The development of safe and effective local anesthetic agents has been an important advancement in dental therapeutics. Their anesthetic effectiveness, however, sometimes is inadequate, particularly after the administration of a mandibular nerve block. The nerves supplying mandibular teeth and periodontal tissue are encased in the bone. The thick cortical plate of the mandible impairs diffusion of anesthetic solutions into the mandible, often limiting the effectiveness of infiltration anesthesia.

Alternative anesthetic techniques that can overcome this barrier are available. The periodontal ligament (PDL) anesthetic technique involves using high injection pressure to force the local anesthetic solution through the PDL into the cancellous medullary bone surrounding a tooth. The intraosseous (IO) anesthetic technique requires mechanical perforation of the thick cortical plate between the roots of the teeth to permit deposition of the local anesthetic into the medullary bone surrounding the tooth. These techniques permit diffusion of anesthetic around the tooth socket to anesthetize all of the nerves supplying the dental pulp. The anesthesia often is limited to the specific tooth undergoing treatment.

THE PERIODONTAL LIGAMENT ANESTHETIC INJECTION

The PDL anesthetic injection technique, also referred to as the “intraligamentary injection technique,” can induce local anesthesia in either maxillary or mandibular teeth. Although occasionally it is used as the primary anesthetic technique (when a single tooth requires anesthesia for a short duration), it can be more useful when nerve block anesthesia fails. The PDL injection technique has been referred to as the “intraligamentary injection technique” and involves the use of high injection pressure to force the local anesthetic solution through the PDL into the cancellous medullary bone surrounding a tooth. The technique is particularly useful for managing nerve block failures and for providing localized anesthesia in the mandible.

Background and Overview. The provision of mandibular anesthesia traditionally has relied on nerve block anesthetic techniques such as the Halsted, the Gow-Gates and the Akinosi-Vazirani methods. The authors present two alternative techniques to provide local anesthesia in mandibular teeth: the periodontal ligament (PDL) injection and the intraosseous (IO) injection. The authors also present indications for and complications associated with these techniques.

Conclusions. The PDL injection and the IO injection are effective anesthetic techniques for managing nerve block failures and for providing localized anesthesia in the mandible.

Clinical Implications. Dentists may find these techniques to be useful alternatives to nerve block anesthesia.

Key Words. Dental anesthesia; local anesthesia; periodontal ligament injection; intraosseous injection.

JADA 2011;142(9 suppl):13S-18S.
dentists most often use the PDL technique when mandibular nerve blocks are unsuccessful. Teeth with irreversible pulpitis generally are considered the most difficult to anesthetize and often require supplemental anesthesia. Investigators surveyed members of the American Association of Endodontists to assess the use of supplemental PDL and IO injections. They found that symptomatic irreversible pulpitis was the endodontic diagnosis that most often required some form of supplemental anesthesia, with the PDL anesthetic injection technique being the most frequently administered.

The PDL anesthetic injection technique was introduced in the early 20th century and gained popularity in the 1970s when dedicated high-pressure dental syringes such as the Peripress Pen (Panadent, Kent, England) and Ligmaject (Henke-Sass, Wolf, Tuttingen, Germany) were introduced. These syringes could be operated with one hand and were capable of delivering small volumes of anesthetic from standard dental cartridges at the high hydrostatic pressures required for the PDL anesthetic injection. Today, there is an array of mechanical and computer-assisted equipment engineered specifically for this anesthetic injection technique, including the IntraFlow Intraosseous Anesthesia Delivery System (Pro-Dex, Irvine, Calif.), the Midwest Comfort Control Syringe (Dentsply Professional, York, Pa.), the STA Single Tooth Anesthesia System (Milestone Scientific, Livingston, N.J.), The Wand handpiece (Milestone Scientific) and the Compu-Dent instrument (Milestone Scientific). Although the authors of three studies did not report improved efficacy with the use of computer-assisted instruments, these tools may provide an advantage by providing more precise control of the injection rate and pressure.

