# The effectiveness of infiltration anesthesia in the mandibular primary molar region

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## Abstract

*The purposes of the present study were to determine the effectiveness of infiltration anesthesia in the mandibular primary molars, and how patient age, tooth location, and anesthetic type relate to the quality of anesthesia. Data were derived from 66 subjects, 42–72 months old, requiring restorative treatment in mandibular primary molars. Infiltration anesthesia was provided with mepivacaine hydrochloride 2%, prilocaine hydrochloride 4%, and articaine hydrochloride 4%. After 10 min, probing, rubber dam placement, and drilling were initiated. Procedures were videotaped and ratings of comfort and behaviors were made using the SEM scale and the Frankl Behavioral Scale. The conclusions were: 1) sixty-five per cent of the subjects experienced little or no pain; 2) children who demonstrated little or no pain during injection were likely to be comfortable during successive procedures; 3) there was a high relationship between children behaving cooperatively and comfort during procedures; and 4) the quality of anesthesia was not significantly related to tooth location, age, or type of anesthetic agent. (Pediatr Dent 13: 278–83, 1991)*

## Introduction

When restoring primary mandibular molars, the customary injection is a mandibular (inferior) dental nerve block. Block anesthesia has some disadvantages for children. Specifically, the lengthy duration of the anesthesia allows for a greater possibility of postoperative trauma, such as lip or tongue biting. Also, parents must maintain close supervision while their children are under anesthesia.

As an alternative for the mandibular block, periodontal ligament (intraligamentary) anesthesia has been suggested (Malamed 1982; Davidson and Craig 1987). Brännström et al. (1982), however, studying periodontal tissue changes after intraligamentary anesthesia, were concerned that injecting anesthetics under pressure could interfere with the formation of an underlying tooth. Variables such as needle placement, applied pressure, and type of anesthetic are involved in the use of this technique. Consequently, the concern raised by Brännström and coworkers deserves serious consideration before this technique is used on a young child.

Although not widely accepted, infiltration in the mandibular molar region of primary teeth has been suggested as another means of achieving anesthesia (McCallum 1973). There are advantages to using an infiltration or supraperiosteal injection rather than a mandibular block: it is relatively easy to administer; it does not numb the tongue and lips; and it offers the possibility of a shorter anesthetic duration. A disadvantage is that it cannot be relied upon for complete anesthesia of mandibular primary molars (McDonald et al. 1987). Empirically, profundity of anesthesia has been related to the child's age and the injection location (Wright et al. 1987).

A recent report by Dudkiewicz et al. (1987) concluded that mandibular infiltration can be the technique of choice for conventional operative dentistry in posterior primary mandibular teeth. Two clinicians performed 84 treatments with 50 children. Anesthetic doses of articaine hydrochloride, ranging from 0.3 to 2.5 ml, were administered to mandibular primary molars using an infiltration technique. After 10 min, a rubber dam was applied and operative dentistry performed. Anesthesia was successful in all cases, and no reinjection was performed. The authors reported that in a few instances in which a child complained of pain at the beginning of the procedure, an additional 5-min waiting period was allowed.

The present investigation has two purposes: to determine the effectiveness of mandibular infiltration anesthesia in the primary molar region, and to assess how variables such as age of the patient, tooth location, and type of anesthesia are related to the quality of anesthesia when the infiltration technique is used.

## Methods and Materials

The study design was double blind, with the following independent variables: child's age, treatment site, and local anesthetic type.

A pilot group of 10 children was selected to refine the methodology and establish rater reliability. The actual experimental group was selected from children who were treated at the clinic at the University of Western

**Table 1. The SEM scale used to measure comfort or pain**

| *Observations* | *Comfort or Pain Level* 1. Comfort | 2. Mild Discomfort | 3. Moderately Painful | 4. Painful |
|---|---|---|---|---|
| Sounds | No sounds indicating pain | Nonspecific sounds; possible pain indication | Specific verbal complaints, e.g., "OW", raises voice | Verbal complaint indicates intense pain, e.g., scream, sobbing |
| Eyes | No eye signs of discomfort | Eyes wide, show of concern, no tears | Watery eyes, eyes flinching | Crying, tears running down face |
| Motor | Hands relaxed; no apparent body tenseness | Hands show some distress or tension; grasps chair due to discomfort, muscular tension | Random movement of arms or body without agressive intention of physical contact, grimace, twitch | Movement of hands to make agressive physical contact, e.g., punching, pulling head away |

