 DOI: 10.21608/adjalexu.2024.338153.1556

EFFECTIVENESS OF OSTEOCENTRAL ANESTHESIA (QUICKSLEEPER 5™) VS LOCOREGIONAL ANESTHESIA IN EXTRACTION OF PRIMARY MAXILLARY MOLARS: RANDOMIZED CONTROLLED CLINICAL TRIAL

Sara M Quritum[1]* *MSC,* Karin M L Dowidar[2] *PHD ,* Nadia A. Wahba[2]*PHD*

ABSTRACT

BACKGROUND: Local anesthesia injection is an anxiety-provoking procedure in the dental office. Pain control is the master-key for effective behavior guidance, especially among pediatric patients.

PURPOSE: To evaluate the effectiveness of intra-osseous (IO) anesthesia using Quicksleeper5 in eliminating pain during extraction of primary maxillary molars, compared to infiltration anesthesia.

METHODS: A randomized controlled clinical trial involved 30 healthy cooperative patients aged 5-9 , who required extracting of one of their primary maxillary molars. They were randomly allocated to receive IO anesthesia (test group) or infiltration anesthesia (control group). Pain response was assessed at injection and extraction phases using Visual Analog Scale (VAS) and heart rate (HR). Pain-related behaviors were evaluated through FLACC scale. Postoperative complications were evaluated through a phone call.

RESULTS: There was no significant difference regarding the mean age of test and control groups (6.6 ± 1.4 and 6.7 ± 1.2 years, respectively). Lower pain scores were reported in the test group than control group using VAS ($p=0.012$, 0.028) and FLACC ($p<0.001$) during injection and extraction phases, respectively. An increase in HR was noticed in both groups at the injection phase. However, higher values were recorded in the control group ($p=0.002$). Unlike the control group, HR returned to baseline records immediately postoperatively in the test group. Postoperatively, 13.3% of the participants in the test group reported residual pain at injection site, compared to 26.7% in the control group.

CONCLUSION: IO anesthesia using QuickSleeper5 is an efficient tool for reducing pain upon local anesthesia administration and primary maxillary molar extraction.

KEYWORDS: Intraosseous anesthesia, Computer–controlled, pain control, dental anesthesia, primary molars, extraction, Pediatrics.

1. Assistant lecturer, Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Alexandria University, Egypt.
2. Professor of Pediatric Dentistry, Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Alexandria University, Egypt.

** Corresponding Author:*
E-mail: sara.quritum@gmail.com

INTRODUCTION

Dental treatment with minimal discomfort is of paramount importance, especially among pediatric patients. Although local anesthesia (LA) is considered one of the valuable inventions to reduce pain during dental visit, the injection itself is considered by many patients to be the most frightening procedure throughout their visits.(1) According to the American Dental Association (ADA), fear of pain may act as a barrier for some patients from receiving the necessary dental treatment in subsequent visits.(2)

Several ongoing dental research aims to investigate and develop more patient-comfortable alternative methods for achieving painless anesthesia.(3, 4) Reducing the injection speed is one of the most effective methods of minimizing such pain; however, manual control in actual clinical settings is difficult.(5)

Accordingly, numerous devices have been introduced that can inject local anesthetic solution at a pre-set speed. Collectively, these “painless anesthetic devices”, are termed “computer-controlled local anesthetic delivery” (CCLAD) devices.(5) The first was the Wand™ (Milestone Scientific, Inc., Livingston, N.J.), introduced in 1997. Later, the device QuickSleeper™ (Dental Hi-Tec, Cholet, France) was marketed in the dental field (2008), followed by numerous refinements until QuickSleeper5 was available.

QuickSleeper5 is characterized by computer-controlled needle rotation as well as flow rate of anesthetic solution. Owing to the different injection speeds and needle lengths used in this system, it can be used to provide a wide range of anesthetic techniques, such as intraosseous (IO) injection, periodontal ligament injection, infiltration, and nerve block anesthetics.

IO injection allows direct placement of the anesthetic solution in the medullary bone adjacent to the apex of the tooth programmed for anesthesia.(6) This technique permits a thorough diffusion of anesthetic fluid to anesthetize all the nerve endings and achieve profound anesthesia without numbness of lips and cheeks. It can be used as a primary anesthetic technique, or to supplement other anesthetic techniques to enhance deep pulpal anesthesia.(7-9)

High success rate of using IO anesthesia via QuickSleeper2 was reported during endodontic treatment, restoration and extractions of primary and permanent teeth.(6, 10) It use was also associated with a higher percentage of patient preference.(10, 11) Another study reported that the use of computer-controlled intraosseous (CCIO) was related to less pain and anxiety upon insertion, solution injection and also during the dental treatment of first permanent molars affected by molar incisor hypominerlization (MIH).(12)

Regarding its efficacy among pediatric patients, a recent controlled clinical trial observed that CCIO was superior to inferior alveolar nerve block (IANB) regarding discomfort upon injection and postoperative morbidity. A slight transient increase in heart rate (HR) after IO was reported by Radwan et al.(13) An improved level of child cooperation among participants in the IO than IANB was also reported in the same study; however, it did not reach a significant level.

