Computer-controlled delivery versus syringe delivery of local anesthetic injections for therapeutic scaling and root planing

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ABSTRACT

Background. The authors conducted a study to compare administration of local anesthetic using a computer-controlled delivery device with an aspirating syringe for therapeutic scaling and root planing. The anterior middle superior alveolar, or AMSA, injection was compared with other maxillary injections.

Methods. Twenty healthy adults with moderate periodontal disease participated in this single-blind crossover study. Subjects were evaluated by a trained examiner and were treated by experienced dental hygienists. Subjects provided written and verbal pain ratings via a visual analog scale, or VAS, and a verbal rating scale, or VRS. AMSA injections were compared with syringe-delivered injections—greater palatine, or GP, and nasopalatine, or NP, blocks, and anterior superior alveolar and middle superior alveolar injections—in maxillary quadrants. Bleeding and changes in attachment were evaluated after one month.

Results. VAS and VRS scores for AMSA were significantly lower for computer-controlled delivery when compared with NP injections and combined maxillary injections (VAS scores) and with GP and combined maxillary injections (VRS scores). Mean injection times were similar for both groups. Mean gains in attachment were equal, 0.19 millimeters for quadrants anesthetized using computer-controlled injections and 0.22 mm for syringe injections.

Conclusions. Subjects reported having less pain with GP and NP injections delivered using the computer-controlled device, and total injection time was similar to that required for syringe injections. Both techniques provided adequate anesthesia for therapeutic scaling and root planing.

Clinical Implications. The two anesthetic delivery techniques were therapeutically equivalent for mandibular injections, and the AMSA injection has clinically significant advantages for maxillary injections.

Effective therapeutic periodontal scaling and root planing procedures frequently require the use of local anesthetic to maintain patient comfort while permitting adequate instrumentation of root surfaces. This allows the clinician to adequately perform the procedures without fear of causing pain in the patient. However, many patients associate injections of local anesthetic —"shots in the mouth"—with pain despite the benefits to treatment.[1,2]

The two anesthetic delivery techniques were therapeutically equivalent for mandibular injections.

As an alternative, a computer-controlled delivery device (CompuDent, Milestone Scientific, Livingston, N.J.) accommodates a conventional local anesthetic cartridge that is linked by tubing to a disposable, penlike handle with an attached needle (Wand, Milestone Scientific). The device is operated by means of a foot control that delivers local anesthetic at precise pressure and volume ratios. The device has been demonstrated to provide adequate anesthesia for cosmetic procedures and has been well-received by patients.[3,4] However, it has not been evaluated for use during therapeutic scaling and root planing procedures, and some people have perceived use of the device to be time-consuming.

We conducted this study to compare the efficacy of a computer-controlled local anesthetic delivery system with that of conventional syringe delivery of local anesthetic. Specifically, we evaluated the adequacy of anesthesia for performing scaling and root planing on

patients with moderate periodontal disease; pain perceived by patients during both types of injections; the adequacy of the anterior middle superior alveolar, or AMSA, block specific to the computer-controlled device for anesthetizing most of the maxillary arch (Figure 1); and time required for the set of injections and treatment.

METHODS AND MATERIALS

Study design. We used a single-blind crossover design study to test the efficacy of computer-controlled delivery versus conventional aspirating syringe delivery of local anesthetic during scaling and root planing. We enrolled 20 healthy adults stratified by sex (10 males and 10 females) in the study. The study required four appointments for each subject: a baseline examination, an appointment to scale and root plane randomly assigned maxillary and mandibular quadrants on one side of the mouth, a second scaling and root planing appointment to treat the opposite side of the mouth, and an exit examination. We randomly assigned an anesthetic delivery device—either the computer-controlled delivery system or the conventional aspirating syringe—at the first scaling and root planing appointment. During the second appointment, we used the other device, resulting in a sex-stratified crossover design with random assignments of delivery device and which side of the mouth was treated first. Each subject served as his or her own control.

At the first treatment appointment, we taught subjects the oral hygiene techniques of toothbrushing—using the modified Bass' method—and flossing, and we provided them with toothbrushes and floss for home use. All subjects were anesthetized using 2 percent lidocaine with 1:100,000 epinephrine. One trained periodontist (P.M.L.) performed all of the baseline and exit examinations and was not aware of which side of the mouth was anesthetized by the computer-controlled delivery device or which side of the mouth was treated first. Three experienced dental hygienists provided the periodontal treatment and collected data for the study. Due to the nature of the study design, the subjects and the dental hygienists knew which treatment was being provided at each visit.

