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Comparison of articaine 4% and lidocaine 2% in paediatric dental patients

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Summary. *Objective*. To evaluate and compare the reaction of children who received local anaesthesia with lidocaine 2% with 1 : 100 000 epinephrine and articaine 4% with 1 : 200 000 epinephrine and to assess the time of the onset, efficacy, duration of numbness of the soft tissues, children's sensation after treatment to both anaesthetic solutions, as well as the occurrence of adverse events.

Samples and methods. Sixty-two children (34 girls and 28 boys) aged 5–13 years (mean age 8·4 ± 2·3) from two established paediatric dental clinics who needed similar operative procedures preceded by local anaesthesia were randomly assigned to receive either lidocaine or articaine at their first or second visit. Modified Taddio's behavioural pain scale was used to evaluate pain reaction during injection and treatment. The sensation after injection and treatment was evaluated using the Wong–Baker FACES pain rating scale. Parents recorded the time when the feeling of local anaesthesia in soft tissues disappeared.

Results. Duration of numbness of soft tissues was significantly longer for articaine (3·43 ± 0·7 h) than for lidocaine (3·0 ± 0·8 h) (P = 0·003). No difference regarding the efficacy of the anaesthesia was observed.

Reaction to pain was similar for both local anaesthetic solutions and no significant difference was found between genders. The efficacy of the anaesthesia was similar for both solutions. The feeling after treatment was similar for both solutions. The rate of adverse effects was similar for the two solutions.

Conclusions. Articaine 4% with 1 : 200 000 epinephrine is as effective as lidocaine 2% with 1 : 100 000 epinephrine. The effect of numbness of soft tissues was longer lasting with articaine than with lidocaine.

Introduction

Fear-related behaviour has long been recognized as the most difficult aspect of patient management and can be a barrier to good care. While patients' fears may be acquired through vicarious experiences and threatening information, direct experience is the most common source of dental fear. It is ironic that local anaesthesia allows virtually pain-free treatment, yet is associated with many anxious thoughts and misconceptions in the young patients [1] and is also the most anxiety-provoking procedure for dental patients and dentists too [2].

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The average duration of anaesthesia with lidocaine 2% with epinephrine is 60 min for pulp tissue and 170 min for soft tissue (maxillary infiltration) compared with 85 min for pulp tissue and 190 min for soft tissue (mandibular block) [3]. Children still feel numbness of the lips, tongue, and soft tissues after dental treatment. A disadvantage of local anaesthesia in children is the feeling of numbness after the treatment. Self-inflicted lesions of lips, tongue, cheek, and soft tissues may occur as a result of this loss of sensation.

Lidocaine is a popular solution for local anaesthesia; however, another solution, articaine, was introduced to clinical practice in Germany in 1976 [4]. In 2000, the US Food and Drug Administration approved the sale of 4% articaine with 1 : 100 000 epinephrine under the name Septocaine (Septodont). The solution is also available in a concentration of 4% with 1 : 200 000 under the name of Ubistesin

(ESPE). Articaine is a 4-methyl-3-[2-(propylamino)-propionamido]-2-thiophene-carboxylic acid, methyl ester hydrochloride with a molecular weight of 320·84. It is the only local anaesthetic that contains a thiophene ring and is the only widely used amide local anaesthesia that contains an additional ester group. Biotransformation of articaine occurs in plasma (hydrolysis by plasma esterase) and the liver (hepatic microsomal enzymes) and is eliminated via the kidneys [5]. It was suggested that articaine hydrochloride has 1·5 times the potency of lidocaine [6], and should be administered according to body weight [7]. Clinically, articaine is used in a 4% concentration with epinephrine 1: 100 000 or 1 : 200 000 in a 1·7 mL solution in the cartridge.

