

A Comparison of Intraoral Injection Discomfort Produced by Plain and Epinephrine-Containing Lidocaine Local Anesthetic Solutions: A Randomized, Double-Blind, Split-Mouth, Volunteer Investigation

J. G. Meechan, BSc, BDS, FDSRCPS, PhD, and P. F. Day, BDS, MFDSRCS

Department of Oral and Maxillofacial Surgery, Newcastle Dental School, Framlington Place, Newcastle upon Tyne, England NE2 4BW

The authors report a clinical trial designed to compare the discomfort produced by plain and epinephrine-containing lidocaine solutions during local anesthesia in the maxilla. Twenty-four healthy volunteers were recruited; each received buccal and palatal infiltrations on each side of the maxilla in the premolar region. The solutions were 2% lidocaine and 2% lidocaine with 1 : 80,000 epinephrine. Allocation to side was randomized and operator and volunteer were blinded to the identity of the solutions. Volunteers recorded injection discomfort on a 100-mm visual analogue scale (VAS). Volunteers were included in the trial if a score of at least 30 mm was recorded for at least 1 of the matched pair of injections. Differences between treatments were measured using Student's paired *t* test. Twelve volunteers recorded a VAS score of at least 30 mm for 1 or both buccal injections, and 17 volunteers reached this score for palatal injections. Buccal injection pain was less when the plain solution was used ($P = .04$) and was not influenced by the order of the injection. Palatal injection discomfort did not differ between the solutions; however, the second palatal injection was more uncomfortable than the first palatal injection ($P = .046$). These results suggest that plain lidocaine produces less discomfort than lidocaine with epinephrine when administered into the maxillary premolar buccal sulcus in individuals who report moderate pain during this injection. Palatal injection discomfort does not differ between these solutions.

Key Words: Lidocaine; Epinephrine; Intraoral injection; Discomfort.

A number of factors may influence the discomfort of dental local anesthetic injections. Parameters independent of technique but relating to materials that might affect pain at delivery include the temperature and the pH of the local anesthetic solution.¹ Buffering the solution can reduce injection discomfort.¹ However, this is impractical when using prefilled dental local anesthetic cartridges. The pH of commercially available dental lo-

cal anesthetic solutions varies.² Therefore, pH-dependent factors can be influenced by the choice of anesthetic; for example, plain lidocaine solutions have a pH closer to physiological pH compared with those that contain epinephrine. The goal of this investigation was to determine whether epinephrine-free and epinephrine-containing lidocaine solutions differed in the discomfort they produced during intraoral injection.

METHODS

A batch of 2-mL 2% plain lidocaine and a pack of 2% lidocaine containing 1:80,000 epinephrine were sup-

Received July 30, 2001; revision requested December 1, 2001; accepted for publication December 4, 2001.

Address correspondence to J. G. Meechan, Department of Oral and Maxillofacial Surgery, Newcastle Dental School, Framlington Place, Newcastle upon Tyne, England NE2 4BW; J.G.Meechan@ncl.ac.uk.

Anesth Prog 49:44-48 2002
© 2002 by the American Dental Society of Anesthesiology

ISSN 0003-3006/02/\$9.50
SSDI 0003-3006(02)

plied by the manufacturer (AstraZeneca, King's Langley, Herts, UK). The cartridges were identical except for an individual label on each cartridge that contained an identifying code number. The pH of a sample of each solution from the same batch numbers was measured on an electronic pH meter (Corning, Sudbury, Suffolk, UK).

Twenty-four healthy young adults (14 men, 10 women) between the ages of 20 and 24 volunteered for this trial after it was approved by the local ethics committee. A power analysis dictated that a sample size of 24 adults provided a 90% chance of detecting a 10-mm difference in the visual analogue scales (VAS) at the 1% level. It was predicted that not all volunteers would have their data entered into the trial and that a level of significance of 5% was acceptable. The power analysis dictated that at the 5% level, there was a 90% chance of detecting a 10-mm difference in the VAS if 17 volunteers were included and an 80% chance of detecting this difference if half the volunteers were included.

