Quality of Anesthesia for the Maxillary Primary Anterior Segment in Pediatric Patients: Comparisonof the P–ASA Nerve Block Using CompuMed Delivery System vs Traditional Supraperiosteal Injections

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ABSTRACT

Purpose: The purpose of this study was to compare the quality of 2 injection techniques to anesthetize the maxillary primary anterior segment by applying either the palatal approach anterior superior alveolar nerve block (P-ASA) utilizing a computer-controlled injection device (CompuMed with the Wand handpiece) or traditional multiple supraperiosteal (TMS) injections with a hand-operated syringe. Depth and duration of anesthesia was assessed by the number of disruptive behaviors 20 minutes following injection.

Methods: Twenty-one preschoolers aged 3 to 5 years, who required pulp tissue removal with subsequent crown placement and/or extraction of at least 2 teeth in the maxillary incisor segment on opposite sides of the midline, participated in this study. They were randomly assigned to either the P-ASA or the TMS injection group. The procedure was separated into 3 segments: (1) the injection; (2) overall procedure; and (3) painful event. Each segment was scored for disruptive behaviors (body movements, crying, restraint, or dentist interference) using an established scale. Scores were analyzed via analysis of variance for significance.

Results: During injection, disruptive behaviors occurred significantly less in the P-ASA group than in the TMS group. No significant differences were found between the 2 groups for the overall procedure and the painful event segments.

Conclusion: Whereas anesthetic solution delivery with CompuMed system caused significantly less disruptive behavior during the injection phase, both methods seem to provide a comparable quality of anesthesia for the maxillary primary incisor segment 20 minutes after deposition of the anesthetic solution. (J Dent Child 2005;72:119-125)

KEYWORDS: LOCAL ANESTHESIA, PEDIATRIC DENTISTRY, MAXILLARY PRIMARYFRONT TEETH, MICROPROCESSOR-CONTROLLED INJECTION SYSTEM, P-ASA NERVE BLOCK, DENTAL ANXIETY REDUCTION

An essential part of dental treatment is pain control with local anesthetics. Inadequate pain management is known to be a major factor contributing to the development of dental fear.[1-4] In fact, children who are hurt while receiving dental treatment are more likely to avoid it as adults.[5] In a study investigating conditioning experiences that lead to dental anxiety in young adults, investigators observed 18-year-old patients over an 8-year period and found a 17% increase in dental anxiety.[3] Avoidance of dental treatment was the strongest predictor of dental anxiety. Experience of invasive dental treatment before age 18 or having 1 or 2 teeth extracted, however, were also predictive of onset of dental fear. Another publication[4] described 5 factors that perpetuate the development of dental fear: (1) anticipation of pain; (2) lack of trust or betrayal by the dentist; (3) loss of control; (4) fear of the un-

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known; and (5) physical invasion of personal space or body cavity (intrusion).

One of the most distressing aspects of dental treatment is the apprehension caused by anticipation of the dental injection itself.[6] Although techniques such as the use of topical anesthetic and slower injection rate have been employed to facilitate the delivery of local anesthetic with traditional devices, the fear of the injection has continued to afflict the dental profession.[1]

In 1998, a microprocessor-controlled local anesthesia delivery system (CompuMed with the Wand handpiece) was introduced and has received considerable attention. Its advantages over the traditional syringe include a pen-like handpiece design which evokes no association with the latter and is therefore less threatening to patients. This shape allows for a pen-grasp hold and improves tactile feel which facilitates more comfortable and precise placement of the needle.[7] The operator activates the flow of anesthetic with a foot pedal and is, thus, able to administer anesthesia ahead of the needle at a constant pressure and controlled rate, regardless of the tissue resistance. Such precise regulation is important, because pressure and volume are thought to be related to pain.[8]

Slow injections, defined as deposition of 1.0 ml of local anesthetic solution in not less that 60 seconds,[9] can be achieved more reliably by this foot-operated and computer-controlled system, as compared to the traditional thumb-operated syringe. This is a significant improvement because, even though dentists try to regulate the amount of anesthetic by pushing slowly with their thumb, manual gauging is only arbitrary. Assessing pressure and volume during injection are difficult because tissue resistance varies with each individual.[1,10,11]