Subjects accepted into the study had probing depths of at least 4 to 6 millimeters; six teeth per quadrant, including at least one molar; and moderate-to-heavy subgingival calculus on more than one-half of the teeth in the mouth. All subjects were in good physical health and did not have any systemic illnesses that would affect healing responses. We obtained written consent from the subjects in accordance with the Committee on Human Research guidelines from the University of California, San Francisco.

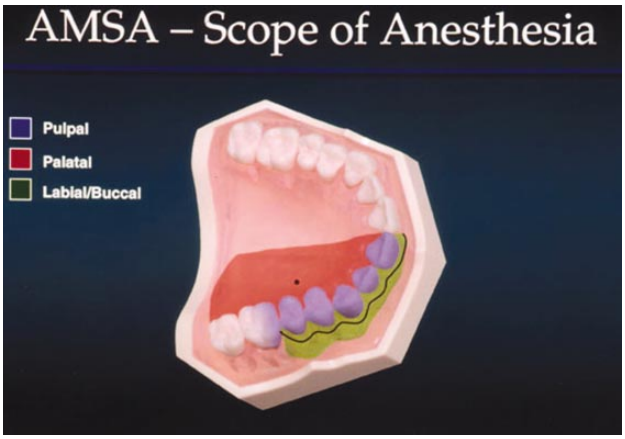

Figure 1. Scope of anesthesia for the anterior middle superior alveolar, or AMSA, injection. Reproduced with permission of Milestone Scientific, Livingston, N.J.

The periodontist conducted a complete periodontal examination at the baseline appointment. He recorded the following indexes: probing pocket depth, clinical attachment loss, presence of gingival bleeding and presence of visible plaque. He calculated clinical attachment loss as the sum of the probing depth and the distance from gingival margin to the cementoenamel junction. The periodontist took a diagnostic series of full-mouth radiographs for each subject so he could assess the amount of alveolar bone loss and other treatment needs.

The periodontist conducted the exit examination four to six weeks after the subjects completed treatment to allow sufficient healing time for accurate periodontal data collection.[5,6] At that time, he performed a second complete periodontal examination and repeated all index measurements except presence of visible plaque. Subjects requiring further dental or periodontal therapy were referred for treatment.

Anesthetic injection procedures. At the baseline examination, the periodontist trained subjects to use a visual analog scale, or VAS,[7] to record the level of pain they felt during treatment procedures. VAS was scored on a 100-mm horizontal line with the left endpoint marked "no pain" and the right endpoint marked "pain as bad as it can be." To eliminate people who were stoic about pain, we enrolled in the study only subjects who

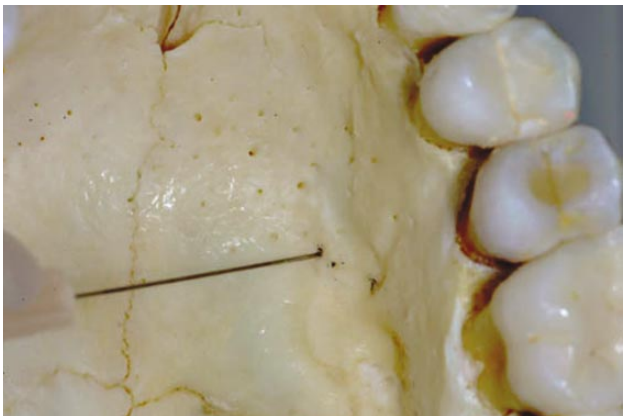

Figure 2. Position of the needle in relation to skull anatomy for the anterior middle superior alveolar injection. Reproduced with permission of Mark Friedman, D.D.S.

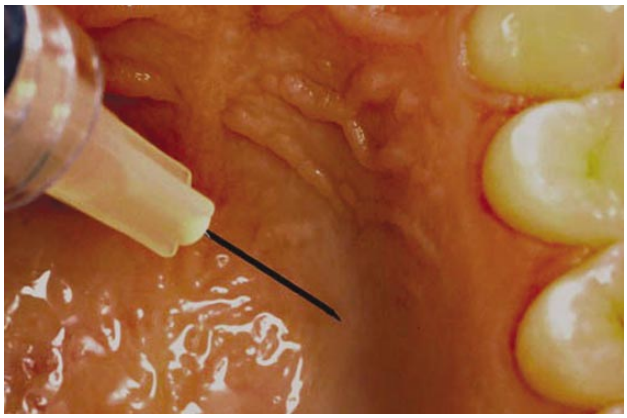

Figure 3. Clinical placement of the needle for the anterior middle superior alveolar injection. Reproduced with permission of Mark Friedman, D.D.S.

registered VAS pain scores of greater than 20 during periodontal probing at the baseline examination.