The administration procedures are similar when using a conventional syringe or a syringe dedicated to PDL anesthetic injection technique. Malamed recommended using short 27- or 30-gauge dental needles for this technique. With the tip of the needle approaching the periodontal sulcus on the mesial or distal aspect of the tooth, advance the tip of the needle into the PDL. With the bevel oriented toward the root surface, advance the tip of the needle into the PDL between the root surface and the adjacent alveolar bone. Administer a small amount (0.2 milliliters) of anesthetic solution slowly. To ensure that the solution is being forced into the tissue, you must feel resistance. Although syringes differ among manufacturers, the technique usually requires deposition of at least 0.2 mL for each root of the tooth. Figures 1, 2 and 3 show the orientation of the syringe and the position of the tip of the needle into the PDL.

The name of the technique may be misleading. Although the solution is deposited into the coronal segment of the PDL, the anesthetic is not forced down the PDL to the tooth apex but instead is redirected into the surrounding cancellous bone through the fenestrations in the dental socket. Unlike the cortical plate of the mandible, the dental socket has multiple passageways to accommodate the blood vessels that supply the periodontium. Investigators used a dog model to simulate this clinical technique and assessed the distribution of the local anesthetic after the PDL injection was administered. By administering a solution containing suspended carbon particles, they found that the solution was distributed into the soft tissue and adjacent hard structures next to the tooth. The distribution was consistently more widespread when they administered injections using moderate to strong pressure. The investigators’ conclusion was that the PDL anesthetic injection technique was a form of the IO anesthetic injection technique.

The results of the first published clinical assessment of the PDL anesthetic injection techniques showed that success rates ranged from 60 percent for endodontic therapies to 100 percent for periodontal therapies and tooth extractions. Anesthesia onset was rapid, and anesthesia duration was 30 to 45 minutes. Adverse reactions included pain during administration of the injection, tenderness at the injection site after treatment and a subjective sensation that the tooth was elevated in the occlusion or “high” after treatment. Investigators in another comparative study reported similar results. They noted slight increases in heart rate.

Investigators compared the inferior alveolar nerve block (IANB) supplemented with the buccal infiltration anesthetic injection technique with the IANB supplemented with a PDL anesthetic injection. Anesthetic success in patients with irreversible pulpitis in the mandibular first molar for these combinations of treatments was comparable (81 percent versus 83 percent; P > .05).

Investigators have attempted to determine the most effective local anesthetic agent for the PDL injection technique. They compared injections of 4 percent articaine with 1:100,000 epinephrine with 2 percent lidocaine with 1:100,000 epinephrine administered with the PDL injection and found no significant differences in pain during administration of the injection, heart rate

increase and postinjection pain. Using electric pulp testing of mandibular molars to assess anesthetic efficacy, these investigators compared 1.4 mL of 4 percent articaine with 1:100,000 epinephrine with 1.4 mL of 2 percent lidocaine with 1:100,000 epinephrine administered with the PDL injection and found that successful pulpal anesthesia was comparable for the two anesthetics (86 percent for the articaine solution and 74 percent for the lidocaine solution; \( P > .05 \)).

Because the PDL anesthetic injection technique requires only a small volume of local anesthetic solution, systemic toxicity is reported rarely. The PDL anesthetic injection technique provides an advantage over regional nerve blocks by inducing anesthesia in only one or two teeth. In situations in which anesthesia of a short duration is required, the PDL anesthetic injection technique might be the preferred treatment. This technique avoids the deep needle insertion associated with mandibular regional blocks and may be considered a safer alternative technique for patients with bleeding disorders. For example, Yamashiro and Furuya described a case of a patient having a large mandibular hemangioma. They administered a PDL injection to avoid the possible rupture, vascular trauma and excessive bleeding potentially occurring with the IANB.

The anesthetic efficacy of the PDL anesthetic injection technique can be unreliable if the needle is not positioned precisely. Malamed recommended not administering injections into inflamed or infected periodontal sites.

The current American Heart Association recommendations do not provide specific guidance regarding antibiotic prophylaxis when administering the PDL injection. The recommendations state that antibiotic prophylaxis is not needed with routine anesthetic injections through noninfected tissue. However, even when it has been administered through healthy periodontal tissue, the PDL injection has induced bacteremia. Because of the potential for bacteremia to induce bacterial endocarditis, dentists should consider antibiotic prophylaxis when administering PDL injections, particularly when administering an injection through inflamed periodontal tissue. For the few patients who have a known risk of developing bacteremia-induced endocarditis, avoiding the use of the PDL anesthetic injection technique is a practical alternative when possible.