Nevertheless, a systematic review and Evidence-Based Clinical Practice Guidelines in 2017 showed insufficient evidence supporting the superiority of IO injection technique over others.(14, 15) In addition, evidence that supports the effectiveness of CCIO in primary teeth is sparse. Most of them were neither randomized nor controlled. Moreover, they did not specify neither the dental arch nor the dental treatment performed, making it challenging to draw lines of comparison. The objective of the present clinical trial was to evaluate the effectiveness of IO anesthesia using Quicksleepr5 in eliminating pain during dental extraction of maxillary primary molars, compared to maxillary supraperiosteal infiltration anesthesia. The PICO question adopted was: did children aged 5-9 years, undergoing extraction of their maxillary primary molars (Population: P) using intraosseous anesthesia delivered by QuickSleeper5 (Intervention: I) in comparison to conventional maxillary supraperiosteal infiltration anesthesia (Control: C) show better tolerance to pain (outcome: O)? The null hypothesis was that anesthesia delivered by QuickSleeper5™ is as efficient as conventional anesthesia for pain control.

MATERIALS AND METHODS

This randomized controlled clinical trial was conducted at the Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Alexandria University. Patients were allocated to receive their LA through either Computer-Controlled IO injection using QuickSleeper5 device (Dental Hi-Tec, Cholet France) in the study group, or buccal and palatal supraperiosteal infiltration as a conventional technique in the control group. The allocation ratio was 1:1.

The study received ethical approval from the Dental Research Ethics Committee, Faculty of Dentistry, Alexandria University (IRB No. 001056 – IORG 0008839), and it was registered in ClinicalTrials.gov (NCT06245161). It was conducted according to the ethical principles for medical research involving human subjects in the Declaration of Helsinki.(16) The CONSORT-PRO checklist was followed for study reporting.(17)

Sample size estimation:

The assumptions made for sample size estimation were based on similar previous studies. Sixou et al. reported that 26.7% of children reported no pain (score 0) on a visual analogue scale, when anesthesia was administered by QuickSleeper2,(10) whereas 80% of children who used traditional injection reported no pain in another study.(18) Based on comparison of proportions and assuming alpha error=5% and study power= 80%, sample size was calculated as a minimum of 13 per group. This was increased to 15 children in each group (20% increase) to make up for patient dropouts. The total sample size required was 30. This was performed by Rosner's method(19) calculated by G*Power 3.1.9.7.(20)

Study Sample:

Healthy cooperative children aged 5–9 years, (score 3 or 4 according to Frankl Behavioral Rating Scale),(21) who require extraction of their maxillary primary molars were recruited for this study after proper clinical and radiographic examination. They had no previous dental local anesthetic experience,(22) nor received any analgesics for the last 12 hours. (23) Teeth with cellulitis, ankylosis, clinical signs of mobility, or more than one-third radiographic root length resorption were excluded from the study. Written informed consent was obtained from all caregivers prior to the study.

Randomization and allocation concealment:

Subjects fulfilling inclusion criteria were randomly assigned - using a computer-generated list of random numbers- to receive either type of local anesthesia.(24) Each participant was given a specific number written on identical sheets with the group to which he/she was allocated and placed inside opaque envelopes carrying their respective names by a trial independent personnel. The study was double-blinded, where patients and statisticians were both unaware of the LA technique used.

Intervention:

The first visit was to acquaint the child with the dental environment. On the intervention visit, topical anesthesia (20% Benzocaine gel, Iolite, Dharma Research Inc., USA) was applied on pre-dried mucosa at the injection site for 1 min. A standard cartridge of 4% Articaine hydrochloride with 1:100,000 epinephrine was used for all cases (Artinibsa, Inibsa Dental S.L.U., Spain). For the test group, **intraosseous anesthesia** was applied via QuickSleeper5 (Figure 1), using a 30-gauge, 9 mm-long disposable DHT needle (Effitec Needles, Dental Hi-tec, France), following the manufacturer's instructions. This was applied through 3 steps: first, by anesthetizing buccal attached mucosa via few drops of anesthetic drug injected by a needle positioned 1-3 mm apical the interdental papilla at an angle of 15°-20°, mesial or distal to the targeted tooth. This was followed by repositioning the needle at 90° to allow cortical bone penetration either by applying simple pressure or through using the computer-assisted rotation if the bone was too thick. Finally, computerized injection of the anesthetic solution was introduced by continuously pressing the foot pedal. Slow injection mode was chosen to inject 0.8 mL of anesthetic solution initially.[25]

For children in the control group, **buccal infiltration** supplemented by palatal infiltration was administered using 30-gauge, 32-mm-long disposable dental needle on a standard metallic syringe. Slow injection rate of anesthetic solution (approximately 1 mL/min) was used to inject 0.9ml of anesthetic drug for buccal infiltration and 0.3ml was given by palatal infiltration.[26]

Time required for administration of the local anesthetic in both groups was measured in seconds.[27] The anesthesia was confirmed in case of IO anesthesia by evaluating sensitivity at vestibular sulcus using a blunt instrument every 5-10 s until loss of sensation,[12] whereas numbness in buccal sulcus opposite to the tooth was evaluated every 30 s till full numbness was achieved in the control group.[28] This was followed by primary molars **extraction** following American Academy of Pediatric Dentistry (AAPD) guidelines,[29] using upper full crown forceps. Post-extraction instructions were provided for all participants and another appointment was scheduled for space maintainers.

