doi:10.1111/j.1365-2591.2006.01144.x

Pulpal anaesthesia for mandibular permanent first molar teeth: a double-blind randomized cross-over trial comparing buccal and buccal plus lingual infiltration injections in volunteers

J. G. Meechan[1], M. D. Kanaa[1], I. P. Corbett[1], I. N. Steen[2] & J. M. Whitworth[3]

Departments of [1]Oral and Maxillofacial Surgery, [2]Health Services Research, and [3]Restorative Dentistry, University of Newcastle upon Tyne, Newcastle upon Tyne, UK

Abstract

Meechan JG, Kanaa MD, Corbett IP, Steen IN, Whitworth JM. Pulpal anaesthesia for mandibular permanent first molar teeth: a double-blind randomized cross-over trial comparing buccal and buccal plus lingual infiltration injections in volunteers. *International Endodontic Journal*, **39**, 764–769, 2006.

Aim To compare the efficacy of buccal and buccal plus lingual infiltration anaesthesia for permanent mandibular first molars.

Methodology Thirty one healthy adult volunteers received each of the following methods of anaesthesia for a mandibular first molar tooth in a randomised order, 1) Buccal infiltration of 1.8 mL and needle penetration lingually. 2) Buccal infiltration of 0.9 mL, plus lingual infiltration of 0.9 mL. Two percent lidocaine with 1:100,000 epinephrine was used. Electrical pulp testing was performed before, and every 2 minutes for 30 minutes after injection. A successful outcome was recorded as the absence of pulp sensation on two or more consecutive maximal pulp tester stimulations (80 μA). Injection discomfort was assessed using visual analogue scales. Data were compared with McNemar and Wilcoxon Signed Ranks tests.

Results Buccal infiltration was successful in 38.7% of cases compared to 32.3% after combined infiltrations; the difference was not significant ($P = 0.63$). Buccal infiltration produced more episodes of no response to maximum stimulation than buccal and lingual infiltrations (129 and 114 respectively), this difference was not significant ($P = 0.11$). Peak anaesthetic effect occurred around 10–14 minutes after injection. There was no difference in injection discomfort between buccal injections of 0.9 mL and 1.8 mL of solution ($P = 0.90$). Lingual injection was more uncomfortable than lingual penetration ($P = 0.002$).

Conclusions Buccal and buccal plus lingual infiltrations did not differ in their efficacy in producing anaesthesia of permanent first molar teeth.

Keywords: lidocaine local anaesthesia, mandibular first molar, pulpal anaesthesia.

Received 29 July 2005; accepted 27 February 2006

Introduction

Pulp anaesthesia of adult mandibular teeth is usually obtained by blockade of the inferior alveolar nerve. Success is not however, guaranteed (Hinkley *et al.* 1991, Clark *et al.* 1999) and may be compromised by many factors including innervation from nerves other than the inferior alveolar nerve (Meechan 2005). A number of methods including infiltration anaesthesia may be useful in overcoming collateral supply. One study (Meechan & Ledvinka 2002) suggested that the combination of buccal and lingual infiltration was more effective than buccal infiltration alone in the anterior mandible. No similar study however, has been reported for mandibular

Correspondence: J. G. Meechan, Department of Oral and Maxillofacial Surgery, School of Dental Sciences, University of Newcastle upon Tyne, Newcastle upon Tyne NE 2 4 BW, UK (Tel.: +44 191 2228292; fax: +44 191 2226137; e-mail: j.g.meechan@ncl.ac.uk).

molars. The aim of the present investigation was to compare the efficacy of buccal infiltration and buccal plus lingual infiltration anaesthesia for mandibular permanent first molar teeth in a prospective, randomized, double-blind, cross-over study in adult volunteers.

Materials and methods

The null hypothesis tested was that buccal and buccal plus lingual infiltrations did not differ in their anaesthetic efficacy for the pulps of lower first permanent molar teeth. A power calculation using data from a previous investigation (Meechan & Ledvinka 2002) indicated that 31 subjects would provide a 90% chance of detecting an effect size of 0.83 (a change of 0.83 SD) in a continuous outcome measure, assuming a significance level of 5% and a correlation of 0.5 between responses from the same subject. All participants required the presence of at least one vital lower first molar tooth. Exclusion criteria included unstable cardiovascular disease, pregnancy, allergy to amide local anaesthetic agents and neurological disorders with sensory disturbance. Ethical approval was obtained and following written informed consent, 31 healthy volunteers were recruited.

