Sharaf and Kabel
Bulletin of the National Research Centre (2022) 46:83
https://doi.org/10.1186/s42269-022-00772-6

Bulletin of the National Research Centre

RESEARCH

Open Access

Biological evaluation of the efficacy of two different anesthetic solutions in pain control during extraction of mandibular second primary molars

Rasha F. Sharaf[1*] and Nihal Kabel[2]

Abstract

Background: The most critical part in management of children in the dental clinic is control of pain and this can be achieved through local anesthesia. When the treatment plan includes extraction of mandibular primary molars, the nerve block technique is the technique of choice for administration of local anesthesia. However, this technique is accompanied with discomfort due to deep penetration of the needle, possibility of nerve injury, hematoma as well as risk of self-inflicted trauma. Therefore, researchers have searched for an alternative technique to facilitate providing painless dental treatment for the child with avoidance of the possible complications of the nerve block technique, and this can be achieved by using a strong and deeply penetrating type of local anesthesia like articaine 4% that can be effective when administered with infiltration technique. The aim of the current study was to compare the efficacy of infiltration anesthesia using alexadricaine 4% and Mepecaine-L 2% in control of pain during extraction of lower 2nd primary molars in children and to compare the change in the heart rate that occurs as a consequence of pain during extraction. A total of 50 children were included in the current study, pain assessment was performed through measuring physiological parameter (pulse rate), subjective parameter (Wong–Baker Facial Pain Scale) and objective parameter (Sound Eye Motor scale). Results showed that there was significant increase in the pulse rate in both groups, while extraction using alexadricaine showed significantly lower pain scores either with Wong–Baker Facial Pain Scale (WBFPS) or with Sound Eye Motor scale (SEM).

Conclusions: Using a potent anesthetic solution like alexadricaine 4% facilitates extraction of mandibular primary molars, and achieves efficient pain control, with infiltration technique only without any need for the invasive nerve block technique.

Keywords: Articaine, Mepivacaine, Infiltration, Extraction

Background

There is a strong relationship between fear and stress the patient is facing during dental treatment, especially when this patient is a child, and this is his first dental appointment (Al-Yasiry et al. 2020). Most of the children have subjective fear of the dental visit due to unpleasant stories and negative experiences of their friends, classmates, and their parents (Kilinç et al. 2016).

The most critical part in management of children is control of pain and this can be achieved through local anesthesia, which produce temporary loss of sensation during performing the dental treatment for the patient (Oulis et al. 1996). When the treatment plan includes extraction of mandibular primary molars, the nerve block

*Correspondence: rasha_sharaf@hotmail.com
[1] Orthodontics and Pediatric Dentistry Department, National Research Centre, Cairo, Egypt
Full list of author information is available at the end of the article

technique is the technique of choice for administration of the local anesthesia.

In spite of the fact that the nerve block technique provides profoundness of the anesthesia which is considered a good chance for performing dental treatment to all teeth in the same quadrant at the same appointment, but unfortunately it is accompanied by risk of failure due to the discrepant landmark (Khalifah 2021). On the other hand, the unpleasant feeling of numbness which lasts for a very long time can lead to tongue and lip biting, in addition to the discomfort due to deep penetration of the needle (Khanna et al. 2021). Therefore, researchers have searched for an alternative technique to facilitate providing painless dental treatment for the child with avoidance of the possible complications of nerve block technique, and this can be achieved by using a strong and deeply penetrating type of local anesthesia administered with infiltration technique.

Articaine is one of the most potent amide anesthetic agents, its biotransformation takes place through the liver and the plasma due to presence of both ester and amide groups. It is characterized by its rapid onset and being more potent than Lidocaine by one and half times (Sood et al. 2014). It is also claimed that articaine is liposoluble and can penetrate the soft and hard tissues efficiently as well as control pain better than other anesthetic solutions (Uckan et al. 2006). These characteristics made articaine the anesthetic solution of choice to be used with infiltration technique, even in the lower arch and substitute the mandibular nerve block technique during extraction of mandibular primary molars in children.

Mepivacaine was approved by the Food and Drug Administration (FDA) in 1960. It is one of the most commonly used types of anesthetic solution in the dental field due to being less toxic than bupivacaine, at the same time, it has rapid onset and long duration of action when compared with lidocaine without vasoconstrictor. The formulation without vasoconstrictor is the most recommended for medically compromised patients (Brockmann 2014).

Therefore, the aim of the current study was to compare the efficacy of infiltration anesthesia using alexadricaine 4% and Mepecaine-L 2% in control of pain during extraction of lower 2nd primary molars in children and to compare the change in the heart rate that occurs as a consequence of pain during extraction.

Aim of the study

The aim of the current study was to compare the efficacy of infiltration anesthesia using alexadricaine 4% and Mepecaine-L 2% in control of pain during extraction of lower 2nd primary molars in children and to compare the change in the heart rate that occurs as a consequence of pain during extraction.