Following its market introduction, CompuMed has been evaluated in the scientific literature. Because its appearance is markedly different from the traditional syringe, it does not elicit the fears in patients produced by a traditional syringe.[12] When used accordingly, CompuMed seems to be capable of decreasing pain-related disruptive behaviors/ratings in patients.[1,13] The results, however, should be interpreted with caution because they may not always be of clinical significance.[10] In one study, injections with CompuMed decreased anxiety scores of patients by two thirds compared to their baseline values when surveyed after the injection.[1]

Maxillary anterior teeth can be anesthetized by 2 different methods:

1. the traditional approach with a hand syringe requiring multiple supraperiosteal injections (TMS);
2. the palatal approach via an anterior superior alveolar nerve block (P-ASA)—a novel method with CompuMed—using only a single palatal injection deep into the nasopalatine canal.[14]

Traditionally, 1 or 2 adjacent maxillary anterior teeth are usually anesthetized with a buccal supraperiosteal and a palatal injection requiring approximately 1.4 ml and 0.4 ml of anesthetic solution, respectively. For several maxillary teeth, multiple injections of this type are usually necessary. The P-ASA injection has been proposed[14] as a CompuMed-specific, new, and less traumatic approach for anesthetizing the entire maxillary incisor segment. Deposition of 0.9 ml to 1.4 ml of anesthetic solution deep into the incisive foramen reportedly delivers pulpal anesthesia for all maxillary anterior teeth, from canine to canine as well as parts of the buccal and palatal gingiva, without the concomitant lip or facial numbness that is invariably present with the traditional injection method.[14] Other studies using the same delivery system found:

1. moderate to severe pain during needle insertion and advancement in at least one third of their adult subjects[15]; and
2. unpredictable modest to low success rates for pulpal anesthesia of the 4 maxillary incisors and canines.[16]

This microprocessor-controlled system has been tested with contradictory results in pediatric patients as well.[13,17,18] No statistical significant differences were found when researchers compared the traditional syringe with CompuMed for the inferior alveolar nerve block as well as palatal and buccal supraperiosteal infiltrations.[19] The injections were administered in the same location and manner and differed only in the device that delivered the anesthetic solution.

There were several acknowledged limitations of the study, including the type of injection, the rate at which it was administered, the experience of the investigator, use of subjective self reports by young patients for pain rating, and the type of patient population being treated.[18,19] These limitations were addressed in subsequent studies by modified protocols. The investigators used only the types of injections recommended by the manufacturer. Consequently, they compared the P-ASA nerve block performed with CompuMed with TMS infiltrations administered by a handheld syringe to anesthetize the same segment. They recorded disruptive behavior in 3- to 5- and 5- to 13-year-old children, respectively, during the injection and in the first few minutes thereafter to assess which method elicited less disruptive behavior.[13,17]

This revised study design yielded encouraging results for CompuMed -specific injections. Proper anesthesia could be achieved by utilizing a single palatal injection site, while the occurrence of disruptive behavior was significantly reduced during the initial 15 seconds of the injection.[13] Similar results were observed for the 3- to 5-year-old age group.[17]

Although these studies reported that CompuMed is superior to the traditional syringe for disruptive behaviors during and immediately surrounding the injection in children, they did not assess the depth and duration of anesthesia produced by either method.

This prospective, randomized, controlled study builds upon and expands the findings of these previously published studies on children. The purpose of this study was to compare the quality of local anesthesia achieved with either of the 2 methods available for local anesthesia of maxillary anterior teeth:

1. CompuMed-specific P-ASA injection, as recommended by the manufacturer; and
2. the traditional multiple supraperiosteal (TMS) injections.

Quality of anesthesia was defined as depth and duration at 20 minutes after the initial injection. Coronal and/or radicular pulp tissue removal with subsequent crown placement and/or extractions were considered high pain-producing procedures. These needed to be performed on at least 2 teeth on opposite sides of the midline to evaluate the effectiveness of the anesthesia for the entire segment.