Two treatments were given at separate visits:

1. Buccal infiltration of 1.8 mL 2% lidocaine with 1 : 100 000 adrenaline (2% Xylocaine Dental with adrenaline 1 : 100 000; Dentsply Pharmaceutical, York, PA, USA) in the mucobuccal fold opposite a mandibular first molar with dummy injection (i.e. needle penetration only) lingually.

2. Buccal infiltration of 0.9 mL 2% lidocaine with 1 : 100 000 adrenaline plus lingual infiltration of 0.9 mL 2% lidocaine with 1 : 100 000 adrenaline.

Each volunteer received both treatments over the two visits at least 1 week apart. Treatment order was randomized using a computer-generated sequence of random numbers by one of the authors who was not involved in delivering the local anaesthetic. The investigator who enrolled the volunteers was blinded to the order of injection. The same molar area was anaesthetized at each visit.

All injections were given by the same operator, who had no involvement in assessing outcome. Injections were administered with a dental aspirating syringe fitted with a 30-gauge needle and solution was deposited at a rate of 15 s per 0.9 mL. During the dummy injection the needle was inserted for 15 s. The buccal infiltrations were always administered first. The dummy injections were administered to blind the patient to the method of infiltration used. The investigator of anaesthetic efficacy was blinded to the treatment given at any particular visit. Pulpal anaesthesia was determined with a pulp tester (Analytic Technology, Redmond, WA, USA). In order to establish a baseline reading, testing was performed at a rate of 5 $\mu A\ s^{-1}$ on the appropriate mandibular first molar twice before injection. The mean of these two readings was taken as baseline. Pulp testing was then repeated once every 2 min after injection for 30 min (15 time-points). In order to test the validity of the reading, an unanaesthetized tooth on the contralateral side of the mandible was tested at the same times.

The difference from baseline was measured at each time-point. Similarly the number of episodes of no response at the maximum reading of 80 μA was recorded. For each subject, for each method of administration, the mean change from baseline was calculated across the 15 time-points. The two methods of administration were then compared across the 31 subjects. In addition, we determined the number of occasions (out of the 15 time-points) on which there was no response to maximum stimulation. The responses for the two treatments were then compared across the 31 subjects.

The criterion for successful anaesthesia was no response to the maximum stimulation on two or more consecutive occasions.

The point of onset of anaesthesia was taken as the first of two or more negative responses to maximal (80 μA) stimulation.

In addition to objective assessments of pulp anaesthesia, volunteers were asked to subjectively gauge soft tissue anaesthesia in the labial and lingual mucosa at each of the times pulp testing was performed. Times to first lower lip and lingual mucosa numbness reported by the volunteer following each treatment were recorded.

The discomfort experienced during each injection was self recorded by volunteers on 100 mm visual analogue scales (VAS) with end-points tagged 'no pain' (0 mm) and 'unbearable pain' (100 mm).

Data were analysed in SPSS (SPSS 11.0; SPSS Inc., Chicago, IL, USA) by McNemar and Wilcoxon signed ranks tests.

Results

The sample of 31 consisted of 15 male (48.4%) and 16 female volunteers (51.6%). The mean age was 22.8 years (SD 2.1 years).

The changes in first molar pulp tester readings (μA) from baseline are shown in Fig. 1. The greatest mean changes were recorded 12 min after buccal infiltration alone (20.7 μA) and 10 min after combined buccal and lingual infiltration (18.1 μA). Over the 30 min of the trial, the mean change from baseline pulp tester readings at first sensation did not differ between buccal infiltration and combined buccal and lingual infiltration (Wilcoxon signed ranks test, $P = 0.92$).

The number of episodes of no sensation on maximal (80 μA) stimulation in first molars at each time-point after injection (Fig. 2) was greater after buccal infiltration alone (129 episodes) compared with the combined buccal and lingual infiltrations (114 episodes), however, this difference was not significant (Wilcoxon signed ranks test, $P = 0.11$).

Twelve (38.7%) volunteers experienced anaesthetic success [two or more consecutive episodes of maximal stimulation (80 μA) without sensation] following buccal infiltration, compared with 10 (32.3%) after the combined buccal and lingual infiltration (Table 1). This difference was not significant (McNemar test, $P = 0.63$).

There was no significant difference between buccal infiltration plus lingual penetration and buccal plus lingual infiltrations for the onset of pulpal anaesthesia (Wilcoxon signed ranks test, $P = 0.86$).

