8

Local Anesthesia

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CHAPTER OUTLINE

LEARNING OBJECTIVES

After reading this chapter, the student should be able to:

1. Explain why apprehension and anxiety, fatigue, and tissue inflammation create difficulties in obtaining profound anesthesia.
2. Define the pain threshold and the factors affecting it.
3. Describe patient management techniques that facilitate obtaining adequate anesthesia.
4. List techniques that are helpful in reducing the pain of injections.
5. Describe the "routine" approach to conventional local anesthesia: when and how to anesthetize.
6. Describe circumstances that create difficulties in obtaining profound anesthesia using conventional techniques.
7. Describe when to use supplemental methods of obtaining pulpal anesthesia if standard block or infiltration methods fail.
8. Review techniques of infiltration, intraosseous, periodontal ligament, and intraseptal and intrapulpal injections.
9. Discuss how to obtain anesthesia for specific pulpal and periapical pathoses: symptomatic irreversible pulpitis, symptomatic teeth with pulpal necrosis, asymptomatic teeth with pulpal necrosis, and surgical procedures.

Factors Affecting Endodontic Anesthesia

Emotional considerations, in addition to tissue changes, impair the effectiveness of local anesthesia.[1] A patient who is psychologically distraught and has an inflamed pulp or periapex has a lower pain threshold (i.e., less stimulus is required to produce pain).[2]

Apprehension and Anxiety

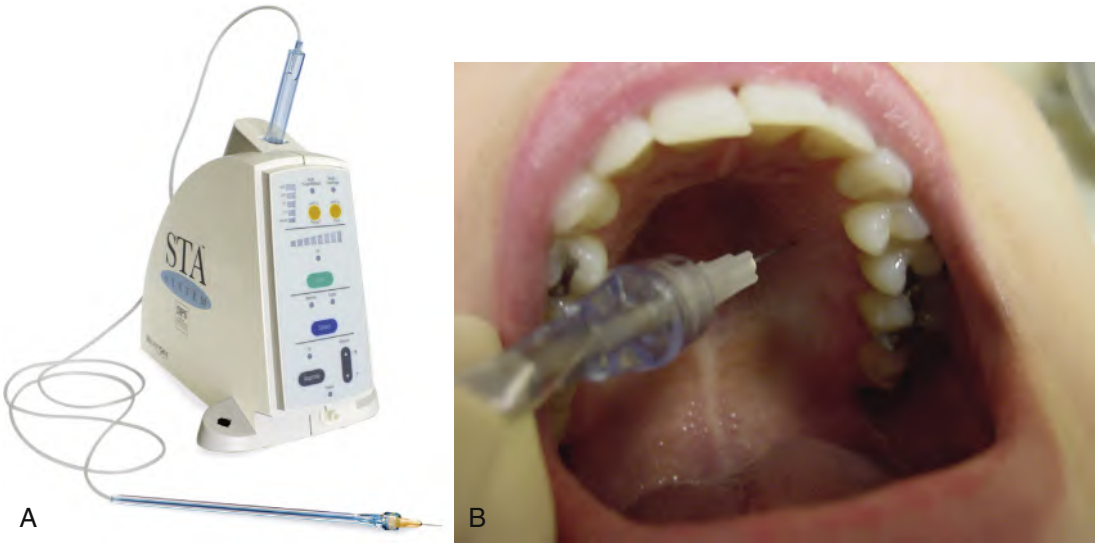
Many endodontic patients have heard horror stories about root canal treatment. The cause may not be the treatment but the experience of a painful or "infected" tooth. They vividly recall the pain, swelling, and sleepless nights associated with the tooth before treatment. The procedure itself is generally less threatening; a survey of endodontic patients completing therapy indicated that 96% would agree to have future root canal treatment.[3] Therefore because they fear the unknown and have heard unfavorable stories, patients are apprehensive or anxious. This emotion plays a role in their perceptions and affects how they react to pain. Many patients can effectively mask this apprehension!

Fatigue

Over a course of days, many patients with a toothache have not slept well, have not eaten properly, or otherwise have not functioned normally. In addition, many are apprehensive or anxious about the appointment. The result is a patient with a decreased ability to manage stress and less tolerance for pain.

Tissue Inflammation

Inflamed tissues have a lower threshold of pain perception[4]; this phenomenon is called *allodynia.* In other words, a tissue that is inflamed is much more sensitive and reactive to a mild stimulus.[4] Therefore an inflamed tissue responds painfully to a stimulus that otherwise would be unnoticed or perceived only mildly. Because root canal treatment procedures generally involve inflamed pulpal or periapical tissues, this phenomenon has obvious importance. A related complication is that inflamed tissues are more difficult to anesthetize.[5]



• **Fig. 8.1** **A,** Computer-controlled injection device. Note the handpiece assembly and microtubing. **B,** The specialized handpiece and needle may be used in most situations. (A, courtesy Milestone Scientific, Inc., Livingston, NJ, USA.)

A good example of the allodynia is sunburn. Exposed tissues that have been sunburned are irritated and inflamed. The skin has now become quite sensitive (lower pain threshold) to contact and is painful. The same principle applies to inflamed pulpal and periapical tissues.[6]

Previous Unsuccessful Anesthesia

Unfortunately, profound pulpal anesthesia is not always obtained with conventional techniques. Previous difficulty with teeth becoming anesthetized is associated with a likelihood of subsequent unsuccessful anesthesia.[7] These patients are likely to be apprehensive (lower pain threshold) and generally identify themselves by comments such as, "Novocain never seems to work very well on me" or "A lot of shots are always necessary to deaden my teeth." The practitioner should anticipate difficulties in obtaining anesthesia in such patients. Often, psychological management and supplemental local anesthesia techniques are required (Video 8.1).

Initial Management

The early phase of treatment is most important. If the patient is managed properly and anesthetic techniques are performed smoothly, the pain threshold elevates. The result is more predictable anesthesia and a less apprehensive, more cooperative patient.

Psychological Approach

The psychological approach involves the four Cs: control, communication, concern, and confidence. *Control* is important and is achieved by obtaining and maintaining the upper hand. *Communication* is accomplished by listening to the patient and explaining what is to be done and what the patient should expect. *Concern* is shown by verbalizing awareness of the patient's apprehensions. *Confidence* is expressed in body language and in a professional approach and communication style, giving the patient confidence in the management, diagnostic, and treatment skills of the dentist. Management of the four Cs effectively calms and reassures the patient, thereby raising the pain threshold.