Methods

Study design and participants

The study design is a parallel randomized triple-blind study with allocation ratio 1:1, which was approved by the Medical Research Ethics committee and the approval number is 34210112021.

A total of 103 children were examined, while 53 were excluded either because they didn't meet the inclusion criteria or because their parents refused to share in the study (Fig. 1). The study sample consisted of 50 children, with lower 2nd primary molars indicated for extraction due to root caries. Patients were selected from the dental clinic of the National Research Centre of Egypt.

Selection of samples

Proper medical and dental histories were obtained for all the participants, followed by clinical and radiographic examination. Patients who met the following inclusion criteria were enrolled in the current study.

Inclusion criteria:

- Co-operative children their age range 6–8 years, with behavior rating scale 3 or 4 according to the Frankl behavior scale.
- Children with non-restorable mandibular second primary molars indicated for extraction due to root caries.
- Children attending their first dental visit.
- Both sexes were included.
- Children with normal intellectual development
- Healthy children with no systemic or mental problems.
- Children's weight was more than 20 kg.

Exclusion criteria:

- Children with an acute dental abscess.
- Children with marked root or bone resorption.
- Children with a history of bleeding disorders or hypersensitivity.
- Patients who had taken analgesics in the 12-h preceding the dental treatment.
- Children whose parents refuse to sign the informed consent.

After full explanation of the purpose, procedures, and the circumstances of the study to the parents, children whose parents accepted their participation in the study signed a written informed consent.

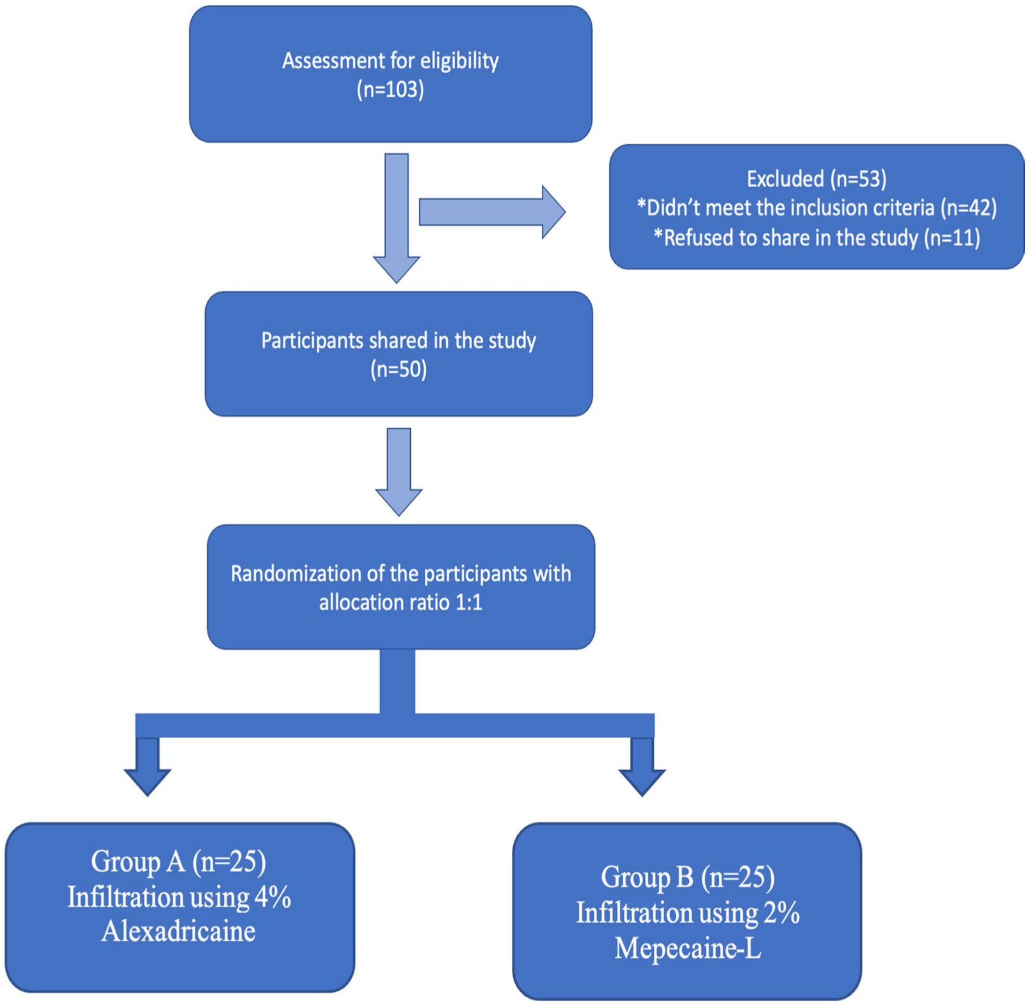

Fig. 1 Flow chart of the patients enrolled in the study. Group A: Infiltration injection was performed using 4% Alexadricaine*. Group B: Infiltration injection was performed using 2% Mepecaine-L**. (4% Alexadricaine and 2% Mepecaine-L manufactured by Alexandria co. for pharmaceuticals—Egypt)