In a multicentre trial conducted on 1325 subjects (children and adults), the safety and efficacy of lidocaine 2% and articaine 4% both with 1 : 100 000 epinephrine were compared [8,9]. In children, several studies also evaluated the safety and efficacy of 4% articaine with 1 : 100 000 and 1 : 200 000 epinephrine [10–13]. Malamed compared the safety and efficacy of articaine 4% and lidocaine 2%, both with epinephrine 1 : 100 000 and found no difference between the two solutions [13]. Wright *et al*. found no adverse effects when articaine 4% with epinephrine 1 : 100 000 or 1 : 200 000 was administered [11]. In another study, when articaine 4% was compared to mepivacaine HCl 2% and prilocaine HCl 4% all solutions with 1 : 200 000 epinephrine, they were found to be equally effective [12]. In addition to safety, Dudkievicz *et al*. studied the efficacy of articaine 4% in 1 : 100 000 and 1 : 200 000 epinephrine. Both anaesthetic solutions were found to be efficient and safe [10].

No study has yet been conducted to assess and compare the responses of children and the duration of numbness of soft tissues when receiving local anaesthesia with articaine 4% (1 : 200 000 epinephrine) and lidocaine 2% (1 : 100 000 epinephrine).

The objective of this study was to evaluate and compare the reaction of children who received local anaesthesia with lidocaine 2% with 1 : 100 000; and articaine 4% with 1 : 200 000 epinephrine and to assess the time of onset, efficacy, duration of numbness of the soft tissues, children's sensation after treatment, as well as the occurrence of adverse events.

Patients and methods

Participants in the study included 62 children (34 girls and 28 boys) aged 5–13 years (mean age 8·4 ± 2·3, median 8), mean weight 30·44 ± 8·80 kg, median 29, from two established paediatric dental clinics in Jerusalem and Tel Aviv. Inclusion criteria were the need for at least two clinical sessions for similar operative procedures with local anaesthesia in the same arch, not as emergency procedures. An experienced paediatric dentist carried out the treatment for each child in each centre (one dentist per centre).

A random cross-over design was used and each child served as his or her own control. The average duration of simple and complex procedures was comparable in each child between articaine and lidocaine. All children were healthy, and none needed a sedative or other pharmacological support to receive dental treatment. Informed consent was obtained from the accompanying parent after explaining and describing the procedure. The child's age and weight, type and amount of local anaesthesia, the need for additional local anaesthesia, and the time of onset were recorded. Each patient was randomly assigned to receive either lidocaine HCl 2% with 1 : 100 000 epinephrine (Octocaine^{R}, Novocol Pharmaceutical of Canada Inc. Cambridge, Ontario, Canada N1R) or articaine HCl 4% with 1 : 200 000 epinephrine (Ubistesin, ESPE Dental AG, D-82229 Seefeld, Germany) for the first visit, with the other solution administered during the second visit.

Up to one cartridge of lidocaine (maximum dose: 4 mg/kg body weight) and articaine (maximum dose: 5 mg/kg body weight) was administered [7]. Before the injection, topical anaesthetic gel on a cotton roll was applied for 1 min to the injection site. The injection of the local anaesthetic solution was slow with an average duration of nearly 2 min (approximately 1 mL/min) [14].

The modified behavioural pain scale, suggested by Taddio *et al*. [15], was used for objective evaluation of the children's reaction during injection. The scale comprised the following parameters: (i) facial display, (ii) arm/leg movements, (iii) torso movements, and (iv) crying. The facial display followed Craig's behavioural description of facial actions, which describes pain [16]. Only two of the four of most descriptive facial actions were evident (eye brow bulge or eye squeeze), as the mouth was open and the nose was partly covered by the operator's hand during injection. All behaviour parameters were evaluated during injection and subsequent treatment.

A trained dental assistant, who did not participate in the treatment and was blinded to the agent being

used, recorded the behavioural parameters in each centre. To check on recording, 15 patients who were not included in this study were evaluated as a pilot study.

The time of onset was evaluated by asking the child when the sensation of numbness started. The Wong–Baker FACES pain rating scale (FPS) was used for subjective evaluation of feeling after the injection [17]. This scale shows good construct validity as a self-report pain measure. The FPS measures the unpleasantness or affective dimension of a child's pain experience after injection and is used in children aged 3–17 years. The child is shown a set of six cartoon faces with varying facial expressions ranging from a smile/laughter to tears. Each face has a numerical value. After verbal instructions were given on how to use the FPS, the children were asked to select the face 'which looks like how you feel deep down inside, not the face you show to the world'. The children were asked to rank their sensation immediately after the injection, and by phone 1 and 2 h after.