Topics Related to Injection Pain

Obtaining the Patient's Confidence

Obtaining the patient's confidence is critical. Before any injection is given, establishing communication, exhibiting empathy, and informing patients of an awareness of their apprehension in addition to their dental problem markedly increases the patient's confidence levels.[8] Most important, having the patient's confidence gives control of the situation to the dentist; this is a requisite!

Topical Anesthetic

Use of a topical anesthetic is popular as an adjunct to oral injections. Some investigators have shown topical anesthetics to be effective,[9-11] whereas others have not.[12,13] The most important aspect of using topical anesthesia is not primarily the actual decrease in mucosal sensitivity, but rather the demonstrated concern that everything possible is being done to prevent pain. Another aspect is the power of suggestion that the topical anesthetic will reduce the pain of injection.[13] When a topical anesthetic gel is used, a small amount on a cotton-tipped applicator is placed on the dried mucosa for 1 minute before the injection.[14]

Needle Insertion

Initially, the needle is inserted *gently* into the mucosal tissue.

Small-Gauge Needles

A common misconception is that smaller needles cause less pain; this is not true for dental needles. Patients cannot differentiate between 25-, 27-, and 30-gauge needles during injections.[15-17] These sizes have similar deflection patterns and resistance to breakage.[17,18] However, to prevent broken needles when administering inferior alveolar nerve blocks, do not use 30-gauge needles, bury the needle to the hub, or bend needles at the hub.[19] As a recommendation, a 27-gauge needle is suitable for most conventional dental injections.

Slow Injection

A slow injection decreases both pressure and the patient's discomfort.[20] A slow inferior alveolar nerve block is more comfortable than a rapid injection.[20,21] A technique for slow injection is to use a computer-controlled anesthetic delivery system (CCLAD) (Fig. 8.1, *A* and *B*).

Most studies on CCLADs compared the pain of injection with delivery systems and pain with standard syringe injections,[22-28] generally with favorable results.[24-28] Therefore although the CCLAD reduces the pain of the injection, the system does not produce a painless injection.[22-28]

Two-Stage Injection

A two-stage injection consists of initial, very slow administration of approximately a quarter-cartridge of anesthetic just under the mucosal surface. After regional numbness has been obtained, the remainder of the cartridge is deposited to the full depth at the target site. The two-stage injection decreases the pain of needle placement for females in the inferior alveolar nerve block.[29] This injection technique is indicated for apprehensive and anxious patients or pediatric patients, but it may be used on anyone. It is also effective for any injection, including the inferior alveolar nerve block.

Gender Differences in Pain

Women try to avoid pain more than men, accept it less, and fear it more.[30,31] Anxiety may also modulate differences in pain responses between males and females.[31] Women react differently to pain and are more likely to present anesthetic challenges.

When to Anesthetize

Preferably, anesthesia should be given at each appointment. A common belief is that instruments may be used in canals with necrotic pulps and periapical lesions painlessly without anesthesia. Occasionally there may be ingrowth of vital tissue in the apical few millimeters of the canal.[32] This inflamed tissue contains nerves and is sensitive. Not only is this vital tissue contacted during instrumentation, but also pressure is created. These factors may cause discomfort if the patient is not anesthetized.

There is an antiquated notion that canal length can be determined in a nonanesthetized patient by passing an instrument into a necrotic canal until the patient shows an "eye-blink response." Unfortunately, patient perceptions and responses are too variable for accuracy. Pain may be felt when the instrument is far short of the apex, or some patients may have no sensation even when the instrument is several millimeters beyond the apex. Not using anesthesia to aid in length determination cannot replace radiographs or an electronic apex locator for accuracy. Another misconception is that after the canals have been cleaned and shaped, it is not necessary to anesthetize the patient at the obturation appointment. Unfortunately, during obturation, pressure is created, and small amounts of sealer may be extruded beyond the apex. This occurrence may be quite uncomfortable for the patient. Many patients (and the dentist) are more at ease if regional hard and soft tissue anesthesia is present.

Adjunctive Pharmacologic Therapy

Anxious patients may benefit from sedation (oral, inhalation, intravenous). However, even with conscious sedation, profound local anesthesia is required to eliminate pain during dental treatment.[33-35] Nitrous oxide administration helps reduce pain during treatment in patients presenting with symptomatic irreversible pulpitis.[34,36] A discussion of agents that control anxiety is included in Chapter 9.

Conventional Pulpal Anesthesia for Restorative Dentistry

Success of local anesthesia is variable. Two surveys of patients and dentists indicated that inadequate anesthesia was common during restorative treatment.[7,37] Several factors affect anesthesia, such as the type of procedure (endodontic, extraction, restorative, periodontal, implant placement, etc.), arch location (maxillary or mandibular), the patient's anxiety level, and the presence of inflamed tissue. This chapter emphasizes the evidence-based requirements for pulpal anesthesia, which differ from those for oral surgery, implant dentistry, periodontics, and pediatric dentistry.

Many clinical studies have objectively evaluated local anesthetic agents and techniques. A measurement of pulpal anesthesia before beginning a clinical procedure is obtained with a cold spray refrigerant (Fig. 8.2) or electric pulp tester (Fig. 8.3). The cold

• **Fig. 8.2** A cold refrigerant may be used to test for pulpal anesthesia before the start of a clinical procedure. (Courtesy Coltene/Whaledent, Cuyahoga Falls, OH, USA.)

• **Fig. 8.3** An electrical pulp tester (EPT) also may be used to test for pulpal anesthesia before a clinical procedure is started. (Courtesy SybronEndo, Glendora, CA, USA.)

• **Fig. 8.4** The pellet with the cold refrigerant is applied to the surface of the tooth.

spray refrigerant is the easiest to use clinically. The cold refrigerant is sprayed on a large cotton pellet held with cotton tweezers. The cold pellet is then placed on the tooth (Fig. 8.4). No pulpal response to the stimuli after administration of anesthetic means probable profound pulpal anesthesia in asymptomatic teeth with vital pulps.[38,39] Experimental studies that have investigated the use of local anesthesia are discussed in the following sections. Conventional injection techniques are detailed in other textbooks.

Mandibular Anesthesia for Restorative Dentistry

Lidocaine with Epinephrine and Vasoconstrictors

The most commonly used local anesthetic agent is 2% lidocaine with 1:100,000 epinephrine, which is a safe and effective drug.[14,40] This agent is indicated for procedures in this chapter unless specified otherwise.