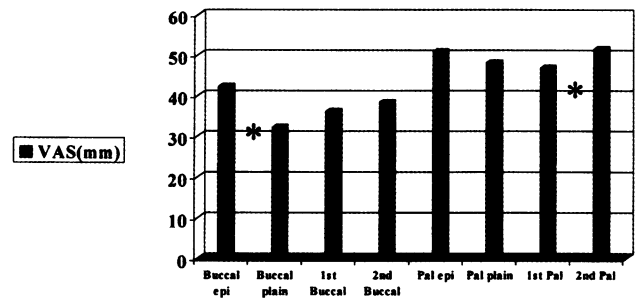
Each volunteer received 4 injections at 1 trial visit. The injections were as follows:

- Injection 1: 1.0 mL of solution injected over 30 seconds following aspiration into the buccal sulcus in the first premolar region on the right-hand side.
- Injection 2: 1.0 mL of solution injected over 30 seconds following aspiration into the buccal sulcus in the first premolar region on the left-hand side.
- Injection 3: 0.2 mL of solution injected over 10 seconds following aspiration into the palatal mucosa distal to the second premolar on the right-hand side.
- Injection 4: 0.2 mL of solution injected over 10 seconds following aspiration into the palatal mucosa distal to the second premolar on the left-hand side.

The same operator, who was blinded to the identity of the solutions, gave all the injections. Thirty-gauge short needles and aspirating syringes were used throughout. No topical anesthetic was applied before injection. The allocation of the cartridges was such that each solution was injected at 1 of each pair of injections. The order in which the solutions were administered was randomized. The solutions used for injections 1 and 3 were determined independently by 2 tosses of a coin (with injections 2 and 4 receiving the other solution).

Immediately after each local anesthetic administration, the volunteer recorded injection discomfort on a continuous 100-mm VAS with endpoints "no pain" and "unbearable pain." Because the sensitivity of acute pain trials is dependent on the production of moderate pain,³ data were entered into the study only if one or both scores in the pair (ie, a pair of buccal or a pair of palatal scores) were at least 30 mm on the VAS. This score is

Mean VAS scores (mm) for buccal and palatal injections



* = significant difference between adjacent values ($p < 0.05$)

Figure. Mean visual analogue scale (VAS) scores in mm for each injection. Buccal epi indicates buccal infiltration with 2% lidocaine with 1 : 80,000 epinephrine; buccal plain, buccal infiltration with 2% lidocaine; 1st buccal, first buccal injection of the pair; 2nd buccal, second buccal injection of the pair; pal epi, palatal infiltration with 2% lidocaine with 1 : 80,000 epinephrine; pal plain, palatal infiltration with 2% lidocaine; 1st pal, first palatal injection of the pair; and 2nd pal, second palatal injection of the pair.

regarded as representing moderate pain.⁴ Pairs of injections where both entries were less than 30 mm were rejected.

In order to compare the pain scores between the sexes, both buccal VAS scores for the 12 individuals included were added to provide a total buccal pain score for each volunteer (maximum possible score = 200). Similarly, a total palatal pain score was determined for each of the 17 individuals included in the palatal injection comparison.

Differences between solutions and order effects were analyzed using Student's paired *t* test. Sex differences were compared with Student's unpaired *t* test. Differences were considered significant when $P \leq .05$.

RESULTS

The pH of the plain lidocaine solution was 6.6; the epinephrine-containing solution's pH was 4.4.

Twelve volunteers (6 men, 6 women) recorded at least one of their buccal injections at a minimum of 30 mm on the VAS, and 17 participants (10 men, 7 women) had palatal injection scores of at least 30 mm for one injection. The results are shown in the Figure and Tables 1 and 2.

Buccal injection discomfort was less when the plain solution was used. The mean difference between solutions for buccal injections was 10 mm with a standard error of 4.3 ($t = 2.3$; $P = .04$); for palatal injections

Table 1. Buccal Injection VAS* Pain Scores (mm)

Volunteer	Plain solution	Epinephrine-containing solution
1	27	33†
2	27†	55
3	73	81†
4	21	43†
5	22†	55
6	30	27†
7	21†	30
8	42	55†
9	17†	31
10	35†	30
11	48†	27
12	24†	40
Mean	32.25	42.25
SD	15.75	16.44

* VAS, visual analogue scale.

† = first injection of pair.

there was no significant difference between solutions, the mean difference was 2.7 mm with a standard error of 2.5 ($t = 1.1$; $P = .29$).

The difference between first and second buccal injections was not significant ($t = 0.37$; $P = .72$). However, the second palatal injection was more uncomfortable than the first ($t = 2.17$; $P = .046$).

There were no differences in the pain scores between men and women. The mean \pm SD total buccal pain scores for men and women were 66.5 ± 17.9 mm and 79.2 ± 37.3 mm, respectively ($t = 1.9$; $P = .09$). The mean \pm SD total palatal scores for men and women were 103.5 ± 30.8 mm and 91.3 ± 28.6 mm, respectively ($t = 0.84$; $P = .42$).

