3 Local Anesthesia

John M. Nusstein

Abstract

Pulpal anesthesia is a cornerstone in the delivery of endodontic therapy. It affects not only the dentist's ability to provide safe, pain-free treatment, but enhances patient compliance and satisfaction. Administration of local anesthesia is one of the first procedures performed by the dentist. This chapter reviews some of the key local anesthetic components and techniques available to providers in the pursuit of providing pain-free dental treatment. This includes both mandibular and maxillary injections, testing for pulpal anesthesia, new technology and drug formulations, and the supplemental techniques that may make all the difference for the provider and patient.

Guiding Reference

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(5):517–21.

This study quintessentially showed the difficulty of anesthetizing mandibular teeth when a state of pulpal inflammation was present and tried to begin to explain why patients report pain during treatment even after a successful inferior alveolar nerve block was delivered.

J.M. Nusstein, DDS, MS
Division of Endodontics, The Ohio State University College of Dentistry, 305 W 12th Ave, Columbus, OH 43210, USA
e-mail: nusstein.1@osu.edu

O.A. Peters (ed.), *The Guidebook to Molar Endodontics*,
DOI 10.1007/978-3-662-52901-0_3

3.1 Introduction

Profound pulpal anesthesia is of obvious importance in endodontic practice and dentistry in general. It benefits not only the patient, for obvious reasons, but also the dentist who does not have to worry about patient reactions or sudden movement during therapy. There are a number of challenges a clinician must overcome in achieving profound local anesthesia. Diagnosis of the status of the pulp and periapical tissues will affect the anesthetic regimens potentially utilized.

Inflammatory changes within the pulp progress as a carious lesion nears the pulp and may cause chronic inflammation to take on an acute exacerbation with an influx of neutrophils and the release of inflammatory mediators such as prostaglandins, interleukins, and proinflammatory neuropeptides, such as substance P, bradykinin, and calcitonin gene-related peptide (CGRP). These mediators, in turn, can sensitize the peripheral nociceptors within the pulp of the affected tooth which may increase pain production and neuronal excitability These changes may lead to moderate-to-severe pain for the patient and influence the anesthetic strategies needed by the dentist/endodontist to gain profound pulpal anesthesia.

Periapical changes due to infection and chronic inflammation may also impact the anesthesia strategy. The development of an acute apical abscess is the result of pyogenic bacteria from the root canal system spreading to the periapical region and stimulating a strong immune response by the host tissue, with neutrophilic leukocytes dominating the early response. The neutrophils secrete lysosomal enzymes that digest both live and dead cell material. As the neutrophilic response progresses, an accumulation of dead and live neutrophils, disintegrated tissue cells, degraded extracellular matrix, and lysosomal enzymes results in a collection of purulent exudate termed pus. If the involved pathogens are of significant virulence and if the host response is of sufficient intensity, an acute apical abscess may arise. Severe percussion pain or swelling will indicate an acute response within the bone and affect the type of local anesthesia techniques that can be utilized.

Once a pulpal diagnosis is made and a treatment plan developed which includes endodontic therapy, the first step in treatment is local anesthesia. The review of a patient's medical history may determine which local anesthetic can and cannot be utilized. Patients with uncontrolled hypertension or sensitivity to vasoconstrictors may require the use of anesthetics such as 3 % mepivacaine or 4 % prilocaine. Patients taking nonselective beta-blockers should not receive an injection of an anesthetic containing levonordefrin. A thorough review of the patient's medical history and drug list will dictate the proper anesthetic choice.

3.2 Topical Anesthesia

The use of topical anesthetic prior to injection has been shown to help reduce the pain of needle insertion in certain locations of the mouth. More popular topical anesthetics include 20 % benzocaine, EMLA (eutectic mixture of local anesthetics – 2.5 % lidocaine and 2.5 % prilocaine), and 5 % lidocaine (Box 3.1).

Box 3.1. Topical Anesthetics

20 % benzocaine
EMLA (2.5 % lidocaine + 2.5 % prilocaine)
5 % lidocaine

These preparations are available as gel, ointment, or spray form, which allows for easy placement at the site of injection. Utilizing a cotton tip applicator, a small amount of topical anesthetic (approximately 0.2 mL) is placed at the injection site and allowed to penetrate for 60 s. Spray forms may be placed on a cotton tip applicator and applied or sprayed directly to the site of injection.

The effectiveness of a topical anesthetic to reduce the pain of needle insertion has been evaluated in several clinical studies. These have reported no significant difference between 20 % benzocaine compared to a placebo for infiltration injections for the maxillary lateral incisor and that 20 % benzocaine had no effect on needle insertion pain for inferior alveolar nerve block and maxillary posterior buccal infiltration injections. However, results did show that topical anesthetic reduced the amount of needle insertion pain for maxillary anterior infiltrations. Evaluation of the pharmacological and psychological effects of topical anesthesia has shown that, using a placebo application and 20 % benzocaine, subjects who believed that they were receiving an active topical anesthetic anticipated significantly less pain than subjects who thought they were receiving a placebo. Whether injections were preceded by the placebo or the active topical anesthetic did not alter the subjects' reported pain. No significant difference between 20 % benzocaine and a placebo was also found when used prior to a palatal anterior superior alveolar nerve block. Gill and Orr reported that topical anesthetic application for 1 min is effective for maxillary infiltrations, but had no significant difference when compared with a placebo for an inferior alveolar nerve block [1]. The sum of these studies suggests that the mere knowledge of the patient that they are receiving a topical anesthetic could lower the pain experienced during needle insertion. A survey of 3051 pediatric dentists reported that the majority of dentists used topical anesthetic prior to local anesthetic injections in private practice.

