# Effectiveness of computerized delivery of intrasulcular anesthetic in primary molars

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## ABSTRACT

**Background.** Pain measures associated with computerized delivery of intrasulcular anesthetic have not been reported. The authors evaluated a computerized delivery system for intrasulcular (CDS-IS) anesthesia in primary molars.

**Methods.** The study population consisted of children aged 2 to 13 years who received CDS-IS injections, 159 in mandibular molars and 48 in maxillary molars. Children were treated by one of three modes of behavioral management: behavior modification (BM) only, inhalation of nitrous oxide ($N_2O$) in addition to BM or intrarectal sedation. Variables evaluated included the subjective perception of the child's well-being before and after administration of the anesthetic, the child's pain behavior during anesthetic administration, effectiveness of the anesthetic during dental treatment, incidence of reported postoperative dental pain (PDP) and analgesic use after the CDS-IS injections.

**Results.** The effectiveness of CDS-IS anesthesia in mandibular molars was 97 percent, 92 percent, 63 percent and 71 percent for restorations, preformed stainless steel crowns, extractions and pulpal therapies, respectively (mean effectiveness, 89 percent). The effectiveness of CDS-IS anesthesia in maxillary molars was 96 percent, 50 percent, 92 percent and 78 percent, respectively (mean effectiveness, 90 percent). CDS-IS was less effective in children aged 2 to 4 years who received sedation than it was in older children. The authors found no differences between children's subjective self-reports of well-being before and after anesthetic administration, between the sexes and/or between modes of behavioral management (that is, BM or $N_2O$). Most children exhibited low pain-related behavior during anesthetic administration, with no differences between boys and girls. The overall incidence of PDP was 31.4 percent; 64.9 percent of these patients received pain-relieving medications as a result, with no correlation to age, tooth treated, effectiveness of anesthesia or type of treatment.

**Conclusions.** CDS-IS is effective for anesthetizing primary molars, mainly for amalgam, resin-based composite and stainless steel crown restorations.


**Key Words.** Computerized anesthesia; intrasulcular anesthesia; primary molars.

Effective pain control in children during dental treatment is important to achieving comfort, cooperation and compliance with dental care during adulthood.[1-3] Several methods have been suggested to reduce injection pain, one of which is slow delivery of the anesthetic solution.[4-6] A low-pressure microprocessor-controlled delivery system (Wand, Milestone Scientific, Deerfield, Ill.) has been developed to decrease the pressure and speed of the injection. Several authors have reported that this system decreased pain-disruptive behavior during palatal injections by two to three times, but had no effect on buccal infiltration or a mandibular block.[5-10]

**The computerized delivery system is effective for anesthetizing primary molars.**

## BACKGROUND

Pain during dental treatment can be a result of ineffective anesthesia.[11-13] Unfortunately, an insufficient level of anesthesia during dental procedures occurs in approximately 11.6 percent of children aged 26 to 155 months,[14] which can be attributed to the child's age, sex,[4,15,16] symptoms,[14,17-21] anxiety at injection,[14,22-25] initial dose of anesthetic agent administered,[26,27] operative procedure performed,[14,15] use of nitrous oxide/oxygen analgesia and oral sedation,[28] arch treated[11,15] and method of local anesthetic administration.[29-32]

**Mandibular primary molars.** The most routinely used method to anesthetize mandibular primary molars

is the inferior alveolar block.[33,34] However, this method has several disadvantages:

- it is significantly more painful than buccal infiltration, sometimes affecting the child's behavior[34];
- its effectiveness is limited to 63 to 87 percent of cases[11-13,35,36];
- the lengthy duration of anesthesia increases the possibility of postoperative trauma, such as lip or tongue biting.[1]

Local infiltration, as an alternative to the mandibular block in children, is unreliable,[30-32] with a success rate of approximately 65 percent.[1] This mode of anesthetic administration is least effective with pulpotomies and extractions.[32,34]

Intraligamentary anesthetic delivered via a high-pressure syringe is another alternative to a mandibular block.[37,38] Its advantages include easy administration, the absence of soft-tissue numbness, short anesthesia duration and a smaller volume of anesthetic solution needed (an important factor in pediatric patients). However, the anesthetic fluid, which is injected under pressure, could interfere with the development of the corresponding permanent dental buds.[39] This technique also is associated with lengthy postoperative pain (up to seven days after the injection) and a relatively short period of anesthesia for quadrant dentistry.[40-43]

**Maxillary primary molars.** The most routinely used procedure for anesthetizing maxillary molars is the buccal infiltration. However, this technique also may be associated with unsuccessful anesthesia because of the deep location of the apex of the second primary molars beneath the zygomatic bone, which may be too dense and thick to allow adequate infiltration.[29,30]

To our knowledge, no data are available regarding the effectiveness of the computerized delivery system for intrasulcular (CDS-IS) anesthesia in primary molars. Moreover, no data are available regarding the incidence of postoperative dental pain (PDP) after intrasulcular anesthetic is injected via a low-pressure delivery system.

