Assessment of the Anesthetic Effectiveness of Anterior and Middle Superior Alveolar injection Using a Computerized Device versus Traditional Technique in Children

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The study aims to evaluate the anesthetic effectiveness of the Anterior and Middle Superior Alveolar (AMSA) injection administered through a computer-controlled local anesthetic delivery system (CCLAD), and compare it with the traditional buccal and palatal injections used to anesthetize maxillary primary molars. ***Materials and methods:*** *the sample included 80 primary maxillary molars, divided into 2 equal groups: Pulpotomy and extraction groups. Each group was divided equally into 4 subgroups: A. First molars anesthetized with the traditional technique, B. first molars anesthetized with the CCLAD, C. second molars anesthetized with the traditional technique, and D. second molars anesthetized with the CCLAD. The evaluation was done single blind using SEM scale.* ***Results:*** *the AMSA injection with the CCLAD was found to be effective in anesthetizing maxillary primary molars in pulpotomy and extraction procedures. There was no significant difference between the two anesthetic techniques except in the step of gingival retraction buccally in, which the traditional injections were more effective than the CCLAD during extractions. No significant difference was found between first and second primary molars in the effectiveness of both techniques.* ***Conclusion:*** *the AMSA injection using CCLAD was found to be effective in children.*

Keywords: *Anesthesia, primary molars, wands, pulpotomy, extraction, children*
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INTRODUCTION

Recently, an injection with a palatal approach to the anterior and middle superior alveolar nerves (AMSA) has been introduced where the anesthetic solution diffuses through the porous bone of the maxilla, producing anesthesia from the second premolar to the central incisor.[1] This technique was facilitated by the introduction of a computer-controlled local anesthetic delivery system (CCLAD) known also as the "Wand" (Milestone Scientific, Livingstone , NJ. USA)) that permits controlled slow delivery of the solution.

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Preliminary studies performed with the CCLAD (The Wand) on children have investigated the efficacy of the Wand in reducing pain related behaviors during injection delivery.[2-13] Five studies[5,9,10,12,13] tested the efficacy of the periodontal ligament anesthesia using the CCLAD in children, and only one[13] assessed the Palatal approach to the anterior superior alveolar nerve block (P-ASA) effectiveness in children. The AMSA injections' effectiveness, however, up to our knowledge has not been evaluated in primary molars before.

The purpose of this study was to evaluate the anesthetic effectiveness of the AMSA injection administered through the CCLAD and compare it with the traditional buccal and palatal injections used to anesthetize maxillary primary molars in procedures that require profound anesthesia, such as pulpotomies and extractions.

MATERIALS AND METHODS

Subject selection

The Sample included children attending the dental clinics in King Abdulaziz University Hospital (KAUH). The age of the children ranged from 5-8 years, children were in a healthy physical and mental state. Children were assessed as being cooperative, having behavioral ratings "positive" or "definitely positive" according to the Frankl[14] behavior classification scale and children had maxillary primary molars that required treatment with pulpotomies or extractions.

The procedures, possible discomforts or risks, as well as the possible benefits were fully explained to the parent or guardian, and their informed consent was obtained.

Tooth selection

Eighty primary posterior maxillary teeth requiring treatment with either pulpotomy or extraction were divided into the following groups:

Group I: The Pulpotomy group, included 40 teeth and was subdivided into 4 groups: Group IA: 10 maxillary 1st molars anesthetized with the traditional technique, Group IB: 10 maxillary 1st molars anesthetized with the CCLAD, Group IC: 10 maxillary 2nd molars anesthetized with the traditional technique, Group ID: 10 maxillary 2nd molars anesthetized with the CCLAD.

Group II: The Extraction group, which included 40 teeth, was subdivided into 4 groups: Group IIA: 10 maxillary 1st molars anesthetized with the traditional technique, Group IIB: 10 maxillary 1st molars anesthetized with the CCLAD, Group IIC: 10 maxillary 2nd molars anesthetized with the traditional technique, Group IID: 10 maxillary 2nd molars anesthetized with the CCLAD.