Randomization and allocation

Children were randomly allocated either in group A or in group B. Every child was asked to pick up a paper from a box which contains 50 folded papers with numbers from 1 to 50, and these numbers were randomly allocated in either group A or B using computer software (http://www.random.org/).

This research was a triple-blinded study, where the patient, the operator, the outcome assessor and the statistician were blind.

The labels on the anesthetic carpules were masked with an adhesive opaque paper by the dental nurse, so that the operator and the assessor have no idea which type of the anesthetic solution was used.

After proper behavior management of the child, and establishment of good verbal and non-verbal communication with him/her, the child was ready to start the dental treatment.

The principal investigator was responsible for administration of anesthesia to all patients and performing the extraction as well. Dryness of the injection site was done by a cotton pellet then topical anesthetic gel 20% benzocaine was applied for 1 min then, the dental assistant loaded the metal syringe with the opaquely sealed anesthetic carpule, a 30-gauge side beveled short needle was used in the injection of the anesthetic solution. One and half ml of the anesthetic solution was injected at the depth of the buccal vestibule between the roots of the mandibular second primary molar. The anesthesia was administered slowly over 30 s then 0.3 ml of the local anesthetic solution was injected in the mesial and distal interdental papilla (Nadeen et al. 2021; Nair et al. 2018).

Lower primary molars forceps was used in the extraction of the mandibular 2nd primary molars. The forceps beaks engaged the bifurcation at a right angle to the handles. A strong apical grip was done followed by steady lingual and buccal movement with reasonable force until luxation occurred. The final movement to get the tooth out of the socket was directed outward and occlusal. A sterile piece of cotton was placed at the extraction site and the child was asked to bite on it firmly for at least 30 min (Nadeen et al.2021).

Positive reinforcement, tell-show-do, non-verbal behavior guidance and verbal distraction were used as behavioral guidance techniques during administration of anesthesia and tooth extraction.

Outcome assessment

Biological evaluation

Biological evaluation was performed through measuring the pulse rate of the patients, by the co-investigator, using a digital fingertip pulse oximeter (Granzia pulse oximeter, Italy) before and after extraction, to evaluate the effect of pain during extraction on the pulse rate of the children with both types of anesthesia.

After administration of the local anesthesia the child and the parent were asked to wait in the waiting area, and that was a good chance for the child to become relaxed and distracted away from the operating room. After 10 min the child and the parent were recalled to the operating room and different techniques of behavior guidance were used to make the child feel friendly with the operator and the assessor, then the pulse rate was measured, and this was recorded as the reading before extraction.

The second reading of the pulse rate was taken after extraction and informing the parents with the post-operative instructions, the pulse rate was measured and recorded.

Pain assessment scales

Wong–Baker Facial Pain Scale (WBFPS)

The Wong–Baker Facial Pain Scale (WBFPS), which is a self-report pain measure scale, was used to perform subjective evaluation after extraction (Bosenberg et al. 2003). Before starting any dental procedure, the WBFPS was explained to the child by the assessor. The child was shown a set of six cartoon faces with varying facial expressions ranging from a smile/laughter to tears, as shown in Fig. 2.

After the extraction, the post-operative instructions were given to the parents and the child, then the child was asked to choose the facial expression that best expresses his/her feeling during extraction.

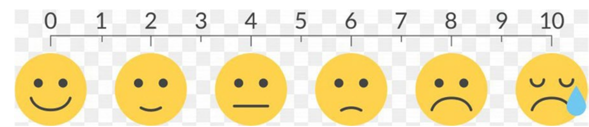

Fig. 2 Photograph showing Wong–Baker Facial Pain Scale

Sound, Eye, and Motor Scale (SEM)

The attitude of the child during extraction was recorded by the assessor using the Sensory, Eye and Motor scale (SEM) to evaluate the pain sensation during extraction. It is an objective parameter, and at the same time it is valid and reliable assessment tool (Abdelmoniem and Mahmoud 2016). Each parameter got 4 levels starting with feeling comfort = 1 and end with feeling with severe discomfort = 4 as shown in Table 1.

Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov–Smirnov and Shapiro–Wilk tests). Age and heart rate data showed normal (parametric) distribution while pain and SEM scores data showed non-normal (nonparametric) distribution. Data were presented as mean, standard deviation (SD), median and range values. For parametric data, Student's t test was used to compare between age values in the two groups. Repeated measures ANOVA test was used to compare between heart rates in the two groups as well as the changes in heart rate after extraction. Bonferroni's post hoc test was used for pair-wise comparisons when ANOVA test is significant. For nonparametric data, Mann–Whitney U test was used to compare between the two groups. Qualitative data were presented as frequencies and percentages. Chi-square test and Fisher's Exact test were used for comparisons between the groups regarding qualitative data. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

Results

After clinical examination of 103 children aged 6–8 years from the patients attending the dental clinic of the National Research Centre of Egypt, 50 children met the inclusion criteria and were included in the current study.

Baseline characteristics

There was no statistically significant difference between mean age values in the two groups, the mean age of the

Table 1 Sound, eye, motor scale

Parameter	Comfort 1	Mild discomfort 2	Moderate discomfort 3	Severe discomfort 4
Sound	No sound	Non-specific sound	Verbal complaint, louder	Verbal complaint, shouting sound, crying
Eye	No sign	Dilated eyes without tears (anxiety sign)	Tears, sudden eye movements	Crying, tears covering the face
Motor	Relaxed body and hand status	Muscular contraction, contraction of hands	Sudden body and hand movement	Hand movements for defense, turning the head to opposite side

Table 2 Mean, standard deviation (SD), frequencies (*n*), percentages and results of Student's *t* test and Chi-square test for comparisons between baseline characteristics in the two groups

	Alexadricaine ($n=25$)	Mepecaine-L ($n=25$)	*P* value
Age (Years)			0.860
Mean (SD)	6.92 (0.81)	6.88 (0.78)	

*Significant at $P \leq 0.05$

patients in group A (Alexadricaine) was 6.92 and the mean age in group B (Mepecaine-L) was 6.88 as shown in Table 2.

Pulse rate

The pulse rate was measured twice using digital pulse oximeter, the first time was after administration of local anesthesia by 10 min (before extraction), and the second time after extraction.

Before as well as after extraction, there was no statistically significant difference between pulse rates in the two groups (P value $=0.142$, Effect size $=0.044$) and (P value $=0.710$, effect size $=0.003$), respectively (Table 3, Fig. 3).

In both groups, there was a statistically significant increase in pulse rate after extraction, the mean pulse rate in the alexadricaine group before extraction was 100 while after extraction it increased to 108.8, while in the Mepecaine-L group the mean pulse rate before extraction was 93.9 and increased after extraction to 110.6 (P value $=0.006$, effect size $=0.146$) and (P value <0.001, effect size $=0.38$).

Pain assessment (WBFPS) scores

Alexadricaine showed a statistically significantly lower pain score than Mepecaine-L (P value $= 0.001$, Effect size $= 1.075$). In the alexadricaine group the median was 4 and the mean was 3.92 while in the Mepecaine-L group, the median was 8 and the mean was 6.96 (Table 4, fig. 4).

Results showed that alexadricaine was more potent and efficient than Mepecaine-L in control of pain during extraction of lower primary molars.

Sound, Eye and Motor Scale (SEM)

Alexadricaine showed statistically significantly lower Sound, Eye, Motor and total SEM scores than

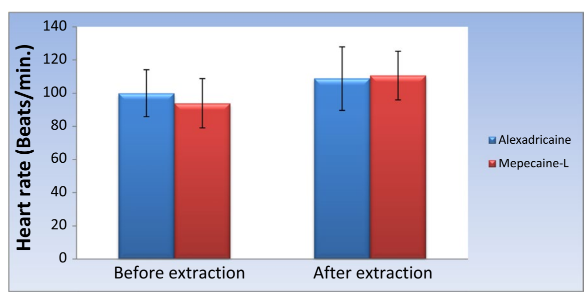

Fig. 3 Bar chart representing mean and standard deviation values for pulse rate in the two groups

Table 3 Descriptive statistics, results of repeated measures ANOVA test for comparison between pulse rates in the two groups and the changes within each group

Time	Alexadricaine ($n=25$)		Mepecaine-L ($n=25$)		*P* value	Effect size (partial eta squared)
	Mean	SD	Mean	SD		
Before extraction	100	14.1	93.9	14.8	0.142	0.044
After extraction	108.8	19.1	110.6	14.6	0.710	0.003
P value	0.006*		< 0.001*			
Effect size (partial eta squared)	0.146		0.38			

*Significant at $P \leq 0.05$

Table 4 Descriptive statistics and results of Mann–Whitney *U* test for comparison between pain in the two groups according to Wong–Baker facial pain rating scale

Alexadricaine ($n=25$)		Mepecaine-L ($n=25$)		*P* value	Effect size (d)
Median (range)	Mean (SD)	Median (Range)	Mean (SD)		
4 (0–10)	3.92 (2.86)	8 (2–10)	6.96 (2.65)	0.001*	1.075