Vasoconstrictors are also generally safe. It has been stated that vasoconstrictors should be avoided in patients who have high blood pressure (higher than 200 mm Hg systolic or 115 mm Hg diastolic), cardiac dysrhythmias, severe cardiovascular disease, or unstable angina, or who are less than 6 months past a myocardial infarction or cerebrovascular accident.[14] These conditions are contraindications to routine dental treatment. Patients taking antidepressants, nonselective beta-blocking agents, medicine for Parkinson disease, and cocaine are at risk for problems.[14,40] In patients taking these medications, plain mepivacaine (3% Carbocaine) can be used for the inferior alveolar nerve block.

Anesthetic Factors Associated with the Inferior Alveolar Nerve Block

Although the most common method of mandibular anesthesia is the inferior alveolar nerve block, this injection also has the greatest number of failures.[40] The following sections discuss the expected signs of successful (and unsuccessful) anesthesia after administration of one cartridge of 2% lidocaine with 1:100,000 epinephrine.

Lip Numbness

Lip numbness usually occurs in 4 to 6 minutes after injection.[40-47] Lip numbness indicates only that the injection blocked the nerves to the soft tissues of the lip, not necessarily that pulpal anesthesia has been obtained.[40-50] If lip numbness is not obtained, the block has been "missed." This circumstance occurs approximately 4% to 6% of the time in asymptomatic patients and 2% to 8% in patients with irreversible pulpitis.[51] Fowler et al. also found that administration of a two-cartridge volume was significantly better than a one-cartridge volume in both asymptomatic subjects and emergency patients presenting with irreversible pulpitis.[51] If missed blocks occur frequently, the injection technique should be reviewed.

Soft Tissue Anesthesia

Lack of mucosal or gingival response to a sharp explorer does not indicate pulpal anesthesia.[40-50]

Onset of Pulpal Anesthesia

Pulpal anesthesia usually occurs in 5 to 9 minutes in the molars and premolars and 14 to 19 minutes in the anterior teeth.[40-50] In some patients, onset occurs sooner, and in others it is delayed.[40-50]

Duration

The duration of pulpal anesthesia in the mandible is very good.[40-50] Therefore if successful anesthesia usually (but not always) persists for approximately 2½ hours.[48]

Success

The incidence of successful mandibular pulpal anesthesia tends to be higher in molars and premolars and lower in anterior teeth.[40-50] Pulpal anesthesia is not achieved in all patients after what appears to be a clinically successful inferior alveolar nerve block (i.e., numb lip and chin). In such cases, other approaches are required.

Alternative Attempts to Increase Anesthetic Success

Increasing the Volume

Increasing the volume of anesthetic from one to two cartridges does not increase the success rate for obtaining pulpal anesthesia with the inferior alveolar nerve block.[40,41,49,50]

Increasing the Epinephrine Concentration

There is no improvement in pulpal anesthesia with a higher concentration (1:50,000) of epinephrine in an inferior alveolar nerve block.[50,52]

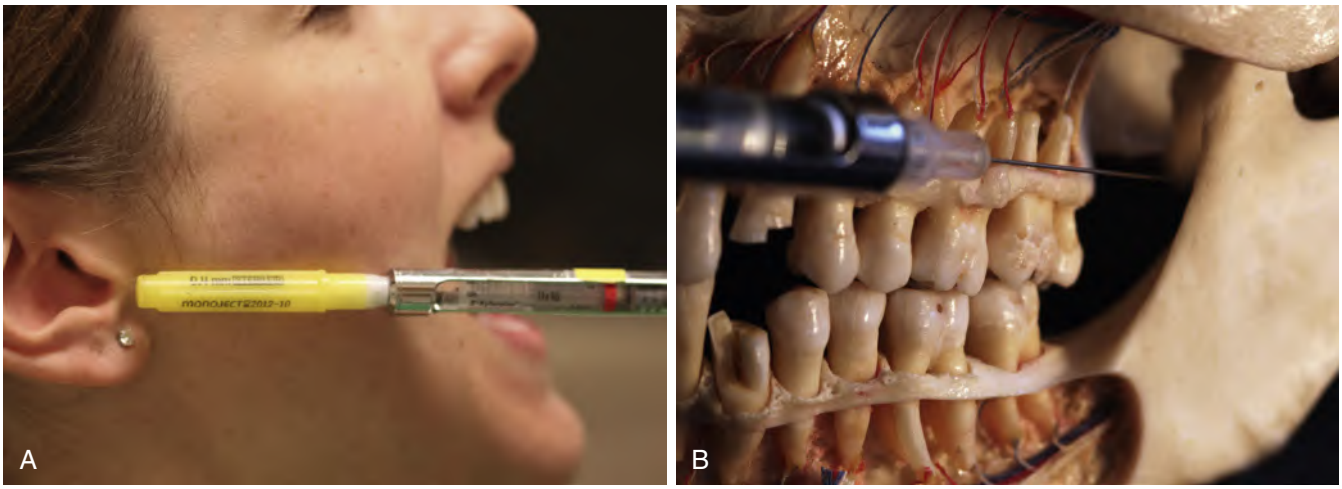
Alternative Solutions

2% Mepivacaine with 1:20,000 Levonordefrin, 4% Prilocaine with 1:200,000 Epinephrine, and Plain Solutions (3% Mepivacaine and 4% Prilocaine)

As alternative solutions, 2% mepivacaine with 1:20,000 levonordefrin; 4% prilocaine with 1:200,000 epinephrine; and plain solutions (3% mepivacaine and 4% prilocaine) are equivalent to 2% lidocaine with 1:100,000 epinephrine in providing pulpal anesthesia for approximately 1 hour after an inferior alveolar nerve block.[44,47]

4% Articaine with Epinephrine for Inferior Alveolar Nerve Blocks

Articaine is a safe and effective local anesthetic agent.[53-62] Anecdotally, articaine has been see to have an improved local anesthetic



•**Fig.8.5** **A**, Extraoral landmark for the Gow-Gates technique: the lower border of the tragus of the ear and the corner of the mouth. The intraoral target site for the Gow Gates technique is the neck of the mandibular condyle. **B,** Vazirani-Akinosi technique. This closed-mouth technique has the landmark for needle insertion online with the mucogingival junction of the maxillary second molar.

effect.[63] However, clinical trials have failed to detect any superiority of articaine over lidocaine in inferior alveolar nerve block anesthesia.[58,61]

Articaine, like prilocaine, has the potential to cause neuropathies.[64] Some authors have found the incidence of paresthesia (involving the lip and/or tongue) associated with articaine and prilocaine to be higher than that found with either lidocaine or mepivacaine.[64-66] Other authors have not found a higher incidence when using articaine.[67] However, because there is no difference in success of pulpal anesthesia between articaine and lidocaine for inferior alveolar nerve blocks, and some attorneys are aware of the proposed association of articaine to paresthesia, it seems reasonable to use articaine for infiltrations but not for nerve blocks.