Outcome assessment:

a-Pain assessment was measured through 3 parameters:

1- **Subjectively** through Visual Analogue Scale (VAS),[30, 31] for self-reported pain. After both injection and extraction phases, children were asked to point out the face matching their own pain level on a scale from 0 to 10, where zero indicated no pain, while score 10 implied extreme pain. (figure 2)

2- **Objectively** using:

i- Face, Legs, Activity, Cry Consolability (FLACC) scale, to evaluate their disruptive behaviors.[32] This was assessed by the operator through the procedural videotapes postoperatively at 3 phases: baseline, during anesthesia administration, and dental extraction. Each of the five criteria was assigned a score of 0, 1 or 2. The total score scale is recorded in a range of 0–10, with 0 representing no pain

ii- Heart rate was assessed as a **physiological pain indicator** using a pulse oximeter (Zacurate,10101 Stafford Centre Dr. Ste B Stafford, Texas, USA). It was recorded at three time periods: baseline, at the onset of injection, and immediately post-operative.

b- Postoperative complications were determined according to a parental phone call 24 hours postoperatively to evaluate the occurrence of self-inflicted injury, pain at the injection site, or any other adverse events.[27]

For standardization, all dental procedures were performed by the same operator, who was trained and calibrated for using the QuickSleeper5. A camera mounted on a tripod was used to videotape all the dental visits. Intra-examiner reliability for objective assessment of pain via FLACC was done by rescoring 10% of the recorded videos after 7-days interval and comparing the results. Those cases were excluded from the study sample. Kappa score of 0.92 was reported, which reveals an excellent agreement.

Figure 1: QuickSleeper5 device

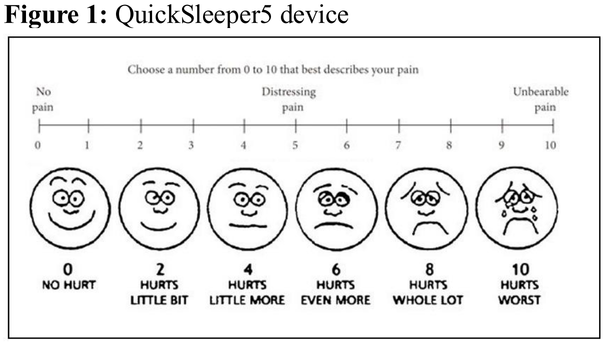

Figure 2: Visual Analog Scale

Statistical analysis:

Descriptive statistics were displayed as mean, standard deviation for quantitative variables (age), and frequencies and percentages for qualitative variables (gender and tooth type). Normality test was conducted for all quantitative variables. Means and standard deviations were calculated and the difference between test and control groups was compared using independent T-test for normally distributed variables (Volume of solution, duration of injection, latency period, and heart rate). Change in the heart rate at different time periods was calculated using Repeated-measures ANOVA followed by post-hoc test with Bonferroni correction. Median and interquartile range was adopted for non-normally distributed data (VAS and FLACC scores), followed by Mann–Whitney *U* test for inter-group comparison and Friedman test for checking difference over time. Fisher's exact test was used to evaluate postoperative complications among both injection techniques. Kappa statistics were used for evaluating intra-examiner reliability. Statistical analysis was carried out using statistical package for social sciences (SPSS for windows, version 23.0, Inc. Chicago, IL, USA). Significance level was set at the 5% level.

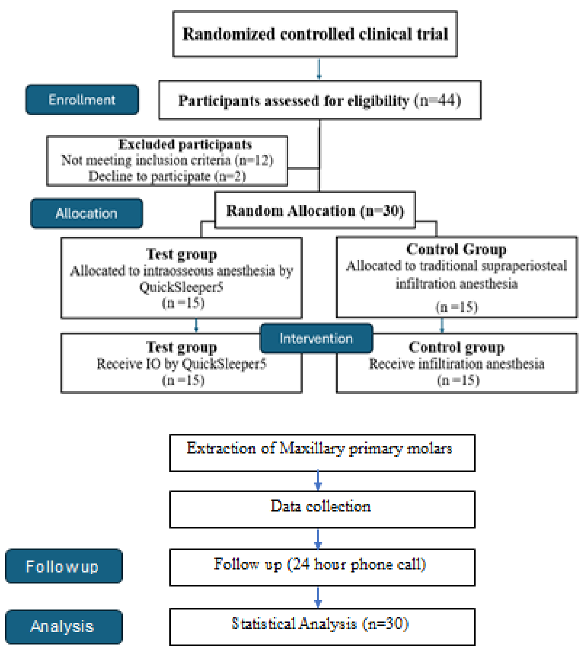

Figure (3): CONSORT PRO flow chart of the study

RESULTS

Subject recruitment, allocation, intervention, data collection, and statistical analysis were reported according to CONSORT-PRO reporting guidelines (**Figure 3**). Case selection and dental treatment were performed between March and October 2022. Forty-two participants were recruited for this study. Twelve of them did not meet inclusion criteria upon clinical and radiographic examination, while the other two refused to participate in the study.

