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Buccal versus lingual articaine infiltration for mandibular tooth anaesthesia: a randomized controlled trial

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Abstract

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Aim To compare the effectiveness of buccal and lingual local anaesthetic injections in the mandibular first molar region in obtaining pulpal anaesthesia in mandibular teeth.

Methodology Twenty healthy volunteers received 1.8 mL of 4% articaine with 1 : 100 000 epinephrine as a buccal or lingual infiltration in the mandibular first molar region in a randomized double-blind cross-over design. The responses of the first molar, a premolar and the lateral incisor teeth were assessed using an electronic pulp tester over a 47-min period. Successful anaesthesia was defined as no response to maximum stimulus from the pulp tester on two or more consecutive tests. Success between techniques was analysed using the McNemar test and variations between teeth were compared with Chi-square.

Results The number of no responses to maximum stimulation from an electronic pulp tester was significantly greater for all test teeth after the buccal injection compared with the lingual approach ($P < 0.001$). Successful anaesthesia was more likely following the buccal infiltration compared with the lingual method for molar (65% and 10%, respectively) and premolar (90% and 15%, respectively) teeth. There was no difference in anaesthetic success for the lateral incisor.

Conclusion Buccal infiltration at the first mandibular molar is more effective than lingual infiltration in the same region in obtaining anaesthesia of the mandibular first molar and premolar teeth.

Keywords: anaesthesia, articaine, infiltration, mandible.

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Introduction

There has been an increase in interest in the use of infiltration anaesthesia in the mandibular molar region since reports that the use of 4% articaine is superior to 2% lidocaine solutions in obtaining first molar anaesthesia following buccal infiltration in this area (Kanaa *et al.* 2006a, Robertson *et al.* 2007). Another study reported that an articaine infiltration in the buccal sulcus opposite the mandibular first molar increased the anaesthetic efficacy of an inferior alveolar nerve block, not only in the first molar but also in the ipsilateral first premolar and lateral incisor (Kanaa *et al.* 2009). This finding of increased efficacy in the premolar and incisor suggests that this buccal infiltration is producing some type of regional nerve block. This could be achieved by diffusion through the cortical plate to the mandibular canal or by diffusion through the mental foramen. One way of isolating the influence of the mental foramen would be to compare the efficacies of buccal and lingual infiltrations in the first

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molar region of the mandible in anaesthetizing first molar, first premolar and incisor teeth. The latter technique eliminates any influence provided by the mental foramen.

The main aim of the present investigation was to compare the efficacies of an infiltration of 4% articaine with 1 : 100 000 epinephrine either buccally or lingually in the mandibular first molar region in anaesthetizing the pulps of the ipsilateral first molar, premolar and lateral incisor teeth. The null hypothesis was that there would be no difference in achieving successful pulpal anaesthesia in mandibular teeth between buccal and lingual infiltrations of articaine with epinephrine.

Materials and methods

Using data from previous studies (Kanaa *et al.* 2006a, Jaber 2009), a power calculation dictated that a sample size of 20 volunteers would provide a 90% chance of finding a significant difference in pulpal anaesthesia at the 0.5% level.

Following institutional and national ethical approval, 20 volunteers were recruited. The trial was carried out in a Dental Teaching Hospital and subjects were recruited from the local University population including dental students.

The design was a prospective randomized double blind cross-over trial. Randomization was performed using a web-based programme (http://department.obg.cuhk.edu.hk/researchsupport/Random_integer.asp) by a researcher not involved in the provision of the treatments or in outcome measure. Health status of the volunteers was assessed verbally and by a written medical history questionnaire. Written informed consent was obtained from each participant. A pre-trial examination was performed to establish that all test teeth were free of caries, large restorations, periodontal disease and had no history of trauma or sensitivity.

Exclusion criteria included:

haematological and clotting disorders,
neurological disorders,
allergies to local anaesthetic drugs or latex,
pregnancy at the time of the study.

The following local anaesthetic regimens were employed in random order over two visits at least 1 week apart:

1. 1.8 mL of 4% articaine with 1 : 100 000 epinephrine (Septanest; Septodont, Saint-Maur-des-Fosses, France) as a buccal infiltration in the muccobuccal fold adjacent to the mandibular first molar followed by dummy lingual injection (needle penetration only) into lingual reflected mucosa adjacent to the same tooth.
2. 1.8 mL of 4% articaine with 1 : 100 000 epinephrine as an infiltration in the lingual mucosa adjacent to the mandibular first molar followed by dummy buccal injection into the muccobuccal fold adjacent to the same tooth.