The purpose of this study was threefold:

- to evaluate children's subjective perception of pain and pain-disruptive behavior during the procedure;
- to evaluate the effectiveness of CDS-IS anesthesia for various dental procedures in primary molars;
- to evaluate the incidence of PDP associated with CDS-IS anesthesia.

## PATIENTS AND METHODS

**Study population.** One hundred ninety-three children aged 2 to 13 years who received dental treatment in two pediatric dental clinics participated in the study. We introduced patients' parents to the CDS-IS system and requested them to give their oral consent. Two of us (M.A., S.B.) administered one maxillary or mandibular injection in each child (14 children underwent treatment in both the mandibular and maxillary arches and received two injections). A structured form was designed to collect all data regarding demographic and dental variables, including the patient's age, sex, mode of behavioral management used (behavior modification [BM] only, inhalation of nitrous oxide ($N_2O$)/oxygen or sedation via intrarectal midazolam), tooth location and dental procedure (resin-based composite or amalgam restoration, stainless steel crown, pulpotomy or tooth extraction).

For analysis, we categorized the children into groups according to their age and treatment mode: group 1: ages 2 to 4 years; group 2: ages 5 to 8 years; and group 3: ages 9 years and older.

**Mode of behavioral management.** The two clinicians achieved proper behavioral cooperation from the children by using three approaches:

- BM (nonpharmacological) techniques only, such as tell-show-do,[44] desensitization, empathy, giving control to the child by raising the left hand, retraining, behavior shaping, reframing and distraction;
- inhalation of $N_2O$/oxygen (up to 45 percent $N_2O$) in addition to BM;
- $N_2O$ inhalation combined with sedation (intrarectal midazolam [0.4 milligram/kilogram], up to a maximum dose of 7.5 mg). The clinicians used this approach only for difficult patients (mainly very young children).

The Ethics Committee of Tel Aviv University, Israel, approved the study.

Table 1 shows the distribution of patients according to mode of behavioral management, age and dental arch treated.

**CDS-IS procedure.** Each injection was preceded by a 50-second application of topical gel (benzocaine 20 percent) outside and inside the sulcus corresponding to the teeth to be anesthetized. The clinicians used the CDS to anesthetize the primary molars, according to the manufacturer's recommendations. The local anesthetic solution was administered intrasulcu-

**TABLE 1**

**PATIENT DISTRIBUTION ACCORDING TO MODE OF BEHAVIORAL MANAGEMENT, AGE AND ARCH TREATED.**

| MODE OF BEHAVIORAL MANAGEMENT | NUMBER OF PATIENTS* | | | | | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | Group 1 (Ages 2 to 4 Years) | | Group 2 (Ages 5 to 8 Years) | | Group 3 (Ages 9 Years and Older) | | | |
| | Lower† | Upper‡ | Lower | Upper | Lower | Upper | Lower | Upper |
| **Behavioral Modification Only** | 6 | 0 | 24 | 11 | 11 | 12 | 41 | 23 |
| **Nitrous Oxide Inhalation and Behavioral Modification** | 10 | 1 | 24 | 5 | 9 | 3 | 43 | 9 |
| **Sedation and Nitrous Oxide Inhalation** | 47 | 14 | 26 | 2 | 2 | 0 | 75 | 16 |
| **TOTAL** | **63** | **15** | **74** | **18** | **22** | **15** | **159** | **48** |

* Fourteen children underwent treatment in both arches.
† Mandibular primary molars.
‡ Maxillary primary molars.

larly, using a 30-gauge extra short needle inserted parallel to the long axis of each root of the anesthetized tooth. Each tooth received a distinct anesthetic injection, one at the mesiolingual and buccal line angle, the other at the distolingual and buccal line angle.

