A 21st Century Computerized Injection System for Local Pain Control

CE 2

Abstract: ***This article describes a new computerized local anesthetic injection system for pain control. The core technology of this system is the microprocessor-controlled delivery of anesthetic solution at a constant pressure and controlled volume, regardless of encountered variations in tissue resistance. This fine-tuned, high suffusion flow rate of anesthetic provides a rapid onset of anesthesia for most patients. Traditional block injections and infiltrations as well as palatal injections and periodontal ligament injections are administered with precision, ease, and patient comfort.***

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In a recently published article by Milgrom,[1] more than 25% of adults surveyed expressed at least 1 clinically significant fear of a dental injection. Almost 1 in 20 indicated that they either avoided, canceled, or did not appear for a dental appointment because of fear associated with dental injections. These statistics likely underestimate the extent of this problem in the general US population.

Review of the Literature

The use of local anesthesia dates back to 1884, when an American surgeon, William Halsted, and his associate, R.J. Hall, administered the first nerve block using cocaine. It was an inferior alveolar nerve block and would prove to have a significant and long-lasting impact on the practice of medicine and dentistry.[2] In 1904, procaine hydrochloride (Novocain®,a) was synthesized and rapidly replaced cocaine because it achieved profound anesthesia with greatly reduced side effects. It served as the "gold standard" in local anesthesia for nearly 40 years. It was replaced in 1943 by lidocaine (Xylocaine®,b), which was synthesized by the Swedish chemist Nils Lofgren. Lidocaine represented an entirely new class of drugs (amides) with local anesthetic properties. Greater potency, more rapid onset, and decreased allergenicity brought lidocaine to the forefront as the preferred local anesthetic for most dental procedures for the next 50 years. Other local anesthetics have been synthesized, such as prilocaine hydrochloride (1953), mepivicaine hydrochloride (1957), bupivacaine hydrochloride (1957), and etidocaine hydrochloride (1971). They offer a variety of potencies and duration of action.[3] In sharp contrast to the advancements in the pharmacology of local anesthetic agents for pain control in dentistry, only minor modifications have been made to the design of the hypodermic syringe which delivers these anesthetic agents.

The hollow-needle hypodermic syringe was introduced by Charles Pravaz and Alexander Wood in 1853.[4] The anesthetic syringe used in today's dental practice bears a striking resemblance to the original design diagrams drawn nearly 150 years ago (Figure 1). Except for the ability to aspirate and accept a standardized anesthetic cartridge (carpule), the antique hypodermic syringes on display at the Smithsonian Institution were operated in exactly the same manner as the "modern" syringes used today. The dentist still manipulates the syringe into position with the wrist, forearm, and shoulder and uses thumb pres-

[a] Sanofi Winthrop Pharmaceuticals, New York, NY 10016
[b] Astra USA, Inc, Westborough, MA 01581

Learning Objectives:

After reading this article, the reader should be able to:

- discuss the overall history of local anesthesia.
- describe the tactile difference between a computer-controlled injection and a traditional syringe injection.
- explain the new anterior middle superior alveolar injection.
- administer a predictable, modified Wand-assisted periodontal ligament injection in lieu of an inferior alveolar block.

sure to operate the plunger. An evolution of the syringe is long overdue.

A Computer-Controlled Injection System

A recently introduced technological advancement to the local anesthetic syringe is the Wand Local Anesthesia System[c]. This computer-controlled injection system is the size of a paperback book. It accommodates a conventional local anesthetic cartridge that is linked by microtubing to a disposable, lightweight, penlike handle with a Luer lock needle attached at the end. The computer is activated by a foot control that automates the delivery of local anesthetic from the cartridge at precise pressure and volume ratios (Figure 2). The consistent metering of anesthetic flow rate results in an effective and comfortable injection. An auto-aspiration feature provides the safety of proper injection technique. The computer-controlled precision of the Wand System is reported to ensure a virtually pain-free anesthetic injection (written communication, Michael Krochack, DMD, July 1997). The constant pressure and volume ratio can be maintained regardless of tissue resistance. Thus, if the anesthetic solution is deposited in tissues of resilience, such as the palate or periodontal ligament (PDL) space, the computer drive compensates to produce a steady and continuous flow rate. Conversely, if an infiltration is administered in buccal mucosa where no resistance is encountered, plunger pressure is automatically adjusted. Maintaining an ideal flow rate of anesthetic solution is probably the major factor in achieving a comfortable anesthetic injection. This new system eliminates the variability of a thumb-operated plunger. Traditional block injections and infiltrations, as well as palatal injections and PDL injections, are all administered with precision, ease, and patient comfort.