DISCUSSION

A number of methods may be used to reduce the discomfort of local anesthetic injections. These might include the application of topical anesthetics before needle penetration and a slow rate of injection. However, there is little evidence in the literature that the various methods proposed are reliable. Even the use of topical anesthetics before injection is not found to be universally effective.⁵

In addition to attention to technique, recommendations concerning the temperature and pH of the solution have been proposed as being important in relation to injection discomfort.¹ There is evidence in the medical literature that these factors influence injection pain.⁶⁻⁸ However, there is little indication that they affect discomfort during intraoral anesthesia. A number of workers have shown that the temperature of the anes-

Table 2. Palatal Injection VAS* Pain Scores (mm).

Volunteer	Plain solution	Epinephrine-containing solution
1	70†	76
2	57†	60
3	25†	35
4	22†	37
5	49	34†
6	68	61†
7	66	65†
8	72	75†
9	38	46†
10	35	29†
11	34	31†
12	46	59†
13	63†	74
14	39†	50
15	47†	40
16	32†	51
17	56	42†
Mean	48.18	50.88
SD	16.14	15.86

* VAS, visual analogue scale.

† = first injection of pair.

thetic does not affect intraoral injection pain as long as the solution is at or above room temperature.^{9,10} Similarly, although it has been suggested that using solutions with a pH closer to physiological should decrease injection discomfort, there is little evidence in the dental literature that this occurs during intraoral anesthesia. Oikarinen et al¹⁰ noted that in volunteers, the injection into the maxillary buccal sulcus of 3% mepivacaine solutions of different pHs produced different levels of pain; the solution with the lower pH produced more discomfort. On the other hand, Primosch and Robinson¹¹ reported the results of a volunteer investigation that showed no difference in injection discomfort during maxillary buccal infiltrations and palatal injections in the permanent canine region with buffered lidocaine solutions.

It is apparent to those who administer dental local anesthetics that injection discomfort varies in different areas of the mouth. The sites used in this investigation were chosen because it was believed that they would produce different levels of injection discomfort. The buccal sulcus in the premolar area is usually considered a relatively comfortable region for local anesthetic administration. In this investigation, 50% of the volunteers did not achieve an injection discomfort score that merited inclusion in the study, rating the injection pain as mild.⁴ The palatal region, however, is considered more uncomfortable. In the present study, only 7 of the 24 subjects considered palatal injection pain to be mild for both solutions.

The present study was designed to determine the influence of the choice of different commercially available

local anesthetic solutions on injection discomfort at 2 sites in the mouth. All other parameters were standardized. The results of this investigation show that different anesthetic solutions can affect discomfort for some injections in those patients who report more than mild pain. Buccal infiltration pain was less when plain lidocaine was used. The plain solution had a pH closer to physiological than the epinephrine-containing anesthetic. These findings are in agreement with those of Oikarinen et al.¹⁰ The differences in pain scores between solutions may be attributed to their different pHs, although the design of this study was such that it could not rule out other effects that epinephrine might produce. However, Oikarinen et al.¹⁰ noted that the addition of epinephrine to mepivacaine solutions did not significantly affect injection pain. Similarly, McKay et al.⁷ noted that the addition of epinephrine to lidocaine without alteration of the pH did not increase discomfort during subcutaneous injections, whereas buffering of lidocaine solutions did reduce perceived pain. The present results differ from those of Primosch and Robinson.¹⁰ This may be because of the different sites of injection. In the present study and in the study reported by Oikarinen et al.¹⁰ buccal infiltrations were given in the maxillary premolar region, whereas in the Primosch and Robinson¹¹ investigation, injections were given in the maxillary canine region. Submucosal tissues are looser in the more posterior region, which may account for the difference. In addition, the rate of injection in this study was the same as that used by Oikarinen et al.,¹⁰ whereas the rate by Primosch and Robinson¹¹ was not as slow. Another difference between the present study and the study reported by Primosch and Robinson¹¹ was that in the latter study the perceived pain scores of their 10 volunteers during buccal infiltration were low (the mean pain being less than that considered moderate in intensity). In the present study, only individuals who recorded pain that was classified as moderate⁴ were included in the trial because the sensitivity of visual analogue scales depends on the production of moderate pain.³

In agreement with the findings reported by Primosch and Robinson,¹¹ this study found no significant difference between solutions for palatal injections. This difference between buccal and palatal injections may be attributed to the factors that produce injection discomfort at different sites. During palatal anesthesia, the pain may be mainly a result of pressure because of the relatively noncompliant nature of this tissue.¹² In the buccal sulcus, the loose nature of the submucosal tissues may cause solution-dependent factors such as the pH to have a greater influence on perceived discomfort. The results of this study add support to this belief.