For the maxillary molars, the clinicians injected several drops of local anesthetic solution into the palatal sulcus until blanching occurred. All procedures involved the use of a lidocaine cartridge (2 percent with 1:100,000 epinephrine). As a rule, the dentists administered 0.9 milliliter of local anesthetic for each root of the primary molar. Two molars in each patient were anesthetized; one for application of the rubber-dam clamp, the other for the operative treatment. Where two adjacent primary molars in one quadrant were treated, the dentists applied the clamp on the second primary molar to prevent anesthetizing three teeth at once. In these cases, they administered up to 1.8 mL of anesthetic and distributed it equally among the teeth. The amount of local anesthetic did not exceed 4.4 mg/kg body weight of the child. Immediately after administration of the anesthetic and before the operative treatment, the dentists applied a tooth clasp and a rubber dam.

**Anesthesia evaluation.** *Childrens' self-report*s. To assess the child's subjective perception of well-being before and immediately after the injection, the clinicians used a face picture scale (FPS).[45-47] The scale consists of five faces, ranging from laughing to crying, painted on a 100-millimeter ruler. The dentists asked the child to indicate, with the use of a free-moving bar, the place on the ruler that best represented his or her feeling at the moment. They measured the distance of the bar from the 0 point (laughing face) on the ruler and used it for further calculations (scores ranged from 0, indicating no pain at all [smiling], to 100, indicating severe pain [crying]). Only children in the BM and $N_2O$ groups completed this scale. Children who received sedation were unable to respond.

*Child's pain behavior during administration of anesthetic.* One of two dental assistants who did not participate in the treatment sat beside the child during the injection and served as an impartial observer. The observer scored the child's behavior according to the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS), which is the most widely used scale to evaluate pain behavior immediately after an operative procedure or for needle pain.[48] This scale has been shown to have excellent interrater reliability (90 to 99.5 percent) and good evidence of validity when used for young children after surgery.[49] In this study, the observer scored the child's behavior immediately after the injection.

The scale refers to several parameters (crying, facial display, verbal expression, torso movements, touching the injection area and leg movements) and rates them according to several possible behaviors: from 0—behavior that is the

antithesis of pain—to 3—behavior indicative of severe pain. The total score ranges from 4 to 13.

Two of us (M.A., S.B.) conducted a pilot study to validate the CHEOPS; the two pediatric dentists watched 15 patients and rated them separately. The dentists discussed each disagreement they had until they reached complete agreement. Afterward, each dentist explained the scale to the impartial observers (that is, each dentist's dental assistant) in her private practice, and practiced it on another 15 patients. At that point, the two dentists and the impartial observers achieved complete agreement. We did not include these patients in this study.

*Anesthesia effectiveness*. The two dentists assessed the effectiveness of anesthesia through the presence or absence (noncontiguous) of pain-disruptive behavior during treatment, as described by Oulis and colleagues.[32] They rated each single sign of discomfort (even mild) as the presence of pain. Signs of discomfort included visual or acoustic changes, such as hand or body tension or movements; eye movements; oral complaints; or tears. The dentists rated anesthesia as adequate only when the child was completely relaxed during treatment (that is, no evidence of pain-disruptive behavior).

**Evaluation of PDP and use of analgesic drugs 24 hours after surgery.** The dentists avoided suggestions from the children or their parents regarding PDP or analgesics during and immediately after treatment. Any questions posed by the child or parent were answered, but the dentists did not give any prescriptions for pain medications. A secretary, who was unaware of the treatment performed, telephoned parents eight to 24 hours after the procedure to request information regarding PDP, the use of analgesic drugs or both by the child. The secretary asked the parents to involve their child in their responses if he or she was mature enough. We excluded the child from the study if parents could not be reached within 24 hours. All parents who could be reached responded to the telephone questionnaire.

**Statistical analysis.** We used the Pearson $\chi^2$ test to evaluate the possible associations between anesthesia effectiveness, sex, age, mode of behavioral management, dental procedure performed and CHEOPS score. We used a *t* test to evaluate differences between FPS scores before and after the anesthetic was administered. Two-way analysis of variance was used to evaluate interactions between CHEOPS scores, age and sex. We evaluated the correlation between FPS and CHEOPS scores using the Spearman rank correlation coefficient. We set an a priori level of statistical significance at $P < .05$.

## RESULTS

**Population description.** Of the 193 children in the study population, 159 (82 percent) (mean ± standard deviation [SD] age, 6.4 ± 2.3 years; median age, 6 years) received treatment in mandibular primary molars and 48 (25 percent) (mean ± SD age, 7.5 ± 3.1 years; median age, 7.4 years) received treatment in maxillary primary molars (14 children received treatment in both arches). Table 1 summarizes the distribution of patients. Within the first 24 hours after treatment, we attempted to reach and interview the parents of 135 patients. Of these parents, 119 (88 percent) were successfully contacted, all of whom agreed to respond to the questionnaire.