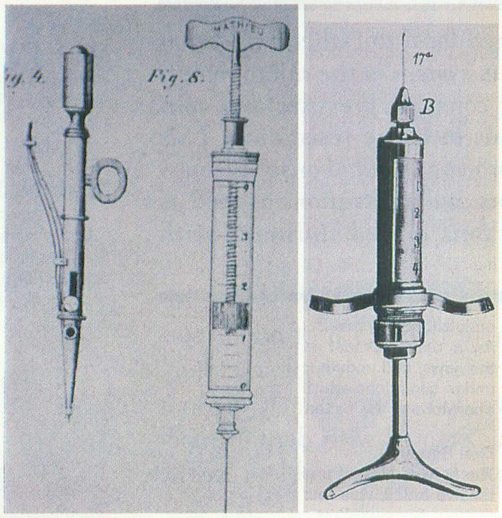


Figure 1—Early syringe designs from Pravaz (1850s).

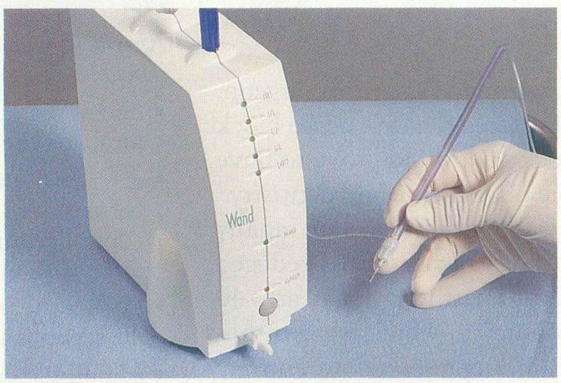


Figure 2—Wand Local Anesthesia System.

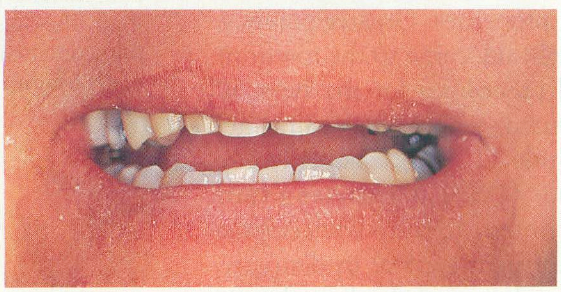


Figure 3—Typical distortion of the face and lip from anterior infiltration of local anesthetic, which makes esthetic assessment during this porcelain veneer cementation appointment difficult.

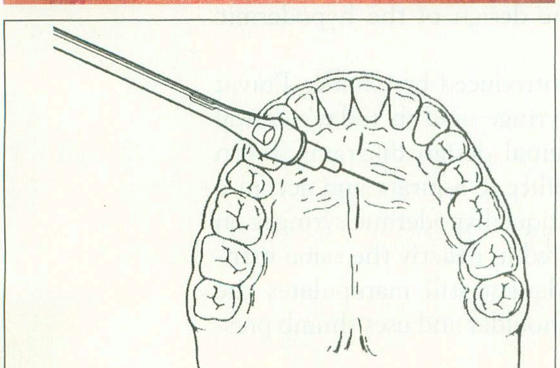


Figure 4—The anatomical location for the new AMSA injection.

Traditional Methods to Achieve Anesthesia of Maxillary Teeth

The traditional route for administration of anesthesia to the maxillary teeth is supraperiosteal infiltration(s) delivered in the mucobuccal fold near the apex of the teeth to be anesthetized.[5(pp202-203)] Although usually effective in achieving pulpal anesthesia of the radicular neurovascular bundle by diffusion of anesthetic through the porous maxilla, this approach routinely anesthetizes the surrounding tissues (ie, lips, surface of the face, and muscles of expression) as well. This results in an inadvertent distortion of the smile. The patient's natural repose, as well as active facial expressions, are temporarily affected. The patient also experiences the annoying sensa-

[c] Milestone Scientific, Livingston, NJ 07039

tion of facial numbness, and the smile line is temporarily invalidated as an esthetic reference for restorative and prosthetic dentistry.