The local anesthetic solution was delivered using either the CCLAD (Wand) or a traditional syringe. The Wand is a U.S. Food and Drug Administration (FDA) approved device. Both techniques used Lidocaine HCl 2% with 1:100,000 epinephrine.(Septodont, France) as the anesthetic solution with a 30-gauge short needle (Caine Tips, J Morita, Irvine, USA) .

Clinical procedure

A complete clinical evaluation of teeth was performed, and a preoperative radiograph was taken to formulate an appropriate treatment for each tooth included. A topical anesthetic was placed at each injection site for 1 minute . For the traditional technique, a buccal infiltration of an average of 0.8ml was administered at the mucobuccal fold above the apices of the buccal roots of the molars to be treated .The rate of solution deposition was 1 ml/min.

A palatal infiltration of an average of 0.2ml was administered at the palatal side midway between the free gingival margin and the midline when extractions were going to be performed. In pulpotomy cases, the palatal injections were located near the free marginal tissue. For the CCLAD (Wand), a cotton tip applicator was pressed firmly against the tissue at the proposed injection site. For the palatal approach for AMSA, an injection was administered half way between the mid-palatal raphae and the free gingival margin bisecting the first and second primary molars. The needle tip bevel was placed flat against the tissue. Administration of anesthesia was carried out at the slow rate (0.5ml/min). After 5 seconds, slight tissue penetration was established. The slow rate of delivery was continued while the needle penetrated the soft tissue. This allowed an anesthetic pathway to develop prior to further tissue penetration. Once the needle tip reached the level of the bony palate, the slow rate of administration was continued until slight blanching of surrounding tissue was visualized. This technique was carried out according to the specifications of the Wand manufacturer.[15] The average amount of local anesthetic administered using the Wand was 1.0ml.

Method of assessment

Sounds, eyes and motor (SEM) scale for anesthetic effectiveness:[16] A trained research assistant, who was blind to the injection technique, observed all treatment sessions and evaluated the effectiveness of the different injection techniques. After administering anesthesia, the equipment and needles were removed before the assistant observer entered the operatory.

The SEM (sound, eye and motor) scale was used to evaluate the anesthetic effectiveness measuring the pain reactions. The SEM scale is an objective method that observes sounds, eyes and motor pain reactions. The reactions are classified on a scale from 1–4 categories; comfort, mild discomfort, moderately painful, and painful for each of the S, E and M codes.

Pain reaction and behavior were recorded in the following steps: In **pulpotomy cases:** During placement of the clamp**,** drilling the tooth, entering the pulp**, p**ulp extirpation and rubber dam removal. In e**xtraction cases:** Buccal gingival retraction, palatal gingival retraction, gripping the tooth with forceps**, t**ooth movement and final movement. Pain reaction for each step of pulpotomy or extraction would range from a minimum of SEM score of 3 and maximum score of 12.

Statistical analysis

The data was collected and the results were statistically analyzed using SPSS version 10.0. The Mann Whitney test was used to compare the anesthetic effectiveness in pulpotomy and extraction procedures between both anesthetic techniques.

RESULTS

Demographic data

Table 1 shows the frequency distribution of children by age, sex and nationality. The sample comprised a total of 80 children with age ranging from 65 months (5 years and 4 months) to 104 months (8 years and 6 months) with a mean age of 86.1± 10.7 months. The sample consisted of 36 males (45%) and 44 females (55%) and mostly Saudi's (90%).

Table 1. Frequency distribution of children by age, gender and nationality

Age group (years) of children	Number	Percentage (%)
5 – 6	31	38.8
7 - 8	49	61.2
Gender of children		
Male	36	45
Female	44	55
Nationality of children		
Saudi	72	90
Non-Saudi	8	10
Total	**80**	**100**

Comparison of anesthetic effectiveness using the two injection techniques:

Table 2 shows the means and standard deviations of the SEM scores recorded during each step of pulpotomy for the two anesthetic techniques. For the CCLAD technique the highest score was obtained upon entering the pulp (3.95 ± 1.15), whereas the lowest score was recorded during clamp and rubber dam removal (3.10 ± 0.31). The same trend was evident when the traditional anesthetic technique was used but to a slightly lower level.

There was no significant difference in the effectiveness of anesthesia between teeth treated with the CCLAD and those treated with the traditional injections in all treatment steps of pulpotomy (P > 0.05).