All volunteers reported lip numbness after buccal and buccal plus lingual infiltrations. The onset of lip numbness ranged between 12 and 188 s (mean 46.9 s, SD 33.1 s) after buccal infiltration alone and between 19 and 309 s after buccal plus lingual (mean 78.2 s,

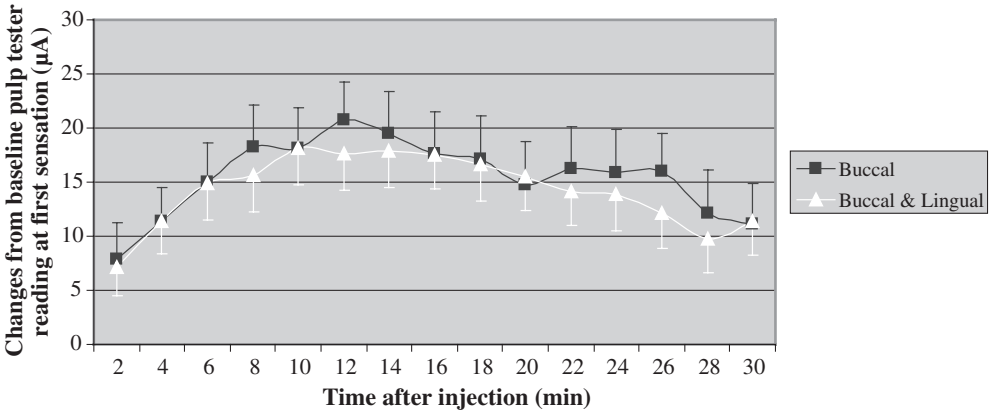

Figure 1 Mean changes from baseline pulp tester readings (μA) at first sensation at time intervals after buccal infiltration and combined buccal and lingual infiltrations (vertical bars represent standard error of mean).

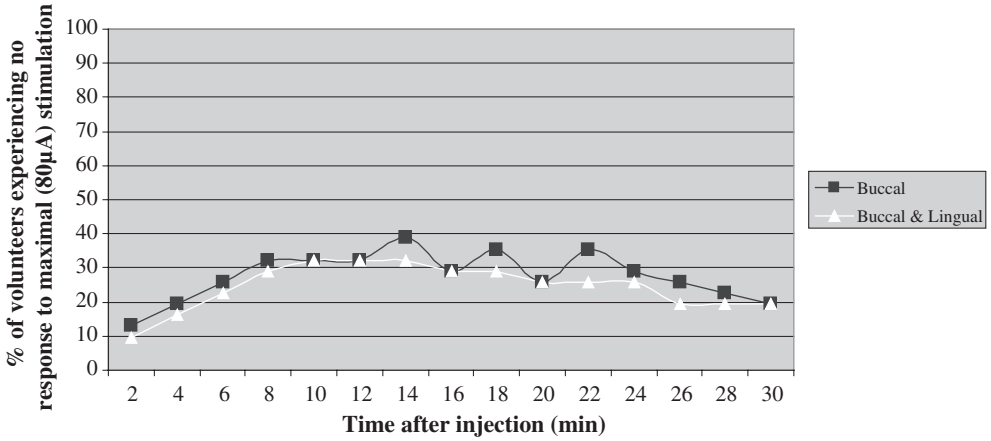

Figure 2 Percentage of volunteers reporting no sensation on maximum stimulation (80 μA) in first molars at time intervals after buccal infiltration and combined buccal and lingual infiltrations.

Table 1 Number (*n*) and percentage (%) of anaesthetic success for the 31 volunteers' first molars

Local anaesthetic technique	Anaesthesia success[a]	
	No	Yes
Buccal	19 (61.3)	12 (38.7)
Buccal and lingual	21 (67.7)	10 (32.3)
McNemar test	$P = 0.63$	

[a]No: failure to achieve two consecutive episodes of maximal (80 μA) stimulation without sensation. Yes: no sensation in first molar on maximal (80 μA) stimulation occurring on two or more consecutive occasions.

Table 2 Visual analogue scale scores (mm) for the different local anaesthetic techniques (1.8 mL = injection of 1.8 mL of solution; 0.9 mL = injection of 0.9 mL of solution; penetration = insertion of needle with no injection)

Visual analogue scale score (mm)	Buccal injection (1.8 mL)	Buccal injection (0.9 mL)	Lingual penetration	Lingual injection (0.9 mL)
Minimum	0	0	0	0
Maximum	62.0	65.0	44.0	64.5
Mean	17.8	19.6	18.6	26.8
Median	17.0	15.5	19.0	28.0
SD	14.9	19.6	12.8	19.3

SD 59.7 s). This difference was significant (Wilcoxon signed ranks test, $P = 0.005$).

Lingual mucosa numbness was reported by three subjects after buccal and 16 after the combined buccal and lingual infiltrations. This difference was significant (McNemar test, $P < 0.001$).