An alternative to maxillary infiltration is the infraorbital nerve block injection which, if properly performed, achieves anesthesia of the anterior superior alveolar branch of the trigeminal nerve.[5(pp214-219)] This injection site, however, is also close to muscles of expression, and anesthesia of cutaneous fibers of the infraorbital nerve results in a corresponding loss of sensation in the face and the upper lip. In about 28% of the US population, the middle superior alveolar (MSA) nerve is present; for these individuals, an infraorbital nerve block does not achieve intrapulpal anesthesia distal to the canine. The literature describes the MSA nerve block as a supraperiosteal infiltration administered in the mucobuccal fold above the apex of the second premolar.[6(pp168-170)] Another option for maxillary anesthesia is a PDL injection, also referred to as an intraligamentary or transligamentary injection. This injection is a viable approach for anesthetizing any single tooth and gingival tissues at the injection site, without accompanying anesthesia of the overlying orofacial tissues. The major limitation of the PDL injection is the inability to anesthetize multiple teeth with a single penetration and the relatively short duration of anesthesia achieved.[7]

The Anterior Middle Superior Alveolar Nerve (AMSA) Block

Recently, a new injection technique for the maxillary arch was discovered while using the computer-controlled local anesthesia system. During the development of this system, a clinical observation was made that pulpal anesthesia could be achieved from a palatal injection (oral communication, Ronald P. Spinello, DDS, July 1996). Further investigation of this effect led to the conclusion that, if the dosage of anesthetic was sufficient, profound pulpal anesthesia of the teeth inervated by the distribution of the anterior and (if present) MSA nerves would result. This injection technique has significant benefits, including patient safety and comfort as well as operator ease and predictability. The clinician can anesthetize several teeth in the maxillary arch, extending from the mesiobuccal root of the first molar to the central incisor, by means of a single palatal infiltration. In addition to profound pulpal anesthesia, palatal soft-tissue anesthesia is realized, which also extends from the maxillary first molar to the central incisor. In sharp contrast to the traditional route of maxillary anesthesia for this region, the overlying facial soft tissues are not anesthetized by this palatal approach AMSA block. Anesthesia is achieved with as little as 0.6 mL

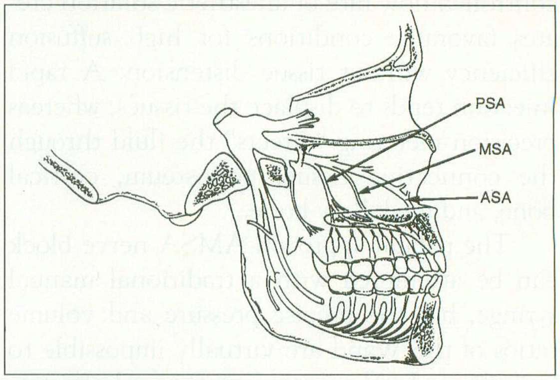


Figure 5—The nerve distribution of the superior alveolar branches.

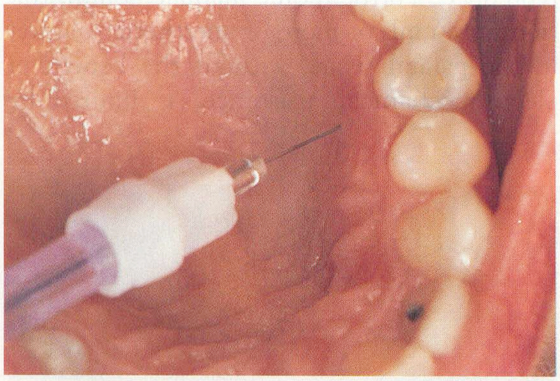


Figure 6—Clinical close-up of palatal AMSA Wand-assisted injection at the moment of needle penetration.

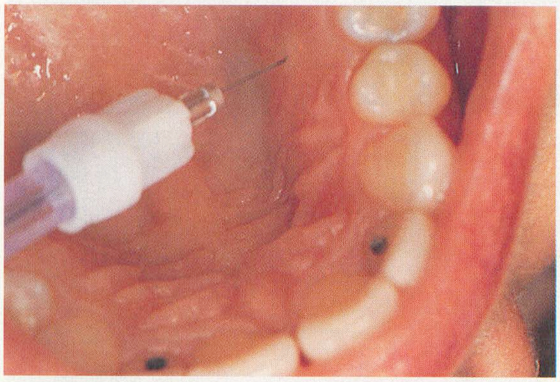


Figure 7—Clinical close-up of initial palatal blanching after 5 seconds. The zone of hemostasis will extend from the central incisor to the first molar from 0.9 mL of anesthetic with 1:100,000 vasopressor concentration.

