesthetize the buccal gingiva and soft tissues.

For the study group, the patients received 1.8 ml of articaine hydrochloride with 1:100,000 epinephrine using infiltration technique, by injecting about 1.5 ml of local anesthetic solution deep in the buccal vestibule between the mesial and distal roots of the lower molar tooth slowly with the bevel of the needle oriented facing the bone, then injecting the remaining 0.3 ml lingually at the junction of mucogingival fold with the bevel of the needle also facing the bone.

For both groups, after 15 minutes of local anesthetic administration, anesthesia was checked by asking the patients about lip numbness in addition to checking the buccal and lingual tissues using sharp dental probe. When local anesthesia was not achieved, the case was considered as a failure and local anesthesia was administered by IANB and extraction proceeded in a conventional manner.

The procedure of tooth extraction started with separation of the attached gingiva, luxation using straight elevator and the extraction was completed using mandibular molar forceps. Such cases were regarded as easy extractions. In some cases extraction was achieved by separation of the roots using a handpiece and carbide fissure bur, the root separation was completed using straight elevator and the teeth were extracted using the elevator and/or the mandibular root forceps. Such cases were regarded as having moderate difficulty of extraction. When separation of the roots alone was not enough to complete the extraction, a mucoperiosteal flap was reflected and alveolar bone was removed using straight handpiece and bur under copious irrigation with normal saline and extraction was completed. These cases were considered as difficult extractions. The duration of extraction was recorded in minutes.

When the patients felt pain or discomfort during extraction the anesthesia was considered inadequate and additional 1.8 ml local anesthetic solution was administered in the same manner for each group and extraction proceeded as described. When pain during extraction continued after the additional anesthesia and the procedure could not be completed the case was considered and recorded as failure. After extraction patients were asked to rate their degree of perceived discomfort during extraction using a pain numerical rating score (NRS) of 0-10 where 0 is no pain and 10 the worst pain. The independent variables in this study included; extraction of the mandibular molars under IANB with 2% lidocaine hydrochloride with 1:80,000 epinephrine or under infiltration with articaine hydrochloride with 1:100,000 epinephrine, difficulty of extraction which was divided into; easy, moderate or difficult, duration of extraction measured in minutes, the molar teeth extracted in addition to the age (the patients were divided into 3 age groups; 18-30, 31-50 and >50 years) and gender of the patients. The outcome (dependent) variables included; the success and failure of extraction, the volume of local anesthetic required to complete the extraction 1.8 or 3.2 ml and the degree of pain experienced during extraction assessed by pain NRS.

The statistical analysis was performed using GraphPad Prism version 6 for Windows (GraphPad Software, La Jolla, CA, USA). Descriptive statistical analysis included calculation of percentages and mean ± standard deviation (SD) and inferential analysis included using unpaired t-test, Chi square, and Fisher's exact test. Probability values <0.05 were considered statistically significant.

RESULTS

The whole sample consisted of 210 patients, their mean ± SD age was 33.21 ± 10.03 years with an age range of 18-82 years, the distribution of patients according to age groups was as follows; 94 (44.8%) patients were 18-30 years of age, 104

(49.5%) were 31-50 years of age and 12 (5.7%) were older than 50 years. The patients were 112 (53.3%) females and 98 (46.7%) males. The mandibular molars that were extracted in the whole sample were: third molars (n=137, 65.2%), second molars (n=37, 17.6%) and first molars (n=36, 17.2%). The indications for extraction were caries and its sequel in 144 patients (68.6%), orthodontic purposes in 26 patients (12.4%), retained roots in 24 patients (11.4%) and eruption problems in 16 patients (7.6%).

All patients received 1.8 ml of either solutions of local anesthetic according to the randomization table, 64 patients (30.5%) required additional 1.8 ml of local anesthesia to complete the extraction. Extraction was completed successfully in 195 patients (92.9%) while in 15 patients (7.1%) there was failure to achieve anesthesia to complete the extraction. The degree of difficulty of extraction in the 195 patients who completed dental extraction was categorized as: Easy in 133 patients (68.2%), Moderate in 55 patients (28.2%) and Difficult in 7 patients (3.6%). The mean ± SD duration of extraction in minutes was 2.767 ± 3.705 minutes with a range of 0.13 to 26.4 minutes and the overall mean ± SD of the pain NRS was 2.887 ± 1.931.