Due to the placebo effect, and since most patients and dentists believe that topical anesthetic reduces the pain of the injection, topical anesthetic should be used, if for nothing more, to have the patient feel that the dentist is attempting everything to make a stressful procedure as comfortable as possible.

3.3 Mandibular Anesthesia

When one considers the challenges of local anesthesia in dentistry, mandibular teeth pose the more severe challenge. The inferior alveolar nerve block (IANB) must be delivered accurately (indicated by soft tissue and lip numbness) to have any chance to attain pulpal anesthesia. Missed blocks (lack of lip numbness) occur about 5 % of the time and should prompt the dentist to re-administer the injection prior to beginning treatment. When one reviews the literature to determine what injection techniques or anesthetic solutions can offer, the dentist needs to be aware of what the definition of "anesthetic success" is utilized. One way used to define anesthetic success for mandibular blocks is the percentage of subjects who achieve two consecutive electric pulp tester (EPT) readings of 80 within 15 min of injection and sustain these readings for at least 60 min. Clinically, this translates into being able to work on the patient no later than 15 min after giving the IANB and having pulpal anesthesia for 1 h. In the available clinical literature, it is reported that, following administration of a successful IANB (lip numbness achieved) using 2 % lidocaine with 1:100,000 epinephrine, for the mandibular first molar, success occurs 53 % of the time, while for the first premolar it is 61 % and for the lateral incisor it is 35 %. Anesthetic failure (the percentage of patients who never achieve two consecutive 80 readings with the EPT during 60 min of testing) for the mandibular first molar is 17 %, 11 % for the first premolar, and 32 % for the lateral incisor. Patients may also be subject to anesthesia of slow onset. These patients generally do not achieve pulpal anesthesia until after 16 min following the IANB. This is reported to occur in mandibular teeth approximately 19–27 % of the time with some patients (8 %) having onset after 30 min. Patients who present a history of anesthesia of slow onset need to be scheduled appropriately earlier than their actual procedure, so that the dentist can give the IANB well before the time it is needed clinically.

3.3.1 Block Technique

The most common injection for obtaining mandibular anesthesia is the inferior alveolar nerve block (Box 3.2).

The inferior alveolar nerve (IAN) and lingual nerve are branches of the posterior division of the trigeminal nerve (V3). The lingual nerve provides sensory innervation to the anterior two-thirds of the tongue as well as the floor of the mouth and the lingual gingiva around the molars. The IAN passes medial to the mandibular ramus and enters the mandibular foramen where it eventually branches at the mental foramen and forms the mental and incisive nerves. The IAN provides sensory innervation to the mandibular posterior teeth and buccal soft tissues. Prior to entering the mandibular foramen, the mylohyoid branch splits off and travels downward and forward along the inferior, medial border of the mandible. This nerve innervates soft tissue on the inferior and anterior mandible. It may also innervate the pulps of mandibular molars.

Box 3.2. Mandibular Anesthetic Blocks

Inferior alveolar nerve block
Gow-Gates block
Vazirani-Akinosi (closed mouth) block

The inferior alveolar nerve block (IANB) is usually administered using a standard aspirating syringe and a 27-gauge 1½-inch needle. The injection site is the soft tissue overlying the medial surface of the ramus, lateral to the pterygomandibular raphe, at a height determined by the coronoid notch on the anterior border of the ramus. With the subject's mouth wide open, the thumb of the noninjecting hand is placed over the pterygomandibular triangle and then pulled laterally until the deepest depression in the anterior border of the ramus was felt. The first or second finger of the noninjecting hand palpates the posterior portion of the ramus, finding a slight depression. The line between the thumb and the finger establishes the vertical height of the injection site. The direction of the needle insertion is from the contralateral mandibular premolars and is directed parallel to the occlusal plane [2]. The needle is advanced until the bone is sounded, then retracted 1 mm before aspiration and injection into the pterygomandibular space.

The injection rate should be slow; research has shown that a slower injection rate is more comfortable for the patient (1 cartridge over 60 s) and may lead to more successful blocks. The standard inferior alveolar nerve block will anesthetize the inferior alveolar nerve, mental nerve, and usually the lingual nerve as well. This would include pulpal anesthesia of mandibular molars, premolars, and incisors on the injected side, along with the associated supporting bony and periodontal structures to the midline. It would also anesthetize the buccal and labial soft tissues and chin to the midline. A long buccal injection can be given if soft tissue anesthesia is required of the buccal gingival tissues next to the molar teeth for rubber dam clamp placement. Onset of pulpal anesthesia will range from 5 to 19 min and is slower than the onset of lip numbness (4–6 min).