Long-Acting Agents

Clinical trials of bupivacaine and etidocaine have been conducted in oral surgery, endodontics, and periodontics.[68-71] These agents provide a prolonged analgesic period and are indicated when postoperative pain is anticipated. However, not all patients want prolonged lip numbness.[69] For those patients, analgesics may be prescribed. Compared with lidocaine, bupivacaine has a somewhat slower onset but almost double the duration of pulpal anesthesia in the mandible (approximately 4 hours).[48]

Buffered Lidocaine

Buffering lidocaine with sodium bicarbonate raises the pH of the anesthetic solution. In medicine there is evidence that buffering lidocaine results in less pain during the injection.[72,73] In dentistry, some studies[74-77] found that buffered lidocaine produced less pain on injection and a faster onset of anesthesia. A number of recent studies[78-84] failed to establish a significant reduction in injection pain, a faster onset, or better success with buffered anesthetic solutions.

Alternative Injections and Locations

Gow-Gates and Vizarani-Akinosi Techniques (Fig. 8.5)

Neither the Gow-Gates[85] nor the Vizarani-Akinosi[86] technique is superior to the standard inferior alveolar nerve block injection.[87-92] These techniques are not replacements for the inferior alveolar nerve block, and both require a two-cartridge volume. The Vizarani-Akinosi is a closed-mouth technique and is useful for patients presenting with trismus. However, patients with trismus should be referred to an endodontist because patient management is complicated.

Neither the Gow-Gates nor the Vazirani-Akinosi technique provides adequate pulpal anesthesia for mandibular posterior teeth in patients presenting with symptomatic irreversible pulpitis.[93] Both injections would require supplemental anesthesia.

Incisive Nerve Block/Infiltration at the Mental Foramen

The incisive nerve block is successful 80% to 83% of the time in anesthetizing the premolar teeth for about 20 to 30 minutes.[46,94-96] It is not effective for the central and lateral incisors.[46]

Lidocaine Infiltration Injections

Labial or lingual infiltrations of a lidocaine solution alone are not effective for pulpal anesthesia in the mandible.[97-99]

Articaine Infiltration Injections

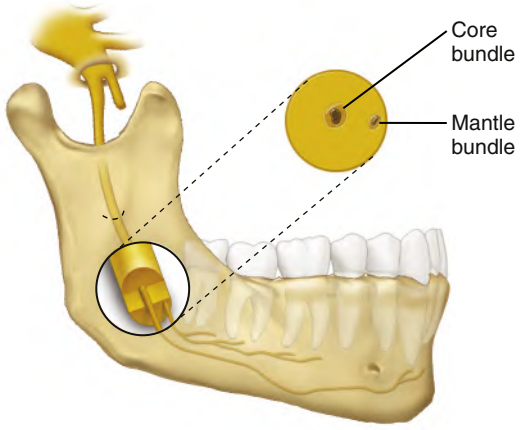
Articaine is significantly better than lidocaine for buccal infiltration of the mandibular first molar.[100-103] However, articaine alone does not predictably provide pulpal anesthesia of the first molar. There is no difference between 4% articaine with 1:100,000 and 1:200,000 epinephrine for buccal infiltration.[104]

In anterior teeth, buccal and lingual infiltrations of articaine provide initial pulpal anesthesia, but anesthesia declines over the course of 60 minutes from the time the injection was given.[105,106]

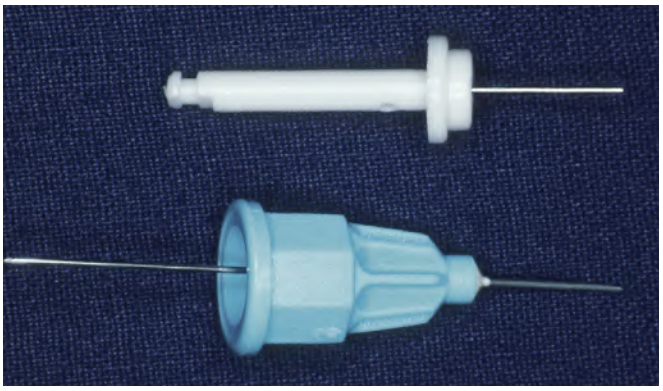
Evaluating Mechanisms of Failure with the Inferior Alveolar Nerve Block

Accuracy of Needle Placement

Accurate anatomic positioning of the needle is no guarantee of a successful block.[107,108] It is interesting to note that even locating the inferior alveolar nerve with ultrasound or with a peripheral nerve stimulator before the injection did not improve success.[109,110] The anesthetic solution may not completely diffuse into the nerve trunk (Fig. 8.6) to reach and block all nerves, even if deposited at the correct site, thus resulting in failure.[111]



• **Fig. 8.6** Central Core Theory. The large diameter and density of the bundle may inhibit diffusion of a sufficient quantity of anesthetic to provide profound pulpal anesthesia.



• **Fig. 8.7** Components of an Intraosseous Injection System. The perforator *(top)* is a small, sharp, latch-type drill used to make an opening through soft tissue and bone. The needle *(bottom)* is short and of small gauge to allow insertion and injection directly through the opening.

Needle Deflection and Needle Bevel

Needle deflection has been theorized to be a cause of failure of the inferior alveolar nerve block.[18,112-115] However, two studies have shown that needle bevel orientation (away or toward the mandibular foramen or ramus) does not affect the success of the inferior alveolar nerve block.[116,117]

Accessory Innervation

Anatomic evidence suggests that accessory innervation exists from branches of the mylohyoid nerve.[118] A study using a mylohyoid injection lingual and inferior to the retromolar fossa, in addition to an inferior alveolar nerve block, showed no enhancement of pulpal anesthesia.[119] Therefore, the mylohyoid nerve is not a major factor in failure of the inferior alveolar nerve block.