**Dental procedures.** The dentists treated 82 first primary molars (65 mandibular and 17 maxillary) and 125 second primary molars (94 mandibular and 31 maxillary). Treatment procedures included placing 121 amalgam or resin-based composite restorations, seating 28 preformed stainless steel crowns, 30 pulpotomies and 28 extractions. Table 2 shows the distribution of teeth according to the treatment performed, teeth treated, arch treated and effectiveness of anesthesia.

**Anesthesia evaluation.** *Children's self-reports.* Ninety-two children treated with BM or $N_2O$ completed the FPS scales before and immediately after they received the anesthetic (64 children treated in the mandibular arch, 28 children treated in the maxillary arch). The mean ± SD FPS score before and after injection was 11.4 ± 18.2 and 9.2 ± 18.0, respectively, in the mandibular molars compared with 23.0 ± 27.4 and 10.8 ± 16.6, respectively, in the maxillary molars. We found no significant differences in the scores received by children treated with BM or $N_2O$ or before and after administration of anesthetic, as well as no significant differences between the sexes.

Age was the only variable that significantly affected the children's self-reports. Children in group 3 (age ≥ 9 years) had significantly higher FPS scores before the injection than did children in the other two age groups (mean ± SD score, 24.3 ± 26.9 compared with 10 ± 17.1 [ages 5 to

8 years]) and 10.7 ± 28.3 [ages 2 to 4 years]; $P = .024$). However, they also tended to change their scores more often after the injection, usually to lower their scores (76.9 percent of children in group 3 compared with 28.6 and 29.4 percent in groups 1 and 2, respectively; $P = .002$).

*Evaluation of children's pain behavior during administration of anesthetic.* The CHEOPS score was available for 186 (96.4 percent) of 193 children (data are based on 157 children who received mandibular anesthetic and 47 children who received maxillary anesthetic). Most children exhibited low pain-related behavior (mean score for the mandibular arch, 6.1 ± 1.9 and for the maxillary arch, 5.61 ± 1.4). We found no significant differences between the sexes or between age groups. However, when receiving the CDS-IS injection, children in the sedation group received significantly higher CHEOPS scores (mean score, 6.9) than did children in the $N_2O$ or BM groups (mean score, 5.4 and 5.4, respectively; $P = .013$).

We found a significant correlation between the FPS score before the injection (data are based on 190 [98.4 percent] of 193 children) and the child's behavior during the injection, as recorded by CHEOPS ($P = .032$).

*Anesthesia effectiveness.* The mean effectiveness of the CDS-IS anesthesia was 90 percent for maxillary primary molars and 89 percent for mandibular primary molars (Table 2). The effectiveness was higher for restorations and preformed crowns and lower for extractions and pulpal therapy ($P < .001$ for mandibular molars; not significant for maxillary molars). We found that anesthesia effectiveness was unaffected by sex or tooth location (first or second primary molars) in both arches. The effectiveness of anesthesia in children aged 2 to 4 years (group 1) and in children treated with sedation was lower than that in older children or in children in the BM or $N_2O$ groups ($P = .042$).

**Correlation analyses.** We found no correlation between children's self-reports of well-being (FPS scores) before and immediately after the injection and the effectiveness of anesthesia in both arches. We found a significant correlation between children's pain behavior during the injection (CHEOPS score) and the effectiveness of anesthesia (mean ± SD CHEOPS score for children with effective and ineffective anesthesia was 5.88 ± 1.69 and 7.42 ± 2.46, respectively; $P < .01$).

**TABLE 2**

**EFFECTIVENESS OF INTRASULCULAR ANESTHESIA IN FIRST AND SECOND PRIMARY MOLARS.**

| TREATMENT | NUMBER (PERCENTAGE) OF TEETH IN WHICH ANESTHESIA WAS EFFECTIVE | | | |
|---|---|---|---|---|
| | First Primary Molar | | Second Primary Molar | |
| | Mandible | Maxilla | Mandible | Maxilla |
| Amalgam or Resin-Based Composite Restoration | 38 (100) | 8 (100) | 55 (95) | 16 (94) |
| Preformed Stainless Steel Crown | 9 (90) | 0 (0) | 15 (94) | 1 (100) |
| Extraction | 3 (38) | 6 (86) | 7 (88) | 5 (100) |
| Pulpotomy | 7 (78) | 1 (100) | 8 (67) | 6 (75) |
| **TOTAL** | **57** (88) | **15** (88) | **85** (90) | **28** (90) |

**PDP.** We evaluated PDP in 118 children. The mean incidence of PDP after the CDS-IS injection was 31.4 percent (37 of 118 patients); 64.9 percent of those with PDP received pain-relieving medication. We found no differences between age groups (15 [31.9 percent] of 47 children aged 2 to 4 years, 17 [36.2 percent] of 47 children aged 5 to 8 years and five [23.8 percent] of 21 children aged 9 years or older had PDP; $P = .6$; age data were missing for three children).