A disadvantage of routinely using the PDL anesthetic injection technique is that some patients report tenderness at the injection site for a day or two after treatment. Among the commonly used local anesthetic injection techniques, patients described needle placement during the administration of an IANB as most painful, followed by the PDL anesthetic injection technique and the mental nerve block injection and infiltration anesthetic injection techniques. They reported that the PDL anesthetic injection technique was the most uncomfortable during solution deposition.

The position of the needle and the pressure of the injection can cause trauma to tissue and subsequent postoperative discomfort. The PDL anesthetic injection technique is not recommended for primary teeth, because there have been cases of enamel hypoplasia and hypomineralization in permanent teeth adjacent to the injection site. The results of histologic evaluations after the PDL injection was administered indicated minimal damage to the crestal bone, followed by rapid repair and healing. Other investigators noted disruption of PDL tissue and indications of active external root resorption with microscopic evaluations of dog periodontium after they administered PDL anesthetic injections. Patients sometimes report having a sense that
the anesthetized tooth is protruding after administration of a PDL anesthetic injection. This sensation can be minimized if the dentist avoids using excessive injection pressure and volume.

THE INTRAOSSEOUS ANESTHETIC INJECTION

Although maxillary infiltration anesthetic injection techniques may have success rates of 95 percent or higher, the success rates for IANBs generally are 80 to 85 percent. Lower success rates may be due to the greater density of the buccal alveolar plate (which restricts supraperiosteal infiltration), limited access to the inferior alveolar nerve and a wide variation in neuroanatomy.

With pulpitis, hyperalgesia may be another reason for anesthetic failure. Inflamed tissues may alter the nerves’ resting membrane potentials and decrease excitability thresholds, changes that are not restricted to the inflamed pulp but affect the entire neuronal pathway, extending to the central nervous system. Therefore, routine local anesthetic techniques may not prevent nerve transmission adequately because of the lowered excitability thresholds.

A description of the IO anesthetic injection technique was first published in 1910. The author described a technique for delivering local anesthetic to the root tip via a small drilled hole. The technique lacked popularity because dentists were reluctant to drill into cortical bone and had difficulties inserting a needle precisely into the tight fit of the drilled hole. Early techniques included instrumentation with a half-round bur or a motorized endodontic reamer and a standard 27-gauge short needle. The volume of anesthetic administered ranged from 0.5 to 1.5 mL. Owing to the lack of intimate fit between the needle and the hole, the effective volume often was less than the total volume administered because of leakage at the injection site.

Instruments. As the IO technique evolved, instruments were designed to control deposition of the solution, including the Stabident system (Fairfax Dental, Miami) and the X-Tip dental anesthesia system (Dentsply Maillefer, Tulsa, Okla.). The technique requires perforating the cortical bone by creating a small hole between the roots of the teeth with a specialized rotary instrument. The dentist makes the perforation approximately 5 millimeters apical to the buccal papilla. Applying constant pressure when the perforator is against the cortical plate can lead to a buildup of heat. Malamed recommended using a light pecking motion with the handpiece as the perforator goes through the cortical plate. The X-Tip system has a unique design that leaves a guide in place after perforating the cortical bone to make it easier to insert the needle through the perforation. The administration of an injection of one-quarter to one-half of a cartridge of local anesthetic by means of a small needle guided into the trabecular bone can induce anesthesia (Figures 4, 5 and 6).

Initially, dentists used the IO anesthetic technique as a supplementary technique when the IANB failed, especially in cases of irreversible pulpitis. With the advent of products such as Stabident and the X-Tip, the technique has gained in popularity as a primary technique for anesthetizing a single mandibular tooth. Although dentists use the IO technique most often to provide anesthesia in a single tooth, they may use it to anesthetize multiple teeth in the same quadrant, depending on the injection site and volume of anesthetic injected.
increase in the overall anesthesia success rate for first molars and second premolars. For teeth with irreversible pulpitis, the administration of a supplemental mandibular IO injection increased total pulpal anesthesia success. The onset of anesthesia after the IO injection was administered was almost immediate. Study results indicate that pulpal anesthesia has a duration of as long as 60 minutes when used with a vasoconstrictor and approximately 15 to 30 minutes when used without a vasoconstrictor.