Table 2. Mean SEM scores of both tested anesthesia techniques in pulpotomy steps

Pulpotomy steps	CCLAD n=20		Traditional n=20		Mann Whitney test	
	Mean SEM	SD	Mean SEM	SD	Mann Whitney U	P-value
Clamp placement	3.50	0.89	3.15	0.37	165.5	0.355
Tooth drilling	3.50	0.95	3.35	0.59	196.0	0.925
Pulp entering	3.95	1.15	3.90	1.07	197.0	0.947
Pulp extirpation	3.65	0.93	3.50	0.69	191.0	0.820
Clamp & rubber dam removal	3.10	0.31	3.00	0.00	180.0	0.602

Table 3 shows the means and standard deviations of the SEM scores recorded during each step of extraction for the two anesthetic techniques. For the CCLAD technique the highest mean score was obtained during tooth movement (4.40 ± 1.10), whereas the lowest mean score was recorded during gingival retraction palatally (3.05 ± 0.22). On the other hand when the traditional anesthetic technique was used, the highest mean score was also obtained during tooth movement (4.00 ± 1.08). However, the lowest mean score was recorded during gingival retraction buccally (3.05 ± 0.22).

Table 3 shows no significant differences in the effectiveness of anesthesia between teeth treated with the CCLAD and those treated with the traditional injections throughout all treatment steps of extractions (P > 0.05), except in extraction step 1 (gingival retraction buccally), where the traditional technique was significantly more effective than the CCLAD (P = 0.028).

Table 3. Mean SEM scores of both tested anesthesia techniques in extraction steps

Extraction step	CCLAD n=20		Traditional n=20		Mann Whitney test	
	Mean SEM	SD	Mean SEM	SD	Mann Whitney U	P-value
Gingival retraction buccally	3.65	0.99	3.05	0.22	119.0	0.028*
Gingival retraction palatally	3.05	0.22	3.20	0.41	170.0	0.429
Gripping the tooth with forceps	3.40	0.75	3.55	0.94	187.5	0.738
Tooth movement	4.40	1.10	4.00	1.08	154.5	0.221
Final movement	3.70	1.42	3.60	1.05	199.5	0.989

*Statistically significant difference between the two injection techniques.

Comparison of anesthetic effectiveness between first and second primary molars:

I. Pulpotomy: Table 4 shows the mean scores obtained during pulpotomy procedures in first and second primary molars anesthetized with the CCLAD technique. For both teeth the highest mean score was obtained during entering the pulp, whereas the lowest mean score was recorded during clamp and rubber dam removal (4.20 ± 1.23, 3.70 ± 1.06) and (3.20 ± 0.42, 3.00 ± 0.00) respectively.

Data showed no significant difference in the effectiveness of anesthesia between both primary molars in all treatment steps of pulpotomy when anesthetized using the CCLAD (P > 0.05).

Table 4. Comparisons between first and second primary molars anesthetized with the CCLAD in pulpotomy steps

Pulpotomy steps	SEM Mean	SD	SEM Mean	SD	Mann Whitney test	
Using CCLAD	1st molar n=10		2nd molar n=10		Mann Whitney U	P-value
Clamp placement	3.70	1.06	3.30	0.67	39.5	0.436
Tooth drilling	3.60	0.97	3.40	0.97	41.0	0.529
Pulp entry	4.20	1.23	3.70	1.06	38.0	0.393
Pulp extirpation	3.70	0.82	3.60	1.07	43.0	0.631
Clamp & rubber dam removal	3.20	0.42	3.00	0.00	40.0	0.481
Using Traditional	1st molar n=10		2nd molar n=10			
Clamp placement	3.10	0.32	3.20	0.42	45. 0	0.739
Tooth drilling	3.50	0.71	3.20	0.42	39.0	0.436
Pulp entry	4.20	1.03	3.60	1.07	32.0	0.190
Pulp extirpation	3.60	0.84	3.40	0.52	46.0	0.796
Clamp & rubber dam removal	3.00	0.00	3.00	0.00	50.0	1.000

Table 4 also shows the mean scores obtained during pulpotomy procedures in both primary molars anesthetized with the traditional technique. The highest mean score for the first primary molar was obtained when entering the pulp, whereas, the lowest mean score was recorded during clamp and rubber dam removal Comparisons revealed no significant differences (P > 0.05).