Cross-Innervation

Cross-innervation from the contralateral inferior alveolar nerve has been implicated in failure to achieve anesthesia in anterior teeth after an inferior alveolar nerve block injection. Cross-innervation does occur in incisors, but it is the failure of the initial inferior alveolar nerve block that accounts for failure of pulpal anesthesia in anterior teeth.[120]

Red Hair

In medicine, red-haired females have shown reduced subcutaneous efficacy of lidocaine and increased requirements for desflurane.[121] However, in dentistry, red hair was unrelated to success rates for the inferior alveolar nerve block. Red hair was associated with higher levels of dental anxiety.[121] Because of this higher dental anxiety, red-haired women may be more likely to report nonpainful sensations (pressure, vibration, etc.) as painful during treatment. This circumstance would cause clinicians to mistake a difference in anxiety for a difference in quality of anesthesia.

Patient Position for an Inferior Alveolar Nerve Block

It has been recommended to place patients in an upright position after administration of an inferior alveolar nerve block, theoretically allowing the anesthetic to diffuse in an inferior direction and resulting in better pulpal anesthesia. When an upright and a supine position were compared after an inferior alveolar nerve block, a study found the two positions were equally successful in the molars.[122] However, clinically, neither position for administration of the inferior alveolar nerve block would provide complete pulpal anesthesia.

Another study evaluated the effect of the head tilted in the direction of the block versus the head tilted to the opposite side in patients with symptomatic irreversible pulpitis. The study found no significant difference in the same side position and the opposite side position. [123]

Methods to Increase Success of the Inferior Alveolar Nerve Block

Infiltrations of Articaine After an Inferior Alveolar Nerve Block

A very important clinical finding is that a supplemental, buccal articaine infiltration of the first molar, premolars, and labial infiltration of anterior teeth after an inferior alveolar nerve block should provide pulpal anesthesia for approximately 1 hour.[105,124,125] The second molar may require a supplemental intraosseous (IO) or periodontal ligament (PDL) injection to achieve success.

Intraosseous Anesthesia After an Inferior Alveolar Nerve Block

Supplemental IO injections of lidocaine and mepivacaine with vasoconstrictors allow quick onset and increase the success of the inferior alveolar nerve block for approximately 60 minutes.[126,127] Using 3% mepivacaine plain results in pulpal anesthesia for approximately 30 minutes.[128] (Figs. 8.7 to 8.11)

Periodontal Ligament Anesthesia After an Inferior Alveolar Nerve Block

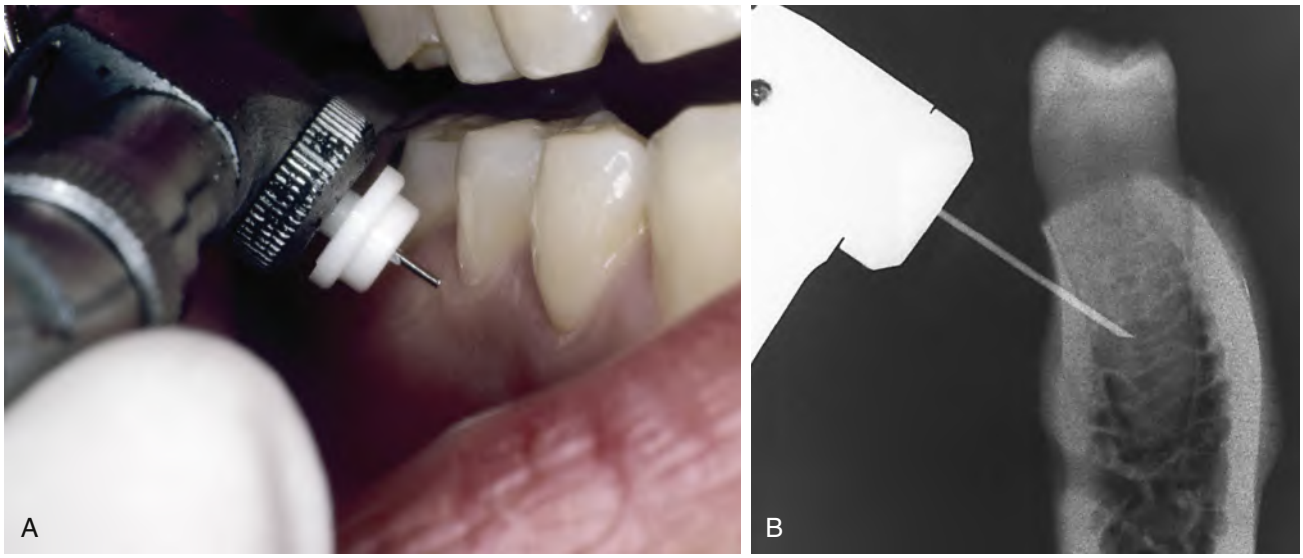
Supplemental PDL injections of 2% lidocaine with 1:100,000 epinephrine increase the success of the inferior alveolar nerve block, but the duration is approximately 23 minutes.[129]

Injection Speed and Success

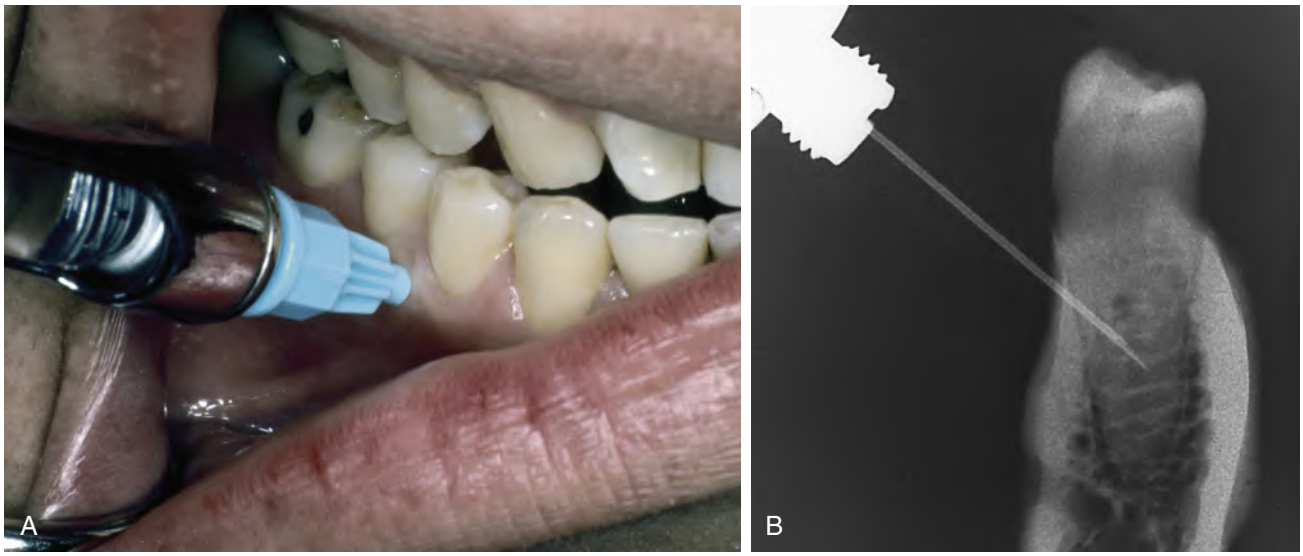
A slow inferior alveolar nerve block increases success over a fast injection[20] but not for patients diagnosed with irreversible pulpitis.[21]