*Significant at $P \leq 0.05$

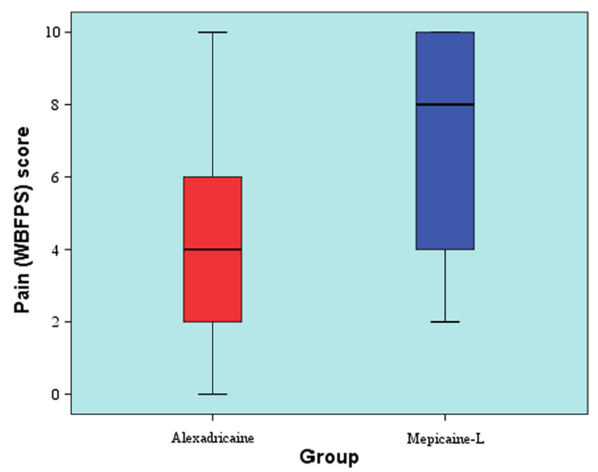

Fig. 4 Box plot representing median and range values for pain scores in the two groups according to Wong–Baker facial pain rating scale

Mepecaine-L (*P* value = 0.023, effect size = 0.646), (*P* value = 0.001, effect size = 1.008), (*P* value = 0.001, effect size = 1.047) and (*P* value = 0.001, effect size = 1.071), respectively, as well as the mean of the total score of the SEM scale in the alexadricaine group was 5.24 while in the Mepecaine-L group was 7.76 which denote that alexadricaine was more effective than Mepecaine-L in pain control (Table 5, Fig. 5).

Discussion

In the present study, two types of anesthetic solutions were used during extraction of the mandibular second primary molars, the first was alexadricaine 4% and the second was Mepecaine-L 2%, using infiltration technique. The efficiency of each of them to control pain during extraction was assessed by subjective and objective pain measuring scales. At the same time the change in pulse rate that occurred as a result of pain of the extraction was measured and compared with the pulse rate before extraction.

Articaine 4% was used in comparison with mepivacaine 2%, because the latter is one of the most commonly used anesthetic solutions, and the most commonly available for many years in the Egyptian dental market. Articaine was recently launched, and it attracted the attention for being a highly efficient and potent anesthetic agent (Gazal et al.2015; Martin et al. 2021).

The inclusion criteria of the participants included lower second primary molars indicated for extraction due to root caries, because in such cases the tooth was beyond possible repair and indicated for extraction. While cases with marked bone or root resorption were excluded because this factor would decrease the bone resistance and facilitate the extraction, and that would be a variable factor that can't be standardized in all patients as the amount of bone and root resorption differs from case to another (Harokopakis-Hajishengallis 2007; Abdellatif 2011).

Patients included in the current study didn't have previous experience at the dental clinic, and that was their first dental visit, to ensure that they didn't have negative previous experience that can affect their attitude and cooperation during extraction. Their age ranged from 6 to 8 years, because that age was the most suitable for communication with the children and explanation of the Wong–Baker Facial Pain Scale (WBFPS) because younger children won't be able to judge the degree of their pain and categorize it on the pain scale. At the same time, alexadricaine is not recommended for children

Table 5 Descriptive statistics and results of Mann–Whitney *U* test for comparison between pain scores in the two groups using sound, eye, and motor pain rating scale

	Alexadricaine ($n=25$)		Mepecaine-L ($n=25$)		*P* value	Effect size (d)
	Median (range)	Mean (SD)	Median (range)	Mean (SD)		
Sound	2 (1–4)	1.88 (0.88)	3 (1–4)	2.48 (0.92)	0.023*	0.646
Eye	1 (1–4)	1.64 (0.81)	3 (1–4)	2.56 (0.96)	0.001*	1.008
Motor	2 (1–4)	1.72 (0.79)	3 (1–4)	2.72 (1.02)	0.001*	1.047
Total score	4 (3–12)	5.24 (2.26)	8 (4–12)	7.76 (2.65)	0.001*	1.071

*Significant at $P \leq 0.05$

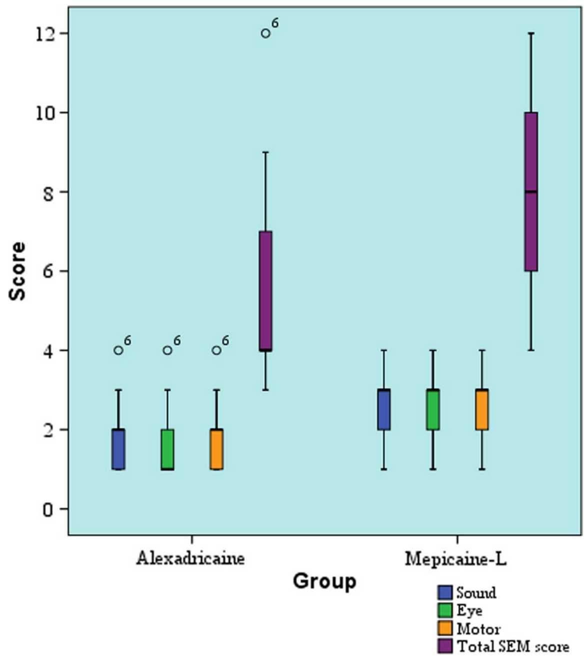

Fig. 5 Box plot representing median and range values for Sound, Eye and Motor Scale scores in the two groups (circles represent outliers)