The study group consisted of 109 patients and the control group consisted of 101 patients, the progress through the phases of the randomized study of the two groups is shown in Figure 1. Data in Table 1 show the distribution of patients according to mean age, age groups, gender, teeth indicated for extraction, the degree of difficulty and the duration of extraction in the

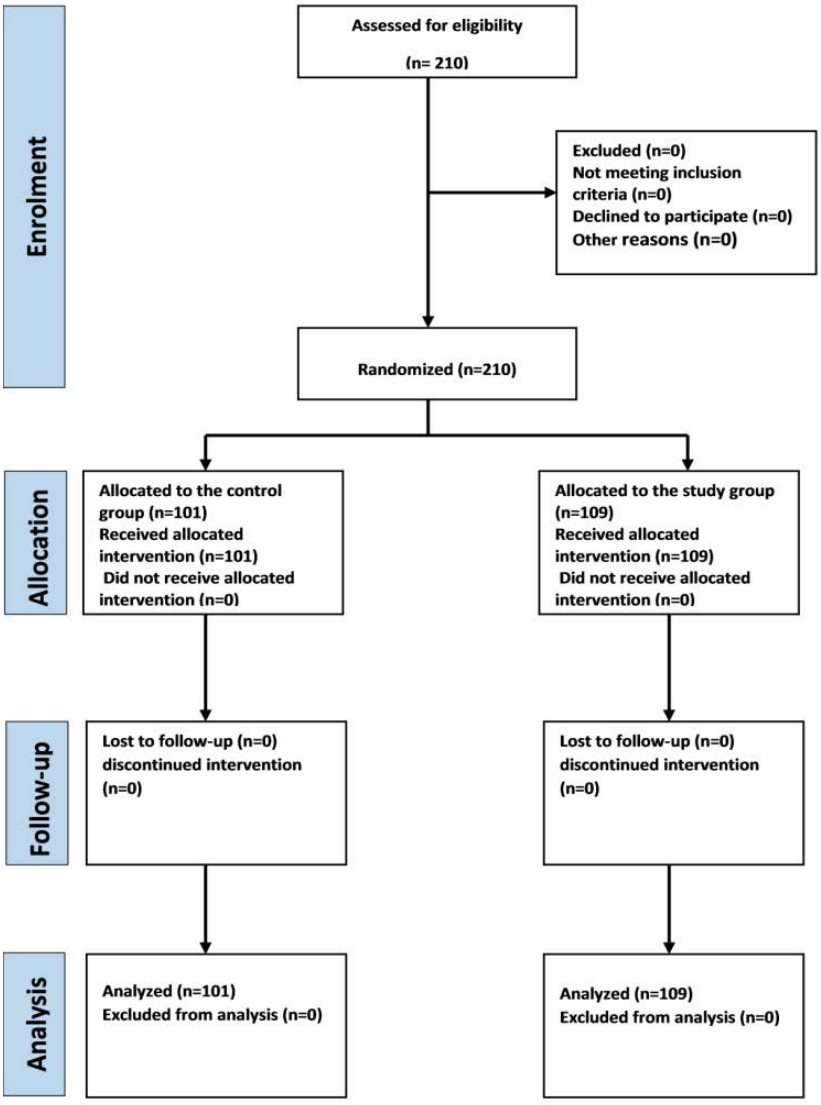

Figure 1: Flow diagram of the progress through the phases of the randomized study of two groups (enrolment, intervention allocation, follow-up, and data analysis).

Table 1: Comparison of the mean age, age groups, gender, teeth indicated for extraction, degree of difficulty and duration of extraction between the control and study groups.

Variable	Control group	Study group	P value
Age/mean ± SD years (n=210)	33.33 ± 9.44	33.09 ± 10.58	0.273* [NS]
Age groups (n=210)			
18-30 years	42 (41.6%)	52 (47.7%)	0.671† [NS]
31-50 years	53 (52.5%)	51 (46.8%)	
>50 years	6 (5.9%)	6 (5.5%)	
Gender (n=210)			
Female	54 (53.5%)	58 (53.2%)	1.000‡ [NS]
Male	47 (46.5%)	51 (46.8%)	
Teeth indicated for extraction (n=210)			
First molar	14 (13.9%)	22 (20.2%)	0.335† [NS]
Second molar	16 (15.8%)	21 (19.3%)	
Third molar	71 (70.3%)	66 (60.5%)	
Degree of difficulty (n=195)			
Easy	59 (60.8%)	74 (75.5%)	0.075† [NS]
Moderate	33 (34%)	22 (22.5%)	
Difficult	5 (5.2%)	2 (2%)	
Duration/mean ± SD minutes (n=195)	3.06± 3.98	2.48 ± 3.51	0.273* [NS]

*Unpaired t-test; †Chi square test; ‡Fisher exact test; [NS] Non-significant

Table 2: Comparison of the outcome variables between the control and study Groups.

Variable	Control group	Study group	P value
Anesthesia (n=210)			
Success	97 (96%)	98 (89.9%)	0.109‡ [NS]
Failure	4 (4%)	11 (10.1%)	
Volume of anesthesia (n=195)			
1.8 ml	88 (90.7%)	43 (43.9%)	0.000‡ [S]
3.6 ml	9 (9.3%)	55 (56.1%)	
Pain/mean ± SD NRS (n=195)	2.03± 1.57	3.73± 1.89	0.000* [S]

* Unpaired t-test; ‡ Fisher exact test; [NS] Non-significant; [S] Significant; NRS Numerical rating scale

control and study groups. All the differences of the aforementioned variables between the two groups were statistically non-significant.