**Table 2. Frankl Behavioral Scale (Frankl et al. 1962) used to measure cooperative behavior**

| | |
|---|---|
| Rating 1: | Definitely negative<br>Refusal of treatment, crying forcefully, fearful, or any other overt evidence of extreme negativism |
| Rating 2: | Negative<br>Reluctant to accept treatment, uncooperative, some evidence of negative attitude but not pronounced (i.e., sullen, withdrawn) |
| Rating 3: | Positive<br>Acceptance of treatment; at times cautious; willingness to comply with the dentist, at times with reservation, but patient follows the dentist's directions cooperatively |
| Rating 4: | Definitely positive<br>Good rapport with the dentists interested in the dental procedures, laughing and enjoying |

Ontario. To be included, children had to: be 42–78 months old; require conventional operative dentistry in the first or second mandibular primary molars; have essentially negative medical histories; and appear compliant at the initial visit, or have a history of compliance at previous clinic visits. A signed informed consent was obtained from each child's parent or guardian as required by the Human Investigation Committee standards.

Children selected for inclusion in the study were assigned by an appointment clerk to one of the three anesthetic groups. The three local anesthetics used, all containing epinephrine 1:200,000, were mepivacaine hydrochloride 2% (Carbocaine® HCl, Cooke-Waite, New York, NY), prilocaine hydrochloride 4% (Citanest Forte®, Astra Pharmaceuticals, Inc. Mississauga, Ontario, Canada), and articaine hydrochloride 4% (Ultracaine® DS, Hoechst Canada Inc., Montreal, Quebec, Canada). On the appointed day, the dental assistant prepared the syringe with the local anesthetics as designated by the appointment clerk. The barrel of the syringe was masked so that the three operators participating in the study were unaware of the anesthetic type. In all cases, topical anesthetic (Xylocaine® Dental Ointment 5%, Astra Pharmaceuticals, Inc., Mississauga, Ontario, Canada) was used and 1.0 ml local anesthetic was injected in the mucobuccal fold, between the roots of the teeth to be restored. The amount of local anesthetic was determined by the operator from markings on the depressing piston of the syringe. Uniject® (Hoechst Canada Inc., Montreal, Quebec, Canada) needles, #30 gauge, were used with all subjects.

Following a 10-min latency period, the carious molar was probed buccally and lingually to ascertain the quality of anesthesia. Subsequently, the rubber dam was applied using an Ivory® 12A or 13A clamp (Miles Inc., St. Louis, MO) on the second primary molar in the quadrant. The operative procedure began and the enamel was penetrated with a high-speed 330 bur using a water coolant. When the operator entered the dentin, he announced that he was "entering dentin." This served as a signal for the raters to evaluate anesthesia during the preparation procedure. Since it is possible under high-speed conditions that an operator could misjudge a dentinoenamel junction location, the raters were instructed to make their evaluations at the time of the pronouncement, as well as up to 5 sec following the signal.

All experimental procedures were videotaped and rating was performed from the videotapes by a single, independent rater with established rating reliability. Ratings were performed using two scales. The first scale was designed for this investigation to measure subject comfort or pain (Table 1). The second scale measured children's behaviors (Table 2).

The ratings of comfort and pain were made at four separate intervals—during the injection, probing for anesthesia, placing the rubber dam, and penetrating the dentinoenamel junction of the tooth. The rating of comfort took into account three types of observations — sounds, eyes, and motor. The level of response for each observation was given a numerical value and these values were averaged to obtain the comfort level at a rating interval. The children's behaviors were rated using the scale of Frankl et al. (1962) at the same four intervals. Data derived from both of these scales were dichotomized when statistical analyses were performed. The dichotomized data were analyzed by a Chi-square analysis. All tests were performed with one degree of freedom, and the 0.05 level of significance was used.