PDP also was not affected by tooth number (mean incidence, 22.2 percent in maxillary first molars [two of nine children], 22.2 percent in maxillary second primary molars [four of 18 children], 27.8 percent in mandibular first primary molars [10 of 36 children] and 38.9 percent in mandibular second primary molars [21 of 54 children]; $P = .45$; the tooth number was missing for one child).

PDP was not affected by sex (19 [33.3 percent] of 57 boys and 18 [29.5 percent] of 61 girls had PDP; $P = .7$) or by the different behavioral management modes (eight [25 percent] of 32 children in the BM group, 12 [36.4 percent] of 33 children in the $N_2O$ group and 17 [32.1 percent] of 53 children in the sedation group had PDP; $P = .6$). The study results showed a slightly higher incidence of PDP after pulpal therapy compared with

restorative therapy (eight [57.1 percent] of 14 children versus 17 [25.8 percent] of 66 children, respectively); however, this difference did not reach statistical significance. The study results showed no significant differences between the two treating dentists with regard to PDP ($P = .89$) or with regard to the effectiveness of anesthesia ($P = .7$).

**General observations.** In 70 percent of the children, administration of the anesthetizing solution at the lingual surface also caused blanching on the buccal surface. Seventy-four percent of the patients reported having lower lip numbness, but we observed no tongue anesthesia or lip biting.

## DISCUSSION

To our knowledge, this is the first study to report the clinical effectiveness of CDS-IS anesthesia in maxillary and mandibular primary molars. Although intrasulcular anesthetic delivered via a low-pressure delivery system is injected into the same area as that of the intraligamentary anesthetic delivered via a high-pressure syringe, these two techniques are completely different. The low-pressure delivery system enables the operator to inject the anesthetic solution at an extremely low pressure (165 pounds per square inch), enabling laminar diffusion into the adjacent bone and avoiding damage to the adjacent tissue. In contrast, the intraligamentary anesthetic injected via a high-pressure syringe induces high pressure on the tissue (1,200 psi), which causes ischemia and, subsequently, transitional necrosis of the adjacent bone and lengthy PDP.[39-42]

**Pain-related behavior.** Several studies have evaluated patients' pain-related behavior during the conventional methods.[4-10,34] These studies have shown that a mandibular block induces significantly more pain-related behavior in children during anesthetic administration than does buccal infiltration, and that quiet behavior could turn negative during administration of the block via a conventional syringe.[4,34]

Moreover, a palatal injection, which is a necessary adjunct to buccal infiltration for the clinician to painlessly place a rubber dam, matrix or wedge in children, also is painful when administered via a conventional syringe.[5,6] To reduce the pain associated with the injection, several clinicians have suggested that the anesthetic be administered at a slow pace (that is, via CDS).

Although Asarch and colleagues[8] and Ram and Peretz[9] reported that CDS had no advantage in reducing pain-related behavior during a mandibular block, other authors[5,6,10] reported that it reduced the pain-related behavior during a palatal injection. Hochman and colleagues[6] compared the pain associated with palatal injections administered via a conventional syringe with that of CDS-administered injections among 50 patients. They found that the mean pain level for CDS and the conventional syringe was 21.42 and 61.64, respectively, on a visual analog scale (with 0 indicating no pain and 100 severe pain). Moreover, when using a 5-point oral scale to compare palatal injections, they found the mean pain score for CDS and a conventional syringe to be 1.02 and 2.5, respectively,[6] which is in accordance with our study results.

In our study, we used the CDS in a new way, by injecting the solution directly into the intrasulcular area. CDS-IS anesthesia was associated with relatively few pain-related behaviors, as rated on the CHEOPS and the FPS. Generally, children rated the experience before and after the injection as relatively nonstressful, with no effect of the behavioral management mode (that is, BM or $N_2O$). Interestingly, most of the oral complaints were directed toward the bitter taste of the anesthetic solution that leaked into their mouths. We should point out that CDS-IS anesthesia was less effective in children aged 2 to 4 years who received sedation than it was in older children (most of whom did not receive sedation); further studies are required for this age group.