A summary of the VAS scores is shown in Table 2. The volume injected did not affect buccal injection discomfort (Wilcoxon signed ranks test, $P = 0.90$). Lingual injection was more uncomfortable than lingual penetration (Wilcoxon signed ranks test, $P = 0.002$).

No adverse events were recorded during the trial.

Discussion

A number of studies have investigated the use of infiltration anaesthesia in the mandible. In children infiltration has been shown to be as effective as regional block when performing some restorative procedures in primary molar teeth, however when the pulp is being manipulated block anaesthesia is more effective (Oulis *et al.* 1996). The use of infiltration anaesthesia in the mandibular incisor region in adults is described in dental local anaesthetic texts (Jastak *et al.* 1995, Robinson *et al.* 2000) and is used in practise. Some recommend the technique as a means of blocking contralateral inferior alveolar nerve supply (Jastak *et al.* 1995, Rood 1977). Rood (1977) reported 100% success for pulpal anaesthesia of mandibular central incisors following a combination of inferior alveolar nerve blocks and buccal infiltration in the mandibular incisor region. Yonchak *et al.* (2001) investigated lower incisor anaesthesia following buccal or lingual infiltrations. These workers reported success rates of 45% after buccal injections of 2% lidocaine with 1 : 100 000 adrenaline and 50% after lingual infiltrations of the same solution for lateral incisor pulpal anaesthesia. The corresponding success rates for central incisors were 63% and 47%. Haas *et al.* (1990) reported on the efficacies of articaine and prilocaine in obtaining pulpal anaesthesia in mandibular teeth. They noted the overall success of anaesthesia for both posterior and anterior teeth following mandibular buccal infiltration to be 64% after 4% articaine and 51% after 4% prilocaine. Rood (1976) investigated the use of infiltration anaesthesia to overcome failed inferior alveolar nerve block injections. In that study 331 cases received block anaesthesia and 79 experienced failure. Buccal infiltration with 1.0 mL of 2% lidocaine with 1 : 80 000 adrenaline was then performed next to the sensitive teeth and 70 patients experienced successful pulpal analgesia. The remaining nine received lingual infiltration, two of whom reported no pain sensation during treatment.

Meechan & Ledvinka (2002) reported the success rates for lower central incisor anaesthesia following infiltration with 2% lidocaine with 1 : 80 000 adrenaline. Success was 50% following the buccal or lingual injection of 1.0 mL of solution, however the success rose to 92% when the same dose was split between both buccal and lingual infiltration. Hawkins & Moore (2002) suggest that the combination of buccal and lingual infiltration may establish profound anaesthesia in mandibular teeth in some cases.

The results of the present study show that infiltration in the mandibular molar region with lidocaine and adrenaline in adults is not as successful as that reported in the anterior mandible (Yonchak *et al.* 2001, Meechan & Ledvinka 2002). Unlike the study of Meechan & Ledvinka (2002) there was no benefit in splitting the dose between buccal and lingual sides. It may be that the benefit of lingual infiltration in the anterior region is due to interference with the mylohyoid nerve, which might supply the pulps of the anterior teeth (Wilson *et al.* 1984) but not provide significant supply to the molar teeth. In the present study, the volume injected was kept constant to

eliminate any dose effect. Any benefit of adding a supplemental lingual injection after an injection of the full dose buccally cannot be determined from the present investigation. The success of pulpal anaesthesia in the present study was less than that reported by Haas *et al.* (1990). These workers employed 4% solutions of prilocaine or articaine and it may be that the difference is due to the decreased concentration of local anaesthetic used in the present study. Similarly, the use of 4% articaine was more successful than 2% lidocaine after mandibular infiltration in the present study population (Kanaa *et al.* 2006).

As well as comparing overall anaesthetic success the present study investigated the effects of the different techniques on changes in pulpal response (Fig. 1). There was no difference between techniques in this regard. The important effect clinically is absence of response at maximum stimulation; changes in pulpal response were recorded to detect any subtle changes that might have occurred.

Previous studies have reported that the peak effect of infiltration anaesthesia in the anterior mandible is around 8–10 min (Yonchak *et al.* 2001, Meechan & Ledvinka 2002). In the present study, the anaesthetic effect peaked between 10 and 14 min depending upon the technique (Fig. 2). This might reflect the thicker bone in the molar compared with the incisor region. These results suggest that if infiltration anaesthesia is used in the mandibular molar region a period of at least 10 min should elapse before testing for pulpal anaesthesia.