Thirty participants were randomly allocated to receive either IO or conventional infiltration anesthesia. The average age of children was 6.6±1.4 and 6.7±1.2years in test and control groups, respectively. No significant difference was detected regarding age, sex, and the distribution of teeth treated among both groups (*p*=0.889, 0.464, and 1.00, respectively). (**Table 1**).

A single IO injection was able to achieve profound anesthesia in the test group, unlike those in the control group who received 2 injections (buccal and palatal infiltrations). Consequently, more anesthetic drug (1.2 ± 0.1 mL) was injected among the control group (*p*=<0.001). Statistically significant longer duration of injection (122.1 ± 20.8 sec) and shorter onset time (21.7± 8.4 sec) was also observed among children enrolled in the test group than those in the control group (54.8 ± 6.1 sec and 73.3 ± 25.3 sec respectively) *p*<0.001. Two children who initially received infiltration anesthesia needed a second injection to complete dental treatment, while no cases required a second injection in the test group (*p*=1.00) (**Table 2**).

Regarding pain assessment, statistically significant lower pain scores were reported among children in the test group than the control group using VAS scale (p=0.012, 0.028) and FLACC scale (p<0.001) during both injection and extraction phases, respectively. Within-group analysis revealed that disruptive pain behaviors recorded by FLACC scale were greater during tooth extraction than the injection phase baseline values among children in the test group (p=0.047). Meanwhile, those who received conventional anesthesia had higher scores at both injection and extraction phases than the initial records (p<0.001). **(Table 3)**

Concerning heart rate, statistically significant less values were observed among children who received IO anesthesia versus those who received conventional anesthesia at both the injection phase (99.9±5.2 and 107.9±7.3 BPM, respectively), as well as extraction phase (93.9±4.8 and 98.6± 6.1 BPM, respectively). In the context of intra-group analysis, elevated heart rate was recognized among both groups at the injection phase than the baseline values. However, it returned immediately postoperatively to its initial level for those children in the test group, while it was still higher than preoperative records in the control group. **(Table 3)**

In Figure 4, the bars indicate the development of complications in a few cases. Since 2 participants in the test group reported post-operative residual pain at the injection site versus 4 in the control group, this difference was not statistically significant (p=0.65).

Table (1): Demographic data of the sample:

		Intraosseous anesthesia (Test group) (n = 15)	Infiltration anesthesia (Control group) (n = 15)	P value
Age (yrs) † (Mean ± SD)		6.6 ± 1.4	6.7 ± 1.2	0.899
Gender § (no,%)	Male	6 (40.0%)	8 (53.3%)	0.464
	Female	9 (60.0%)	7 (46.7%)	
Tooth location § (no,%)	First primary molar	8 (53.3%)	9 (60.0%)	1.000
	Second primary molar	7 (46.7%)	6 (40.0%)	

† Student T test
§ Chi-squared test

Table (2): Anesthesia parameters (injected volume, duration of injection, latency, and need for extra-injection):

Variables	Intraosseous anesthesia (Test group) (n = 15)	Infiltration anesthesia (Control group) (n = 15)	*p* value
	(Mean ±SD)		
Injected volume (ml) †	0.9 ± 0	1.2 ± 0.1	<0.001*
Duration of injection (sec) †	122.1 ± 20.8	54.8 ± 6.1	<0.001*
Latency (sec) †	21.7 ± 8.4	73.3 ± 25.3	<0.001*
Need for second injection §	0	2 (13.3%)	0.483

*Statistically significant at P < 0.05.
† Student T test
§ Fisher's Exact Test

Table 3: Time-dependent changes of pain parameters (Visual analogue scale, FLACC score, and heart rate) for the two groups:

	Intraosseous anesthesia (Test group) (n = 15)	Infiltration anesthesia (Control group) (n = 15)	P value
a) Visual Analogue Scale (VAS) § (Median – IQR)			
Post-injection	0 (0-1)	2 (0-3)	0.012*
Immediately post-Operative	0 (0-2)	2 (1-3)	0.022*
Change in VAS over time ‡	0.052	0.051	
b) FLACC score § (Median – IQR)			
Baseline	1 (0 – 2) ^{a}	2 (1 – 3) ^{a}	0.109
Injection phase	1 (0 – 1) ^{a}	4 (3 – 5) ^{b}	<0.001*
Operative phase	2 (1 - 3) ^{b}	4 (4- 6) ^{b}	<0.001*
Change in FLACC over time ‡	0.005*	<0.001*	
c) Heart Rate (Beat/min) † (Mean ±SD)			
Baseline	90.9 ± 5.9 ^{a}	91.9 ± 5.8 ^{a}	0.644
Injection phase	99.9 ± 5.2 ^{b}	107.9 ± 7.3 ^{b}	0.002*
Immediately postoperative	93.9 ± 4.8 ^{a}	98.6 ± 6.1 ^{c}	0.044*
Change in HR over time ¶	<0.001*	<0.001*	