An interesting problem arose in data management. Following the injection, each of the remaining three evaluative intervals ascends a hierarchy of potentially painful stimuli. Operators discontinued the procedure if they believed that it was causing the child considerable pain. The incomplete data under these circumstances were completed as if the child was in pain. Thus, the data reflect the worst possible scenario. Children whose behavior interfered with an assessment of discomfort or pain were removed from the study and were not considered in the data analyses. This usually was discovered at the time of injection or shortly thereafter.

## Results

The initial study population consisted of 75 children; however, the results of the investigation are derived from 66 children, 35 males and 31 females. Six children were eliminated from the study because their behaviors did not allow reasonable pain evaluation, and three children were omitted because of technical problems during the videotaping procedures.

The reliability of the rater was established in two ways. First, the rater's evaluations on the scales were compared to the evaluations of two others. The interrater reliability was found to be 90% for 40 observations, with little difference between scales. Second, the rater evaluated the same group of subjects on two different occasions. The intrarater reliability was found to be 95%.

Table 3 provides an assessment of the comfort or lack of pain experienced during the experimental procedure. When all subjects are considered, 43 of 66, or 65%, of the patients appeared to have no pain during cavity preparation. Note that following the injections there is a decrease in subject comfort with each succeeding evaluation interval. This was anticipated because each successive procedure ascends a pain hierarchy following the injection. No statistically significant gender differences in pain response were found.

Since pain tolerance varies between patients, the subjects' responses also were analyzed, taking into account their reactions to injections. In Table 3, subjects' responses also are divided into two groups; those who demonstrated comfort or mild discomfort (little or no pain) and those who had apparent pain. These data revealed that those children demonstrating comfort at the time of injection were more likely to exhibit no pain during successive procedures. This finding was statistically significant for the probing ($P = 0.05$) and rubber dam placement ($P = 0.05$), and tended toward significance when drilling ($P = 0.1$). Conversely, subjects experiencing pain during injections were likely to demonstrate further pain from other experimental procedures ($P < 0.05$ at all observations).

Three operators participated in the investigation and the data were analyzed to assess operator differences (Table 4). While the data reveal that operators 1 and 2 had a lower percentage of comfortable patients during the injection in comparison to operator 3, a consistent pattern was lacking when all procedures were considered. A comparison of the results between operators failed to reach statistical significance as all $P$ values exceeded 0.1.

**Table 3. Comfort or pain assessment using infiltration anesthesia for mandibular molars**

| | | Evaluation Intervals | | |
|---|---|---|---|---|
| *Subjects* | *Injection* | *Probe* | *Rubber Dam* | *Preparation* |
| All subjects | 39/66 (59%) | 55/66 (83%) | 53/66 (80%) | 43/66 (65%) |
| No injection pain | — | 35/39 (90%) | 35/39 (90%) | 28/39 (72%) |
| Injection pain | — | 20/27 (74%) | 18/27 (67%) | 15/27 (56%) |

**Table 4. A comparison of patient comfort for each dentist**

| | | Evaluation Intervals | | |
|---|---|---|---|---|
| *Operator* | *Injection* | *Probe* | *Rubber Dam* | *Preparation* |
| #1 | 8/15 (53%) | 10/15 (67%) | 10/15 (67%) | 9/15 (60%) |
| #2 | 12/24 (50%) | 22/24 (92%) | 22/24 (74%) | 14/24 (58%) |
| #3 | 19/27 (70%) | 23/27 (85%) | 21/27 (78%) | 20/27 (74%) |

In Table 5, subjects are divided into cooperative and uncooperative groups and these behaviors are related to patient comfort. For example, at the time of injection, 56 patients were judged to be cooperative; 39 of this group were considered to be pain free or have little discomfort. All of the uncooperative children were judged as having pain during the injection. The other evaluation intervals also show high relationships between cooperative behavior and comfort. These findings attained statistical significance ($P < 0.05$) at all intervals except the probing interval, which tended toward significance.

Three variables in mandibular infiltration anesthesia are considered in Table 6. None reached statistical significance when all subjects were considered. Even when the responses of children who were comfortable at injection were considered, the findings were inconsistent.