In the present study, the reporting of subjective lip numbness was dependent on the volume injected buccally. The mean onset time after the smaller buccal dose was more than 50% longer than that following the larger volume (78 and 47 s respectively). Not surprisingly the reporting of subjective numbness of the lingual mucosa was more common after a lingual injection was received, however almost half (15/31) of the volunteers did not report lingual mucosa anaesthesia after lingual infiltration in the first molar region.

The injection discomfort reported by the volunteers did not differ between the infiltration of 0.9 and 1.8 mL in the buccal sulcus and the volunteers only reported mild discomfort after this type of injection (Collins *et al.* 1997). Lingual injection was significantly more uncomfortable than lingual needle penetration only, which suggests that deposition of solution in this region adds to the discomfort produced by the needle. Although the VAS scores for the lingual infiltration were greater than those for the buccal infiltrations, it is not valid to compare these values as the lingual injections were always given as the second of the pair. There is a well-recognized order effect concerning intraoral injection discomfort. The second injection is more likely to produce greater discomfort (Martin *et al.* 1994). Nevertheless, the mean scores reported by the volunteers for lingual infiltration anaesthesia in the first molar region represent mild discomfort (Collins *et al.* 1997).

Conclusions

There is no evidence that buccal and buccal plus lingual infiltration anaesthesia with 2% lidocaine with 1 : 100 000 adrenaline differ in their efficacy in providing anaesthesia of mandibular first permanent molar teeth. The onset of subjective lower labial soft tissue anaesthesia after buccal infiltration in the mandibular first permanent molar region is dose-dependent. Infiltration anaesthesia in the mandibular molar region produces mild discomfort.

References

Clark S, Reader A, Beck M, Meyers WJ (1999) Anesthetic efficacy of the mylohyoid nerve block and combination inferior alveolar nerve/mylohyoid nerve block. *Oral Surgery, Oral Medicine, and Oral Pathology* **87**, 557–63.

Collins SL, Moore A, McQuay HJ (1997) The visual analogue pain intensity scale: what is moderate pain in millimetres? *Pain* **72**, 95–7.

Haas DA, Harper DG, Saso MA, Young ER (1990) Comparison of articaine and prilocaine anesthesia by infiltration in maxillary and mandibular arches. *Anesthesia Progress* **37**, 230–7.

Hawkins JM, Moore PA (2002) Local anesthesia: advances in agents and techniques. *Dental Clinics of North America* **46**, 719–32.

Hinkley SA, Reader A, Beck M, Meyers WJ (1991) An evaluation of 4% prilocaine with 1 : 200 000 adrenaline and 2% mepivacaine with 1 : 20 000 levonordefrin compared with 2% lidocaine with 1 : 100 000 adrenaline for inferior alveolar nerve block. *Anesthesia Progress* **38**, 84–9.

Jastak JT, Yagiela JA, Donaldson DA (1995) *Local Anesthesia of the Oral Cavity*. Philadelphia, PA, USA: WB Saunders, pp. 233–7.

Kanaa MD, Whitworth JM, Corbett IP, Meechan JG (2006) Articaine and lidocaine mandibular buccal infiltration anesthesia: a prospective randomized double-blind cross-over study. *Journal of Endodontics* **32**, 296–8.

Martin MD, Ramsey DS, Whitney C, Fiset L, Weinstein P (1994) Topical anesthesia: differentiating the pharmacological and psychological contributions to efficacy. *Anesthesia Progress* **41**, 40–7.

Meechan JG (2005) Why does local anaesthesia not work every time? *Dental Update* **32**, 66–72.

Meechan JG, Ledvinka JIM (2002) Pulpal anaesthesia for mandibular central incisor teeth: a comparison of infiltration and intraligamentary injections. *International Endodontic Journal* **35**, 629–34.

Oulis CJ, Vadiakis GP, Vasilopoulou A (1996) The effectiveness of mandibular infiltration compared to mandibular block anesthesia in treating primary molars in children. *Pediatric Dentistry* **18**, 301–5.

Robinson PD, Pitt Ford TR, McDonald F (2000) *Local Anaesthesia in Dentistry*. Oxford, UK: Wright, p. 43.

Rood JP (1976) The analgesia and innervation of mandibular teeth. *British Dental Journal* **140**, 237–9.

Rood JP (1977) The nerve supply of the mandibular incisor region. *British Dental Journal* **143**, 227–30.

Wilson S, Johns P, Fuller PM (1984) The inferior alveolar and mylohyoid nerves: an anatomic study and relationship to local anesthesia of the anterior mandibular teeth. *Journal of the American Dental Association* **108**, 350–2.

Yonchak T, Reader A, Beck M, *et al.* (2001) Anesthetic efficacy of infiltrations in mandibular anterior teeth. *Anesthesia Progress* **48**, 55–60.