METHODS

SUBJECTS

Twenty-one healthy pediatric patients were recruited from a continuous patient pool in a pediatric dental clinic at a large, urban, Midwestern medical center. The patients were determined by a power analysis and ranged from 3 to 5 years of age with no gender, race, or ethnic restrictions. Participants with previous dental experience were selected based on the need for partial or complete pulp tissue removal and subsequent crown placement and/or extraction of at least 2 teeth in the anterior maxillary segment on opposite sides of the midline.

After a suitable subject was identified, the intent of the investigation, the planned procedures, and possible discomforts or risks were fully explained to the parent or guardian and informed consent was obtained prior to treatment. The subject was then randomly assigned to either CompuMed or the traditional syringe group. Exclusion criteria consisted of an easily noticeable limitation of mental status or significant contributing medical conditions. This study was approved by the University of Nebraska Medical Center Institutional Review Board (074-01-FB).

EQUIPMENT

The local anesthetic solution was administered using either CompuMed anesthetic solution delivery system or a traditional handheld syringe. For all injections, 2% lidocaine with 1:100K epinephrine in a standard 1.8 ml cartridge was administered with a 30-gauge needle. CompuMed uses standard 1.8-ml cartridges, similar to the hand-held syringe. Nevertheless, 0.2 ml remains unused in the cartridge and microtubing, and 0.2 ml is wasted during the purging of air from the tubing prior to injection. Therefore, the maximum amount of local anesthetic solution that can be delivered by CompuMed with a standard cartridge is 1.4 ml.[13]

PROCEDURE

After the child was seated in the dental operatory, the procedure was explained to the patient in age-specific language. Prior to injection, topical anesthetic was applied in a typical manner to the injection site and wiped off after 30 seconds for both methods. The injection was then administered. All procedures were carried out by the same operator (CH).

For the P-ASA injection with CompuMed, a cotton swab was pressed firmly against the typical palatal injection site lateral to the incisive papilla. Initially, the bevel of the needle was placed flat against the palatal mucosa and the flow of anesthetic started diffusion of the anesthetic solution into the underlying tissue. After achieving mild anesthesia with this approach, a few seconds later the tissue was penetrated with the needle and delivery of anesthetic solution was maintained to allow spread of anesthetic solution ahead of the needle tip. When blanching of the area was observed, the needle was advanced into the nasopalatine canal and the injection was sustained until the reminder of anesthetic solution in the cartridge was deposited. This protocol conforms to the manufacturer's directions.

The TMS injection technique required several buccal infiltrations and an additional palatal injection. Topical anesthetic was applied again to both injection sites. In addition, a distraction technique of cheek wiggling during the buccal infiltration was employed. A cotton swab was used to apply pressure to the palatal injection site prior to the injection. Once the tissue was penetrated and the target depth reached, the flow of anesthetic was initiated at a slow rate after negative aspiration, until the desired amount was administered.

Following delivery of anesthetic solution and a 5-minute time lapse allowing onset of the anesthesia, tooth preparation for the pulp removal and crown began. To test the duration and evaluate the depth of anesthesia 20 minutes after the deposition of the anesthetic solution, 2 particularly painful procedures were conducted on at least 2 teeth on opposite sides of the midline:

1. entering the pulp chamber with subsequent partial or complete pulp tissue removal; or
2. extraction of the tooth.

Twenty minutes were chosen because this is the average duration for single pediatric restorative procedures.

The entire procedure was separated into 3 segments, all subdivided for scoring purposes in 15-second intervals (Figure 1 depicts the sequence of the experimental procedure and its division into 3 segments):

1. Segment no. 1 included the time from placement of topical anesthetic including the injection itself.
2. Segment no. 2 consisted of 80, 15-second intervals for an overall duration of 20-minute.
3. Segment no. 3 began immediately preceding the extraction of the tooth or entrance into the pulp chamber and comprised the entire pulp removal procedure including placement of zinc oxide-eugenol.

Both the first and third segments were of variable length, depending on the type of injection employed and the pain-producing procedure rendered.

DEPENDENT MEASURES

Disruptive behavior was measured using an established anxious and disruptive behavior code (ADBC).[13,19] The entire procedure was videotaped by an experienced research assistant (SH), who later rated the occurrence of disruptive behaviors on a recording system based on 15-second intervals. During each interval, the authors coded, according to ADBC definitions (Table 1):

1. body movements (B);
2. crying (C);
3. movements requiring restraint (R); and
4. movements requiring temporary interruption of treatment for behavior management interventions (D).