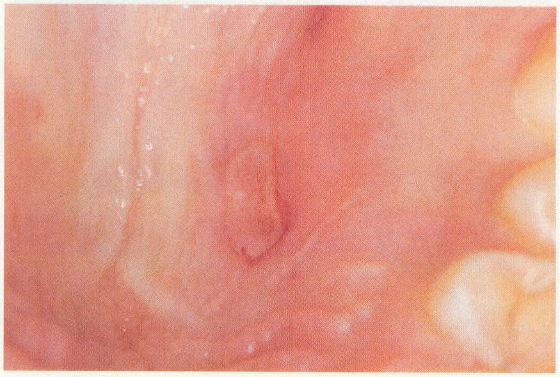


Figure 8—Clinical close-up of soft-tissue damage as a result of a rapid infiltration of 0.9 mL of prilocaine hydrochloride with 1:200,000 epinephrine. This complication is avoided if the Wand's slow flow rate is maintained on all palatal injections.

of solution, and even with minimal concentrations of vasopressor in the anesthetic, a substantial measure of hemostasis results in the palate. The broad zone blanching effect observed during the administration of this injection provides a visual indication of the unique dynamic that this injection system produces. A combination of the resilient nature of the palatal connective tissue and the controlled flow rate of anesthetic solution creates favorable conditions for high suffusion efficiency without tissue distension. A rapid injection tends to displace the tissues, whereas precision metering "directs" the fluid through the connective tissue, periosteum, cortical bone, and medullary bone.

The palatal approach AMSA nerve block can be attempted with a traditional manual syringe, but the precise pressure and volume ratios of the Wand are virtually impossible to reproduce. Furthermore, manual administration of 0.6 mL or more of anesthetic solution in the palatal tissue, without the benefit of electromechanical assistance, is limited by muscle fatigue of the operator and patient tolerance. Equally if not more important, it is recognized that palatal injections administered with a traditional syringe are associated with patient discomfort and operator stress.[8]

Hochman et al[9] reported that 48 of 50 dentists who volunteered to receive palatal injections with the new system found that it had a statistically significant decrease in the level of discomfort compared to a traditional syringe for the identical injection, and operators did not experience undue stress while administering the palatal injection with the new system.

The AMSA offers pain elimination without loss of muscle control and does so with a minimal volume of anesthetic. It also eliminates the potential for an intravascular injection because no major vessels are encountered in this region of the palate. This changes the entire perception of maxillary anesthesia and offers a more comfortable alternative to traditional anesthesia in this region of the mouth. The increasing popularity of esthetic restorative dentistry makes this technique invaluable in maintaining normal lip and face mobility, thus improving accuracy and productivity while decreasing the number of postoperative visits required (Figure 3).

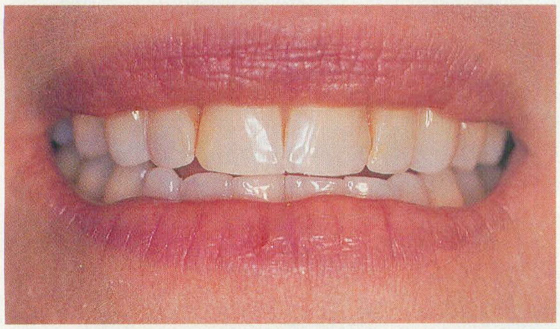


Figure 9A—A 41-year-old woman presented for a porcelain veneer procedure on the maxillary six anterior teeth.

Figure 9B—Patient received a bilateral AMSA injection. After porcelain veneer preparations were completed, accurate esthetic assessment relative to the lips was still possible.