The efficacy of the anaesthesia was evaluated during treatment. Additional local anaesthetic solution was added when children showed or reported signs of pain. Parents were instructed to ask the child and to record the time when the feeling of numbness disappeared (offset time). They were asked by phone after 1, 2 or more hours to report it and were also asked about the occurrence of adverse effects. Differences in parameters were evaluated by McNemar test and paired *t*-test. Significance was set at $P < 0{\cdot}05$.

Results

As no significant differences were found between the two operators, results were pooled. No significant differences were found in outcomes for the two solutions with regard to gender.

No differences were seen between solutions in onset time, with this being immediate in more than 80% of instances.

Treatment included 40 maxillary local infiltrations and 22 mandibular block injections. Onset time during the first and second sessions and by type of local anaesthesia given (local infiltration or mandibular block) is shown in Table 1. In neither case were differences significant.

In addition, no significant difference was found when articaine or lidocaine was used during the first or second visit.

In this study no difference in subjective evaluation (Wong–Baker FPS) of pain reaction between lidocaine and articaine between boys and girls when maxillary infiltration or mandibular block techniques were used. Ninety-eight percent of scores were of 3 or less were recorded when either method was used and for either solution.

No significant difference was found between solutions in the objective evaluation (according to Taddio's scale) during injection or between first and second sessions or in the technique of local anaesthesia when delivering maxillary infiltration or mandibular block. The number of children crying during administration at first and second visits and in relation to type of injection is shown in Table 2.

No significant difference was found in duration of numbness between local infiltration and mandibular block and between boys and girls for each local anaesthetic solution. However, the duration of

Table 2. Frequency table of children crying during injection by visit (first or second) and by type of local anaesthesia (local infiltration and mandibular block)

Crying during local infiltration in first visit	Crying during local infiltration in second visit			Crying during mandibular block in second visit		
	Yes	No	Total	Yes	No	Total
Yes	6	4	10	2	2	4
	15%	10%	25%	9%	9%	18%
No	3	27	30	0	18	18
	7·5%	67·5%	75%		82%	82%
Total	9	31	40	2	20	22
	22·5%	77·5%	100%	9%	91%	100%

Table 1. Frequency table of children regarding to onset time by type of local anaesthesia (local infiltration or mandibular block) and session

Onset time session 1	Local infiltration Onset time in session 2			Mandibular block Onset time in session 2		
	Immediate	After 2 min	Total	Immediate	After 2 min	Total
Immediate	31 (77·5%)	3 (7·5%)	34 (85%)	19 (86·5%)	1 (4·5%)	20 (91%)
After 2 min	2 (5%)	4 (10%)	6 (15%)	1 (4·5%)	1 (4·5%)	2 (9%)
Total	33 (82·5%)	7 (17·5%)	40 (100%)	20 (91%)	2 (9%)	22 (100%)

Table 3. Duration of numbness and subjective measurements of reaction to pain for both solutions

	Lidocaine 2%	Articaine 4%	Significance
Duration of numbness	3·01 ± 00·82 h	3·43 ± 00·74 h	$P = 0·003$
Wong–Baker FPS After injection	1·06 ± 0·73	1·08 ± 0·79	NS
Wong–Baker FPS After 1 h	1·03 ± 0·63	0·95 ± 0·65	NS
Wong–Baker FPS After 2 h	1·03 ± 0·81	0·90 ± 0·68	NS

$P < 0·05$ – paired samples statistics.

Table 4. Adverse effects with both solutions

Adverse effects	Lidocaine 2%	Articaine 4%
Accidental lip/cheek injury	2	1
Post-procedural pain	1	3
Haematoma	1	0

numbness of soft tissues was longer for articaine (3·43 ± 0·7 h) than for lidocaine (3·0 ± 0·8 h). This difference was statistically significant ($P = 0·003$) (Table 3).