II. Extraction: Table 5 shows the mean scores obtained during extraction procedures of the first and second primary molars anesthetized with the CCLAD technique. For both molars the highest mean score was recorded during tooth movement and the lowest mean score was obtained during palatally gingival retraction No significant differences were found (P > 0.05).

The mean scores obtained during extraction procedures for both primary molars anesthetized with the traditional technique is presented also in Table 5. The highest mean scores for both teeth were recorded during tooth movement

Table 5. Mean SEM scores of first and second primary molars anesthetized with the CCLAD in extraction steps

Extraction steps	SEM Mean	SD	SEM Mean	SD	Mann Whitney test	
Using CCLAD	**1st molar n=10**		**2nd molar n=10**		Mann Whitney U	P-value
Gingival retraction buccally	3.30	0.48	4.00	0.99	32.0	0.190
Gingival retraction palatally	3.10	0.32	3.00	0.22	45.0	0.739
Gripping the tooth with forceps	3.70	0.95	3.10	0.75	33.5	0.218
Tooth movement	4.60	1.26	4.20	1.10	42.5	0.579
Final movement	3.90	1.91	3.50	1.42	48.0	0.912
Using Traditional	**1st molar n=10**		**2nd molar n=10**			
Gingival retraction buccally	3.00	0.00	3.10	0.32	45.0	0.739
Gingival retraction palatally	3.10	0.32	3.30	0.48	40.0	0.481
Gripping the tooth with forceps	3.70	1.16	3.40	0.70	46.5	0.796
Tooth movement	4.10	1.29	3.90	0.88	48.5	0.912
Final movement	3.70	1.25	3.50	0.85	46.5	0.796

and the lowest mean score was obtained during gingival retraction buccally. No significant difference was found in the effectiveness of anesthesia between both teeth ($P > 0.05$).

DISCUSSION

The computer-controlled local anesthetic device was introduced by Milestone Scientific.[15] This device was designed to deliver a "virtually painless" injection of local anesthetic.[1,17,18] In conjunction with this new technology, two new palatal injections that can anesthetize multiple maxillary teeth have been suggested. These injections were described as a palatal approach to the Anterior and Middle Superior Alveolar nerves (AMSA) introduced by Friedman and Hochman,[1] as well as a palatal approach to the Anterior Superior Alveolar nerve (P-ASA) proposed in 1999.[19]

Studies using the computer-controlled local anesthetic device with children are only beginning to emerge.[2-5,7,8,11-13] However, these studies have mainly focused on the presence or absence of pain associated with administrating injections using this device. On the other hand, the efficacy of these injections and the newly introduced nerve blocks (AMSA & P-ASA) did not receive much attention especially in the pediatric population. The dental literature reveals no information on the effectiveness of the AMSA approach when performed with the CCLAD to anesthetize primary teeth, especially the second primary molar which is innervated by the middle superior alveolar nerve and in its absence by the anterior superior alveolar nerve, or by the posterior middle superior alveolar nerve plexus.

In this study the anesthetic effectiveness was evaluated through measuring the level of pain at different steps of pulpotomy or extraction. The age group ranged between 5 and 8 years; this young age excluded the option of using subjective methods to record pain because the validity of rating pain in such age group may be questionable. Recording physiological changes, such as the heart rate, blood pressure and respiration is another method to measure pain. However, in this study physiological measures were considered inappropriate because an injection is an anxiety-evoking stimulus especially among children and it is difficult to distinguish anxiety from pain, physiologically.[16] For this reason, only patients who were cooperative, having "positive" or "definitely positive" behavioral ratings according to The Frankl[14] scale were included in the study to eliminate anxiety reactions that might be misinterpreted as pain reactions.

The (SEM) scale introduced by Wright[16] was selected as the method of recording pain reactions and accordingly effectiveness of anesthesia. This scale is a subjective method that observes sounds, eyes and motor pain reactions, and has been used in previous studies to measure comfort or pain in children.[16,20,21]

Pulpotomies and extraction procedures were selected as these procedures are considered to be the most painful procedures for children.