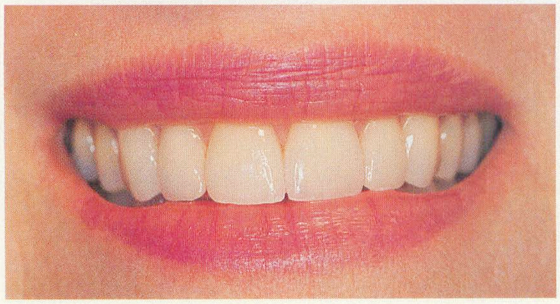
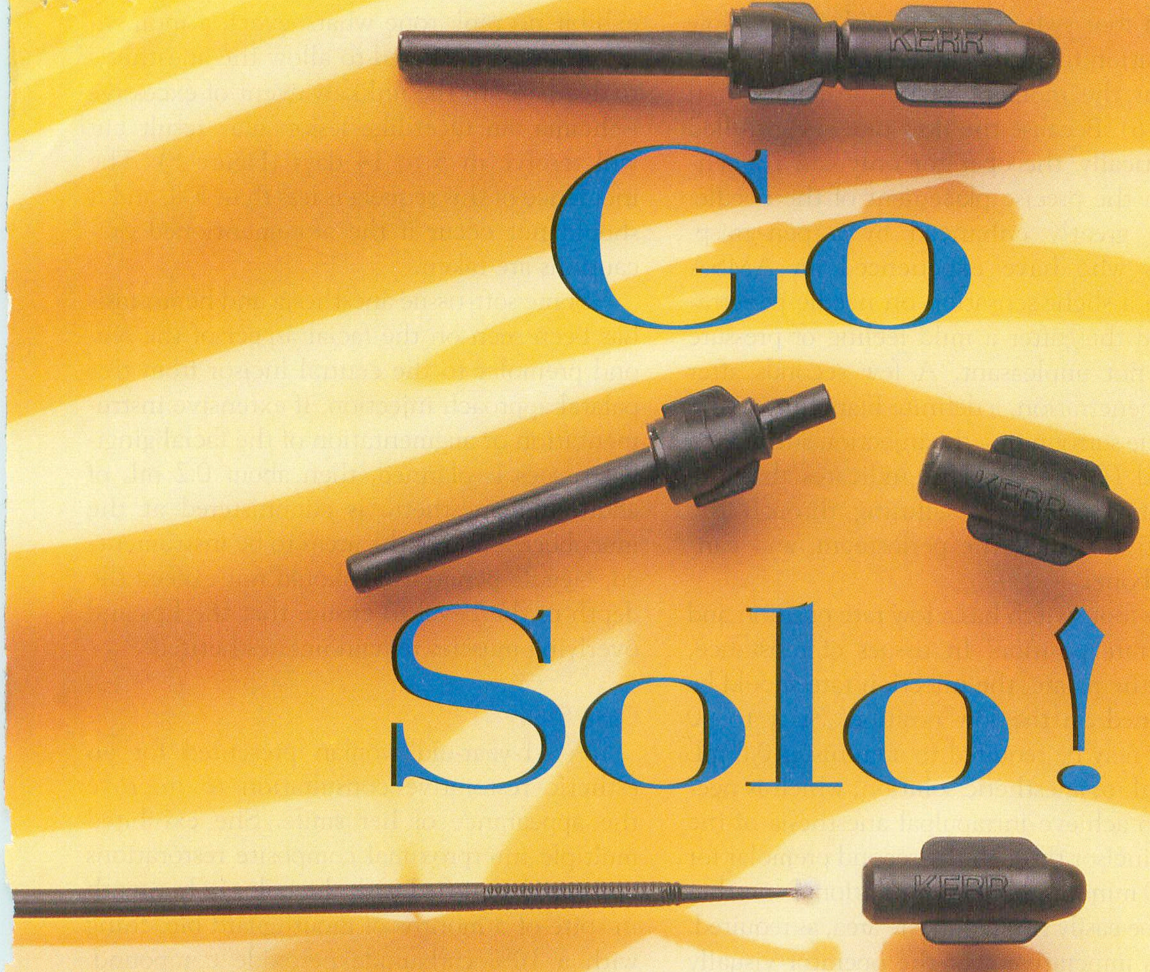


Figure 9C—An AMSA injection administered at the cementation appointment controlled pain, but allowed for precise esthetic adjustments of the final restorations in relation to the smile line.

The Wand-Assisted AMSA Technique

The AMSA block is administered with a 30-gauge extra-short needle. The specific anesthetic agent chosen and the concentration of vasoconstrictor selected will depend on the desired duration of action and whether elevated levels of palatal hemostasis are desirable. Administration of 0.9 mL of lidocaine 1:100,000 or prilocaine hydrochloride 1:200,000 results in profound pulpal anesthesia and palatal tissue anesthesia and a duration of 40 to 60 minutes. A significant degree of palatal tissue hemostasis is also achieved.