Pain and Inflammation

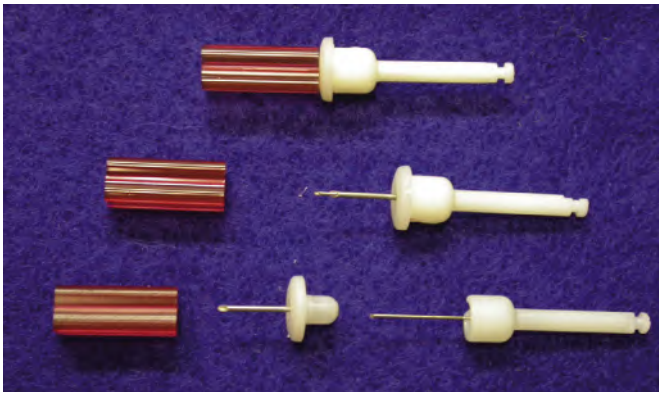
Most studies have evaluated anesthesia in the absence of symptoms and inflammation; results differ if these conditions are



• **Fig. 8.8** Intraosseous Injection Technique. **A,** Location and angulation of the perforator. **B,** The perforator "breaks through" cortical bone into the medullary space.



• **Fig. 8.9** **A,** The needle is inserted directly into the opening. **B,** Anesthetic is injected into medullary bone, where it diffuses widely to block dental nerves.



• **Fig. 8.10** Components of another approach to intraosseous injection: the drill and guide sleeve and cover *(top).* The drill (a special hollow needle) leads the guide sleeve through the cortical plate *(middle),* in which it is separated and withdrawn *(bottom).* The remaining guide sleeve is designed to accept a 27-gauge needle that injects the anesthetic solution.

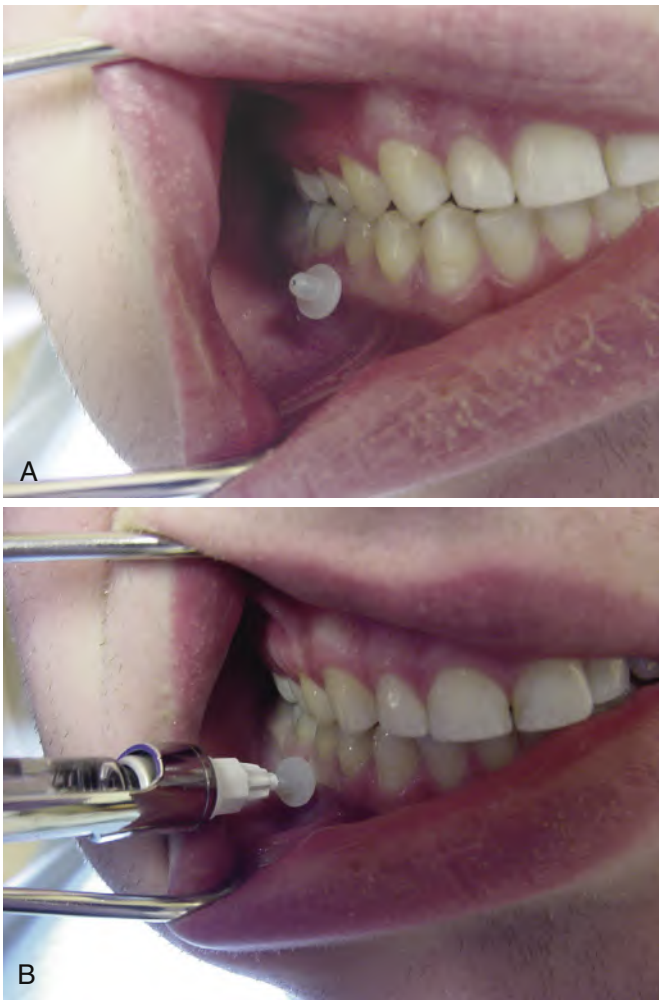
present.[5,40,130] As discussed later, patients who have symptomatic pulpal or periapical pathosis (and/or who are anxious) present significant anesthesia problems.

Maxillary Anesthesia for Restorative Dentistry

Unless otherwise specified, the conventional solution used is 2% lidocaine with 1:100,000 epinephrine.

Anesthesia-Related Factors

Anesthesia is more successful in the maxilla than in the mandible.[40] The most common injection for the maxillary teeth is infiltration. Several events can be expected with this technique when one cartridge of anesthetic is used.



• **Fig. 8.11** **A,** The tissue and bone have been perforated, and the perforator now serves as a guide sleeve. **B,** The anesthetic needle is in place in the guide sleeve.

Lip/Cheek Numbness or Dead Feeling of the Teeth

Lip/cheek numbness usually occurs within a few minutes. Lip or cheek numbness or a dead feeling when tapping the teeth together does not always indicate pulpal anesthesia. Additionally, lip or cheek numbness does not correspond to the duration of pulpal anesthesia, because the pulp does not remain anesthetized as long as the soft tissues do.[40,131-139]

Success

Infiltration results in a fairly high incidence of successful pulpal anesthesia (around 87% to 92%).[11,40,131-139] However, some patients may not be anesthetized due to individual variations in response to the drug administered, operator differences, and variations of anatomy, in addition to tooth position.