Our results show that CDS-IS anesthesia is highly effective for restorations, but it is less effective for pulpal therapy. This is in agreement with the findings of Nakai and colleagues,[14] and it might be attributed to the fact that many of these teeth were symptomatic initially and associated with acute local inflammation, which could have reduced the efficacy of the anesthetic and lowered the patient's pain threshold. Furthermore, extractions require that pressure be placed on the tooth, which can be interpreted by the child as pain and discomfort. This is an important factor, because we considered even a single mild sign of discomfort, such as sound, eye movement and hand or body movement, to be an indicator of pain. Although this method probably lowered the apparent effectiveness of the anesthesia, we chose it because there is no valid method to differentiate between reactions to pressure or discomfort and to pain.

The effectiveness of CDS-IS anesthesia is equivalent, and even superior, to that of the mandibular block or mandibular buccal infiltration, according to data reported in previous studies.[1,14,20,35,50] The reported effectiveness of buccal infiltration in the mandibular arch was 65 to 95 percent for restorations (a total of 120 teeth), 47 to 62 percent for pulpal therapy (a total of 28 teeth) and 75 percent for extractions (a total of only four teeth).[1,31-33,35]

Similarly, the effectiveness of the mandibular block, which is the most routinely used anesthetic procedure in the restoration of mandibular primary molars, has been reported to be 63 to 87 percent.[11-13,33-35] Furthermore, the mandibular block has several additional disadvantages when administered in children; it is significantly more painful than buccal infiltration, sometimes affecting the child's behavior,[34] and the lengthy duration of anesthesia increases the possibility of postoperative trauma, such as lip or tongue biting.[1,30] Mild lip anesthesia occurred in 74 percent of the patients in our study, with no incidents of tongue anesthesia or lip-, tongue- or cheek-biting episodes observed within 24 hours after treatment (data not shown). Our results show that CDS-IS is at least as effective as the conventional methods used to achieve local anesthesia in children, without the disadvantages mentioned above.

The overall incidence of PDP after using CDS-IS in children was 31.4 percent, which is similar to the findings of Acs and Drazner[51]; they are the only authors, to our knowledge, to have reported the prevalence of PDP after conventional injections for operative dental procedures in children. Thus, CDS-IS anesthesia did not increase the incidence of PDP, which is in contrast with what has been reported for intraligamentary anesthesia achieved via a high-pressure syringe.[40-43] This suggests that CDS-IS anesthesia does not damage the periodontium.

**Antibiotic prophylaxis.** Usually, when an intraligamentary anesthetic is delivered via a high-pressure syringe to patients with possible cardiac problems, a systemic antibiotic prophylaxis is recommended.[52] This is because the gingival sulcus is populated by gram-positive anerobic bacteria that cannot be eliminated by an oral chlorhexidine rinse and possibly can initiate bacteremia and, subsequently, subacute bacterial endocarditis. Because CDS-IS also is injected into the gingival sulcus, clinicians should follow the same protocol of antibiotic prophylaxis in appropriate patients.

The CDS-IS technique has several advantages over the mandibular block. It is applied easily, self-inflicted injuries are decreased owing to its localized effect and bilateral dental procedures can be completed in one session. Dentists also can consider this technique for patients who suffer from hemophilia without replacement of deficient factor.[53]

**Minor disadvantages.** However, we should point out that CDS-IS anesthesia is associated with several minor disadvantages that clinicians should consider:

- an inability to calculate the precise amount of local anesthetic that has been injected owing to leakage of the solution into the mouth;
- longer injection time;
- high costs caused by the relatively high price of the disposable units needed for the injection.

Moreover, our preliminary results indicate that CDS-IS has not been as successful in anesthetizing permanent premolars and molars (data not shown). The reason is not completely clear, but it might be attributed to the longer roots of permanent teeth and slower diffusion within the denser alveolar bone.