The AMSA injection site is located at a point that bisects the maxillary first and second premolar and is midway between the crest of the free gingival margin and the midpalatine suture (Figures 4 and 5). Use of a 30-gauge extra-short needle seems to preclude the need for a topical anesthetic, although one can be applied if desired. The needle is oriented at a 45-degree angle with the bevel facing the palatal tissue as described in traditional techniques.[6(pp174-180)] As the bevel contacts the tis-



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sue, the foot switch is activated on the slow rate position to ensure a positive flow of anesthetic at the moment of needle penetration (Figure 6). Because the flow rate is controlled automatically, the operator only can concentrate on the precise placement of the needle. This is greatly enhanced by a pen-grasp. Patients who have experienced an AMSA describe a slight sensation on needle penetration and thereafter a mild feeling of pressure that is not unpleasant. A few seconds after needle penetration, a definite blanching of the soft tissue surrounding the injection site will be observed (Figure 7). This indicates that the anesthetic is actively suffusing through the connective tissues, the periosteum, and cancellous bone.

The foot switch has a low rate position and a high rate position. In tissues of resistance, such as the palate, the injection rate should be maintained on the low position. Sixty to 90 seconds may be required to administer 0.6 mL to 0.9 mL of anesthetic solution, which is necessary to achieve intrapulpal anesthesia of the central incisor through the second premolar for 40 to 60 minutes duration. Additional anesthesia can be easily titrated in the area, as required.

It is imperative that the operator visually monitor the level of tissue blanching. If excessive blanching occurs (indicated when tissues exhibit no pink tone whatsoever), a momentary pause is indicated to allow the anesthetic to dissipate. In the unlikely event of excessive ischemia, an ulcer-like lesion may result but will resolve in 5 to 14 days (Figure 8). The incidence of this sequela is less than 5%, and it should not occur if the aforementioned precautions are taken.

Some soft-tissue anesthesia and hemostasis has been seen on the facial aspect of the second premolar to the central incisor from this palatal approach injection. If extensive instrumentation or augmentation of the facial gingival tissues is planned, then about 0.2 mL of additional anesthetic is administered at the mucobuccal fold of the areas to be instrumented. Needle penetration should not exceed the depth of the bevel to ensure that the lips and overlying muscles remain unanesthetized.

Case Study

A 41-year-old woman presented for an esthetic restorative consultation to improve the appearance of her smile. She exhibited multiple interproximal composite restorations and was dissatisfied with the color of her teeth in spite of 3 months of mouthguard bleaching with a 10% carbamide peroxide compound. The treatment option selected was the placement of six porcelain veneer restorations (Figure 9A).

Maxillary anesthesia was achieved with 1.8 mL of prilocaine hydrochloride 1:200,000 epinephrine, administered bilaterally (0.8 mL each) at the AMSA injection sites. The onset of anesthesia occurred within 2 minutes of administration. The six maxillary anterior teeth were prepared with a modified bullet diamond[d]. Because the lip was not affected by the AMSA block, the incisal alignment of the preparations could be referenced to the lips in repose. This is an especially important assessment criteria in porcelain veneer procedures because the preparation designs are conservative and porcelain thickness of the incisal segment is minimal. The tooth preparations were completed within 20 minutes from the initial injection. Tooth reduction was evaluated in relationship with the lips to ensure that the final porcelain veneers would create an ideal outline form with the curvature of the lips. The lack of facial anesthesia ensured that this evaluation was accurate (Figure 9B). The final

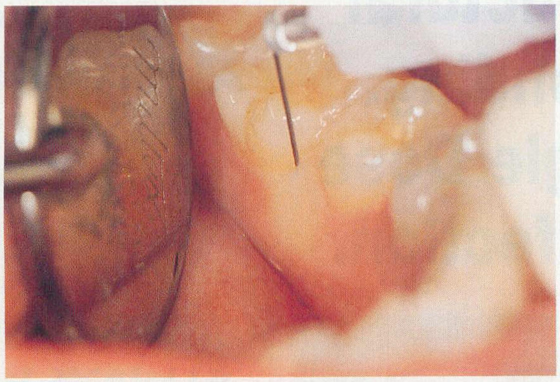

Figure 10—Precision flow rate of anesthetic makes PDL injections simple and effective to perform. Usually one or two penetrations are all that is required to achieve profound anesthesia.

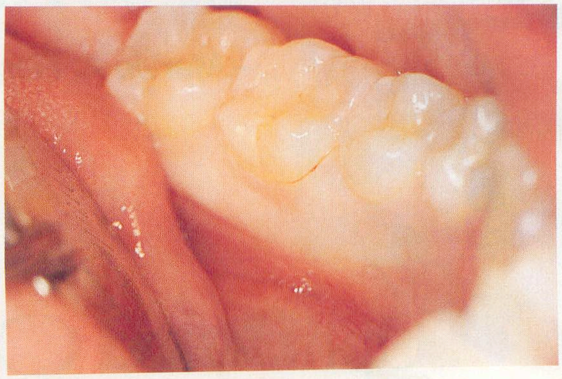

Figure 11—Tissue blanching indicates the zone of suffusion of the anesthetic providing a visual cue that adequate pulpal anesthesia has been achieved.