Contraindications. Contraindications to the use of the IO anesthetic injection technique include gross periodontal disease or acute periapical infection. Formation of fistula has been reported at perforation sites. This technique should be used cautiously in cases in which the roots of the teeth are so close together that they preclude clear access to the interdental trabecular bone. A relative contraindication is when there is difficulty perforating the cortical plate where it is thick, such as areas distal to the second molar, increasing the chance of perforator fracture. Some areas of the mandible also may have constricted cancellous bone, which may impede anesthetic distribution.

Adverse effects and complications. There are some possible adverse effects and complications of using the IO technique. Heart palpitations frequently occur when a vasopressor-containing anesthetic is used. To minimize the risk, a slow injection using a local anesthetic without a vasopressor, such as 3 percent mepivacaine plain, is recommended. Only one-eighth to one-quarter of a dental cartridge should be administered at one time until adequate anesthesia is achieved. Because the cancellous bone in the mandible is vascular, keep the volume of local anesthetic to the recommended minimum to avoid possible rapid systemic uptake and overdose.

The use of vasoconstrictors is dictated by treatment needs and patients’ health histories. Patients with moderate to severe cardiovascular disease or who are taking tricyclic antidepressants or nonselective β-adrenergic blocking agents are poor candidates for use of the IO anesthetic injection technique where solutions containing epinephrine or levonordefrin are used.

Investigators have reported a transient increase in heart rate after administration of vasopressor-containing anesthetic solutions by means of IO injections. Coggins and colleagues found that 60 percent of participants reported perceiving an increase in heart rate as determined by subjective questioning after administration of an IO injection of 1.8 mL of 2 percent lidocaine with epinephrine 1:100,000. Replogle and colleagues reported that 67 percent of participants had an objective increase in heart rate as determined by means of electrocardiography when 2 percent lidocaine with epinephrine 1:100,000 was administered by means of IO injection. The mean increase in heart rate was 28 beats per minute. Investigators in other studies found similar increases in heart rate when local anesthetics with vasoconstrictors were administered. Replogle and colleagues and Chamberlain and colleagues did not observe any clinically significant changes in blood pressure after administration of IO injections of 2 percent lidocaine with 1:100,000 epinephrine.

In general, the results from all of these studies showed that the heart rate returned to baseline within four minutes in most patients. To reduce patient anxiety, inform patients that they may experience a transient increase in heart rate and that any symptoms of palpitations are short-lived and will dissipate quickly. The administration of IO injections with 3 percent mepivacaine plain has not produced a clinically significant increase in heart rate, so there is no need to inform patients about an increase in heart rate with the use of mepivacaine 3 percent without a vasoconstrictor.

Pain during the perforation, as well as after the procedure, is another complication. Reisman and colleagues noted that 27 percent of patients reported having moderate pain and 6 percent reported having severe pain during administration of the injection. There was a 2 to 15 percent incidence of postoperative pain at the injection site that dissipated within a few days and a 4 to 5 percent incidence of swelling, bruising or purulence that healed within two weeks. Four to 13 percent of patients reported that their teeth felt “high” for a few days after the IO injection was administered.

Although rare, separation of the perforator or needle can occur. If this happens, the perforator or needle cannula usually gets lodged in the bone. A hemostat can be used to remove the fragment from the bone. Perforation of the lingual plate of the bone or injury to the roots of the teeth can occur. The IO anesthetic injection technique is not recommended for use in areas of mixed dentition because of insufficient cancellous bone and the possibility of damaging developing tooth buds.

Conclusions

PDL and IO anesthetic injection techniques can be used in dentistry to induce local anesthesia. They provide alternative approaches to establishing effective anesthesia for mandibular dental procedures and are particularly useful.
when mandibular nerve block anesthesia has failed. Adverse reactions such as stimulation of the cardiovascular system, injection pressure discomfort and postoperative tenderness have been reported. Advanced anesthetic methods permitting controlled administration may minimize adverse reactions associated with these alternative techniques.

Disclosures. Dr. Moore is a consultant to the Pharmacovigilance Division of Dentsply International, York, Pa. Drs. Cuddy, Cooke and Sokolowski did not report any disclosures.

The authors thank Christine T. Bettiinger for the illustrations created for Figures 3 and 6. They also thank Darcie Burns for her assistance in the editing this manuscript.