All injections were given by the same clinician using a self-aspirating syringe with a pre-fitted 30 gauge dental needle (Ultra Safety Plus; Septodont). Injections were administered at rate of 30 s per 1.8 mL. Dummy injections involved needle penetration for 30 s, with no administration of solution. The investigator administering the active and dummy injections had no participation in measuring outcome.

Anaesthetic efficacy was assessed by electronic pulp testing using an electronic pulp tester (Analytic Technology, Redmond, WA, USA). Testing was performed on the ipsilateral mandibular first molar, first or second premolar (the second premolar was used only if the first premolar was absent), and lateral incisor. Testing was commenced on cycles starting from the time of completion of active and dummy injections based on the protocols of Mikesell *et al.* (2005), i.e.:

At 1 min after injection on the first molar.
At 2 min after injection on the premolar.
At 3 min after injection on the lateral incisor.
At 4 min after injection no test (rest).

Pulp testing continued on this 4 min cycle for 47 min. The test teeth were stimulated in a similar way twice before injection to determine baseline sensitivity. In addition, a maxillary central incisor had pulp sensibility tested before injection and at 12, 24 and 47 min post-injection to ensure that the pulp tester was working normally.

Two methods were used to determine the efficacy of anaesthesia. First, the total numbers of episodes of no response to the maximum stimulation (80 reading) of the pulp tester were recorded for each tooth for each technique, the maximum being 240 per tooth. Secondly, anaesthesia for a particular tooth was considered successful if that tooth did not respond to the maximum stimulation of the pulp tester on two or more consecutive tests. Successful anaesthesia was compared between techniques.

The onset of anaesthesia was taken as the time from the end of injection until the first of two or more consecutive no responses to maximum stimulation from the pulp tester. Data were analysed in SPSS (SPSS

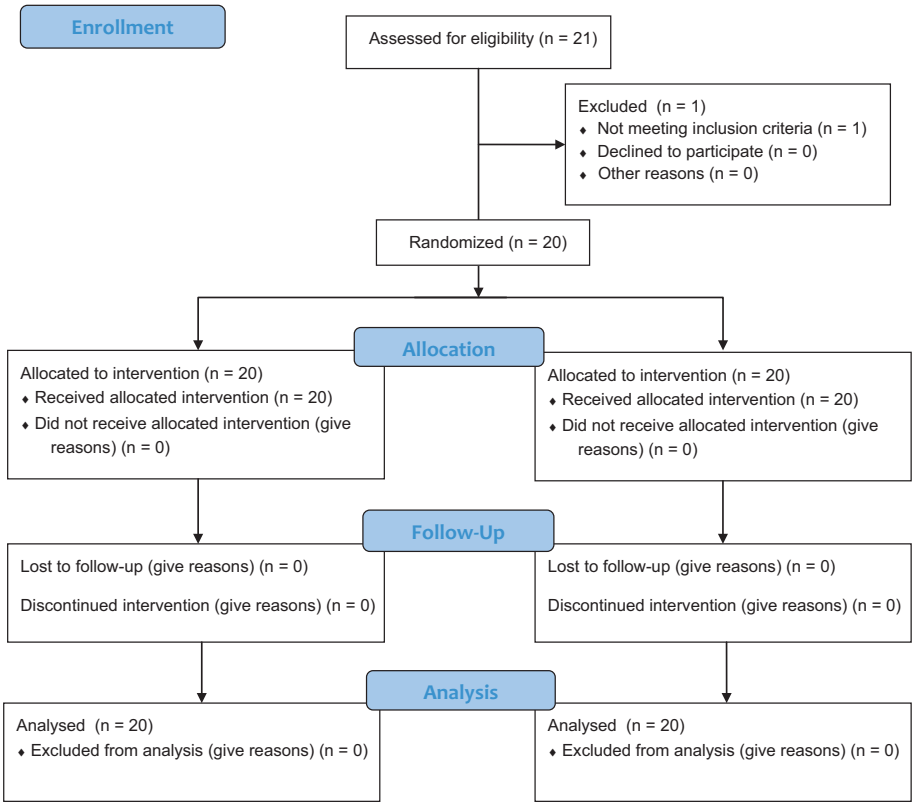

Figure 1 CONSORT 2010 flow diagram.