younger than 4 years (Katyal 2010; Malamed et al. 2000; Smith et al. 2014).

Anesthesia administration using infiltration techniques has many advantages, among these advantages being less painful and less invasive when compared to the nerve block technique. Different complications that can occur with nerve block technique are less common to occur with infiltration technique, like hematoma, muscle spasm and nerve injury. All these advantages make the infiltration technique the best choice to be used to provide dental treatment for pediatric patients (Awad and Mourad 2020; Kaufman et al. 2005; Peedikayil and Vijayan 2013).

The key for successful dental treatment for a child patient is control of pain, which in turn reduces stress and anxiety. Assessment of pain can be performed through 3 main tools, observation of behavior, self-reporting, and physiologic measurement. In the current study, 3 different parameters for assessment of pain were used following the 3 pain assessment tools.

WBFPS is a self-reporting scale, so that the child can express his/her feeling or degree of pain in a simple and easy way through choosing one of the 6 faces (Tomlinson et al. 2010).

The SEM scale is an observational assessment tool, used for assessment of the body reaction of the child in response to pain and clarifies the relationship between the pain and its effect on the eyes, sound produced by the child and body movement (Lathwal et al. 2015).

The third method used for assessment of pain and stress the patient is facing during dental treatment is measuring the physiological parameters as the pulse rate, it is an indirect assessment tool and not subjected to bias. Increase in the pulse rate or blood pressure is an alert that the patient is facing a stressful or painful situation (Alemany-Martínez et al. 2008; Sancho-Puchades et al. 2012).

The 3 tools of pain assessment were used in the current study with both groups for accurate assessment of pain.

Results showed that, there was a statistically significant increase in pulse rate after extraction in both groups, but the mean pulse rate after extraction was higher in the Mepecaine-L group than the alexadricaine. This can be attributed to better pain control by the alexadricaine, which is reflected upon the physiological parameters of the body. These results were in accordance with Bahroloomi and Rezaei (2021) and Gazal (2015)

One of the methods used for assessment of pain was the Wong–Baker Facial Pain Scale, it is a self-reporting scale by the patient. Results showed that Alexadricaine showed statistically significantly lower pain score than Mepecaine-L, it was more potent and efficient than Mepecaine-L in control of pain during extraction of lower second primary molars. These results were in accordance with Azad et al. (2019), who found that articaine 2% was clinically more efficient than mepivacaine 2% in pain control. The marked efficacy of articaine in pain control can be attributed to its characteristic liposolubility due to its chemical structure and the presence of thiophene ring resulting in marked penetration ability, and superior pain control in comparison with mepivacaine 2%.

A contradicting result was reported by Odabaş et al. (2012), who stated that there was no significant difference between articaine 4% and mepivacaine 3% in pain control evaluated by WBFPS as well as there was no significant change in the heart rate or blood pressure readings taken during the whole session of treatment between both anesthetic solutions. These contradictions can be attributed to difference in the mean age of the patients as well as the difference in the concentration of the mepivacaine.

Regarding pain assessment using SEM scale, results showed that Alexadricaine showed statistically significantly lower Sound, Eye, Motor and total SEM scores than Mepecaine-L, which highlight the capability of alexadricaine to control intra-operative pain during extraction better than Mepecaine-L, these results agree with Gazal (2015) and Gao and Meng (2020) who found that Articaine proved to be more potent, with fast onset of action compared to the mepivacaine group.

This may be due to difference in the penetration ability of anesthetic agents through the soft tissue and cortical bone, which in turn affects the anesthetization of the lingual tissues, which is important during extraction of mandibular molars.

Conclusions

Base on the results of the present study it can be concluded that:

Using a potent anesthetic solution like alexadricaine 4% facilitates extraction of mandibular primary molars, and achieving efficient pain control, with infiltration technique only without any need for the invasive nerve block technique.

Abbreviations

WBFPS: Wong–Baker Facial Pain Scale; SEM: Sound, Eye, and Motor Scale; FDA: Food and Drug Administration; SD: Standard deviation.