The study was conducted using a model that would reduce bias as much as possible.. No matter what anesthetic technique was used, no explanation was given to children other than that their tooth was going to be put to sleep. Furthermore, the same operator administered all the injections and performed all pulpotomies and extraction procedures.

In pulpotomy cases, the results showed that both techniques effectively anesthetized the primary maxillary molars throughout the whole treatment steps, and no significant differences were found in their effectiveness. The mean SEM scores did not exceed 3.95 using the CCLAD and 3.90 using the traditional injections, indicating that the teeth were effectively anesthetized.

In the extraction cases, no significant difference in anesthetic effectiveness was found between the two injection techniques in all steps except the step of gingival retraction buccally, where a significant difference existed between the two techniques. The CCLAD was less effective than the traditional technique and had a higher mean SEM score. Although the CCLAD was significantly less effective during this step than the traditional technique, yet the recorded score still remained in the very mild pain categorization, indicating that the teeth receiving this injection technique were still effectively anesthetized.

Our results agree with the findings of Friedman and Hochman,[1] who reported that when they first introduced the AMSA nerve block, using this single palatal injection, profound pulpal and palatal soft tissue anesthesia as well as hemostasis were achieved extending from the central incisor to the second premolar. They also reported some soft tissue anesthesia and hemostasis on the buccal aspect in the same region. This observation was related in part to the efficient diffusion of anesthetic solution that the controlled flow rate creates into the medullar bone. To eliminate pain during extensive instrumentation on the facial gingival tissue, they suggested the injection of about 0.2 ml of additional anesthetic at the muccobuccal fold of the areas to be

instrumented.[1,17] Our findings regarding the significant difference between buccal and palatal gingival retraction during extraction using the CCLAD, supports the suggestions of Friedman and Hochman[1,17] to provide an additional minimal amount of anesthesia in case of extensive instrumentation planned on the buccal gingival tissue.

The effectiveness of anesthesia was also compared between the first and second primary molars. The results revealed that there was no significant difference in all pulpotomy and extraction treatment steps using both anesthetic techniques. This finding indicates that the second primary molar was effectively anesthetized with the AMSA injection although it may receive its innervation from the posterior middle superior alveolar nerve plexus. Extensive research of the literature revealed no data on the effectiveness of the AMSA injection using the CCLAD in children to anesthetize the primary molars. However, from the clinical point of view, similar findings supporting our data were presented by Fukayama *et al,*[22] who conducted a study on an adult population to test the efficacy of the AMSA anesthesia using the CCLAD through evaluating the degree of pulpal anesthesia using electric pulp stimulation. They reported that the AMSA injection using the Wand was very effective for anesthetizing lateral incisors, canines and first and second premolars.

On the other hand, the anesthetic efficacy of the AMSA injection was evaluated in another adult population and was found to have relatively low effectiveness rates.[23] The AMSA block was administered twice, one time with the CCLAD and the other with a conventional syringe. The anesthetic effectiveness was measured by using a pulp tester. Their results revealed that for the computer-assisted injection system successful pulpal anesthesia ranged from 35 to 58%, and for the conventional syringe it ranged from 20 to 42%. Although, the AMSA injection using the computer-assisted injection system was considered to be more successful than the conventional syringe technique, its rather modest success rates achieved did not ensure predictable pulpal anesthesia. These results regarding the effectiveness of the AMSA anesthesia are in contrast to what was found in our study and in the study of Fukayama *et al.*[22] It is important to note that Lee *et al* [23] considered anesthesia to be successful when the pulp tester revealed 2 consecutive no responses with the reading of 80. A reading of 80 on the scale is the maximum electrical current of the pulp tester. However, a reading of less than 80 often indicates adequate pulpal anesthesia.[22]

CONCLUSIONS

- The AMSA injection with the CCLAD was found to be as effective as the buccal and palatal infiltrations given with the traditional syringes in anesthetizing maxillary primary molars in pulpotomy and extraction procedures.

- Gingival retraction buccally was the only step in which the traditional injections were more effective than the CCLAD during extraction procedures. However, the mean pain reaction score when using the CCLAD remained in the mild pain categorization.

- No significant differences were found between both primary molars in the effectiveness of the two anesthetic techniques despite of the unique innervations of second primary molars which received fibers from PSA nerve block in addition to middle MSA nerve block

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