Subjective pain reaction, measured by the FPS of Wong–Baker, showed that children reacted positively to injection with either solution immediately, and 1 and 2 h after receiving the local anaesthetic solution with no statistically significant differences between solutions in this outcome measure (Table 3).

Adverse events related to articaine and lidocaine were similar for the two solutions and included: accidental lip and/or cheek injury (three patients), post-procedural dental pain (four patients), and haematoma (one patient). Differences between the two solutions were not statistically significant (Table 4).

Complete anaesthesia was achieved in 53 of 62 subjects. Nine patients needed additional local anaesthesia. In eight of them, the addition was needed for both solutions.

Discussion

Few studies have evaluated the safety and efficacy of articaine 4% with 1 : 200 000 epinephrine in children [10–12].

In this study the reaction to pain during injection and the duration of numbness of soft tissue with lidocaine and articaine were assessed and compared.

The onset was similar for both solutions, which is in accordance with results of Malamed *et al*. [13]. The fast onset of both solutions may be due to the fact that lidocaine and articaine have the same pKa of 7·8. The administration of the local anaesthetic solution was slow (between 1·5 and 2 min) and the onset was almost immediately after injection for the great majority of children included. Lemay *et al*. [19] and Donaldson *et al*. [20] reported also a fast onset time in children when articaine 4% was administered compared to adults.

No significant difference in the subjective pain reaction (Wong–Baker FPS) was observed between solutions, a finding that is in accordance with Malamed *et al*. [13].

Although similar in speed of onset, articaine was significantly longer lasting when compared to lidocaine. The duration of action of local anaesthetic agents may be related primarily to their degree of protein binding. As local anaesthetic solutions are believed to act binding to a protein receptor in the sodium channel, the greater protein binding of a specific agent presumably results in a longer period of sodium channel blockade and a longer duration of anaesthesia [21]. The reported protein-binding values for lidocaine and articaine are 65% and 95%, respectively [8].

No significant difference was found between both solutions regarding efficacy, although the anaesthetic solutions were of a different concentration: articaine 4% and lidocaine 2%. This may be explained by the fact that lipid solubility of articaine is 1·5 and for lidocaine 4·0. Lipid solubility is a primary determinant of intrinsic anaesthetic potency, as the nerve membrane that represents the site of action of local anaesthetics consists primarily of lipids.

Few adverse reactions were reported with both solutions and despite the greater duration of numbness with articaine, no significant differences were found in their frequency. This result is again in accordance with findings reported by Malamed *et al*. [13].

Additional anaesthesia was administered to nine of 62 subjects, in eight of them the addition was needed for both solutions, perhaps suggesting a need for greater depth of analgesia in some children of variation in sensitivity and response to sensation.

No difference in duration of numbness of the soft tissues was found between maxillary infiltration and mandibular block. This finding is not in accordance with others' who found that duration of local anaesthesia in the maxilla when infiltration was used was shorter for the mandible where nerve block injections were employed [8,22,23].

What this paper adds
- The time that the effect of numbness of soft tissue lasts after dental treatment when using articaine.
- The reaction of children during injection with articaine.

Why this paper is important to paediatric dentists
- It is demonstrated that articaine 4% 1:200 000 and lidocaine 2% 1:100 000 presented the same efficacy.
- The effect of numbness of soft tissues is longer using articaine than lidocaine.

Conclusions

1 Children displayed the same behaviour during injection and reported the same feeling after treatment when receiving articaine and lidocaine.
2 Both solutions presented the same efficacy.
3 The effect of numbness of soft tissues was longer using articaine than lidocaine.
4 Few adverse events were reported following use of either solution.