## CONCLUSION

CDS-IS is a safe, efficient and reliable technique to achieve adequate anesthesia in children's primary molars, primarily for amalgam, resin-based composite or stainless steel crown restorations. The effectiveness is not related to sex or to tooth location (first or second primary molars). In addition, unlike intraligamentary anesthetic delivered via a high-pressure syringe, low-pressure CDS-IS anesthesia does not increase the incidence of PDP. ■

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1. Wright GZ, Weinberger SJ, Marti R, Plotzke O. The effectiveness of infiltration anesthesia in the mandibular primary molar region. Pediatr Dent 1991;13:278-83.
2. Berggren U, Meynert G. Dental fear and avoidance: causes, symptoms, and consequences. JADA 1984;109:247-51.
3. Milgrom P, Vignehsa H, Weinstein P. Adolescent dental fear and

control: prevalence and theoretical implication. Behav Res Ther 1992;30:367-73.
4. Jones CM, Heidmann J, Gerrish AC. Children's ratings of dental injection and treatment pain, and the influence of the time taken to administer the injection. Int J Paediatr Dent 1995;5:81-5.
5. 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;24:315-20.
6. 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;63:24-9.
7. Krochak M, Friedman N. Using a precision-metered injection system to minimize dental injection anxiety. Compend Contin Educ Dent 1998;19:137-46.
8. Asarch T, Allen K, Petersen B, Beiraghi S. Efficacy of a computerized local anesthesia device in pediatric dentistry. Pediatr Dent 1999;21:421-4.
9. Ram D, Peretz B. The assessment of pain sensation during local anesthesia using a computerized local anesthesia (Wand) and a conventional syringe. J Dent Child (Chic) 2003;70:130-3.
10. Gibson RS, Allen K, Hutfless S, Beiraghi S. The Wand vs. traditional injection: a comparison of pain related behaviors. Pediatr Dent 2000;22:458-62.
11. Kaufman E, Weinstein P, Milgrom P. Difficulties in achieving local anesthesia. JADA 1984;108:205-8.
12. Gow-Gates G, Watson JE. Gow-Gates mandibular block: applied anatomy and histology. Anesth Prog 1989;36:193-5.
13. Childers M, Reader A, Nist R, Beck M, Meyers WJ. Anesthetic efficacy of the periodontal ligament injection after an inferior alveolar nerve block. J Endod 1996;22:317-20.
14. Nakai Y, Milgrom P, Mancl L, Coldwell SE, Domoto PK, Ramsay DS. Effectiveness of local anesthesia in pediatric dental practice. JADA 2000;131:1699-705.
15. Wilson TG, Primosch RE, Melamed B, Courts FJ. Clinical effectiveness of 1 and 2% lidocaine in young pediatric dental patients. Pediatr Dent 1990;12:353-9.
16. Liddell A, Locker D. Gender and age differences in attitudes to dental pain and dental control. Community Dent Oral Epidemiol 1997;25:314-8.
17. Horrobin DF, Durand LG, Manku MS. Prostaglandin E1 modifies nerve conduction and interferes with local anaesthetic action. Prostaglandins 1977;14:103-8.
18. Najjar TA. Why can't you achieve adequate regional anesthesia in the presence of infection? Oral Surg Oral Med Oral Pathol 1977;44:7-13.
19. Brown RD. The failure of local anaesthesia in acute inflammation. Br Dent J 1981;151:47-51.
20. Rood JP, Pateromichelakis S. Local anaesthetic failures due to an increase in sensory nerve impulses from inflammatory sensitization. J Dent 1982;10:201-6.
21. Wallace JA, Michanowicz AE, Mundell RD, Wilson EG. A pilot study of the clinical problem of regionally anesthetizing the pulp of an acutely inflamed mandibular molar. Oral Surg Oral Med Oral Pathol 1985;59:517-21.
22. von Graffenried B, Adler R, Abt K, Nuesch E, Spiegel R. The influence of anxiety and pain sensitivity on experimental pain in man. Pain 1978;4:253-63.
23. Lautch H. Dental phobia. Br J Psychiatry 1971;119:151-8.
24. Chaves JF, Barber TX. Cognitive strategies, experimenter modeling, and expectation in the attenuation of pain. J Abnorm Psychol 1974;83:356-63.
25. Asmundson GJ, Taylor S. Role of anxiety sensitivity in pain-related fear and avoidance. J Behav Med 1996;19:577-86.
26. Aberg G, Sydnes G. Studies on the duration of local anesthesia: effects of volume and concentration of a local anesthetic solution on the duration of dental infiltration anesthesia. Int J Oral Surg 1978;7:141-7.
