Articaine buccal infiltration *vs* lidocaine inferior dental block – a review of the literature

G. Bartlett*[1] and J. Mansoor[2]

VERIFIABLE CPD PAPER

IN BRIEF

- Summarises evidence related to common local anaesthetics and their administration for use in dentistry.
- Appraises the current literature and suggests possibilities for future research.
- Gives brief descriptions of implications for the dentist.
- Suggests that while articaine buccal infiltrations have a place in dentistry, they cannot yet replace lidocaine IANBs as the gold standard.

RESEARCH

Aim This paper aims to compare the effectiveness of articaine buccal infiltrations (BIs) and lidocaine inferior alveolar nerve blocks (IANBs) for inducing pulpal anaesthesia in mandibular molars. **Method** Studies which compared articaine BIs with lidocaine IANBs were identified by completing a full literature search using the MEDLINE, EMBASE and Cochrane Central Register of Controlled Trials databases. Only studies that used permanent mandibular molars were included. Two papers were accepted for appraisal. **Results** It was found that 55.6–69.2% and 65.4–70.4% of lidocaine IANBs and articaine BIs were successful, respectively. Neither study was able to determine a significant difference between the two techniques. **Conclusions** Articaine BIs are no more effective than lidocaine IANBs and the decision of which method to practice should be based on patient selection, cost and time efficiency. The studies present a number of weaknesses in their design, hence, the level of evidence they provide is inconclusive. Further investigation in this field is warranted.

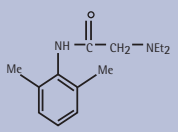
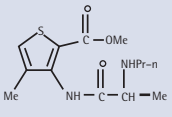
INTRODUCTION

In dentistry, local anaesthesia is an essential element of daily practice. Local anaesthesia, achieved through the application of local anaesthetics, provides temporary 'numbness' and reduced anxiety during dental procedures.[1] Many local anaesthetics are available to dentists in the UK; the most popular of these are lidocaine and articaine.[2] The physicochemical properties of these are summarised in Table 1.[3,4]

Lidocaine, synthesised in 1943, was the first amide anaesthetic.[5] In the UK, lidocaine remains the most popular local anaesthetic, with over 20 million cartridges sold in 2008 alone. However, this figure is down from nearly 35 million cartridges in 1998, which corresponds with the increasing popularity of articaine.[2] Articaine is one of the most modern local anaesthetic agents. Articaine was synthesised in 1969[5] and introduced into dental practices in the UK in 1998.[6] Since then, articaine sales have risen each year to reach almost ten million cartridges sold in 2008.[2] Articaine is unique to other amide local anaesthetics in that it is derived from thiophene, rather than benzene. The thiophene ring within its structure renders articaine more lipid-soluble. This allows more anaesthetic to diffuse across the nerve membrane, increasing its potency. Articaine, like lidocaine, has a relatively low pKa which confers enhanced diffusibility. The low pKa increases the availability of uncharged base molecules for diffusion through the nerve sheath; as such onset time is reduced.[3]

The inferior alveolar nerve block (IANB) is common practice for anaesthetising mandibular molars and/or premolars on one side of the jaw. Achieved by depositing local anaesthetic solution at the entrance to the mandibular canal, it inhibits the transmission of action potentials along the inferior alveolar nerve towards the central nervous system.[7] This is very technique sensitive. While the IANB remains the first choice for anaesthetising mandibular molars, with some studies reporting success rates of approximately 92%,[8] others suggest that up to 45% of IANBs fail.[9] A recent clinical audit completed in December 2015 at the Manchester Dental Hospital reported that the success rate of IANBs administered by undergraduate students was 68%. (This audit was conducted by the author. The author observed 100 consecutive IANBs delivered by undergraduate dental students years 3-5. Success was defined by: (1) subjective lower lip and tongue numbness on the same side and (2) pain-free treatment provided).