At the treatment visits, the conventional aspirating syringe delivery injections the dental hygienists used for the mandibular arch were the inferior alveolar, or IA, (which included the lingual block) and the long buccal, or LB. The computer-controlled delivery injections for the mandibular arch used also were the IA and the LB. The conventional aspirating syringe delivery injections the dental hygienists used for the maxillary arch were the posterior superior alveolar, or PSA; the middle superior alveolar, or MSA; the anterior superior alveolar, or ASA; the greater palatine, or GP; and the nasopalatine, or NP. The computer-controlled delivery system injections used for the maxillary arch were the AMSA (Figure 2 and Figure 3) and the PSA. We assessed pain response using a five-point verbal rating scale, or VRS (none, mild, moderate, severe or very severe pain), scored 0 through 4. The dental hygienists obtained the VAS and VRS for each injection immediately after the injection was administered.

Subjects were encouraged to ask for more anesthetic if they needed it during the scaling and root planing procedure, and we trained the dental hygienists to ask the subjects after the first 10 minutes of treatment if anesthesia was sufficient and to offer more anesthetic when it was not. The hygienists recorded the use and amount of additional anesthetic.

The hygienists administered the AMSA injection to the middle portion of the anterior palate through the fibrous palatal tissue, and the anesthetic was deposited next to the palatal bone. Once the needle tip had reached the bone, the slow and steady delivery of anesthetic solution was continued until a sufficient amount of solution was deposited and diffused through the tissue. The injection required 0.6 to 0.9 milliliters of anesthetic solution—one-third to one-half of a cartridge of anesthetic. It took 60 to 90 seconds to deliver.

The palatal bone is porous enough to permit the anesthetic solution to diffuse through the tissues and anesthetize both the anterior and middle branches of the superior alveolar nerve when the injection is deliberately slow and steady. For this reason, the successful deposition of the anesthetic solution through the fibrous tissue is said to be accomplished more easily with the use of a computer-controlled delivery device that regulates the pressure and volume ratio of solution delivered.[3,4] Attaining this consistency in deposition of anesthetic solution is difficult to achieve using a manual syringe.

The time needed for injections and treatment was recorded at every visit. The clinician noted the time required for administering injections at each treatment appointment, the start and end times for the injections, and the half-mouth scaling and root planing. This represented the time required to complete the scaling and root planing treatment appointment.

The dental hygienists telephoned the subjects the day after treatment and asked a scripted set of questions to identify possible adverse events.

Data analysis. We analyzed VAS and clinical attachment loss data using the Wilcoxon signed rank test, a nonparametric test for paired samples. We analyzed VRS data using a binomial

TABLE 1

CHANGES IN CLINICAL ATTACHMENT: COMPUTER-CONTROLLED VERSUS CONVENTIONAL SYRINGE DELIVERY.

CLINICAL ATTACHMENT	BASELINE VAS* SCORE (mm ± SD†)		EXIT VAS SCORE (mm ± SD)		DIFFERENCE	
	Computer-Controlled Device Delivery	Conventional Syringe Delivery	Computer-Controlled Device Delivery	Conventional Syringe Delivery	Computer-Controlled Device Delivery	Conventional Syringe Delivery
All Sites	2.95 ± 0.87	2.90 ± 0.87	2.77 ± 0.85	2.67 ± 0.95	0.19 ± 0.24	0.22 ± 0.24
Severe Loss (> 6 Millimeters)	6.45 ± 0.47	6.58 ± 0.54	5.14 ± 1.13	4.83 ± 1.48	1.31 ± 0.91	1.75 ± 1.40
Moderate Loss (4-6 mm)	4.32 ± 0.15	4.34 ± 0.13	3.45 ± 1.04	3.68 ± 0.62	0.87 ± 0.94	0.66 ± 0.54
Mild Loss (< 4 mm)	2.19 ± 0.25	2.21 ± 0.25	2.23 ± 0.42	2.24 ± 0.65	−0.05 ± 0.29	−0.03 ± 0.05

* VAS: Visual analog scale.
† mm: Millimeter. SD: Standard deviation.

probability distribution. We used the Student paired *t* test for nondirectional data and correlated samples to assess data for time needed to complete all injections required to anesthetize the half-mouth and for total treatment time.