27. Vreeland DL, Reader A, Beck M, Meyers W, Weaver J. An evaluation of volumes and concentrations of lidocaine in human inferior alveolar nerve block. J Endod 1989;15:6-12.
28. Malamed SF. Pharmacology, anatomy, and physiology In: Malamed SF, Quinn CL. Sedation: A guide to patient management. 2nd ed. St. Louis: Mosby; 1989:185.
29. Ralph E, McDonald RE, Avery DR. Local anesthesia for the child and adolescent. In: McDonald RE, Avery DR, eds. Dentistry for the child and adolescent. 7th ed. St. Louis: Mosby; 2000:288-90.
30. Wright GZ, Starkey PE, Gardner DE. Managing children's behavior in the dental office. St. Louis: Mosby; 1983:127-43.
31. Andlaw RJ, Rock WP. A manual of paedodontics. 3rd ed. Edinburgh, Scotland: Churchill Livingstone; 1993:64.
32. Oulis CJ, Vadiakas GP, Vasilopoulou A. The effectiveness of mandibular infiltration compared to mandibular block anesthesia in treating primary molars in children. Pediatr Dent 1996;18:301-5.
33. Donohue D, Garcia-Godoy F, King DL, Barnwell GM. Evaluation of mandibular infiltration versus block anesthesia in pediatric dentistry. ASDC J Dent Child 1993;60:104-6.
34. Sharaf AA. Evaluation of mandibular infiltration versus block anesthesia in pediatric dentistry. ASDC J Dent Child 1997;64:276-81.
35. Malamed SF. Handbook of local anesthesia. 4th ed. St. Louis: Mosby; 1997:194.
36. McCallum CA Jr. Oral surgery for children. In: Finn SB, Akin J, eds. Clinical pedodontics. 4th ed. Philadelphia: Saunders; 1973:389.
37. Malamed SF. The periodontal ligament (PDL) injection: an alternative to inferior alveolar nerve block. Oral Surg Oral Med Oral Pathol 1982;53:117-21.
38. Davidson L, Craig S. The use of periodontal ligament injection in children. J Dent 1987;15:204-8.
39. Brännström M, Nordenvall KJ, Hedstrom KG. Periodontal tissue changes after intraligamentary anesthesia. ASDC J Dent Child 1982;49:417-23.
40. Faulkner RK. The high-pressure periodontal ligament injection. Br Dent J 1983;154:103-5.
41. Kaufman E, Galili D, Garfunkel AA. Intraligamentary anesthesia: a clinical study. J Prosthet Dent 1983;49:337-9.
42. White JJ, Reader A, Beck M, Meyers WJ. The periodontal ligament injection: a comparison of the efficacy in human maxillary and mandibular teeth. J Endod 1988;14:508-14.
43. Schleder JR, Reader A, Beck M, Meyers WJ. The periodontal ligament injection: a comparison of 2% lidicaine, 3% mepivacaine, and 1:100,000 epinephrine to 2% lidocaine with 1:100,000 epinephrine in human mandibular premolars. J Endod 1988;14:397-404.
44. Lenchner V, Wright GZ. Nonpharmaco-therapeutic approach to behavior management. In: Wright GZ, ed. Behavior management in dentistry for children. Philadelphia: Saunders; 1975:98.
45. Hicks CL, von Baeyer CL, Spafford PA, van Korlaar I, Goodenough B. The Faces Pain Scale-Revised: toward a common metric in pediatric pain measurement. Pain 2001;93:173-83.
46. Buchanan H, Niven N. Validation of a Facial Image Scale to assess child dental anxiety. Int J Paediatr Dent 2002;12:47-52.
47. Shields BJ, Cohen DM, Harbeck-Weber C, Powers JD, Smith GA. Pediatric pain measurement using a visual analogue scale: a comparison of two teaching methods. Clin Pediatr (Phila) 2003;42:227-34.
48. McGrath PJ, Johnson G, Goodman JT, Schillinger J, Dunn J, Chapman JA. CHEOPS: a behavioral scale for rating postoperative pain in children. In: Fields HL, Dubner R, Cervero F, eds. Proceedings of the 4th World Congress on Pain: Advances in pain research and therapy. Vol. 9. New York: Raven Press; 1985:395-401.
49. McGrath PJ. Behavioral measures of pain. In: Finley GA, McGrath PJ, eds. Measurement of pain in infants and children: Progress in pain research and therapy. Vol. 10. Seattle: IASP Press; 1998:86-7.
50. Hayward J, Richardson ER, Malhotra SK. The mandibular foramen: its anteroposterior position. Oral Surg Oral Med Oral Pathol 1977;44:837-43.
51. Acs G, Drazner E. The incidence of postoperative pain and analgesic usage in children. ASDC J Dent Child 1992;59:48-52.
52. Taubert KA, Dajani AS. Preventing bacterial endocarditis: American Heart Association guidelines. Am Fam Physician 1998;57:457-68.
53. Steinle CJ, Kisker CT. Pediatric dentistry for the child with hemophilia. New Engl J Med 1970;283:1325-6.