SD: Standard deviation; **IQR** : interquartile range;
† Student T test
§ Mann–Whitney *U* test;
¶ Repeated measure ANOVA with Bonferroni post hoc corrections for pairwise comparisons;
‡ Friedman test
*Statistically significant at P < 0.05;
a,b,c represent statistically significant differences within each group over time

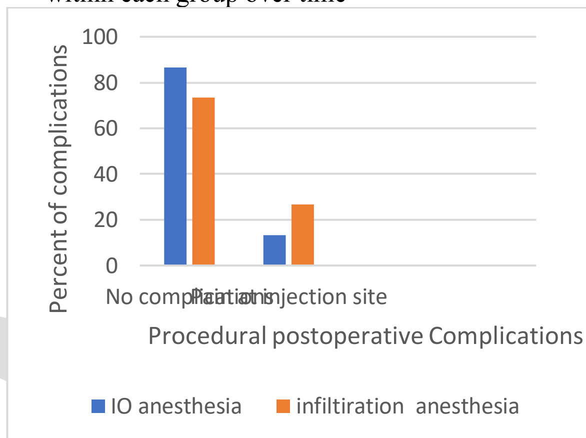

Figure 4: Procedural postoperative complications among different injection techniques

DISCUSSION

Every pediatric dentist's primary objective is to provide pain-free anesthesia, which ensures efficient treatment and builds patient trust and cooperation.[33] Computer-controlled intra-osseous injection devices are one of the recent advances in the dental field. However, very few controlled studies using this technology to treat primary teeth are available in the literature,[11, 13, 34] and many of them were neither controlled nor randomized.[6, 10, 35]

Most of the previously published studies comparing CCIO versus conventional injection did not specify the arch or the treatment performed; however, the present study bridged the gap of knowledge by being a clinical trial comparing CCIO and infiltration anesthesia for extraction of maxillary primary molars. The results obtained from this study revealed statistically significant differences in favor of CCIO, in terms of pain and disruptive behaviors, thus rejecting the proposed null hypothesis.

Dental therapy adopted in the present study was restricted to extractions, as they are usually associated with high levels of pain and anxiety, which can reflect the efficacy of the anesthetic technique. This clinical trial followed a parallel design to avoid the adverse influence of negative experiences related to anesthesia or extraction on the participant's behavior in subsequent visits.[36]

Pain assessment was the main outcome of this study since the perceived pain during dental treatment can influence the child's behavior and attitude.[37] Visual analogue scale was used for subjective pain reporting, as some authors have shown it to be reliable for use with children aged 5 years and older.[38, 39] Furthermore, objective appraisal of disruptive behaviors such as facial expressions, body movement, and crying through FLACC scale, in addition to physiological indicators of pain such as heart rate, were used to better visualize the pain control efficiency of the new CCIO device (QuickSleeper5).[40]

All subjective and objective pain assessment parameters demonstrated lower pain during both the injection and extraction phases upon using the QuickSleeper5™ than the conventional anesthesia. These findings were in line with previous studies,[10, 12, 34, 41] which could be credited to the nature of IO injection that allows selective and precise deposition of anesthetic solution as close as possible to root apices, thus providing profound anesthesia. [42] Additionally, the unique design of Quicksleeper5 needle (DHT Effitec Needles) has a patented asymmetric double bevel, giving it a scalpel-like function. This pattern allows painless soft tissue incision rather than tearing, as well as better perforation capacity into the alveolar bone with a lower risk of obstruction.[43] Nonetheless, topical anesthesia was applied before the initial prick to standardize the procedure between the two arms.

On the contrary, greater pain upon traditional infiltration using standard metallic syringes could be attributed to collateral innervation for maxillary primary molars that may hinder attaining profound anesthesia.[44] Over more, manual control of the rate of injection could not always be achieved due to wide variation in tissue resistance and poor collaboration of pediatric patients.[45]

More disruptive behaviors were noted in the test group using FLACC scale at the extraction phase than during the injection phase, which was not in line with the pain level reported either by VAS or the measured heart rate at the same point of time. It also did not affect the level of child cooperation during extraction. These higher scores could be attributed to pressure and anxiety felt, governing tooth movement during extraction, rather than pain. Conversely, statistically significant higher disruptive behaviors were observed following conventional anesthesia during both injection and extraction phases than baseline data. Nevertheless, the mean FLACC scores recorded throughout the session in both groups were not overt and did not involve any defensive movement. In agreement with the present results, Prol Castelo et al. (2022)[41] noted that physical reaction during the anesthesia injection was lower in the IO group than in the control group. However, their results were not statistically significant.