## Discussion

If mandibular infiltration is considered an effective means of achieving anesthesia for restorative dentistry in primary molars, treatment has to be rendered without pain. In designing this study, the question of how to measure pain became an important issue. Physiological measures were deemed inappropriate because an injection is an anxiety-evoking stimulus and it is difficult to distinguish anxiety from pain, physiologically. Anxiety and pain are psychological constructs lacking clear physical parameters and they are perceived to have considerable overlap in their physiological and psychological components (Levitt 1967; Talbot et al. 1971; Pawlicki 1988).

In the past, observational scales have been a means of pain measurement. None of these scales, however, measures situational or acute pain. Most scales are used to measure chronic pain in patients having leukemia, arthritis or other debilitating diseases and they were not feasible for measuring pain in the dental situation because questions often were misdirected (e.g., Did you sleep last night?). Chronic pain scales, however, offered a framework for the development of the SEM scale (Table 1) that was used in this study and key questions were selected from these scales. Similar to some chronic pain scales, the SEM scale focuses on patient sounds, ocular, and motor changes.

Since this is its initial application, the SEM scale's validity can be questioned. Only through further research and application will its value be assessed further. The SEM scale was pretested for its reliability and ease of use. The 90% interrater reliability was comparable to other observational scales and there was little problem with its implementation. Rarely were there disparate responses. Sounds and movements usually accompanied one another. Hence, the SEM scale became the instrument for comfort or pain measurement.

There has been divided opinion on whether mandibular infiltration anesthesia can provide adequate anesthesia for restorative dentistry (McCallum 1973; McDonald et al. 1987; Wright et al. 1987). Since 43 children had a pain-free experience, the technique could be regarded as effective. However, since these subjects represent only 65% of the study population, the technique cannot be considered as reliable. The finding agrees with the opinion of McDonald et al. (1987), but disagrees with the suggestion of Dudkiewicz et al. (1987), who reported good mandibular infiltration anesthesia for 84 primary molar restorative treatments. The latter, in some instances, used larger anesthetic doses, sometimes waited longer than 10 min before completing treatments, used only articaine hydrochloride, and based

**Table 5. Relationship between comfort or pain and cooperative behavior**

| | *Evaluation Intervals* | | | |
|---|---|---|---|---|
| | *Injection* | *Probe* | *Rubber Dam* | *Preparation* |
| Comfort/cooperative | 39/56 (70%) | 53/63 (84%) | 52/59 (88%) | 42/57 (74%) |
| Comfort/uncooperative | 0/10 (0%) | 2/3 (67%) | 1/7 (14%) | 1/9 (11%) |

**Table 6. The relationship of three variables — age of patient, tooth and anesthetic type to the quality of mandibular infiltration anesthesia**

| | | *Evaluation Intervals* | | |
|---|---|---|---|---|
| | | *Probe* | *Rubber Dam* | *Drill* |
| Age | 42 mo. to 59 mo. | 30/35 (86%) | 28/35 (80%) | 18/35 (51%) |
| | 60 mo. to 78 mo. | 25/31 (81%) | 25/31 (81%) | 25/31 (81%) |
| Tooth | 1° molar | 28/35 (80%) | 25/35 (71%) | 25/35 (71%) |
| | 2° molar | 27/31 (87%) | 28/31 (90%) | 18/31 (58%) |
| Anesthetic Type | Citanest | 15/19 (70%) | 16/19 (84%) | 11/19 (58%) |
| | Ultracaine DS | 22/25 (88%) | 17/25 (68%) | 17/25 (68%) |
| | Carbocaine 2% | 18/22 (82%) | 20/22 (91%) | 15/22 (68%) |

their report solely on subjective observations.

To determine the effectiveness of the infiltration anesthesias, pain was assessed at three procedural stages — probe, rubber dam placement, and drilling. These three stages ascend a pain hierarchy. Probing tests anesthesia of the buccal and lingual soft tissues; the rubber dam adds clamp pressure buccally and lingually; and the drilling assesses anesthesia of the tooth per se. Table 3 shows that the comfort level of anesthesia declines as pain stimuli increase. Interestingly, four of five children had adequate anesthesia on the lingual to allow pain-free rubber dam placement. The comfort may be due to diffusion of the anesthetic; however, the data did not reveal a significant difference between the diffusion capabilities of anesthetic types (Table 5).