Table 1 Physicochemical properties of articaine and lidocaine

Agent	Chemical configuration	Molecular wt.	pKa	Lipid solubility	Protein binding (%)	Onset (min)	Duration (pulpal [min])
Lidocaine HCl 2% w/adrenaline 1:100,000		234	7.7	4	65	8.7	60
Articaine HCl 4% w/adrenaline 1:100,000		320	7.8	17	95	7.4	60–75

[1]University of Manchester School of Dentistry, University of Manchester, Higher Cambridge Street, Manchester, M15 6FH; [2]Ravat and Ray Dental Practice, 1 Bateman Street, Bradford, BD8 7DH
*Correspondence to: G. Bartlett
Email: george_bartlett92@hotmail.com

Refereed Paper
Accepted 8 January 2016
DOI: 10.1038/sj.bdj.2016.93
©British Dental Journal 2016; 220: 117–120

The buccal infiltration (BI) is most commonly used to anaesthetise individual teeth. Traditionally, this technique is used to anaesthetise the maxilla and the anterior mandible.[7] Infiltration anaesthesia may be successful in up to 100% of cases in the maxilla regardless of whether articaine or lidocaine is administered.[10] However, for the posterior mandible, the success rate is between 48% and 76% (when using articaine).[11]

MATERIALS AND METHODS

MEDLINE, EMBASE and the Cochrane Central Register of Controlled Trials were searched for appropriate literature (see below).

Study design

The search terms used in the literature search are listed in Table 2. Only randomised controlled trials were accepted.

Inclusion criteria

The inclusion criteria for the search were:

- Studies must compare the effectiveness of 4% articaine BI against 2% lidocaine IANB
- Studies must include permanent teeth only as the anaesthetics and techniques may impact differently on deciduous teeth
- Studies must only look at adult patients because changes in mandibular bone density throughout pubertal growth will affect diffusion of the anaesthetic
- Studies must include mandibular molar teeth only – this is due to the varying bone densities in different mandibular regions through which the anaesthetic has to diffuse
- The outcome assessed must be pulpal anaesthesia.

Twenty-seven papers were identified through the literature search. Following removal of duplicates, ten were considered for appraisal. Two of these ten studies met the inclusion criteria; these are summarised in Table 3.[12–13] The rejected papers are summarised in Table 4.[14–21]

Table 2 Identification of studies

Number	Search terms	Results
1	carticaine.mp. [mp = ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	671
2	articaine.mp. [mp = ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	1,377
3	1 OR 2	1,605
4	lidocaine.mp. [mp = ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	96,332
5	xylocaine.mp. [mp=ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	4,578
6	lignocaine.mp. [mp=ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	6,541
7	4 OR 5 OR 6	98,127
8	3 AND 7	765
9	infiltration.mp. [mp=ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	246,591
10	long buccal.mp. [mp=ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	81
11	9 OR 10	246,658
12	8 AND 11	141
13	inferior alveolar nerve block.mp. [mp=ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	694
14	inferior dental nerve block.mp. [mp=ti, ot, ab, sh, hw, kw, tn, dm, mf, dv, nm, kf, px, rx, an, ui]	24
15	13 OR 14	716
16	12 AND 15	42
17	limit 16 to 'all adult (19 plus years)'	37
18	limit 17 to randomised controlled trial	27

RESULTS

Corbett reported that, 70.4% and 55.6% of volunteers achieved successful anaesthesia following articaine BI and lidocaine IANB, respectively. Poorni reported success rates of 65.4-69.2% for both articaine BI and lidocaine IANB. These results were not statistically significant. The results are summarised in Table 5.

DISCUSSION

Both studies were double-blind randomised controlled trials; Corbett's being crossover in design and Poorni's being parallel. The crossover design has obvious advantages as subjects serve as their own control, reducing the impact of confounding variables.

Both studies used a power calculation to identify the number of participants that would provide a 90% chance of detecting an effect size of 0.83, assuming a significance level of 5%; the correct numbers of volunteers were enrolled. There were no withdrawals from the Poorni study. It should be noted that only 27 were subjects enrolled in Corbett's concurrent IANB study and there is no information on whether a power calculation was used to determine this figure.

All volunteers were assessed for eligibility. Corbett required volunteers to have at least one vital lower first molar tooth; the average age of participants was 23 years. This reduces the influence of confounding variables, but also the clinical relevance (patients requiring invasive dental treatment in which local anaesthetic is necessary may not have healthy dentitions – any surrounding tissue pathology, infection and/or inflammation can affect the action of local anaesthetic agents). Also, the UK has an ageing population and whether the results are applicable to the wider population warrants further investigation. In comparison, Poorni used very strict inclusion criteria, rendering the study relatively niche.

All volunteers were randomly allocated into groups using computer programmes. Both operators and investigators were blinded to the interventions to minimise the risk of selection bias. Neither study made participant characteristics known; meaning confounding variables may have been unevenly distributed.