Other injection techniques have been developed and advocated in attempting to block the inferior alveolar nerve. The Gow-Gates technique [3] has been reported to have a higher success rate than a conventional IANB, but other well-controlled clinical studies have not been able to confirm this. The Vazirani-Akinosi technique (closed mouth) [4, 5] also has not been shown to be superior in terms of achieving profound anesthesia compared to the conventional IANB technique. Therefore, replacing the conventional IANB injection with these techniques will likely not improve success in attaining pulpal anesthesia in mandibular teeth.

Inaccuracy of the IANB injection has been cited as a contributor to failed mandibular pulpal anesthesia. Hannan et al. [6] used medical ultrasound to guide an anesthetic needle to its target site for the IANB. This group reported that accurate injections could be attained by this method, but it did not result in more successful pulpal anesthesia. Simon et al. [7] studied the anesthetic effectiveness of an IANB after using a peripheral nerve stimulator to locate the inferior alveolar nerve at the injection site. The technique was no more successful than the conventional injection technique. Therefore, the accuracy of the injection technique (needle placement) is not the primary reason for anesthetic failure with the IANB. Needle deflection as related to the needle bevel direction (toward or away from the mandibular ramus) has also been shown not to affect the anesthetic success rate of the IANB.

Accessory nerves have also been implicated as a potential reason for the failure of the IANB. The incisive nerve block at the mental foramen has been shown to improve anesthetic success of the IANB in first molars and premolars, but the success rate was not as good as other supplemental anesthetic techniques (to be discussed later). The mylohyoid nerve is the accessory nerve most often implicated as the cause for mandibular anesthesia failure. However, Clark and coauthors [8], when combining the IANB with a mylohyoid injection after locating the mylohyoid nerve with a peripheral nerve stimulator, found no significant improvement in mandibular anesthesia when the mylohyoid injection was added.

3.3.2 Local Anesthetic Compounds for Mandibular Anesthesia

Lidocaine with epinephrine is still considered the standard to compare all other local anesthetics too. The emergence of 4 % articaine has decreased the use of lidocaine in many countries. When one looks at the literature, no local anesthetic has significantly improved the success rate of the IANB. Research comparing various local anesthetic agents such as 3 % mepivacaine plain (Carbocaine, Polocaine, Scandonest), 4 % prilocaine (Citanest Plain), 4 % prilocaine with 1:200,000 epinephrine (Citanest Forte), 2 % mepivacaine with 1:20,000 levonordefrin (Carbocaine with Neo-Cobefrin), 4 % articaine with 1:100,000 epinephrine (Septocaine) to 2 % lidocaine with 1:100,000 epinephrine for the IANB in patients with normal pulps showed that there was no difference in success rates. Therefore, changing local anesthetic agents may not be of benefit for endodontic procedures. When confronted with the increased difficulty of achieving anesthesia due to a diagnosis of symptomatic irreversible pulpitis, clinical studies have also failed to show any superiority of 3 % mepivacaine or 4 % articaine with 1:100,000 epinephrine over 2 % lidocaine with 1:100,000 epinephrine for the IANB. The use of a buffering agent, such as sodium bicarbonate to increase the pH of the anesthetic solution, has also not been found to improve success rates of pulpal anesthesia clinically [9].

Increasing the volume of local anesthetic delivered during the IANB, therefore increasing the amount of anesthetic in the pterygomandibular space and potentially exposing the nerve to more anesthetic, has also been found not to increase the incidence of pulpal anesthesia in asymptomatic patients or those diagnosed with symptomatic irreversible pulpitis. Increasing the concentration of epinephrine (1:50,000) in hopes of keeping the anesthetic agent at the injection site longer showed no advantage in the IANB.

The duration of pulpal anesthesia utilizing 1.8 mL 2 % lidocaine with 1:100,000 epinephrine or 0.5 % bupivacaine with 1:200,000 epinephrine has been reported to be 2.5 h and 3–4 h, respectively. Therefore, adequate time is available for the dentist to complete endodontic therapy. The actual duration of pulpal anesthesia for anesthetics has not been studied.

The choice of local anesthetic may therefore be more a preference of the provider, medical condition of the patient, or even the desired duration of anesthesia. A volume of 3.6 mL (two cartridges) may improve achieving a successful IANB block (lip numbness), but may not improve the success rate of pulpal anesthesia.

3.4 Maxillary Anesthesia

The supraperiosteal (infiltration) injection is the most commonly used local anesthetic technique for maxillary pulpal anesthesia. Ninety-five percent (95 %) of maxillary infiltration injections (supraperiosteal or field blocks) produce successful anesthesia (Box 3.3).

Clinical studies have evaluated the success of maxillary infiltrations using the electric pulp tester. Using a volume of 1.8 mL or less, pulpal anesthetic success (obtaining maximum output with an electric pulp tester) ranged from 87 to 100 %. The duration of pulpal anesthesia with a lidocaine solution varied from 31 to 100 min, with the majority of studies showing duration times of less than 60 min. This is an important point to remember when the endodontic procedure takes longer than approximately 45 min. Anesthesia will diminish, and re-injection may be necessary to ensure patient's continued comfort.