The amount of time to administer each injection type was also determined from this recording.

To account for varying durations of the procedures with each patient, the authors divided the number of intervals with B, C, R, or D behavior by the total number of intervals in that segment. This yielded a patient-specific percentage score of B, C, R, or D behavior for that segment. The resulting scores were then compared for statistical significance for all 4 behaviors during each of the 3 segments.

Table 1. The Anxious and Disruptive Behavior Code (ADBC)

Type of disruptive behavior	Explanation and criteria for scoring
Body movements (B)	Movement of any part of the body of 15 cm or more. This could be one motion or a continuum of uninterrupted motions without a break. Scoring occurred during the interval in which it occurred or when the criteria were met.
Crying (C)	Any crying, complaining, or vocalizations in general were scored within this category. Not included were responses to questions from the dentist or dental assistant or laughing or talking that was patently not due to pain.
Restraint (R)	Any restraint by the dental assistant to control the patient. Not counted were light touches to calm the child or hands placed on the child to prepare for possible disturbances.
Dentist interference (D)	This included any disturbance that interfered with the dental procedure and caused the dentist to stop temporarily.

DATA ANALYSIS

A 1-way analysis of variance (ANOVA) at the .05 probability level was used to assess the effects of the 2 different injection methods on observed anxious and disruptive behaviors. The occurrence of these behaviors during the 3 defined segments of the procedure was recorded on a scoring sheet. The raw percentage scores for all patients of each group and segment (Table 3 presents average scores for all patients) were compared and analyzed for statistical significance.

The independent variables were the types of injections and the dependent variables were the reaction of the children based on the individual scores determined earlier, according to the anxious and disruptive behavior code. The data for age, time, and volume of anesthetic used were evaluated by 2 sample *t* tests.

RESULTS

Table 2 describes gender and age distribution among the subjects. The mean ages for both the P-ASA and the TMS groups were 4.81 (±0.84 SD) and 4.79 (±0.83) years, respectively. The gender distribution was:

1. 5 females and 7 males for the P-ASA group; and
2. 5 females and 4 males for the TMS group.

Neither age nor gender was statistically significantly different between the 2 groups. All treatment was performed in the 6 anterior maxillary primary teeth. The P-ASA group was composed of 12 patients:

1. 7 patients who received formocresol pulpotomies/pulpectomies and subsequent stainless steel crowns; and
2. 5 patients who received extractions.

The TMS group had:

1. 5 patients receiving pulpotomies/pulpectomies and crowns;
2. 2 patients receiving extractions; and
3. 2 patients with a combination of both.

Average scores for the 4 disruptive behaviors were calculated for each of the 3 segments by dividing the number of time periods with disruptive behaviors by the number of total time periods in that segment (Table 3). Statistically significant differences were found only during the injection phase. In the TMS group, body movement and crying occurred more often and restraint needed to be applied more frequently. The 20-minute segment of the overall procedure was unremarkable for both types of procedures. The third segment with the painful procedure showed no statistically significant differences between the groups. Crying occurred more frequently in the TMS group, however, but the difference was not statistically different.

On average, the TMS group required 72 seconds (±54) for injection of 1.64 ml (±0.29). In the CompuMed group, the dentist spent, on average, 123.1 seconds (±35) to deposit 1.45 ml (±0.49). The difference in time was significantly different (P=.017), but the difference in volume was not. Calculations based on these data show that, on average, twice as much volume was injected per time unit with the hand syringe (1.36 ml/minute) than with CompuMed (0.7 ml/minute.).

DISCUSSION

Administration of local anesthesia is a challenging part of any restorative appointment in young children. Maxillary teeth are generally anesthetized with several buccal supraperiosteal infiltrations and a supplemental transpapillary or palatal deposition of local anesthetic for the palatal mucosa. The buccal route is favored because palatal injections are considered to be more painful. The authors would expect less disruptive behavior if it was possible to reduce the overall amount of injections from the normal 4 to 5 injections for anesthetizing the anterior maxillary segment to just one, albeit palatal, injection.