RESULTS

Twenty subjects were enrolled in and completed the study. There were no adverse events, and no reports of ulcerations, soreness or swelling related to the injections were reported by subjects the day after treatment. In addition, we noted no history or clinical evidence of swelling or ulceration at any treatment visit or the exit examination. Two subjects had incomplete data scores for the PSA injection, and one subject was missing the AMSA injection score. All other data points were recorded and available for analysis.

Each subject received seven injections per half-mouth using the conventional syringe, and four injections for the half-mouth using the computer-controlled delivery system for anesthesia, resulting in 11 injections for each subject. Three subjects requested additional anesthetic during the 40 treatment sessions, for a total of four re-administered injections required of the 220 injections that were administered.

Periodontal healing. We evaluated periodontal healing four to six weeks after treatment[8,9] to ensure that adequate treatment had been performed and that there were no systematic differences in ability to perform treatment based on the type of anesthetic delivery device. Because the dental hygienists were not blinded to treatment, we thought that the periodontal scaling and root planing could have been less vigorous when performed after anesthetic injections administered using the computer-controlled delivery system compared with the conventional syringe techniques that were more familiar and trusted.

The periodontist measured clinical attachment in all subjects (N = 20) for all teeth, six surfaces per tooth. We measured and compared attachment changes for all surfaces, surfaces with severe attachment loss (> 6 mm at baseline), surfaces with moderate attachment loss (4 to 6 mm loss at baseline) and surfaces with mild attachment loss (< 4 mm at baseline). Overall, the subjects demonstrated significant improvement between the baseline and exit examinations. Comparisons between the computer-controlled delivery device data and the conventional syringe delivery data showed that all subjects improved equally. Attachment loss data and statistical comparisons between the computer-controlled delivery data and the conventional syringe data are presented in Table 1.

The percentage of sites with bleeding provides a commonly used clinical measurement of inflammation.[10] We compared the percentages of sites

TABLE 2

VISUAL ANALOG SCALE RESULTS BY DELIVERY METHOD AND INJECTION TYPE.

INJECTION TYPE*	N	MEAN VISUAL ANALOG SCALE SCORE ± STANDARD DEVIATION
Computer-Controlled Delivery		
PSA	19	11.2 ± 12.8
IA	20	18.4 ± 16.6
LB	20	11.9 ± 11.0
AMSA	19	20.6 ± 15.3
Conventional Syringe Delivery		
PSA	19	14.9 ± 15.1
IA	20	22.9 ± 21.4
LB	20	17.8 ± 15.8
ASA	20	34.4 ± 26.6
MSA	20	21.1 ± 18.9
GP	20	43.4 ± 30.0
NP	20	36.4 ± 23.6
Maxillary-ASA, MSA, GP, NP	20	48.8 ± 48.8

* PSA: Posterior superior alveolar; IA: inferior alveolar; LB: long buccal; AMSA: anterior middle superior alveolar; ASA: anterior superior alveolar; MSA: middle superior alveolar; GP: greater palatine; NP: nasopalatine.

with bleeding per subject at the baseline and exit examinations and between delivery devices. Subjects improved equally after receiving injections administered by both delivery devices and demonstrated less bleeding after treatment than at baseline. Eighteen of 20 subjects had equal or fewer numbers of sites with bleeding on the sides of the mouth that received the anesthetic injections using the computer-controlled device, and 17 of 20 subjects had equal or fewer sites with bleeding on the side of the mouth that received the anesthetic using the conventional syringe. There were no statistical differences ($P = .91$) in percentages of sites with bleeding between the two delivery devices at the exit examination.

Pain perception. *VAS.* We compared individually the pain scores for injections delivered with the computer-controlled device with those of injections delivered using conventional syringes. We also compared the area of the maxillary arch that was anesthetized by the AMSA injection with the mean of the combination of pain scores for the corresponding conventional syringe injections (ASA, MSA, GP and NP). Perceived pain for the conventional syringe delivery NP injection was highly statistically different from that of the computer-controlled delivery of the AMSA ($P = .008$). Scores for the corresponding conventional syringe injections in the maxillary arch compared with the scores for the AMSA computer-controlled injection revealed a highly significant difference in favor of the computer-controlled device ($P < .0001$). There were no differences in the pain perceived by the subjects during the IA or LB injections in the mandibular arch. Data are shown in Table 2 and Table 3.