The comparison of the outcome variables between the two groups is summarized in Table 2; both groups showed statistically non-significant difference in providing local anesthesia although the control group had higher success rate. With respect to the volume of anesthesia required to complete the extraction the study group required additional anesthesia (3.6 ml) more often than the control group with a statistically significant difference, also the study group demonstrated statistically higher scores of pain NRS than the control group.

DISCUSSION

It is hard to provide adequate anesthesia by infiltration of lidocaine for the posterior mandible because of the thick buccal cortex that prevents diffusion of solution into the cancellous bone, which made research workers to look for an anesthetic agent that will anaesthetize the lower teeth by infiltration alone [6, 13]. The introduction of 4 % articaine has led to a renewed interest in the use of this technique in the mandible because the results have shown it to be more effective than 2 % lidocaine [6]. The aim of this study was to evaluate the effectiveness of 4% articaine infiltration technique by comparison with 2% lidocaine IANB technique in extraction of mandibular molar teeth.

The adequacy of randomization process for patients eligible for extraction into both study and control groups was evaluated (Table 1) and there were no statistically significant differences in the age, gender, teeth indicated for extraction, difficulty and duration of extraction between the two groups, therefore these variables did not act as confounding factors that may affect the outcome of this study.

Studies that compared the efficacy of 4% articaine and 2% lidocaine through mandibular infiltration to achieve pulpal anesthesia have reported significantly better success rates with articaine [14-17]. Sierra-Rebolledo et al. [18]

and Kambalimath, et al. [2] compared the use of articaine in IANB with lidocaine in extraction of impacted lower third molars and found that there was no difference in anesthetic efficacy although articaine showed better clinical performance, also Zhang et al. in 2019, concluded that IANB with articaine demonstrated superior anesthetic efficiency relative to lidocaine in extraction of lower third molars. Few studies, however, compared the efficacy of 4% articaine infiltration technique with 2% lidocaine IANB technique in extraction of mandibular molar teeth [12].

There was no statistical difference between the two solutions and techniques in providing anesthesia to complete extraction of mandibular molars although the success of anesthesia using 4% articaine infiltration (89.9%) was lower than that achieved by 2% lidocaine IANB (96%). Sawadogo et al. [19] in a prospective cohort study that included extraction of mandibular third molars using 4% para-apical and lingual infiltration, a success rate of 87% was reported which is close that demonstrated in our study.

More patients in the study group required 3.6 ml of aricaine to complete their dental extraction than patients in the control group and with a significant difference, this is in agreement with El-Kholey, et al. [20] who reported a higher success rate (93%) with 3.6 ml articaine compared with 56% success rate with 1.8 ml in extraction of mandibular third molars, the author considered the low success rate with 1.8 ml articaine as not enough to support its use as a primary injection technique in mandibular third molar surgery. Sawang, et al. [21] also reported that 3.4 ml of articaine infiltration demonstrated a significantly higher success rate (83.3%) than 1.7 ml (53.3%) in extraction of lower third molars. Martin, et al. [22] made a similar observation in that the anesthetic efficacy of 3.6 ml 4% articaine with 1:100,000 epinephrine is better than 1.8 ml of the same anesthetic solution in a primary mandibular buccal infiltration for providing pulpal anesthesia of the first molar, the authors achieved a 50% success rate using 1.8 ml and 70% success when using 3.6 ml.

Achieving local anesthesia by infiltration of articaine in the posterior mandible may depend on the thickness of the buccal cortex, Flanagan, et al. [23] observed that effective local anesthesia could be provided in patients with thin cortices and when there is facial cortical bone thicker than 2.0 mm, as measured on a CBCT, adequate anesthesia may not occur, the author also observed that the cortical density expressed in Hounsfield units or tooth apex distance from the facial cortical aspect of the site did not appear to affect anesthetic effect and he recommended a waiting time of 5–10 minutes for effective anesthesia and that an additional 1.8 ml of articaine may be required to attain anesthesia if an initial 1.8 ml fails as this may allow better penetration.

Patients in the study group who had extraction after articaine infiltration experienced significantly more intraoperative pain than the patients in the lidocaine group, this is in contrast to Rayati, et al. [13] who reported significantly more pain during extraction of mandibular molars with 2% lidocaine IANB than with 4% articaine buccal infiltration but despite their result, the authors, concluded that buccal infiltration with articaine cannot be recommended as an alternative to IANB.

CONCLUSION

In conclusion, this study demonstrated that the success of local anesthesia using 4% articaine infiltration is comparable to that of 2% lidocaine IANB, but the volume of anesthesia required and the pain experienced during extraction was more with articaine infiltration than lidocaine IANB.

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