Onset of Pulpal Anesthesia

Pulpal anesthesia usually occurs in 3 to 5 minutes.[40,131-139]

Duration of Pulpal Anesthesia

A problem with maxillary infiltration is the duration of pulpal anesthesia.[40,131-139] Pulpal anesthesia of the anterior teeth declines after about 30 minutes, with most losing anesthesia by 60 minutes.[40,131-139] In premolars and first molars, pulpal anesthesia is effective until about 40 to 45 minutes, and then it starts to decline.[40,131-139] Additional local anesthetic must be administered, depending on the duration of the procedure and the tooth group affected.

Alternative Anesthetic Solutions

Plain Solutions of Mepivacaine and Prilocaine

Anesthesia duration is shorter with plain solutions of mepivacaine and prilocaine.[137,138] Therefore these anesthetics are used for procedures of short duration (10 to 15 minutes).

4% Prilocaine with 1:200,000 Epinephrine, 2% Mepivacaine with 1:20,000 Levonordefrin, and 4% Articaine with 1:100,000 Epinephrine

The duration of anesthesia with 4% prilocaine with 1:200,000 epinephrine; 2% mepivacaine with 1:20,000 levonordefrin; and 4% articaine with 1:100,000 epinephrine is similar to that for 2% lidocaine with 1:100,000 epinephrine.[134,138,139]

Bupivacaine with Epinephrine

Bupivacaine has a lower success rate than a lidocaine formulation in anterior teeth.[132,140] There is no difference between success rates of the two formulations in the first molar.[132] Neither agent provides pulpal anesthesia for an hour.[132,140]

Increasing the Duration of Pulpal Anesthesia

Increasing the Volume of Solution

A two-cartridge volume of 2% lidocaine with epinephrine extends the duration of pulpal anesthesia but not for 60 minutes.[133]

Increasing the Epinephrine Concentration

Increasing the epinephrine concentration to 1:50,000 epinephrine increases duration for the lateral incisor but not for the first molar.[137] Neither tooth achieved a duration of 60 minutes.[137]

Repeating an Infiltration After 30 or 45 Minutes

Adding a cartridge of 2% lidocaine with epinephrine at 30 minutes in anterior teeth and 45 minutes in posterior teeth significantly improves the duration of pulpal anesthesia and may be the best way to extend the duration of pulpal anesthesia.[136]

Alternative Injection Techniques

The *posterior superior alveolar (PSA) nerve block* anesthetizes the second molars and about 80% of first molars.[141,142] An additional mesial infiltration injection may be necessary to anesthetize the first molar. Generally, the PSA block injection is not advocated for routine restorative procedures. An infiltration of the molars is preferred.

The *infraorbital block* results in lip numbness but does not predictably anesthetize incisor pulps.[143,144] It usually anesthetizes the canines and premolars, but duration is less than 1 hour.[143,144] Generally, the infraorbital injection is not advocated for routine restorative procedures. An infiltration of the individual teeth is preferred.

The *second division block* usually anesthetizes pulps of molars and some second premolars but does not predictably anesthetize first premolars, canines, or lateral and central incisors.[145,146] The high tuberosity technique is preferred to the greater palatine approach, because it is easier and less painful.[145] Generally, the second division nerve block is not advocated for routine restorative procedures. An infiltration of the individual teeth is preferred.

The *palatal anterior superior alveolar (P-ASA) nerve block* has been advocated for anesthetizing all the maxillary incisors with a single palatal injection into the incisive canal.[147] However, this injection technique does not provide predictable pulpal anesthesia for the incisors and canines[148] and is often painful.[26]

The *anterior middle superior alveolar (AMSA) nerve block* has been advocated for unilaterally anesthetizing the maxillary central and lateral incisors, canines, and first and second premolars with a single palatal injection in the premolar region.[149] However, this injection technique does not provide predictable pulpal anesthesia for these maxillary teeth[150] and is often painful.[27]

Pain, Inflammation, and Anxiety

As mentioned, results differ from normal when an anesthetic is given to patients with either pain or inflammation (or both) or to those with anxiety.

Supplemental Anesthesia for Restorative Dentistry in the Mandible and Maxilla

Indications

A supplemental injection is used if the standard injection is not effective. It is useful to repeat an initial injection only if the patient is not exhibiting the "classic" signs of soft tissue anesthesia. Generally, if the classic signs are present, reinjection is not very effective.[151] For example, after the inferior alveolar nerve block, the patient develops lip, chin, and tongue numbness and quadrant "deadness" of the teeth. A useful procedure is to test the pulp of the tooth with cold (cold refrigerant) or an electric pulp tester before the cavity preparation is begun.[38,39] If the patient feels pain to cold, a supplemental injection is indicated. Assuming that reinjection using the inferior alveolar nerve block approach will be successful is wishful thinking; failure the first time is usually followed by failure on the second attempt. The dentist should go directly to a supplemental technique. Four such injections are the (1) *infiltration injection,* (2) *IO injection,* (3) *PDL injection,* and (4) *intraseptal injection.*

Infiltration

Additional Infiltration of Lidocaine in the Maxilla

Because the duration of pulpal anesthesia for infiltration in the maxilla is less than 60 minutes, adding a cartridge of 2% lidocaine with epinephrine at 30 minutes in the anterior teeth and at about 45 minutes in premolar and molar teeth significantly improves the duration of pulpal anesthesia and may be the best way to extend the duration of pulpal anesthesia in maxillary teeth.[136] That is, if the patient experiences pain during the later stages of a dental appointment, an additional infiltration will be helpful.

Infiltration of Articaine in the Mandible

An important clinical finding is that a supplemental, buccal articaine infiltration of the first molar and premolars and a labial infiltration of the anterior teeth, after an inferior alveolar nerve block, should provide pulpal anesthesia for approximately 1 hour.[105,124,125] The second molar may require a supplemental IO or PDL injection.