This study's goal was to investigate whether it was possible to adequately anesthetize all 6 maxillary primary teeth as well as the buccal and palatal gingiva with 1 palatal injection, as previously suggested for adults.[14] Using the palate as the sole site to anesthetize the ASA nerve and dental plexus to which it contributes, the described P-ASA injection reportedly achieves bilateral pulpal anesthesia of the 6 maxillary anterior teeth and their labial gingi-

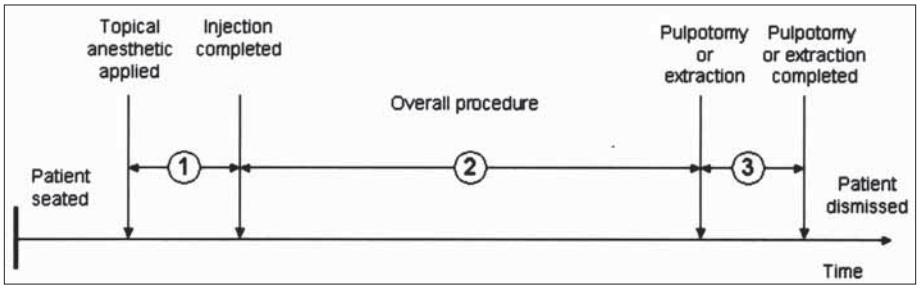

Figure 1. Segments and time sequence of the experiment.

Table 2. Patient Statistics and Distribution Within Groups				
	P-ASA*	TMS†	Total	Mean age
Male	7	4	11	4.68‡
Female	5	5	10	4.92‡
Total	12	9	21	
Mean age	4.81§	4.79§	P=.95§	P=.52‡

**Palatal approach anterior superior alveolar nerve block.*
†Traditional multiple supraperiosteal injections.
‡The mean age between males and females is statistically not different.
§The mean age between P–AMA and TMS groups is statistically not different.

val. It also provides anesthesia to the anterior palatal gingiva and mucoperiosteum like the nasopalatine nerve block. The P-ASA injection uses the same injection site lateral to the incisive papilla as the nasopalatine nerve block, however, the depth of insertion and the amount of anesthetic solution deposited is different. Malamed[20] recommends that not more than 0.45 cc be injected in adult patients for the nasopalatine nerve block, compared to 1.4 ml to 1.8 ml for the P-ASA approach in adults. Other sources[14,21] suggest 0.9 ml to 1.4 ml for the P-ASA injection.

The ASA nerve provides pulpal innervation to the maxillary anterior teeth and sensory innervation to the facial surrounding tissues, while the nasopalatine nerve innervates sensorily the palatal mucosa in the premaxillary region. Anesthetic solution deposited under the dense, fibrous palatal mucosa enters the bone marrow spaces of the premaxilla and spreads 3-dimensionally in a bilateral and concentric manner. This is due to the cancellous character of the maxillary bone and numerous natural openings (nutrient canals and exiting blood vessels). As a result, both the nasopalatine nerve and the subneural plexus for the maxillary anterior teeth are anesthetized. Depending on the amount of anesthetic solution deposited, the authors expect to see cumulative clinical effects of a nasopalatine nerve block and P-ASA injection: anesthesia of the soft and hard tissues of the anterior palate and pulpal anesthesia to the 6 maxillary anterior teeth. When anesthetic solution is deposited buccally, it delivers collateral anesthesia to the lip and muscles that affect facial expression.[22]

Anesthesia of the upper maxillary segment using the traditional TMS approach requires multiple needle sticks, whereas the P-ASA injection utilizes only 1 palatal injection. Clinical experience suggests that multiple tissue penetrations would trigger more disruptive behavior than a single injection. The data from this experimental study, which involves 21 preschoolers, support this assumption. During the entire injection segment, the authors found significantly less disruptive behavior for body movement, crying, and restraint in the children receiving the P-ASA injection than in those receiving the TMS injections.