3.4.1 Maxillary Technique

For molar endodontic procedures, the maxillary infiltration technique may be selected. The maxillary division (V2) of the trigeminal nerve branches off in four regions, including the pterygopalatine fossa. In the pterygopalatine fossa, the maxillary division branches off into the zygomatic nerve, the pterygopalatine nerves, and the posterior superior alveolar (PSA) nerve. The PSA nerve commonly has two branches: The second branch of the PSA provides sensory innervation to the alveoli, periodontal ligaments, and pulpal tissues of the maxillary third, second, and first molars (with the exception in 20 % of patients of the MB root of the first molar). The maxillary division also branches off into the infraorbital canal. Within the infraorbital canal, the maxillary division gives off the middle and anterior superior alveolar (MSA and ASA) nerves. The MSA nerve provides sensory innervation to the two maxillary premolars, and perhaps, to the MB root of the first molar as well as the periodontal tissues, buccal soft tissue, and bone in the premolar region. These are the nerves the dentist is most concerned about when treating a maxillary posterior tooth.

The basic infiltration technique taught in dental school is one of the easier injections to administer. Using a 27-gauge short needle, the lip/cheek is pulled outward to make the vestibular tissue taut. The needle is inserted at the height of the mucobuccal fold parallel to the tooth being anesthetized, with the target being the apical

Box 3.3. Maxillary Anesthetic Injections

Infiltration injection
Posterior superior alveolar (PSA) block
Division V2 block

area of the tooth. The direction of the needle bevel may not be important, since no study has looked at its effect on anesthesia, and the anesthetic solution will dissipate in all directions from the needle tip. Following aspiration, injection speed should be slow – approximately 1 min for a cartridge to reduce the potential pain on solution deposition. Onset time for pulpal anesthesia ranges from 2 to 5 min in premolars and molars.

Anesthesia of the palatal tissues may also be needed. Utilization of this injection will help reduce the pain of rubber dam clamp placement in all cases, but especially for teeth that have lost structure in which the clamp may impinge on the palatal gingiva. The use of either a topical anesthetic and/or pressure anesthesia may help reduce the pain of needle insertion on the palate. Pressure anesthesia can be obtained by placing a blunt instrument handle at the target site for approximately 30 s and maintaining that pressure as the needle is inserted immediately adjacent to the pressure site. The insertion site should be adjacent to the tooth being treated and approximately 10 mm from the free gingival margin. The needle bevel should be oriented toward the bone. A small amount of anesthetic (0.3–0.5 mL) is then deposited slowly until blanching of the tissues is identified.

Alternate techniques for posterior maxillary anesthesia include the PSA and second division nerve blocks. These techniques can be very successful, but have potential risks including hematoma, pain, and difficulty in technique.

The posterior superior alveolar (PSA) nerve block anesthetizes the third and second molars and about 80 % of first molars. Often, an additional mesial infiltration injection may be necessary to anesthetize the first molar. The injection targets the PSA nerve and is given superiorly and medially to the maxillary second molar. The maxillary second division nerve block can be attained using two intraoral techniques. The first technique, the greater palatine approach, involves negotiating the greater palatine canal to the pterygopalatine fossa. The second technique, the high tuberosity approach, places the needle around the posterior maxilla until the needle enters the pterygopalatine fossa. Success rates have been reported as high as 95–100 % for second molars using either approach. However, the challenge in tracking the greater palatine canal and the pain associated with this approach may limit the clinical value of this technique.

3.4.2 Local Anesthetic Compounds for Maxillary Anesthesia

The use of a 2 % lidocaine solution with 1:100,000 epinephrine has resulted in a good rate of pulpal anesthesia success. In reviewing numerous clinical studies, an overall success rate of 87 % is reported for molars.

Alternate anesthetic solutions have also been clinically evaluated. The use of plain solutions such as 3 % mepivacaine and 4 % prilocaine has resulted in relatively good success rates (70–73 %), but greatly diminished duration of anesthesia – 25 min. This reduced duration would preclude their use in endodontic therapy unless the patient's medical condition warranted their use. Repeated injections of these solutions would then be necessary. Solutions of 4 % articaine with 1:100,000 epinephrine, 2 % mepivacaine with 1:20,000 levonordefrin, and 4 % prilocaine with 1:200,000 epinephrine achieved the same level of anesthetic success in maxillary first molars as 2 % lidocaine with 1:100,000 epinephrine. Therefore, the use of these anesthetics is of no clinical benefit. Research on the use of 0.5 % bupivacaine with 1:200,000 epinephrine in maxillary first molars revealed a delayed onset time (almost 8 min) and a lower success rate (64 versus 82 % for lidocaine). Anesthetic duration was not extended significantly with the use of bupivacaine. The use of 2 % lidocaine with 1:50,000 epinephrine has also been shown to increase the duration of anesthesia versus a 1:100,000 epinephrine solution, but it did not extend it beyond 60 min. Success rates were the same. No research, published to date, has reported on the effect of buffering on achieving pulpal anesthesia in maxillary molars.