Acknowledgements

-Not applicable

Authors' contributions

RS was responsible for administration of local anesthesia to the patients and performing extraction, NK was responsible for measuring the pulse rate for the patients before and after extraction, and assessment of the patients' behavior during extraction. Both authors wrote, reviewed, and approved the final manuscript.

Funding

The research is funded by the authors only.

Availability of data and materials

All the data included in the current study are available in the article.

Declarations

Ethics approval and consent to participate

The study was approved by the Medical Research Ethics committee of the National Research Centre of Egypt and the approval number is 34210112021. Parents of all the patients who participated in the current study, signed an informed consent that they accept participating in the study and publication of the results.

Consent for publication

All the participants in the current study signed a consent that they accept publication of the results of the study.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Orthodontics and Pediatric Dentistry Department, National Research Centre, Cairo, Egypt. [2]Pediatric Dentistry and Community Dentistry Department, Misr University for Science and Technology, Giza, Egypt.

Received: 18 February 2022 Accepted: 17 March 2022
Published online: 28 March 2022

References

Abdellatif A (2011) Pain assessment of two palatal anesthetic techniques and their effects on the child's behavior. Pediatr Dent J 21(2):129–137. https://doi.org/10.1016/S0917-2394(11)70239-7

Abdelmoniem SA, Mahmoud SA (2016) Comparative evaluation of passive, active, and passive-active distraction techniques on pain perception during local anesthesia administration in children. J Adv Res 7(3):551–556. https://doi.org/10.1016/j.jare.2015.10.001 (**Epub 2015 Oct 19**)

Alemany-Martínez A, Valmaseda-Castellón E, Berini-Aytés L, Gay-Escoda C (2008) Hemodynamic changes during the surgical removal of lower third molars. J Oral Maxillofac Surg 66(3):453–461. https://doi.org/10.1016/j.joms.2007.06.634

Al-Yasiry A, Hindy A, Al-Jammali Z, Almuthaffer A, Ghanim A (2020) The effect of local anesthesia and tooth extraction on blood pressure and heart rate. Int J Psychosoc Rehabil 24:1621–1631. https://doi.org/10.37200/IJPR/V24I9/PR290180

Awad S, Mourad S (2020) Extraction of mandibular posterior teeth: comparison between standard inferior alveolar nerve block and local infiltration anesthesia. Egypt Dent J 66:107–112. https://doi.org/10.21608/edj.2020.77521

Azad A, George A, Mustafa M, Jamin N, Haron A, Mayya S, Mayya A, Majeed S (2019) Efficacy of 4% articaine and 2% mepivacaine without palatal injection in assessing pain during maxillary teeth extraction: a randomized clinical trial. J Clin Diagn Res 13(12):5–8. https://doi.org/10.7860/JCDR/2019/42621.13337

Bahrololoomi Z, Rezaei M (2021) Anesthetic efficacy of single buccal infiltration of 4% articaine compared to routine inferior alveolar nerve block with 2% lidocaine during bilateral extraction of mandibular primary molars: a randomized controlled trial. J Dent Anesth Pain Med 21(1):61–69. https://doi.org/10.17245/jdapm.2021.21.1.61

Bosenberg A, Thomas J, Lopez T, Kokinsky E, Larsson LE (2003) Validation of a six-graded faces scale for evaluation of postoperative pain in children. Paediatr Anaesth 13(8):708–713. https://doi.org/10.1046/j.1460-9592.2003.01142.x

Brockmann WG (2014) Mepivacaine: a closer look at its properties and current utility. Gen Dent 62(6):70–75 (**quiz 76**)

Gao X, Meng K (2020) Comparison of articaine, lidocaine and mepivacaine for buccal infiltration after inferior alveolar nerve block in mandibular posterior teeth with irreversible pulpitis. Br Dent J 228(8):605–608. https://doi.org/10.1038/s41415-020-1434-9

Gazal G (2015) Comparison of speed of action and injection discomfort of 4% articaine and 2% mepivacaine for pulpal anesthesia in mandibular teeth: a randomized, double-blind cross-over trial. Eur J Dent 9(2):201–206. https://doi.org/10.4103/1305-7456.156811

Gazal G, Alharbi AM, Al-Samadani KH, Kanaa MD (2015) Articaine and mepivacaine buccal infiltration in securing mandibular first molar pulp anesthesia following mepivacaine inferior alveolar nerve block: a randomized, double-blind crossover study. Saudi J Anaesth 9(4):397–403. https://doi.org/10.4103/1658-354X.159463

Harokopakis-Hajishengallis E (2007) Physiologic root resorption in primary teeth: molecular and histological events. J Oral Sci 49(1):1–12. https://doi.org/10.2334/josnusd.49.1

Katyal V (2010) The efficacy and safety of articaine versus lignocaine in dental treatments: a meta-analysis. J Dent 38(4):307–317. https://doi.org/10.1016/j.jdent.2009.12.003