References

1 Milgrom P, Coldwell SE, Getz T, Weinstein P, Ramsay DS. Four dimensions of Fear of dental injections. *Journal of the American Dental Association* 1997; **128**: 756–766.
2 Dower JS Jr, Simon JF, Peltier B, Chambers D. Patients who make a dentist most anxious about giving injections. *Journal of the Californian Dental Association* 1995; **23**: 35–40.
3 Saxen MA, Newton CW. Anesthesia for endodontic practice. *Dental Clinics of North America* 1999; **43**: 247–261.
4 Ferger P, Marxkors R. Ein neues Anasthetikum in der zahnarzlichen Prosthetik (A new anesthetic in dental prosthetics). *Deutsch Zahnarz Zeitung* 1973; **28**: 87–89.
5 Van Oss GE, Vree TB, Baars AM, Termond EF, Booij LH. Pharmacokinetics, metabolism, and renal excretion of articaine and its metabolite articainic acid in patients after epidural administration. *European Journal of Anaesthesiology* 1989; **6**: 49–56.
6 Malamed SF. *Handbook of Local Anesthesia*, 4th edn. St Louis, MO: Mosby, 1997: 63–64.
7 USP DI. *Drug Information for the Health Care Professional*, 19th edn. Vol. I. Micromedex, Thomson Publishing Corporation US, 1999: 145.
8 Malamed SF, Gagnon S, Leblanc D. Efficacy of articaine: a new amide local anesthetic. *Journal of the American Dental Association* 2000; **131**: 635–642.
9 Malamed SF, Gagnon S, Leblanc D. Articaine hydrochloride: a study of the safety of a new amide local anesthetic. *Journal of the American Dental Association* 2001; **132**: 177–185.
10 Dudkiewicz A, Schwartz S, Lalibert JR. Effectiveness of mandibular infiltration anesthesia in children using the local anesthetic Ultracaine® (articaine hydrochloride). *Journal of the Canadian Dental Association* 1987; **1**: 29–31.
11 Wright GZ, Weinberger SJ, Friedman CS, Plotske OB. The use of articaine local anesthesia in children under 4 years of age: a retrospective report. *Anesthesiology Programs* 1989; **36**: 268–271.
12 Wright GZ, Weinberger SJ, Marti R, Plotske OB. The effectiveness of infiltration anesthesia in the mandibular primary molar region. *Pediatric Dentistry* 1981; **13**: 278–283.
13 Malamed SF, Gagnon S, Leblanc D. A comparison between articaine HCl and lidocaine HCl in pediatric dental patients. *Pediatric Dentistry* 2000; **22**: 307–311.
14 Ram D, Peretz B. The effect of warming anesthetic solution prior to injection of dental local anesthesia in children. *Pediatric Dentistry* 2002; **24**: 333–336.
15 Taddio A, Nulman I, Goldbach M, Ipp M. Use of lidocaine–prilocaine cream for vaccination pain in infants. *Journal of Pediatrics* 1994; **124**: 643–648.
16 Craig KD. The facial display of pain. In: *Measurement of Pain in Infants and Children*. Seattle: IASP Press, 1998: 103–121.
17 Wong DL, Baker CM. Pain in children: comparison of assessment scales. *Pediatric Nursing* 1988; **14**: 9–17.
18 Ram D, Peretz B. Reactions of children to maxillary infiltration and mandibular block. *Pediatric Dentistry* 2001; **23**: 343–346.
19 Lemay H, Albert G, Helie P, *et al*. L'articaine en dentisterie operatoire conventionelle. *Le Cirurgien Dentiste du France* 1985; **281**: 39–43. [Articaine in conventional operative dentistry (French)].
20 Donaldson D, James-Perdok L, Craig BJ, Derkson GD, Richardson AS. A comparison of Ultracaine DS (articaine HCl) and Citanest forte (prilocaine HCl) in maxillary infiltration and mandibular nerve block. *Journal of Canadian Dental Association* 1987; **53**: 38–42.
21 Covino BG. Pharmacology of local anesthetic agents. In: Rogers M, Tinker JH, Covino B, Glongnecker DE. *Principles and Practice of Anesthesiology*, Vol. 2, 9th edn. St Louis, MO: Mosby, 1997: 1235–1257.
22 Cowan A. Clinical assessment of a new local anesthetic agent: carticaine. *Oral Surgery Oral Medicine and Oral Pathology* 1977; **43**: 174–180.
23 Lemay H, Albert G, Helie P, *et al*. Ultracaine en dentisterie operatoire conventionelle (Ultracaine in conventional operative dentistry). *Journal of the Canadian Dental Association* 1984; **50**: 703–708.