In terms of the volume to utilize, Mikesell et al. [10] compared the degree of anesthesia obtained with 1.8 and 3.6 mL of 2 % lidocaine with 1:100,000 epinephrine in maxillary infiltrations (first molar). The success rates (defined as two consecutive 80 readings with the electric pulp tester) ranged from 97 to 100 % for the two anesthetic volumes. There was no statistically significant difference between the two anesthetic volumes. However, the 3.6 mL volume of lidocaine provided a statistically longer duration of pulpal anesthesia than the 1.8 mL volume for the lateral incisor, first premolar, and first molar.

No current local dental anesthetic preparation has been found to be superior in attaining pulpal anesthesia in maxillary posterior teeth. The choice of anesthetic for a maxillary infiltration injection may be dictated by the patient's health history, desired anesthetic duration, or provider preference.

3.5 Determining Pulpal Anesthesia Prior to Initiating Treatment

Determining whether adequate local anesthesia has been achieved prior to treatment is important (Box 3.4).

Mandibular anesthesia via the inferior alveolar nerve block (IANB) has traditionally been confirmed by asking the patient if their lip feels numb, probing or sticking the gingiva around the mandibular tooth to be treated, or simply starting treatment and waiting for a patient response. These techniques are not very effective in determining if pulpal anesthesia has been achieved. For maxillary teeth, lip and/or cheek numbness may be assessed. Objective tests are available that can be utilized to better assess the level of pulpal anesthesia for all teeth. The use of an electric pulp tester (EPT) and/or the application of a cold refrigerant have been shown

Box 3.4. Determining Successful Pulpal Anesthesia

Thermal testing – cold
Electric pulp testing – maximum reading

to accurately determine pulpal anesthesia in teeth with a normal pulp prior to treatment. If the patient responds negatively to the stimulus (cold or electric current), then pulpal anesthesia has been attained and the patient should not experience pain during treatment. However, in teeth diagnosed with a symptomatic irreversible pulpitis, a failure to respond to the stimulus may not necessarily guarantee pulpal anesthesia [11]. The patient may still report pain with treatment. Of course, teeth with necrotic pulp chambers but whose root canals contain vital tissue may not be tested using the above means. In these cases, testing for pulpal anesthesia of the neighboring teeth may give the clinician an indication of the anesthetic status of the treatment tooth.

3.6 Supplemental Anesthetic Techniques

Patients in pain due to a tooth diagnosed with symptomatic irreversible pulpitis frequently have difficulties attaining pulpal anesthesia. One theory to explain this is that the inflamed tissue has a lowered pH, which reduces the amount of the base form of anesthetic needed to penetrate the nerve sheath and membrane. Therefore, there is less ionized form of the anesthetic within the nerve to produce anesthesia. Obviously, this theory may only explain the local effects of inflammation on the nerve and not explain why an IANB injection is less successful when given at a distance from the area of inflammation (the "hot" tooth). Another theory states that the nerves arising from inflamed tissue have altered resting potentials and reduced thresholds of excitability. Electrophysiological research indicated that local anesthetic agents were not able to prevent the transmission of nerve impulses due to the lowered nerve excitability thresholds of inflamed nerves. Other theories have considered the presence of anesthetic-resistant sodium channels and upregulation of the so-called tetrodotoxin-resistant sodium channels in pulps diagnosed with irreversible pulpitis.

The failure of the traditional IANB in asymptomatic and symptomatic patients requires that a clinician have strategies to attain good pulpal anesthesia. This is very important when a patient complains of pain too severe for the clinician to proceed with endodontic treatment, as is often the case of patients with "hot" (symptomatic irreversible pulpitis) teeth. There are several supplemental anesthetic techniques (Box 3.5) available to help the dentist. It should be reiterated that these supplemental techniques are used best after attaining a clinically successful inferior alveolar nerve block (lip numbness).

Box 3.5. Supplemental Injection Techniques

Mandibular buccal infiltration with articaine
Intraligamentary injection (PDL)
Intraosseous injection (IO)
Intrapulpal injection

3.7 Preemptive Strategies to Improve Success of the IANB Injection

Recent clinical studies have looked at the use of various oral medications prior to treatment of a patient with a tooth diagnosed with symptomatic irreversible pulpitis attempting to improve the success rate of the IANB injection. The use of acetaminophen and ibuprofen (various strengths), acetaminophen/ibuprofen combinations, methylprednisolone, ketorolac and triazolam all failed to improve the rate of success of the IANB injection in these patients. However, Stanley et al. [12] did report on an improvement in block success when nitrous oxide was used in a concentration of 30–50 %.