In the Corbett study, pathological and anatomical variances were minimised by using only sound mandibular first permanent molars. Reliability could have been further improved possibly by comparing to the contralateral molar, as it could be assumed that this tooth would be in a comparable state of health. Poorni's study examined the effects of the local anaesthetics on any mandibular molar diagnosed with irreversible pulpitis. While this may increase the clinical relevance, a concern with this is that the inflammation associated with pulpitis can acidify the surrounding tissues; this acidification is believed to decrease the effectiveness of local anaesthetics.[22] A recent systematic review concluded that there was no significant difference in success rates when comparing 1.8 ml and 3.6 ml of lidocaine administered via IANB, suggesting the doses used in both studies were appropriate.[23] Malamed reported that the mean volume of articaine required to achieve anaesthesia was 2.5 ml; as both studies used 1.8 ml of articaine it could be that an insufficient dose was administered.[24] Corbett's study had a clear and strict definition of pulpal anaesthesia which increases the likelihood of achieving

Table 3 Appraisal of the literature

Study	Patient group	Intervention details	Outcomes assessed	Strengths, weaknesses and potential biases
Corbett (2008)[12]	31 volunteers, aged ~23 years with min. one vital lower first molar.	Volunteers received:	Pulpal anaesthesia was determined via electronic pulp testing (EPT).	Randomised, double-blind, controlled trial Approved by relevant authorities Subjects assessed for eligibility Only lower first molars included Power calculation Single operator/investigator Electronic pulp tester calibrated Same subject control Pulpal anaesthesia was clearly defined Outcome assessed objectively No withdrawals p-value stated at 0.05 Appropriate statistical analysis Adhered to CONSORT statement
	Exclusion criteria: LA allergy, unstable CV disease, pregnancy, neurologic disorders.	BI with 1.8 mL 4% articaine adjacent to a mandibular first molar	The number of occasions where there was no response to EPT was recorded.	
	27 of these volunteers participated in concurrent IANB investigation to serve as control.	IANB with 2 mL of 2% lidocaine	For the IANB study, EPT was performed under almost identical conditions; the only difference being the time interval used for recordings.	
		The investigator was blinded.	No response to maximal stimulation on two consecutive recordings was considered successful anaesthesia.	Only 27 volunteers in concurrent study No table of characteristics Demographic of volunteers may not reflect the population for whom intervention is most relevant No details of funding/conflict of interest
Poorni (2011)[13]	156 healthy volunteers (90 men, 66 women) aged 18-30 with active pain of ≥54 mm on Heft-Parker Visual Analogue Scale (HP VAS) in a mandibular molar and symptoms of irreversible pulpitis.	Test arm A: IANB with 4% articaine.	Subjective pain was recorded on HP VAS following intervention. Recordings were taken 20 minutes after injection of LA, following access cavity preparation, and after pulp extirpation.	Randomised, double-blind, controlled trial Approved by relevant authorities Subjects assessed for eligibility Power calculation Single operator No withdrawals p-value stated at 0.05 Appropriate statistical analysis Adhered to CONSORT statement Non-biased source of funding No conflicts of interest
		Test arm B: BI with 1.8 ml of 4% articaine.		
		Control arm: IANB with 1.8 ml of 2% lidocaine.		
	Subjects were distributed into three groups.	The type of syringe, size of needle, volume of solution, rate of deposition, and operator remained constant.	Successful pulpal anaesthesia was defined as, 'no pain or weak/mild pain during endodontic access preparation and pulp extirpation'.	No table of characteristics Any mandibular molar accepted Teeth had irreversible pulpitis so result may not apply to general population Interventions assessed subjectively No same subject control

true results. Within Poorni's study, the definition of pulpal anaesthesia was less clear, and subjective, as, 'mild/weak' pain was accepted as successful anaesthesia.

For both studies, the same operator administered all of the local anaesthetic injections, although, it should be noted that some operators will be more skilled and/or more experienced at delivering an IANB to either the right or left side.

A major advantage of Corbett's study is that the primary outcomes were assessed objectively. This was a notable weakness of Poorni's study as the outcomes were assessed subjectively – individual patients have different baseline pain thresholds and confounding factors, such as stress and anxiety, can cause a subject's pain threshold to decrease.[25]

In summary, suggested improvements include: using a crossover design; grouping patients based on age; ensuring strict inclusion criteria (including sound, bilateral mandibular first permanent molars); clearly defining pulpal anaesthesia; making a table of characteristics available; standardising the side as to which the IANB is administered; measuring outcomes objectively with EPT; and comparing results with the equivalent contralateral tooth.