17.0; SPSS Inc., Chicago, IL, USA) by McNemar and Chi-square tests.

Results

Twenty volunteers (Fig. 1) completed the trial [8 men, 12 women; mean age 23.6 years (range 21–29 years)]. In one volunteer, the premolar tooth tested was the second premolar as the first premolar was absent.

The results are shown in Figs 2–4. The number of episodes of no sensation on maximum stimulation at each time-point after injection for first molars was significantly greater after buccal infiltration compared with lingual infiltration (141 versus 23 respectively, McNemar test $P < 0.001$). Similarly, for premolars, the number of episodes of no sensation on maximum stimulation was significantly greater following the buccal infiltration compared with the lingual infiltration (180 and 37 episodes respectively; McNemar test, $P < 0.001$). A significantly greater number of no responses at maximum stimulation also occurred in the lateral incisor following the buccal infiltration compared with the lingual infiltration (80 and 35 episodes respectively; McNemar test, $P < 0.001$). The premolar had significantly more episodes of no

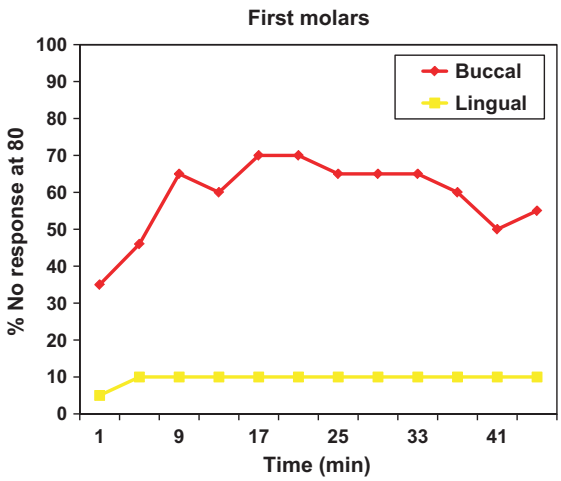

Figure 2 The percentage of volunteers reporting no response to maximum stimulation from the pulp tester in mandibular first molar teeth.

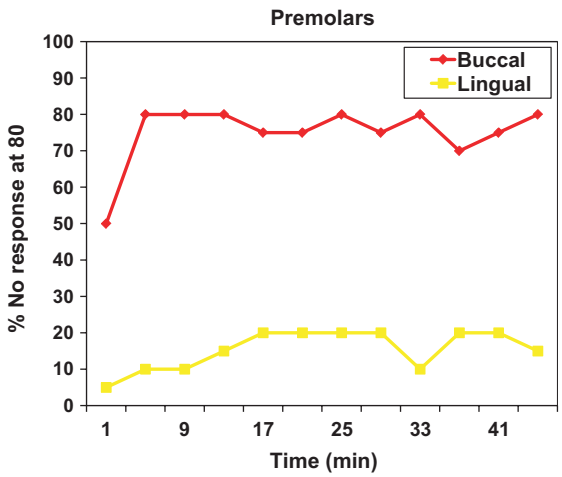

Figure 3 The percentage of volunteers reporting no response to maximum stimulation from the pulp tester in mandibular premolar teeth.

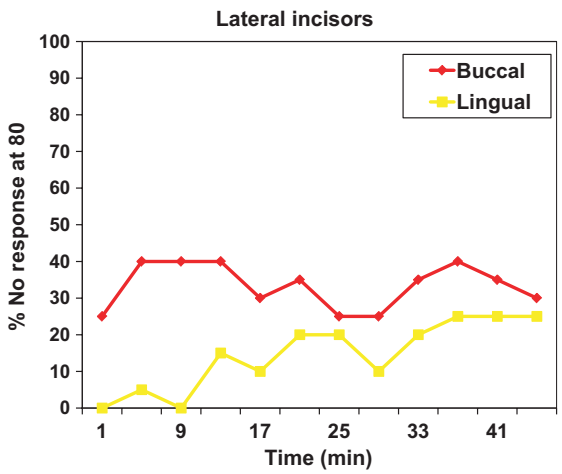

Figure 4 The percentage of volunteers reporting no response to maximum stimulation from the pulp tester in mandibular lateral incisor teeth.

sensation on maximum stimulation compared with the first molar following buccal infiltration (180 vs. 141 episodes, respectively, $\chi^2 = 14.3$, $P < 0.001$).