Although the results of this investigation suggest one benefit for the use of plain lidocaine solutions, this local

anesthetic is not recommended for definitive anesthesia of the teeth. A number of studies have shown that epinephrine-containing local anesthetics provide longer-lasting and more profound pulpal anesthesia compared with plain solutions when injected by various methods intraorally.^{13–16} Therefore, lidocaine with epinephrine is preferred as the definitive anesthetic. Plain solution may produce satisfactory soft tissue anesthesia,¹⁶ but the duration may be shorter than that obtained with vasoconstrictor-containing solutions.¹⁷

Although the results of this study demonstrate a reduction in perceived discomfort when a plain lidocaine solution is used, it is important to point out that this finding relates to those individuals who find buccal infiltration anesthesia moderately painful. It is also important to point out that injection pain was not completely eliminated when the plain solution was used.

Consideration of the data presented in the Figure and Tables 1 and 2 might be used to confirm the clinical impression mentioned earlier that palatal injections appear to be more uncomfortable than buccal infiltrations. However, such a conclusion cannot be drawn using the present results because the palatal injections were always given after the buccal administrations. Thus, an order effect cannot be excluded. Indeed, an order effect is apparent in relation to the palatal injections. The fact that palatal injection pain was dependent on the order of injection confirms results of other investigations of intraoral injection discomfort. For example, Martin et al.¹⁸ found that patients who received bilateral buccal injections in the maxillary premolar region reported the second injection to be significantly more uncomfortable than the first administration. This suggests that the best chance of obtaining comfortable anesthetic delivery is at the first injection. Thus, choosing an area where such a possibility exists as the first site of injection is to be encouraged. If further administrations can be delivered into areas where the initial anesthetic has spread, the overall pain experience for the patient might be reduced.

REFERENCES

1. Courtney D, Agrawal S, Revington PJ. Local anaesthesia: to warm or alter the pH? A survey of current practice. *J Royal Coll Surg Edinburgh*. 1999;44:167–171.
2. Punnia Moorthy A, Punnia Moorthy S, O'Neill R. A study of pH of dental local anaesthetic solutions. *Br Dent J*. 1984;157:394–395.
3. Lasagna L. The psychophysics of clinical pain. *Lancet*. 1962;2:572–575.
4. Collins SL, Moore A, McQuay HJ. The visual analogue pain intensity scale: what is moderate pain in millimetres? *Pain*. 1997;72:95–97.

5. Meechan JG. Intra-oral topical anaesthetics: a review. *J Dent.* 2000;28:3-14.
6. Bainbridge LC. Comparison of room temperature and body temperature local anaesthetic solutions. *Br J Plast Surg.* 1991;44:147-148.
7. McKay W, Morris R, Mushlin P. Sodium bicarbonate attenuates pain on skin infiltration with lidocaine, with or without epinephrine. *Anesth Analg.* 1987;66:572-574.
8. Martin AJ. pH-adjustment and discomfort caused by the intradermal injection of lignocaine. *Anaesthesia.* 1990;45:975-978.
9. Rood JP. The temperature of local anaesthetic solutions. *J Dent.* 1977;5:213-214.
10. Oikarinen VJ, Ylipaavalnpemi P, Evers H. Pain and temperature sensations related to local analgesia. *Int J Oral Surg.* 1975;4:151-156.
11. Primosch RE, Robinson L. Pain elicited during intraoral infiltration with buffered lidocaine. *Am J Dent.* 1996;9:5-10.
12. Pashley EL, Nelson R, Pashley DH. Pressures created by dental injections. *J Dent Res.* 1981;60:1742-1748.
13. Lilienthal B. Cardiovascular responses to intra-osseous injections of prilocaine containing vasoconstrictors. *Oral Surg.* 1976;42:552-558.
14. Meyer F-U. Haemodynamic changes under emotional stress following a minor surgical procedure under local anaesthesia. *Int J Oral Maxillofac Surg.* 1987;16:688-694.
15. Gray RJM, Lomax AM, Rood JP. Periodontal ligament injection: with or without a vasoconstrictor? *Br Dent J.* 1987;162:263-265.
16. Jastak JT, Yagiela JA. Vasoconstrictors and local anesthesia: a review and rationale for use. *J Am Dent Assoc.* 1983;107:623-630.
17. Meechan JG, Day PF, McMillan AS. Local anaesthesia in the palate: a comparison of techniques and solutions. *Anesth Prog.* 2000;47:139-142.
18. Martin MD, Ramsey DS, Whitney C, Fiset L, Weinstein P. Topical anesthesia: differentiating the pharmacological and psychological contributions to efficacy. *Anesth Prog.* 1994;41:40-47.