3.8 Mandibular Buccal Infiltration Injection with Articaine

Research has looked at the use of a mandibular buccal infiltration injection of 4 % articaine with 1:100,000 epinephrine as a supplemental injection to increase the success of the IANB injection (Box 3.6). In asymptomatic patients, the use of the articaine solution was found to be superior to a lidocaine solution (88 % versus 71 %, respectively). However, when the buccal infiltration injection is used as a supplement to the IANB in patients diagnosed with irreversible pulpitis, success was reported as only 58 %. This result was much less than that attained with the IO and PDL injections.

Deposition of one cartridge of 4 % articaine solution in the buccal vestibule next to a mandibular posterior tooth is a simple adjunct technique. Research has shown that only articaine is able to provide this added anesthesia. The use of other

Box 3.6. Mandibular Buccal Infiltration with Articaine*

Technique

- Utilize 27-gauge short needle and 4 % articaine solution
- Insert needle directly next to the tooth to be anesthetized in the buccal vestibule
- Place needle to approximate depth or root apex
- Inject one cartridge of articaine solution over 1–2 min
- (Optional) For anterior teeth – inject additional one cartridge of articaine solution, lingual to the treatment tooth
- Wait for a minimum of 5 min before beginning treatment
- Test tooth for anesthesia
- Begin treatment

*Note: If a technique is being used as a supplemental injection, do not give until successful IANB injection is confirmed (lip/soft tissue numbness).

anesthetics (lidocaine or prilocaine) and/or different concentrations of anesthetics (2 or 4 %) has failed to match the success of articaine. The use of a 4 % articaine solution with either 1:100,000 or 1:200,000 epinephrine achieves the same rate of success, with the only difference being the duration of anesthesia (less for less epinephrine). For mandibular anterior teeth, the same level of success may be achieved when the injections are given primarily without an IANB injection. The addition of a second injection of articaine on the lingual of an anterior tooth will increase the success rate. However, duration of these primary injections is only approximately 45 min.

3.9 Intraligamentary (PDL) Injection

The PDL supplemental injection is still one of the most widely taught and used supplemental anesthetic techniques (Box 3.7). The success of supplemental PDL injections in helping achieve anesthesia for endodontic procedures has been reported to be 50–96 %. The key to giving a successful PDL injection remains the attainment of back pressure during the injection.

PDL injections are usually given utilizing either a standard dental anesthetic syringe or a high-pressure syringe. A 30-gauge ultrashort needle or 27- or 25-gauge short needle is utilized. The gauge of the needle does not influence the effectiveness. The needle is inserted into the mesial gingival sulcus with the bevel of the needle facing away from the tooth. Maximum penetration within the sulcus is required. Utilizing a standard syringe, slow, but heavy pressure is applied to the syringe plunger for approximately 20 s. With a pressure syringe, the trigger is slowly squeezed until it clicks one or two times. As stated earlier, back pressure must be felt as the injection is given. Failure to get back pressure will most likely lead to

Box 3.7. Intraligamentary Injection

Technique

- Prepare syringe with needle and anesthetic
- Determine need for injection
- Place needle in mesial gingival sulcus
  - Bevel facing bone
- Apply pressure to needle for maximum soft-tissue penetration
- Slow, moderate-to-heavy pressure on syringe
  - Approximately 20 s
  - Two clicks with pressure syringe
  - 0.7 mL with CCLAD device
- Repeat injection in distal sulcus
- Test tooth for anesthesia
- Begin treatment

failure. The same injection is then given in the distal sulcus of the tooth. Approximately 0.2 mL of anesthetic is expressed in both locations.

The development of computer-controlled local anesthetic delivery systems (CCLAD for short), the Wand/CompuDent and Single Tooth Anesthesia System (both Milestone Scientific, Livingston, NJ) have been found to also be able to deliver a PDL injection. These systems are able to deliver 1.4 mL of anesthetic over the course of the two injections. The duration of anesthesia with the CompuDent/Wand system is almost three times what is afforded with a standard/pressure syringe (first molar averaged 31–34 versus 10 min). Currently, no research on the STA device is available for review.

The onset of anesthesia utilizing the PDL injection is immediate. The dentist should not wait to begin treatment. After delivering the injection, the tooth should be pulp-tested and, if no response is recorded, treatment should begin. A repeated set of injections may be necessary if the first set does not help attain adequate pulpal anesthesia.

The intraligamentary injection forces local anesthetic solution through the cribriform plate and into the cancellous bone around the tooth. In a sense, it is an intraosseous injection. The duration of anesthesia is dependent on the volume and type of anesthetic utilized. Anesthetic solutions not containing any vasoconstrictor (3 % mepivacaine) will have a shorter duration of action compared to those anesthetics containing epinephrine. Success of anesthesia is also dependent on the presence of a vasoconstrictor with plain solutions showing less effectiveness.

Patients should be advised of potential post-treatment, moderate pain of the tooth that was injected. This is usually due to the trauma to the soft tissue where the needle was inserted and not the pressure of the injection.