VRS. We also measured subjects' pain responses with a VRS that was recorded by the clinician after each injection. The data indicated that the computer-controlled injections were considered less painful than the conventional syringe injections by the population studied. When compared individually, the GP and the AMSA differences were statistically significant ($P = .0117$). We compared the mean of the combined scores for the maxillary injections using the conventional syringe with the computer-controlled delivery of the AMSA and found highly significantly different pain scores ($P = .0002$). Data are presented in Table 4.

TABLE 3

COMPARISON OF VISUAL ANALOG SCALE RESULTS.

CONVENTIONAL SYRINGE DELIVERY VERSUS COMPUTER-CONTROLLED DELIVERY*	N	MEAN VISUAL ANALOG SCALE SCORE ± STANDARD DEVIATION	*P* VALUE
PSA-PSA	18	3.9 ± 19.8	.229
IA-IA	20	4.6 ± 18.6	.297
LB-LB	20	5.9 ± 13.6	.085
ASA-AMSA	19	15.4 ± 29.9	.060
MSA-AMSA	19	1.5 ± 21.7	.806
GP-AMSA	19	24.9 ± 29.4	.060
NP-AMSA	19	17.3 ± 26.9	.008†
Maxillary-AMSA	19	30.3 ± 28.3	< .0001†

* PSA: Posterior superior alveolar; IA: inferior alveolar; LB: long buccal; ASA: anterior superior alveolar; AMSA: anterior middle superior alveolar; MSA: middle superior alveolar; GP: greater palatine; NP: nasopalatine.
† Highly statistically significant.

TABLE 4

VERBAL RATING SCALE SCORE: DIFFERENCES BETWEEN DELIVERY SYSTEMS.

CONVENTIONAL SYRINGE DELIVERY VERSUS COMPUTER-CONTROLLED DELIVERY*	N (NONZERO COMPARISONS)	N (%) CONVENTIONAL SYRINGE DELIVERY > COMPUTER-CONTROLLED DELIVERY	*P* VALUE
PSA-PSA	10	6 (60)	.7539
IA-IA	7	4 (57)	.9984
LB-LB	10	7 (70)	.3438
ASA-AMSA	11	9 (82)	.0654
MSA-AMSA	11	4 (36)	.5488
GP-AMSA	11	10 (91)	.0117†
NP-AMSA	11	8 (73)	.2266
Maxillary-AMSA	13	13 (100)	.0002†

* PSA: Posterior superior alveolar; IA: inferior alveolar; LB: long buccal; ASA: anterior superior alveolar; AMSA: anterior middle superior alveolar; MSA: middle superior alveolar; GP: greater palatine; NP: nasopalatine.
† $P < .05$.

Time. We compared the total time required by the computer-controlled device and the conventional syringe to deliver all injections for one side of the mouth and perform scaling and root planing. We also compared the time needed to administer the injections using the computer-controlled delivery device and the conventional syringe; we included the time for readministered injections in the time total. Both indications of time—time required for injections and treatment, and time required for injections alone—included the additional time required for data collection after each injection.

Total treatment time data represent four injections per half-mouth using the computer-controlled device plus treatment time and readministered injections, compared with seven injections per half-mouth using the conventional syringe technique plus treatment time and readministered injections. Three subjects required a total of four readministered injections. The readministered injections were the LB and GP

using the conventional syringe for one subject, the IA using the conventional syringe for one subject, and the AMSA for one subject receiving computer-controlled anesthetic delivery.

The mean minutes of treatment time required for injections plus scaling and root planing was 81.0 ± 23.5 standard deviation, or SD, per subject using the computer-controlled delivery device, and 80.4 ± 24.0 SD for the conventional syringe injections. These means were not statistically different (P = .81). There was considerable variation in total time required to treat the subjects, ranging from 49 to 120 minutes. Fifteen of the subjects had treatment times for the two scaling and root planing appointments that were within 10 minutes or less of each other. The other five subjects had treatment times that varied by 15 or 20 minutes (P = .2874).

The mean number of minutes required for administering the injection and collecting data for the half-mouths receiving anesthetic using the computer-controlled delivery device was 19.4 ± 4.5 SD; the mean number of minutes for the half-mouths receiving anesthetic using the conventional syringe was 20.5 ± 5.1 SD. These differences were not statistically significant.

Injections administered using the computer-controlled device were scored regularly as less painful than were injections administered using the conventional syringe.