This confirms findings from a previous study of 5- to13-year-olds which described that disruptive behavior was significantly reduced during the initial 15 seconds of an injection when CompuMed delivery system was used.[13] A subsequent investigation in preschoolers[17] replicated the same results for the first 15 seconds as well as the second interval. Both, however, found no significant differences for the following intervals. An additional assumed factor accounting for the decreased amount of disruptive behavior during the injection could be the pen-like, less threatening appearance of the Wand handpiece, although injection devices are generally kept out of the patient's direct view.

These results are remarkable because palatal injections are generally considered to be more painful.[23] Moderate to severe pain was noted during needle insertion for P-ASA injections in 30% and during needle advancement in 54% of patients, respectively, when using lidocaine.[15] In this study, it took 45 seconds longer on average to apply the P-ASA anesthesia with CompuMed than the TMS approach. The added time benefits the dentist, however, because a child who is initially less upset is more likely to be compliant.

While previous publications addressed disruptive behavior during the injection phase, they did not assess the adequacy of anesthesia. In this study, the authors introduced a particularly painful procedure 20 minutes after deposition of the local anesthetic to test for depth and duration of the administered local anesthetic. The results yielded no statistically significant differences in all categories of this segment. Crying was observed less in the TMS group, but not to a statistically significant degree. Although crying can be interpreted as a reaction to pain, the authors would expect other defensive mechanisms in 3- to 5-year-olds. When comparing all types of disruptive behavior, there was no significant difference between the 2 groups during the overall procedure and the painful stimuli segment. This fact supports the assumption that depth and duration of anesthesia for both techniques may be similar. Based on the available data, however, an unequivocal decision cannot be made at this time.

Table 3. Percent Scores for Each Observed Segment*				
Observed segment	Type of disruptive behavior	% score P-ASA†	% score TMS !	*P*-value
Injection	Body movement	0.418	0.852	.015
	Crying	0.097	0.407	.027
	Restraint	0.020	0.185	.040
	Dentist Interference	0.476	0.805	.085
Overall procedure	Body movement	0.296	0.466	.144
	Crying	0.434	0.493	.661
	Restraint	0.052	0.058	.837
Pulpotomy and/or extraction	Dentist interference	0.024	0.032	.696
	Body movement	0.405	0.328	.672
	Crying	0.805	0.426	.055
	Restraint	0.166	0.106	.636
	Dentist interference	0.071	0.307	.628

**No. of time periods with disruptive behavior/no. of all time periods.*
†Palatal approach anterior superior alveolar nerve block.
!Traditional multiple supraperiosteal injections.

In adults, reported successful anesthesia of the 6 maxillary anterior teeth ranged only from 32% to 58% for lidocaine solutions.[16]

The authors averaged 1.45 ml of anesthetic solution for the P-ASA technique and 1.64 ml for the TMS approach. A technique with less anesthetic solution requirements in children appears to be beneficial, as practitioners are often hampered by the maximum dose for anesthetic solutions in young children when they want to treat several quadrants in one (sedation) appointment.

Average injection times of 72 seconds in the TMS group (1.36 ml/minute) and 123 seconds for CompuMed (0.7 ml/minute) were well within the recommendations of Malamed, who defined slow injections as deposition of 1.0 ml of local anesthetic solution in not less than 60 seconds[9] and proposed for clinical situations a more realistic time of 60 seconds for a full 1.8 ml cartridge (1.8 ml/minute). The average time it took a pediatric dentist in a private practice setting to deliver 1.8 ml of anesthetic solution in 5- and 6-year-old children was 80 seconds (±35; 1.35 ml/minute).[8] The authors found no correlation between the injection rate and the behavior of the children or the success of anesthesia.

Future studies should test if CompuMed-specific injections can be performed equally well with a traditional hand syringe or with another computerized injection system available in North America—the Comfort Control Syringe. Also, the amount of anesthetic solution deposited for both methods should be standardized to eliminate volume as an additional variable.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. During the injection segment, P-ASA injections with CompuMed delivery system produced significantly less disruptive behavior (body movement, crying, restraint application) compared to TMS injections.
2. For the overall procedure segment and the painful procedures segment that began 20 minutes after deposition of the anesthetic solution, there were no significant differences for all 4 disruptive behavior categories. Both methods appear to provide a similar level of pain control for the maxillary primary anterior teeth segment in 3- to 5-year-old children.

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