Table 4 Rejected studies

Study	Reason for rejection
Arali (2015)[14]	Paediatric patients
Aggarwal, Jain *et al.* (2009)[15]	Patients received supplemental articaine plus lidocaine IANB
Aggarwal, Singla *et al.* (2011)[16]	Patients received supplemental articaine plus lidocaine IANB
Ashraf, Kazem *et al.* (2013)[17]	Patients received articaine IANB
Dou, Luo *et al.* (2013)[18]	Patients received supplemental articaine plus lidocaine IANB
Haase, Reader *et al.* (2008)[19]	Paatients received articaine IANB
Kanaa, Whitworth *et al.* (2009)[20]	Patients received supplemental articaine plus lidocaine IANB
Kanaa, Whitworth *et al.* (2012)[21]	Patients received supplemental articaine plus lidocaine IANB

CONCLUSION

It is widely accepted that an IANB with lidocaine is the gold standard for anaesthetising mandibular molar teeth. However, articaine BIs are gaining popularity for such applications due to the simplicity of administration,

Table 5 Percentage of volunteers with successful anaesthesia

	Success (%)
Corbett (2008)[12]	
4% articaine BI	70.4
2% lidocaine IANB	55.6
P value	>0.05
Poorni (2011)[13]	
4% articaine BI	69.2 (during access prep.)
	65.4 (during pulp extirpation)
2% lidocaine IANB	69.2 (during access prep.)
	65.4 (during pulp extirpation)
P value	>0.05

and avoidance of iatrogenic damage to the inferior alveolar and lingual nerves.[26]

A recent clinical study demonstrated a significant difference between articaine BIs and lidocaine IANBs for achieving pulpal anaesthesia in mandibular molars with irreversible pulpitis. Monteiro reported 40% success in the articaine group *versus* 10% success in the lidocaine group when undertaking emergency endodontic treatment.[27] This result contradicts the research presented in this review. Much of the wider research on this topic has been carried out on the paediatric population, with mixed results. Arrow reported that lidocaine IANBs achieve significantly greater success rates while, more recently, Arali demonstrated that paediatric patients found treatment with articaine BIs significantly less painful.[14,28]

Within the limitations of these trials, it can be concluded that 4% articaine BI's are no more effective than 2% lidocaine IANBs. The results of these studies therefore suggest that the selection of which technique to use, following careful patient selection, can be decided on the basis of personal preference and convenience of the dentist. Although, as on average the cost of a lidocaine carpule in the UK is less than the cost of articaine it could be argued that lidocaine remains the most cost-effective method available to the dentist.