DISCUSSION

It was important in this study for us to be assured that subjects who received injections of anesthetic using the computer-controlled delivery device demonstrated evidence of expected healing to ensure adequate therapy. Four to six weeks after treatment, periodontal tissues usually have had time to heal and become less inflamed and, therefore, demonstrate less bleeding on probing.[11-13] In addition, probing pocket depths generally are reduced after treatment by 1 to 2 mm, representing both a reduction in gingival swelling and a decrease in the ability of the probe to penetrate the long junctional epithelial attachment.[14,15] Without that assurance in this study, subjects could have been attracted to a different anesthetic technique because it was a novelty and appealed to them on that basis alone, even if the clinician was unable to scale adequately. As a result, we monitored the periodontal parameters during the study to ensure that anesthesia was sufficient enough to permit the clinicians to provide a high level of therapy. Data showed that the percentage of sites with bleeding per subject was reduced from baseline to exit examination without any difference between modes of anesthetic delivery. In addition, we saw substantial healing—measured by 1 to 2 mm improvements in attachment loss—in deep pockets, and, as expected, smaller changes in shallower pockets.[16] These findings were consistent with the healing seen after scaling and root planing procedures in a variety of studies[17,18] and indicated that the level of anesthesia achieved using either the computer-controlled delivery device or the conventional syringe permitted adequate therapy to be performed.

Our data indicate that injections administered using the computer-controlled device were scored regularly as less painful than were injections administered using the conventional syringe, though when compared individually the differences were statistically significant only for the GP injection. Due to the nature of the computer-controlled delivery device, it was possible for the dental hygienists to use the AMSA injection recently described by Friedman and Hochman[3] instead of the four maxillary injections delivered by conventional syringe: the ASA, MSA, GP and NP. The pain scores the subjects reported for the AMSA were significantly lower than the mean scores for the conventional injections it replaced, suggesting that intraoral anesthesia of the anterior maxilla and palate can be achieved with fewer injections and less pain. It is conceivable that if the AMSA injection were administered with a conventional syringe, the pain response would be similar to that of the injection administered using the computer-controlled device. However, we did not compare the delivery of an AMSA injection using the computer-controlled device with delivery using the conventional syringe because of the difficulty of delivering an adequate volume of anesthetic solution over one minute or more with a conventional syringe. The performance of the computer-controlled device is based on the slow and consistent speed of deposition of the anesthetic, which allows for comfortable penetration into the fibrous palatal tissue and adequate diffusion through the tissues in the center of the hard palate to the bone and nerve complex. The consistent finding of lower pain scores with the computer-controlled device was confirmed at

the exit examination when subjects expressed clear preferences for computer-controlled delivery of anesthetic. Nineteen of the 20 subjects endorsed the injections as being less painful than any injections they had received previously.

The computer-controlled device uses a conventional dose of anesthetic delivered drop by drop using a slow flow rate of one cartridge over 90 seconds or a faster flow rate of one cartridge over 60 seconds. The slower flow rate is recommended for injections in dense tissue such as palatal mucosa, and we used it for all computer-controlled injections for this study.[19] This could be a concern for clinicians because it might extend the time required for scaling and root planing treatment appointments. During this study, the time required to administer injections and treat the subjects for the half-mouth periodontal scaling and root planing procedures was not statistically different for the two techniques. However, the total time for administering injections—close to 20 minutes per half-mouth—may seem excessive. These total times included the time it took subjects to complete VAS scoring sheets and respond to VRS questions, so the times were greater than would be found in actual dental practice. Although the clinicians found that the computer-controlled injections were slower to administer, fewer injections were required to achieve adequate anesthesia for the half-mouth treatments.

Total time required for administering anesthetic injections and for treatment was consistent among subjects, given that extra time was required to complete the data collection. Total visit times varied from about one hour to about two hours among the subjects. This variation commonly is the amount of time required to adequately scale and root plane half-mouths for patients with moderate periodontal disease characterized by substantial deposition of calculus. The variation in total time required per subject more likely was related to the difference in time required to remove the calculus from the teeth because total injection times were so similar for the subjects.

CONCLUSIONS

The two anesthetic delivery techniques were therapeutically equivalent for mandibular injections. The AMSA delivered by the computer-controlled device had clinically significant advantages for maxillary injections. Anesthesia of sufficient depth and duration was achieved to allow therapeutic periodontal scaling and root planing procedures. The time required for providing the injections to achieve half-mouth anesthesia was similar for both techniques, but fewer injections were needed when using the computer-controlled device. ■

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