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impressions were accomplished with an elastomeric impression material (Impregum-F[e]). Provisionals were not fabricated; however, the patient wore her maxillary bleach tray to "protect" the teeth while the restorations were being fabricated in the laboratory.

At the cementation appointment, this patient exhibited marked sensitivity to the air/water syringe. A bilateral AMSA block was administered using a total of 1.3 mL of prilocaine hydrochloride 1:200,000. The sensitivity was immediately controlled and the teeth were treated routinely for the bonding phase of the veneer cementation. Again, the lip relationships were unaltered by the local anesthesia, and the veneer incisal tables and embrasures were accurately adjusted to reflect appropriate alignment with the smile. This enhanced the accuracy of the cementation procedure. A posttreatment appointment confirmed that the refinements of the veneer incisal outlines and embrasure forms were in harmony with the lips and no further corrections were required (Figure 9C).

Traditional Methods to Achieve Anesthesia of the Mandibular Teeth

Achieving effective and predictable anesthesia of the mandibular arch has long been a formidable challenge for the dental professional. It is reported that the success rate for the inferior alveolar nerve block is 80% to 85%. Variations in the height of the mandibular foramen location coupled with the depth requirement of the needle penetration combine to reduce the success rate of the inferior alveolar nerve block. The density of the mandibular bone makes it imperative that the anesthetic solution be deposited to within 1 mm of the target nerve.[6(p193)]

Alternatives to the traditional inferior alveolar block have been proposed. The Gow-Gates and Vazirani-Akinosi blocks provide regional anesthesia to the pulps of the mandibular teeth in a quadrant. The mandibular anterior teeth can be easily anesthetized with the incisive nerve block. It is a valuable alternative to the inferior alveolar nerve block when treatment is limited to these teeth; however, anesthesia of the mandibular molars is usually approached with a block injection.[6(pp193-212)] Supplemental mandibular anesthesia techniques include the PDL injection. Although this supplemental injection can be used in either arch, it is most often used to anesthetize mandibular teeth.[10,11]

Wand-Assisted Mandibular Anesthesia Techniques

The computer-controlled local anesthesia system is an excellent means of achieving a traditional inferior alveolar nerve block injection because the tactile control of the needle during penetration is heightened with a pen-grasp. The operator's attention is focused on the precise needle placement and the physical demands of injecting solution are controlled by the computer technology. In theory, the anesthetic solution is deposited ahead of the advancing needle path, making the injection procedure virtually pain-free. Krochack (written communication, Michael Krochack, DMD, July 1997) has reported a high rate of success with Wand-assisted traditional inferior alveolar block injections and a resulting reduction in patient anxiety associated with the injection. This system is ideally suited for the administration of intraligamentary injections.

In clinical instances when a single mandibular tooth needs to be anesthetized or multiple teeth require anesthesia for a brief period, the intraligamentary or PDL injection may be warranted. Although this injection has been investigated thoroughly and is often used to augment

[e] ESPE, Norristown, PA 19404

the inferior alveolar block, it is usually ignored as a viable alternative to an inferior alveolar block. It uses less anesthetic to achieve similar success with traditional techniques, which validates its efficacy.[12] Special syringes have been developed to make administration of the PDL injection easier and more predictable (Figure 10). However, whether the injection is administered with a traditional syringe or a modified injection device, adequate pressure is required. If too much pressure is applied, it can result in an uncontrolled "leakage" of solution from the sulcus or a sudden "explosion" of the anesthetic cartridge. If too little pressure is exerted, the solution is not adequately suffused within the interseptal bone and anesthesia is not achieved. Therefore, a successful PDL injection requires that the proper pressure and volume of anesthetic be sustained over an adequate period to ensure that sufficient volume of anesthetic has suffused the surrounding marrow spaces to achieve complete anesthesia of the tooth.[13] The ability to generate the precise flow rate is what distinguishes the computer-controlled local anesthetic system from a manual syringe. It is being used routinely to achieve PDL injections and requires no physical exertion to do so. Additionally, the "leakage" of anesthetic solution is greatly reduced and the danger of carpule "explosion" is eliminated.