Heart rate evaluation in the current study revealed that both injection techniques induced a noticeable elevation in HR immediately following the injection phase; however, this was significantly less among children receiving IO than in the control group. This can be explained by the pain and anxiety encountered with traditional injections. Nevertheless, this was a transient situation among children who received IO, as it reached comparable baseline values immediately postoperatively. This implies that QuickSleeper5 induces less pain and anxiety than the traditional infiltration, which was confirmed by the reported pain parameters in this study.

A similar observation was reported recently among children by Radwan et al. (2024).[13] Previously published reports concerning IO were in adults, and their results were inconsistent. Some trials reported an increase in the HR following IO anesthesia, which was explained by the rapid diffusion of the anesthetic solution into the highly vascularized cancellous bone,[27, 42, 46] along with the effect of epinephrine.[47] Peñarrocha-Oltra[48] reported positive aspiration in 61% of cases when a plain solution of 3% mepivacaine was injected intraosseously via Stabident. A contrasting finding was mentioned by Pereira et al.,[49] who did not notice any changes in the cardiovascular parameters (clinically or statistically) during the IO injection, which was explained by the lower speed of injection used (0.45 mL/min).

Another positive aspect of Quicksleeper5 was confirmed in terms of its shorter onset time, representing an important milestone in the field of pediatric dentistry. This agrees with all previously published reports concerning this issue.[12, 34, 35] It could be explained by the targeted injection technique used, allowing instantaneous action.[50] Consequently, it saves the operator time and provides better satisfaction for both children and parents. Additionally, the significantly lower anesthetic dosage of IO anesthesia, minimizes its systemic toxicity.[51]

A lower percentage of postoperative pain was noticed among children who received IO anesthesia than in the control group, which could be due to the fact that the slow rate of anesthetic solution deposition controlled by the computer is associated with less tissue damage, which cannot be achieved with the manual anesthetic deposition.[10] Furthermore, it could be postulated that overheating of the bone did not occur, as only one needle rotation was performed if needed.[52]

Despite that slow deposition rate of LA using QuickSleeper5 is one of its main advantages, the time consumed is lengthy in terms of children's attention span. This could increase apprehension and would not be tolerated by some patients. This was observed in 2 cases where only a quarter carpule (0.45 mL) was injected, since they started fretting and did not endure the full injection time. However, this volume was enough to achieve profound anesthesia during the operative phase. Therefore, further studies are recommended to evaluate lower volumes of intraosseously injected LA than those previously suggested by Biocanin et al[25]. Other limitations could include the operator's inability to be blinded during this study due to the different characteristics of the injection devices used. On top of that, this electronic device has a high initial and running cost,[43] and a learning curve is required to master its use. Furthermore, patients selected in this study were chosen to be cooperative children; thus, additional investigations are also required to test its efficacy in uncooperative pediatric patients.

In conclusion, the lower pain levels reported using subjective and objective parameters provide evidence supporting the efficacy of computer-controlled IO using QuickSleeper5 among pediatric patients. Thus, it has the potential to become the preferred choice for satisfying the needs of both the patient and the healthcare provider.

REFERENCES

1. Pinkham JR, Casamassimo PS, Fields HW, McTigue DJ, Nowak AJ. Pediatric Dentistry In: Infancy through Adolescence. 4th ed. St Louis, Mo. Elsevier Saunders 2005, pp394-413.
2. Appukuttan DP. Strategies to manage patients with dental anxiety and dental phobia: literature review. *Clin Cosmet Investig Dent*. 2016;8:35-50.
3. Angelo Z, Polyvios C. Alternative practices of achieving anaesthesia for dental procedures: a review. *J Dent Anesth Pain Med*. 2018;18(2):79-88.
4. Patel BJ, Surana P, Patel KJ. Recent Advances in Local Anesthesia: A Review of Literature. *Cureus*. 2023;15(3):e36291.
5. Hochman M, Chiarello D, Hochman CB, Lopatkin R, Pergola S. Computerized local anesthetic delivery vs. traditional syringe technique. Subjective pain response. *N Y State Dent J*. 1997;63(7):24-9.
6. Sixou JL, Barbosa-Rogier ME. Efficacy of intraosseous injections of anesthetic in children and adolescents. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2008;106(2):173-8.
7. Bigby J, Reader A, Nusstein J, Beck M, Weaver J. Articaine for supplemental intraosseous anesthesia in patients with irreversible pulpitis. *J Endod*. 2006;32(11):1044-7.
8. Remmers T, Glickman G, Spears R, He J. The efficacy of IntraFlow intraosseous injection as a primary anesthesia technique. *J Endod*. 2008;34(3):280-3.
9. Nilius M, Mueller C, Nilius MH, Haim D, Leonhardt H, Lauer G. Intraosseous anesthesia in symptomatic irreversible pulpitis: Impact of bone thickness on perception and duration of pain. *J Dent Anesth Pain Med*. 2020;20(6):367-75.
10. Sixou JL, Marie-Cousin A, Huet A, Hingant B, Robert JC. Pain assessment by children and adolescents during intraosseous anaesthesia using a computerized system (QuickSleeper). *Int J Paediatr Dent*. 2009;19(5):360-6.
11. Prol Castelo A, García Mato E, Varela Aneiros I, Sande López L, Outumuro Rial M, Abeleira Pazos MT, et al. Evaluation of Intraligamentous and Intraosseous Computer-Controlled Anesthetic Delivery Systems in Pediatric Dentistry: A Randomized Controlled Trial. *Children (Basel)*. 2022;10(1).
12. Smaïl-Faugeron V, Muller-Bolla M, Sixou JL, Courson F. Evaluation of intraosseous computerized injection system (QuickSleeper™) vs conventional infiltration anaesthesia in paediatric oral health care: A multicentre, single-blind, combined split-mouth and parallel-arm randomized controlled trial. *Int J Paediatr Dent*. 2019;29(5):573-84.
13. Radwan MZ, Wassel MO, El Geleel OA, Elghazawy RK. Influence of computerized intraosseous anesthesia compared with traditional mandibular nerve block on children's behavior: A randomized clinical trial. *Int J Paediatr Dent*. 2024.
14. Kühnisch J, Daubländer M, Klingberg G, Dougall A, Spyridonos Loizides M, Stratigaki E, et al. Best clinical practice guidance for local analgesia in paediatric dentistry: an EAPD policy document. *Eur Arch Paediatr Dent*. 2017;18(5):313-21.
15. Klingberg G, Ridell K, Brogårdh-Roth S, Vall M, Berlin H. Local analgesia in paediatric dentistry: a systematic review of techniques and pharmacologic agents. *Eur Arch Paediatr Dent*. 2017;18(5):323-9.
16. World Medical A. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bull World Health Organ. 2001;79(4):373-4.
17. Calvert M, Blazeby J, Altman DG, Revicki DA, Moher D, Brundage MD, et al. Reporting of patient-reported outcomes in randomized trials:

the CONSORT PRO extension. *Jama*. 2013;309(8):814-22.
18. El Hachem C, Kaloustian MK, Cerutti F, Chedid NR. Metallic syringe versus electronically assisted injection system: a comparative clinical study in children. *Eur J Paediatr Dent*. 2019;20(4):320-4.
19. Rosner B. Hypothesis Testing: Two-Sample Inference. In: Fundamentals of biostatistics. 7th ed. Boston: Brooks/Cole. Nelson Education. 2015;269-301.
20. Universität Düsseldorf. G*Power.2019. Retrieved from http://www.gpower.hhu.de/.
21. Mathur J, Diwanji A, Sarvaiya B, Sharma D. Identifying Dental Anxiety in Children's Drawings and correlating It with Frankl's Behavior Rating Scale. *Int J Clin Pediatr Dent*. 2017;10(1):24-8.
22. Alshoraim MA, El-Housseiny AA, Farsi NM, Felemban OM, Alamoudi NM, Alandejani AA. Effects of child characteristics and dental history on dental fear: cross-sectional study. *BMC Oral Health*. 2018;18(1):33.
23. Saber SM, Hashem AA, Khalil DM, Pirani C, Ordinola-Zapata R. Efficacy of four local anaesthesia protocols for mandibular first molars with symptomatic irreversible pulpitis: A randomized clinical trial. *Int Endod J*. 2022;55(3):219-30.
24. Sealed Envelope. Available at: https://www.sealedenvelope.com/simple-randomiser/v1/lists.
25. Biocanin V, Brkovic B, Milicic B, Stojic D. Efficacy and safety of intraseptal and periodontal ligament anesthesia achieved by computer-controlled articaine + epinephrine delivery: a dose-finding study. *Clin Oral Investig*. 2013;17(2):525-33.
26. American Academy of Pediatric Dentistry. Use of local anesthesia for pediatric dental patients. The Reference Manual of Pediatric Dentistry. Chicago, Ill.: American Academy of Pediatric Dentistry; 2023:385-92.
27. Dixit UB, Joshi AV. Efficacy of Intraosseous Local Anesthesia for Restorative Procedures in Molar Incisor Hypomineralization-Affected Teeth in Children. *Contemp Clin Dent*. 2018;9(Suppl 2):S272-s7.
28. Martin E, Nimmo A, Lee A, Jennings E. 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*. 2021;7(1):27.
29. Council on Clinical Affairs AAPD. Guideline on pediatric oral surgery. *Pediatr Dent*.2006;27:158–64.
30. Wong DL, Hockenberry-Eaton M, Wilson D, Winkelstein M, Schwartz P. Whaley and Wong's essentials of pediatric nursing. 5th ed. St. Louis: Mosby; 2001. p. 1301.
31. Tak BA, Mir BA, Jan SM, Behal R. Effect of Pre-Treatment with Ketorolac Tromethamine on Post-operative Pain Following Periodontal Surgery: A Randomized Crossover Clinical Trial. 2023.
32. Merkel SI, Voepel-Lewis T, Shayevitz JR, Malviya S. The FLACC: a behavioral scale for scoring postoperative pain in young children. *Pediatr Nurs*. 1997;23(3):293-7.
33. Nakai Y, Milgrom P, Mancl L, Coldwell SE, Domoto PK, Ramsay DS. Effectiveness of local anesthesia in pediatric dental practice. *J Am Dent Assoc*. 2000;131(12):1699-705.
34. Alkhouli M, Al-Nerabieah Z, Dashash M. Can computerized intraosseous anaesthesia replaces the inferior alveolar nerve block in children? A randomized controlled clinical trial. *Oral Surgery*. 2024.
35. Sixou JL, Marie-Cousin A. Intraosseous anaesthesia in children with 4 % articaine and epinephrine 1:400,000 using computer-assisted systems. *Eur Arch Paediatr Dent*. 2015;16(6):477-81.
36. Nikolova-Varlinkova K, Kabaktchieva R. Reaction of 5 and 6 year old children to local anesthesia during dental treatment. *Journal of IMAB: Annual Proceeding (Scientific Papers)–2008–Book*. 2008;2:47-51.
37. Deepak V, Challa RR, Kamatham R, Nuvvula S. Comparison of a New Auto-controlled Injection System with Traditional Syringe for Mandibular Infiltrations in Children: A Randomized Clinical Trial. *Anesth Essays Res*. 2017;11(2):431-8.
38. Shields BJ, Palermo TM, Powers JD, Grewe SD, Smith GA. Predictors of a child's ability to use a visual analogue scale. *Child Care Health Dev*. 2003;29(4):281-90.
39. Adams JN. A methodologic study of pain assessment in Anglo and Hispanic children with cancer: The University of Texas School of Public Health; 1987.
40. Crellin DJ, Harrison D, Santamaria N, Huque H, Babl FE. The Psychometric Properties of the FLACC Scale Used to Assess Procedural Pain. *J Pain*. 2018;19(8):862-72.
41. Prol Castelo A, García Mato E, Varela Aneiros I, Sande López L, Outumuro Rial M, Abeleira Pazos MT, et al. Evaluation of intraligamentous and intraosseous computer-controlled anesthetic delivery systems in pediatric dentistry: a