1. Oliveira P C, Volpato M C, Ramacciato J C, Ranali J. Articaine and lignocaine efficiency in infiltration anaesthesia: a pilot study. *Br Dent J* 2004; **197:** 45–46.
2. Zahedi S. *Retrospective review of dental local anaesthetic induced paraesthesia in the United Kingdom.* Toronto:University of Toronto, 2012. MSc Thesis.
3. Malamed S (ed). *Handbook of local anaesthesia, sixth edition.* St Louis: Mosby, 2012.
4. 4. Tortamano I P, Siviero M, Lee S, Sampaio R M, Simone JL, Rocha R G. Onset and duration period of pulpal anesthesia of articaine and lidocaine in inferior alveolar nerve block. *Braz Dent J* 2013; **24:** 371-374.
5. Rahn R, Ball B (eds). Local anaesthesia in dentistry-articaine and epinephrine for dental anaesthesia, first edition. Germany; Seefeld, 2001.
6. Corbett I P, Ramacciato J C, Groppo F C, Meechan J G. A survey of local anaesthetic use among general dental practitioners in the UK attending postgraduate courses on pain control. *Br Dent J* 2005; **199:** 784–787.
7. Evers H, Haegerstam G. *Introduction to Dental Local Anaesthesia.* Mediglobe, 1990.
8. Keetley A, Moles DR. A clinical audit into the success rate of inferior alveolar nerve block analgesia in general dental practice. *Prim Dent Care* 2001 ; **8:** 139–142.
9. Potocnik I, Bajrovic F. Failure of inferior alveolar nerve block in endodontics. *Endod Dent Traumatol* 1999; **15:** 247–251.
10. Vähätalo K, Antila H, Lehtinen R. Articaine and lidocaine for maxillary infiltration anaesthesia. *Anesth Prog* 1993; **40:** 114–116.
11. Kwon H, Shin Y, Cho S Y, Park S H, Jung I Y. Factors affecting the success rate of buccal infiltration anaesthesia in the mandibular molar region. *Int Endod J.* 2014; **47:** 1117–1122.
12. Corbett I P, Kanaa M D, Whitworth J M, Meechan J G. Articaine infiltration for anaesthesia of mandibular first molars. *J Endod* 2008; **34:** 514–518.
13. Poorni S, Veniashok B, Senthilkumar A D, Indira R, Ramachadran S. Anaesthetic efficacy of four percent articaine for pulpal anaesthesia by using inferior alveolar nerve block and buccal infiltration techniques in patients with irreversible pulpitis: A prospective randomized double-blind clinical trial. *J Endod.*2011; **37:** 1603–1607.
14. Arali V, P M. Anaesthetic efficacy of 4% articaine mandibular buccal infiltration compared to 2% lignocaine inferior alveolar nerve block in children with irreversible pulpitis. *J Clin Diagn Res* 2015; **9:** ZC65–ZC67.
15. Aggarwal V, Jain A, Kabi D. Anaesthetic efficacy of supplemental buccal and lingual infiltrations of articaine and lidocaine after an inferior alveolar nerve block in patients with irreversible pulpitis. *J Endod* 2009; **35:** 925–929.
16. Aggarwal V, Singla M, Rizvi A, Miglani S. Comparative evaluation of local infiltration of articaine, articaine plus ketorolac, and dexamethasone on anaesthetic efficacy of inferior alveolar nerve block with lidocaine in patients with irreversible pulpitis. *J Endod* 2011; **37:** 445–449.
17. Ashraf H, Kazem M, Dianat O, Noghrehkar F. Efficacy of articaine *versus* lidocaine in block and infiltration anaesthesia administered in teeth with irreversible pulpitis: A prospective, randomized, double-blind study. *J Endod* 2013; **39:** 6–10.
18. Dou L, Luo J, Yang D. Anaesthetic efficacy of supplemental lingual infiltration of mandibular molars after inferior alveolar nerve block plus buccal infiltration in patients with irreversible pulpitis. *Int Endod J* 2013; **46:** 660–665.
19. Haase A, Reader A, Nusstein J, Beck M, Drum M. Comparing anaesthetic efficacy of articaine *versus* lidocaine as a supplemental buccal infiltration of the mandibular first molar after an inferior alveolar nerve block. *J Am Dent Assoc* 2008; **139:** 1228–1235.
20. Kanaa M D, Whitworth J M, Corbett I P, Meechan J G. Articaine buccal infiltration enhances the effectiveness of lidocaine inferior alveolar nerve block. *Int Endod J* 2009; **42:** 238–246.
21. Kanaa M D, Whitworth J M, Meechan JG. A prospective randomized trial of different supplementary local anaesthetic techniques after failure of inferior alveolar nerve block in patients with irreversible pulpitis in mandibular teeth. *J Endod* 2012; **38:** 421–425.
22. Tsuchiya H, Mizogami M, Ueno T, Takakura K. Interaction of local anaesthetics with lipid membranes under inflammatory acidic conditions. *Inflammopharmacology* 2007; **15:** 164–170.
23. Fowler S, Reader A. Is a volume of 3.6 mL better than 1.8 mL for inferior alveolar nerve blocks in patients with symptomatic irreversible pulpitis? *J Endod* 2013; **39:** 970–972.
24. Malamed S F, Gagnon S, Leblanc D. Efficacy of articaine: a new amide local anaesthetic. *J Am Dent Assoc* 2000; **131:** 635–642.
25. Vedolin G M, Lobato V V, Conti P C, Lauris J R. The impact of stress and anxiety on the pressure pain threshold of myofascial pain patients. *J Oral Rehab* 2009; **36:** 313–321.
26. Renton T. Prevention of iatrogenic inferior alveolar nerve injuries in relation to dental procedures. *Dent Update* 2010; **37:** 350–352, 354–356, 358–360.
27. Monteiro M R, Groppo F C, Haiter-Neto F, Volpato M C, Almeida JF. 4% articaine buccal infiltration *versus* 2% lidocaine inferior alveolar nerve block for emergency root canal treatment in mandibular molars with irreversible pulpits: a randomized clinical study. *Int Endod J* 2015; **48:** 145–152.
28. Arrow P. A comparison of articaine 4% and lignocaine 2% in block and infiltration analgesia in children. *Aust Dent J* 2012; **57:** 325–333.