Since anxiety levels could influence pain perception, an attempt was made to differentiate between subjects with high and low anxiety levels. The subjects were divided by their responses during injection. Thirty-nine (59%) of the subjects exhibited little or no pain at injection time and they could be a low anxiety group. The findings then revealed that these children are likely to exhibit no pain during successive procedures. Thus, the reactions of children at the time of injection may be helpful in deciding whether or not to proceed with a procedure using only infiltration alone.

Since the SEM scale was untested previously, we also decided to assess the subjects' cooperation with the scale of Frankl et al. (1962). The latter scale has been used frequently. Since it is unlikely that children experiencing discomfort would be compliant, the Frankl scale could serve as a check on the new SEM scale. There was a statistically significant relationship ($P < 0.05$) between cooperative behavior and patient comfort at all evaluation intervals. The result would be expected if the SEM scale had any validity. It is clinically important to note that children who were uncooperative at injection tended to exhibit discomfort on successive procedures.

Studying the effectiveness of mandibular infiltration anesthesia requires taking into account several variables. One of these is tooth location. Wright et al. (1987) suggested that mandibular infiltration would be more effective for treatments on first primary molars in comparison to second primary molars. The basis for the suggestion was that bone porosity in the mandible is greater toward the anterior, making the first primary molar regions more favorable for the infiltration technique (Bloom 1954). In the present study, a relationship between tooth location and little or no pain during treatment was inconsistent for the entire subject group.

Another variable investigated was the subject's age. It had been suggested that chronologic age could have some bearing on the quality of anesthesia, since the bone of younger children might be less dense than the bone of older subjects (McCallum 1973; Wright et al. 1987). When the subjects' ages were divided into two groups, 42–59 months and 60–78 months, no statistically significant relationships were found between the age of children and anesthetic effectiveness. Both groups performed similarly for the probe and rubber dam, but the younger children were affected more adversely during drilling. It is possible that the noise of the high-speed drill raised their anxieties and their pain perception.

Infiltration effectiveness could depend upon a local anesthetic's potency and diffusion capabilities. Consequently, type of local anesthesia was another variable taken into consideration. To make the anesthetics somewhat comparable, the three anesthetics that were selected for the investigation all contained 1:200,000 vasoconstrictor. It was disappointing when the data failed to show any significant differences between anesthetics. Possibly, anesthetic differences may have been found with a briefer latency period. Since Malamed's (1986) descriptions of anesthetics suggested that articaine hydrochloride had 1.5 times the potency of lidocaine, it was hoped that the greater potency would provide better infiltration results.

Operator technique and management skills also could influence results. As shown in Table 4, while there were operator differences, they did not attain statistical significance.

In the design of this investigation, we considered using a mandibular block as a standard of comparison. This presented problems, such as obtaining a study population with bilateral treatment needs, the possibility of not identifying inadequate mandibular blockage, or adversely affecting a child's behavior with recently administered block anesthesia. Nonetheless, in any future investigations of this type, it might be considered in the study design.

This was the first objective investigation into the effectiveness of mandibular infiltration anesthesia for the treatment of primary molars. Since there are advantages to using infiltration rather than block anesthesia, further research is required to assist clinicians in determining under what conditions the technique can be applied, and what variables influence the reliability of the technique.

## Conclusions

Data for this investigation were derived from 66 children undergoing restorative procedures in their mandibular primary molars. All children were provided with local anesthesia using an infiltration technique. Based on observational data, the findings were:

1. Little or no pain is experienced by 65% of subjects during cavity preparation.
2. Children who demonstrate comfort at the time of injection are likely to exhibit no pain during successive procedures.
3. There is a high relationship between children behaving cooperatively and comfort during procedures.
4. When profoundness of anesthesia for all subjects was considered, the three variables — tooth location, chronologic age, and anesthetic type — were not statistically significant.

The authors thank Hoechst Canada Inc. for its financial support of this investigation.

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## Future Annual Session Sites

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| May 27–June 1, 1993 | Hyatt Regency Crown Center and Westin Crown Center, Kansas City, MO |
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