randomized controlled trial. *Children*. 2022;10(1):79.
42. Özer S, Yaltirik M, Kirli I, Yargic I. A comparative evaluation of pain and anxiety levels in 2 different anesthesia techniques: locoregional anesthesia using conventional syringe versus intraosseous anesthesia using a computer-controlled system (Quicksleeper). *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2012;114(5 Suppl):S132-9.
43. Dental Hi Tec. The keys to success with Quicksleeper. User manual and clinical guide.2014. Cholet, France.
44. Renuka MS, Rao AP, Natarajan S, Karuna YM, Nayak PA, Rao S. Reliability of the electric pulp tester as an indicator of pulpal anesthesia in primary maxillary posterior teeth to assess the need for supplemental injections: An observational clinical study. *J Indian Soc Pedod Prev Dent*. 2023;41(3):228-33.
45. Allen KD, Kotil D, Larzelere RE, Hutfless S, Beiraghi S. Comparison of a computerized anesthesia device with a traditional syringe in preschool children. *Pediatr Dent*. 2002;24(4):315-20.
46. Zarei M, Ghoddusi J, Sharifi E, Forghani M, Afkhami F, Marouzi P. Comparison of the anaesthetic efficacy of and heart rate changes after periodontal ligament or intraosseous X-Tip injection in mandibular molars: a randomized controlled clinical trial. *Int Endod J*. 2012;45(10):921-6.
47. Knoll-Köhler E, Frie A, Becker J, Ohlendorf D. Changes in plasma epinephrine concentration after dental infiltration anesthesia with different doses of epinephrine. *J Dent Res*. 1989;68(6):1098-101.
48. Peñarrocha-Oltra D, Ata-Ali J, Oltra-Moscardó MJ, Peñarrocha-Diago M, Peñarrocha M. Side effects and complications of intraosseous anesthesia and conventional oral anesthesia. *Med Oral Patol Oral Cir Bucal*. 2012;17(3):e430-4.
49. Pereira LA, Groppo FC, Bergamaschi Cde C, Meechan JG, Ramacciato JC, Motta RH, et al. Articaine (4%) with epinephrine (1:100,000 or 1:200,000) in intraosseous injections in symptomatic irreversible pulpitis of mandibular molars: anesthetic efficacy and cardiovascular effects. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2013;116(2):e85-91.
50. Tom K, Aps J. Intraosseous anesthesia as a primary technique for local anesthesia in dentistry. *Clin Res Infect Dis*. 2015;2(1):1012.
51. Moore PA, Cuddy MA, Cooke MR, Sokolowski CJ. Periodontal ligament and intraosseous anesthetic injection techniques: alternatives to mandibular nerve blocks. *J Am Dent Assoc*. 2011;142 Suppl 3:13s-8s.
52. Simeonova E, Canova S, Zagorchev P, Dimitrova S. Temperature Changes in Cortical Bone during Intraosseous Anesthesia with Anesto And Quicksleeper. *Journal of Dental and Medical Sciences*. 2017;20:197.