The incidence of anaesthetic success (no response to two or more consecutive 80 readings) with each technique for each tooth is summarized in Table 1. Thirteen (65%) volunteers experienced successful anaesthesia in first molars following buccal infiltration compared to 2 (10%) after lingual infiltration. This difference was significant (McNemar test, $P < 0.001$). Buccal infiltration achieved anaesthetic success in 18 (90%) premolars compared to 3 (15%) after lingual infiltration. This difference was significant (McNemar test, $P < 0.001$). Successful anaesthesia was obtained in 11 (55%) lateral incisors after buccal infiltration compared to 5 (25%) following lingual infiltration. This difference was not significant (McNemar test, $P = 0.109$).

Table 1 Anaesthetic success after each regimen

Anaesthetic success	Molar buccal infiltration Success *n* (%)	Molar lingual infiltration Success *n* (%)	*P* values
First molar	13 (65)	2 (10)	0.001
Premolar	18 (90)	3 (15)	0.001
Lateral incisor	11 (55)	5 (25)	0.109

The onset times of anaesthesia for the test teeth with the different techniques are shown in Table 2. The tooth with the earliest onset time after the lingual infiltration was the first molar, whereas the premolar was the quickest to achieve anaesthesia following the buccal infiltration.

One volunteer reported an adverse event following the active lingual infiltration. This was of injection site pain and difficulty in swallowing. These symptoms resolved spontaneously with no active treatment.

Discussion

The present study compared the efficacy of two techniques in obtaining pulpal anaesthesia of first mandibular molar, first premolar and lateral incisor teeth. Two methods were used in this comparison. First, the numbers of no responses to the maximum stimulation from an electronic pulp tester were analysed. Secondly, the numbers of teeth successfully anaesthetized using the criterion for success as two consecutive episodes of no response to maximum stimulation from an electronic pulp tester were assessed. This definition of success has been used by a number of workers in local anaesthetic trials (Burns *et al.* 2004, Kanaa *et al.* 2006a, Robertson *et al.* 2007, Berberich *et al.* 2009, da Silva *et al.* 2010, Karkut *et al.* 2010). The results clearly show that the buccal infiltration was more effective for molar and premolar teeth compared with the lingual infiltration using both methods of comparison. For the lateral incisor, the absolute number of no responses showed a difference between treatments, whereas the comparison of success did not. The greater overall success of the buccal injection suggests that the

Table 2 Onset of pulpal anaesthesia (min) after each injection regimen

	First molar		Premolar		Lateral incisor	
Onset	B	L	B	L	B	L
Median	5.0	3.0	2.0	10.0	7.0	23.0
Range	1–17	1–5	2–22	2–22	3–19	15–35

B, first molar buccal infiltration; L, first molar lingual infiltration.

mental foramen may play an important part in allowing the solution access to the inferior alveolar nerve. The fact that the greatest anaesthetic success and the most episodes of no response occurred in the premolar tooth could also be used to support this view.

Another finding that suggests that buccal infiltration in the first molar region may be a modified mental and incisive nerve block is the pattern of onset of anaesthesia. The pattern of anaesthetic onset following an inferior alveolar nerve block (IANB) is molar, before premolar (Kanaa *et al.* 2006b). This is not the same as the sequence after a mental and incisive nerve block (MINB), which is premolar followed by molar (Whitworth *et al.* 2007). Following the lingual infiltration in this study, the onset pattern was similar to an IANB; however, after the buccal infiltration, the onset mimicked that of the MINB. Another relevant finding in this regard is the relationship between anaesthesia of different teeth. None of the molars that obtained anaesthetic success achieved this status in the absence of premolar anaesthesia following the buccal infiltration suggesting passage of solution from premolar to molar area. On the contrary, molar anaesthesia was obtained in the absence of premolar anaesthesia after lingual infiltration.