The Wand-assisted PDL injection is administered with a 30-gauge extra-short needle. For mandibular molars and premolars, two insertion sites are used. One is at the mesiolingual transitional line angle and the other at the distolingual transitional line angle. Similar to the traditional technique, the needle is inserted in the sulcus parallel to the long axis of the tooth with the bevel facing the tooth. As the needle enters the sulcus, the foot switch is activated at the slow rate of flow and maintained at that rate throughout the entire injection. The needle is advanced firmly until it will advance no further, and 0.6 mL of anesthetic is administered (Figure 11). Injecting directly into the interdental papilla should be avoided because the suffusion efficiency of this system can cause ischemia, which may result in tissue necrosis. The administration of 1.2 mL (0.6 mL mesiolingual and 0.6 mL distolingual) of lidocaine 1:100,000 epinephrine or prilocaine hydrochloride 1:200,000 epinephrine for a mandibular molar will provide pulpal anesthesia and adjacent tissue anesthesia for approximately 30 minutes. Additional anesthesia can be titrated as necessary even with a rubber dam in place.

Summary

A computer-controlled local anesthesia system represents a contemporary alternative to the traditional syringe. This system generates a precisely controlled anesthetic flow rate that eliminates the need for the operator to use thumb pressure to administer the injection. The lightweight pen-grasp handle results in greater tactile feedback, precision, operator ease, and patient comfort. In the maxillary arch, the AMSA injection offers clinical advantages over traditional anesthesia techniques. In the mandibular arch, a safe and predictable PDL injection technique may replace the need for an inferior alveolar block in numerous clinical situations. More research is needed to ascertain the potential efficacy of other traditional and nontraditional computer-controlled local anesthetic injections.

Acknowledgment

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CE 2

Quiz 2

This article provides 1 hour of CE credit from Dental Learning Systems, Co., Inc., in association with the University of Southern California School of Dentistry and the University of Pennsylvania School of Dental Medicine. Record your answers on the enclosed answer sheet or submit them on a separate sheet of paper.

1. The AMSA nerve block injection anesthetizes which anatomical structures?

a. The maxillary central incisor through the second molar and the palatal tissues associated with these teeth.

b. The same maxillary structures anesthetized by the more difficult second division nerve block.

c. The maxillary central incisor through the second premolar and the facial tissues associated with these teeth.

d. The maxillary central incisor through the mesiobuccal root of the first molar and the palatal tissues associated with these teeth.

2. The computer-controlled local anesthetic system referred to as the Wand has all of the following advantages *except*:

a. it eliminates the manual administration of the anesthetic solution.

b. it delivers a more rapid anesthetic injection.

c. it produces an injection with improved comfort over traditional techniques.

d. it improves the tactile control of the needle placement.

3. On mandibular teeth, the Wand-assisted PDL injection is administered:

a. at the mesiolingual and distolingual transitional line angles on molars and premolars.

b. at the mesiobuccal, distobuccal, mesiolingual, and distolingual line angles on molars and premolars.

c. as an adjunctive injection only to a traditional inferior alveolar block injection.

d. in the buccal furca and lingual furca of molars.

4. Which of the following advantages of the AMSA nerve block has the most profound effect on restorative dentistry techniques?

a. Rapid onset of anesthesia of multiple maxillary teeth from a single injection site.

b. Outstanding hemostasis of the palatal tissues.

c. Reduced anesthetic volume required to achieve pulpal anesthesia.

d. Elimination of anesthesia of the lips and muscles of expression.

5. The middle superior alveolar nerve branch is present in approximately what percentage of the US population?

a. 10%

b. 20%

c. 30%

d. 40%

6. Which of the following is *not* an advantage of the computer-controlled local anesthesia system?

a. an auto-aspiration feature.

b. consistent metering of anesthetic.

c. injections are administered more rapidly than with a syringe.

d. ideal flow rate regardless of tissue resistance.

7. It is speculated that the major factor in the administration of a comfortable injection is:

a. maintaining ideal flow rate.

b. using small amounts of anesthetic solution.

c. inserting the needle slowly.

d. warming the anesthetic before injection.

8. The AMSA block can best be achieved with all of the following *except*:

a. a single palatal infiltration.

b. approximately 0.6 mL of anesthetic.

c. a 30 gauge extra-short needle.

d. a rapid perfusion of anesthetic.

9. Typical duration of action for an AMSA block injection is:

a. 10 minutes.

b. 20 minutes.

c. 30 minutes.

d. 40 minutes.

10. The computer-controlled local anesthesia system is contraindicated for:

a. traditional infiltrations.

b. traditional block injections.

c. PDL injections.

d. none of the above