3.10 Intraosseous Injection (IO)

The use of the intraosseous injection (IO) allows the dentist to deliver local anesthetic solutions directly into the cancellous bone surrounding the affected tooth (Box 3.8). There are several intraosseous systems available on the market including the Stabident system (Fairfax Dental, Wimbledon, UK), X-Tip system (Dentsply Maillefer, Tulsa, OK), and QuickSleeper made by Dental Hi Tec (Cholet, France). The Stabident system consists of a 27-gauge, beveled wire driven by a slow-speed handpiece which perforates the cortical bone. Anesthetic solution is then delivered into the cancellous bone with a 27-gauge ultrashort needle through the perforation, using a standard anesthetic syringe. The X-Tip system consists of a two-part perforator/guide sleeve component, which is also driven by a slow-speed handpiece. The perforator leads the guide sleeve through the cortical bone and then is separated from it and removed. This leaves the guide sleeve in place and allows for a 27-gauge needle to be inserted to inject the anesthetic solution. The guide sleeve is removed with a hemostat when treatment is complete. The QuickSleeper is an electronic handpiece that holds and drives a perforating needle as well as an anesthetic cartridge. Once perforation is attained, the handpiece uses an electric injection system to deliver the local anesthetic through the perforation.

Box 3.8. Intraosseous Injection

Technique

- Prepare syringe with needle and anesthetic
- Determine need for injection
- Advise patient of the technique's side effects (transient increased heart rate)
- Select perforation site (generally distal to tooth, if accessible)
  - In attached, healthy gingiva
  - Above mucogingival line
    - Exception: X-Tip and QuickSleeper system
  - Equidistant from approximating roots
- Anesthetize perforation area (if needed)
  - 0.5 mL anesthetic
- Place perforator and align perpendicular to bone surface
- Perforate cortical bone over a 5–7 s time period
  - Pecking motion until breakthrough is felt
- Immediately place needle in perforation and/or inject anesthetic
  - 0.9–1.8 mL anesthetic over 1 min
- Retest tooth for anesthesia
- Begin treatment immediately

One of the benefits of the IO injection is the immediate onset of anesthesia (Box 3.8). The injection is recommended to be given distal to the tooth to be anesthetized for best success. The exceptions to this rule are maxillary and mandibular second molars, where a mesial site of injection is appropriate. The perforation site for the IO injection should be equidistant between the teeth and the *attached* gingiva. This allows for the perforation to be made through a minimal thickness of tissue and cortical bone, and prevents damage to the roots of the teeth. Perforation in attached tissue also allows for easier location of the perforation site with the Stabident system. The X-Tip and QuickSleeper could be used in a more apical area below the mucogingival junction if needed, since there is no difficulty in locating the perforation hole. The apical location of the injection would be advisable when the patient has no attached tissue around the affected tooth, there is a lack of interproximal space between adjacent roots, or the Stabident IO injection did not achieve adequate anesthesia.

Injection of the anesthetic solution should be slow – approximately 1 min for 1.8 mL of solution. The volume of solution injected can range from 0.9 to 1.8 mL. Most clinical research has been conducted with these volumes. Research on the supplemental IO injection for asymptomatic patients and those diagnosed with irreversible pulpitis has shown good results. Rates have ranged from 75 to 93 % for mandibular first molars. No specific anesthetic has been found to be superior when used with the IO injection. However, duration of effect has been shown to be dependent on the presence of a vasoconstrictor (like the PDL injection). The Stabident and X-Tip systems show equal effectiveness in terms of anesthesia. No published research is currently available on the effectiveness of the QuickSleeper system. Failure of the IO injection is usually due to back pressure or backflow of anesthetic out of the perforation site. This backflow is usually indicative of an incomplete perforation or blockage of the guide sleeve. The duration of anesthesia for a supplemental IO injection in patients with irreversible pulpitis has been reported to last the entire debridement appointment of approximately 45 min. The duration will be shorter with the 3 % mepivacaine solution.

One of the concerns when utilizing the IO injection is the reported transient heart rate increase with both the Stabident and X-Tip systems (and most likely the QuickSleeper system) when injecting epinephrine-containing and levonordephrin-containing anesthetic solutions. Replogle et al. [13] reported that 67 % of subjects had an increase in heart rate as measured on an electrocardiograph when 1.8 mL of 2 % lidocaine with 1:100,000 epinephrine was utilized. The increase in the heart rate reported ranged from 12 to 32 beats per minute. The use of 3 % mepivacaine has been reported not to cause any significant increase in heart rate [13] and may be an excellent alternative when a patient's medical history or drug therapies contraindicate the use of epinephrine or levonordephrin. Prior to the injection of a vasoconstrictor-containing anesthetic, the patient should be warned of the side effect and reassured that the increase in heart rate is transient (2–3 min) and is not dangerous.

3.11 Intrapulpal Injection

In approximately 5–10 % of mandibular teeth diagnosed with irreversible pulpitis, supplemental injections (PDL and IO) do not produce adequate anesthesia, even when repeated, to enter the pulp chamber painlessly. This is a prime indication that an intrapulpal injection may be necessary (Box 3.9).