The data presented here suggest that the mechanism of action of a buccal infiltration in the mandibular first molar region may involve diffusion through the mental foramen. The greater success of the buccal compared with the lingual infiltration is unlikely to be the result of differences in direct access (that is independent of foramina) through bone to the inferior alveolar nerve. The mandibular cortex is about 0.5 mm thicker on the lingual compared with the buccal side (Katranji *et al.* 2007); however, the inferior alveolar canal is predominantly towards the lingual aspect (Ylikontiola *et al.* 2002).

Previous investigations have reported that mental and incisive nerve blocks can provide anaesthesia of the first molar, however, this being less effective than for the premolar (Nist *et al.*1992, Whitworth *et al.* 2007); a similar finding is reported here. The success of molar and premolar and lateral incisor anaesthesia in the present study following a buccal infiltration in the first molar region with 4% articaine and 1 : 100 000 epinephrine is greater than that reported in an earlier MINB study using the same criterion for success in a similar population with 2% lidocaine with 1 : 80 000 epinephrine (Whitworth *et al.* 2007). In that study, the success rates were reported as 48.7%, 81.8% and 38.5% for molars, premolars and lateral incisors respectively. This higher success rate reported in the present study (see Table 1) may represent a greater diffusion capability of the 4% articaine solution through the foramen. The present success with the premolar is also higher than that reported (72–80%) by da Silva *et al.* (2010) for premolar anaesthesia using an MINB with 4% articaine with 1 : 100 000 epinephrine. The difference may reflect the much larger volume used in the present study; only 0.6 mL was used in the latter investigation. The success of first molar anaesthesia following buccal infiltration in the present study (65%) is almost identical to that reported in an earlier study (64.5%) using the same anaesthetic solution in the same technique in a similar population (Kanaa *et al.* 2006a). The current data for first premolar anaesthesia are similar to some of the results presented by Joyce & Donnelly (1993), who reported no difference in the effectiveness of MINBs using 2% lidocaine with 1 : 100 000 epinephrine given inside or outside the mental foramen. These workers used no response to a single episode of maximal stimulation (80 reading) as the criterion for successful pulpal anaesthesia and reported success for injections given inside the mental foramen as 88% for first premolars and 93% for second premolars. When injections were given outside the foramen, the success was 73% for first premolars and 76% for second premolars.

Although the data presented here show success similar to that reported with mental and incisive nerve blocks, the technique failed in a number of cases. This could be the result of a number of factors including variations in the position of the mental foramen and inferior alveolar nerve canal.

The method of assessing local anaesthetic efficacy used in this investigation (response to electronic pulp testing in a double-blind design) is that used in many local anaesthetic studies (Nist *et al.* 1992, Burns *et al.* 2004, Mikesell *et al.* 2005, Kanaa *et al.* 2006a, Robertson *et al.* 2007, Berberich *et al.* 2009, da Silva *et al.* 2010, Karkut *et al.* 2010) and permits comparison with other trials. This outcome measure may not be identical to clinical anaesthesia during operative

dentistry. It must also be stressed that this trial was performed on healthy volunteers all of whom were in the third decade of life and all the teeth tested were free of pathosis. This makes generalization of the findings limited. The success rates in this trial may not be achieved in teeth with inflammed pulps. In addition, variations in the quality of bone with age could influence the results. Nevertheless, the present data are of value in enlightening the mechanism of action of infiltration anaesthesia in the adult mandible.

It is not possible to determine from the design of this trial whether or not a traditional mental and incisive nerve block with 4% articaine would be more or less effective in obtaining pulpal anaesthesia of the test teeth compared with the molar buccal infiltration used here. A comparison of those two techniques is worthy of investigation.

Conclusions

Buccal infiltration in the mandibular first molar region was significantly more effective than lingual infiltration at the same tooth in obtaining pulpal anaesthesia of first molar and premolar teeth in healthy volunteers with sound teeth when using 4% articaine with 1 : 100 000 epinephrine. Both techniques provide limited success in obtaining anaesthesia of lateral incisor teeth.

The success and onset pattern of anaesthesia following buccal infiltrations in the mandibular first molar region suggest that the mental foramen may play an important role in the mechanism of this technique.

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