Kaufman E, Epstein JB, Naveh E, Gorsky M, Gross A, Cohen G (2005) A survey of pain, pressure, and discomfort induced by commonly used oral local anesthesia injections. Anesth Prog 52(4):122–127. https://doi.org/10.2344/0003-3006(2005)52[122:ASP]2.0.CO;2

Khalifah M (2021) A comparative study for a novel technique for the inferior alveolar nerve block versus the conventional technique. Egypt Dent J 67:211–218. https://doi.org/10.21608/edj.2020.43747.1273

Khanna SR, Rao D, Panwar S, Ameen S (2021) An in vivo, randomized, controlled comparative evaluation of efficacy, hemodynamic changes, and postoperative complications of 4% articaine using buccal infiltration and 2% lidocaine using inferior alveolar nerve block in mandibular primary molars of children aged 6 to 8 years. Quintessence Int 52(9):780–786. https://doi.org/10.3290/j.qi.b1492247

Kilinç G, Akay A, Eden E, Sevinç N, Ellidokuz H (2016) Evaluation of children's dental anxiety levels at a kindergarten and at a dental clinic. Braz Oral Res 30(1):S1806-83242016000100700. https://doi.org/10.1590/1807-3107BOR-2016.vol30.0072

Lathwal G, Pandit IK, Gugnani N, Gupta M (2015) Efficacy of different precooling agents and topical anesthetics on the pain perception during intraoral injection: a comparative clinical study. Int J Clin Pediatr Dent 8(2):119–122. https://doi.org/10.5005/jp-journals-10005-1296

Malamed SF, Gagnon S, Leblanc D (2000) A comparison between articaine HCl and lidocaine HCl in pediatric dental patients. Pediatr Dent 22(4):307–311

Martin E, Nimmo A, Lee A, Jennings E (2021) Articaine in dentistry: an overview of the evidence and meta-analysis of the latest randomised controlled trials on articaine safety and efficacy compared to lidocaine for routine dental treatment. BDJ Open 7(1):27. https://doi.org/10.1038/s41405-021-00082-5

Nadeen H, Gawad R, Aly M (2021) Anesthetic efficacy of 4% artpharmadent versus 2% mepecaine-l for infiltration anesthesia in extraction of badly decayed lower first primary molars: a pilot study. Egypt Dent J 67:2875–2884. https://doi.org/10.21608/edj.2021.78818.1658

Nair M, Jeevanandan G, Mohan M (2018) Comparing the efficiency of 2% lidocaine and 4% articaine as a local anesthetic agent in children. Asian J Pharm Clin Res 11:295. https://doi.org/10.22159/ajpcr.2018.v11i5.24440

Odabaş ME, Cınar C, Deveci C, Alaçam A (2012) Comparison of the anesthetic efficacy of articaine and mepivacaine in pediatric patients: a randomized, double-blind study. Pediatr Dent 34(1):42–45

Oulis CJ, Vadiakas GP, Vasilopoulou A (1996) The effectiveness of mandibular infiltration compared to mandibular block anesthesia in treating primary molars in children. Pediatr Dent 18(4):301–305

Peedikayil FC, Vijayan A (2013) An update on local anesthesia for pediatric dental patients. Anesth Essays Res 7(1):4–9. https://doi.org/10.4103/0259-1162.113977

Sancho-Puchades M, Vílchez-Pérez MÁ, Valmaseda-Castellón E, Paredes-García J, Berini-Aytés L, Gay-Escoda C (2012) Bupivacaine 0.5% versus articaine 4% for the removal of lower third molars. A crossover randomized controlled trial. Med Oral Patol Oral Cir Bucal 17(3):e462–e468. https://doi.org/10.4317/medoral.17628

Smith T, Urquiola R, Oueis H, Stenger J (2014) Comparison of articaine and lidocaine in the pediatric population. J Mich Dent Assoc 96(1):34–37

Sood R, Hans MK, Shetty S (2014) Comparison of anesthetic efficacy of 4% articaine with 1:100,000 epinephrine and 2% lidocaine with 1:80,000 epinephrine for inferior alveolar nerve block in patients with irreversible pulpitis. J Clin Exp Dent 6(5):e520–e523. https://doi.org/10.4317/jced.51617

Tomlinson D, von Baeyer CL, Stinson JN, Sung L (2010) A systematic review of faces scales for the self-report of pain intensity in children. Pediatrics 126(5):e1168–e1198. https://doi.org/10.1542/peds.2010-1609

Uckan S, Dayangac E, Araz K (2006) Is permanent maxillary tooth removal without palatal injection possible? Oral Surg Oral Med Oral Pathol Oral Radiol Endod 102(6):733–735. https://doi.org/10.1016/j.tripleo.2005.12.005

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.