Box 3.9. Intrapulpal Injection

Technique

- Pulpal exposure
- Select appropriate size needle to fit snuggly into perforation or canal orifice
- Advise patient of side effects of technique (severe, short-term pain)
- Place needle into perforation or canal orifice with firm pressure to achieve maximum penetration
- Inject anesthetic slowly under back pressure (20–30 s)
- Have patient indicate relief of pain
- Resume coronal pulp tissue removal or removal of tissue from canal (anesthetic duration is approximately 10 min)
- Repeat injection in individual canals as needed

The intrapulpal injection works very well when it is given under back pressure. Onset of anesthesia is immediate. Various techniques have been advocated in giving the injection; however, the key factor is giving the injection under strong back pressure. Simply placing local anesthetic solution in the pulp chamber will not achieve adequate pulpal anesthesia.

A disadvantage of the intrapulpal injection is its short duration of action (approximately 15–20 min). Once anesthesia is achieved, the practitioner must work quickly to remove all the tissue from the pulp chamber and the canals. The intrapulpal injection also requires that the pulp tissue be exposed to permit the injection to be given. Achieving a pulpal exposure could be very painful to the patient, since the pain of treatment may begin when the dentin is exposed. Finally, the injection itself can be very painful for the patient. The patient should be warned to expect moderate-to-severe pain during the initial phase of the injection.

To give the injection, the pulp of the tooth must be exposed. With pinpoint exposures, a 30-gauge needle can be utilized. A large-gauge needle may be needed if the exposure is larger in diameter. The needle is placed on a standard syringe containing any type of local anesthetic. The patient is warned about the pending occurrence of the injection. The needle is then placed into the exposure hole and driven into the pulp chamber. Anesthetic is immediately delivered under strong back pressure. The failure to achieve back pressure with the injection may result in a failure to attain any more useful pulpal anesthesia. If the pulp exposure is larger and the pulp canal orifices can be visualized or probed, the 30-gauge needle is driven into the canal as deeply as it can go while anesthetic is being delivered. Ask the patient to signal if and when the pain of the injection subsides. This can be used as an indication that some degree of pulpal anesthesia has been attained in that canal. Removal of the tissue in the injected canal should begin immediately. The duration of the injection is as little as 10 min. This injection may be required for all of the canals.

3.12 Checklist for Anesthesia in Endodontics

- Check allergies, premedications to determine appropriate local anesthetic selection.
- Select appropriate injection technique for clinical diagnosis and location.
- Test for anesthetic success prior to beginning treatment.
- If anesthesia is insufficient, use supplementary technique to enhance anesthesia.
- Retest for adequate pulpal anesthesia prior to beginning treatment.
- If insufficient anesthesia, repeat previous supplemental technique or select a different one.
- Once adequate anesthesia is achieved, begin treatment.

References

1. Gill CJ, Orr DL. A double-blind crossover comparison of topical anesthetics. J Am Dent Assoc. 1979;98(2):213–4.
2. Jorgensen NB, Hayden Jr J. Local and general anesthesia in dentistry. 2nd ed. Philadelphia: Lea & Febiger; 1967.
3. Gow-Gates GA. Mandibular conduction anesthesia: a new technique using extraoral landmarks. Oral Surg Oral Med Oral Pathol. 1973;36(3):321–8.
4. Vazirani S. Closed mouth mandibular nerve block: a new technique. Dent Dig. 1960;66:10–3.
5. Akinosi J. A new approach to the mandibular block. Br J Oral Surg. 1977;15:83–7.
6. Hannan L, Reader A, Nist R, et al. The use of ultrasound for guiding needle placement for inferior alveolar nerve blocks. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1999;87(6):658–65.
7. Simon F, Reader A, Drum M, Nusstein J, Beck M. A prospective, randomized single-blind study of the anesthetic efficacy of the inferior alveolar nerve block administered with a peripheral nerve stimulator. J Endod. 2010;36(3):429–33.
8. Clark S, Reader A, Beck M, Meyers WJ. Anesthetic efficacy of the mylohyoid nerve block and combination inferior alveolar nerve block/mylohyoid nerve block. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1999;87(5):557–63.
9. Whitcomb M, Drum M, Reader A, Nusstein J, Beck M. A prospective, randomized, double-blind study of the anesthetic efficacy of sodium bicarbonate buffered 2% lidocaine with 1:100,000 epinephrine in inferior alveolar nerve blocks. Anesth Prog. 2010;57(2):59–66.
10. Mikesell A, Drum M, Reader A, Beck M. Anesthetic efficacy of 1.8 mL and 3.6 mL of 2% lidocaine with 1:100,000 epinephrine for maxillary infiltrations. J Endod. 2008;34(2):121–5.
11. Dreven LJ, Reader A, Beck M, et al. An evaluation of an electric pulp tester as a measure of analgesia in human vital teeth. J Endod. 1987;13(5):233–8.
12. Stanley W, Drum M, Nusstein J, Reader A, Beck M. Effect of nitrous oxide on the efficacy of the inferior alveolar nerve block in patients with symptomatic irreversible pulpitis. J Endod. 2012;38(5):565–9.
13. Replogle K, Reader A, Nist R, Beck M, Weaver J, Meyers WJ. Cardiovascular effects of intraosseous injections of 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine. J Am Dent Assoc. 1999;130(5):649–57.