Intraosseous Anesthesia (Figs 8.7–8.11)

The IO injection has been shown to be effective by substantial research and clinical use. It is particularly useful in conjunction with a conventional injection when it is likely that supplemental anesthesia will be necessary (e.g., in mandibular second molar teeth).[126-128] The IO injection allows placement of a local anesthetic directly into the cancellous bone adjacent to the tooth. There is an IO system with two components (Stabident; Fairfax Dental, Miami, Florida, USA). One part is a slow-speed handpiece–driven perforator, which drills a small hole through the cortical plate. The anesthetic solution is delivered into cancellous bone through a matching 27-gauge, ultrashort injector needle. Another IO system uses a guide sleeve (X-tip; Dentsply Maillefer Tulsa, Oklahoma, USA) that remains in the perforation. This sleeve serves as a guide for the needle, and it may remain in place throughout the procedure in case reinjection is necessary. The perforation may be made in attached gingiva or alveolar mucosa with this system (Video 8.2).[152]

Technique for the Stabident System

The area of perforation and injection is on a horizontal line of the buccal gingival margins of the adjacent teeth and a vertical line that passes through the interdental papilla distal to the tooth to be injected. A point approximately 2 mm below the intersection of these lines is selected as the perforation site. This site must be in attached gingiva. The soft tissue is first anesthetized by infiltration. The perforator is placed through the gingiva perpendicular or a 45-degree angle to the cortical plate. With the point gently resting against bone, the clinician activates the handpiece at full speed while pushing the perforator, with light pressure, against bone and then slightly withdrawing the perforator and pushing it again against the bone (i.e., a pecking motion). This action is continued until a "breakthrough" into the cancellous bone is achieved (this process takes approximately 2 to 5 seconds).[152]

The standard syringe is held in a "pen-gripping" fashion, and the needle is precisely aligned with and inserted into the perforation. A full cartridge of anesthetic solution is *slowly* delivered over 1 to 2 minutes with light pressure. If back-pressure is encountered, the needle is rotated approximately a quarter turn, and deposition is reattempted. If this attempt is unsuccessful, the needle should be removed and checked for blockage. If the needle is not blocked, it is reinserted or the site is opened with a new perforator and the injection is repeated.[152]

Perforator "Breakage"

Rarely, the metal perforator "separates" from the plastic hub. If this separation occurs, the perforator is easily removed with a hemostat; there are no reports of a perforator breaking into parts.[126-128,152-154]

Injection Discomfort

When the IO injection is used as a primary injection, pain is experienced about one-fourth of the time.[153-155] When the IO injection is used as a supplemental injection, fewer patients experience pain.[126-128,156,157]

Selection of Perforation Site

With IO injections, a distal perforation site results in the best anesthesia.[126-128,152-154,156,157] The second molars are an exception; in those teeth, a mesial site is preferred.[126-128,152-154,156,157]

Anesthetic Agents

When the IO injection is used as a supplemental injection after the inferior alveolar nerve block in patients without pain, excellent success has been reported for 2% lidocaine with 1:100,000

epinephrine and 2% mepivacaine with 1:20,000 levonordefrin.[126,127] However, because of the adverse cardiovascular reactions with a long-acting anesthetic (0.5% bupivacaine with 1:200,000 epinephrine)[158] and the lack of a prolonged duration of pulpal anesthesia, this agent does not offer any advantage over lidocaine. Furthermore, 3% mepivacaine plain is successful, but the duration of pulpal anesthesia is shorter.[128]

Onset of Anesthesia

Onset of anesthesia is rapid with the IO injection.[126-128,152-154,156,157] There is no waiting period for anesthesia.

Success

When the IO injection is used as a supplemental injection after an inferior alveolar nerve block in pain-free patients, success rates are very good.[126,127]

Failure

If the anesthetic solution squirts out of the perforation (backflow) with an IO injection, anesthesia will not be obtained.[152] Reperforation or choosing another perforation site is then necessary.

Duration

With a primary IO injection, the duration of pulpal anesthesia declines steadily over 1 hour.[153,154] There is an even shorter duration with 3% mepivacaine, compared with 2% lidocaine with 1:100,000 epinephrine.[154] With a supplemental IO injection of lidocaine with 1:100,000 epinephrine after the inferior alveolar nerve block in patients without pain, the duration of pulpal anesthesia is very good for 1 hour.[126,127] A solution of 3% mepivacaine, when used as a supplemental IO injection, results in a shorter anesthetic duration.[128]

Postoperative Pain and Problems

With primary and supplemental IO injection techniques, the majority of patients report no pain or mild pain postoperatively.[126-128,152-154,156,157] Fewer than 5% develop exudate and/or localized swelling at the perforation site, possibly from overheating of the bone during perforation.[126-128,152-154,156,157]

Systemic Effects

With both primary and supplemental IO injection techniques using anesthetics with a vasoconstrictor (epinephrine or levonordefrin), most patients perceive an increased heart rate.[153,154,156,157,159] When these agents are used, patients should be informed *before the injection* of this tachycardia to lessen their anxiety. No significant heart rate increase occurs with 3% mepivacaine plain.[154,160] The venous plasma levels of lidocaine are the same for an IO injection as for infiltration injection.[161] Therefore the same precautions for the maximum amount of lidocaine given for an infiltration injection also apply to an IO injection.[161]

Medical Contraindications

Patients taking antidepressants, nonselective beta-blocking agents, medicine for Parkinson disease, and cocaine should not receive IO injections of solutions containing epinephrine or levonordefrin[40]; 3% mepivacaine plain is preferred.

Precautions

An IO injection should not be used with painful necrotic teeth with periapical radiolucencies or with teeth exhibiting cellulitis or abscess formation. This injection would be very painful and would likely not provide profound anesthesia.

Periodontal Ligament Injection

The PDL injection is also a useful technique if a conventional injection is unsuccessful.[162,163] The technique is clinically less effective than the IO injection technique because more anesthetic solution can be delivered to the cancellous bone (Video 8.3).[151]

Technique

The procedure for a PDL injection (Fig. 8.12, *A–D*) is not difficult but does require practice and familiarity. A standard syringe or pressure syringe is equipped with a 30-gauge, ultrashort needle or a 27- or 25-gauge short needle. The needle is inserted into the mesial gingival sulcus at a 30-degree angle to the long axis of the tooth. The needle is supported by the fingers or a hemostat and is positioned with maximum penetration (wedged between the root and crestal bone). Heavy pressure is *slowly* applied on the syringe handle for approximately 10 to 20 seconds (conventional syringe), or the trigger is *slowly* squeezed once or twice with resistance (pressure syringe). *Back-pressure is important.* If there is no back-pressure (resistance)—that is, if the anesthetic readily flows out of the sulcus—the needle is repositioned, and the technique is repeated until back-pressure is attained. The injection is then repeated on the distal surface. Only a small volume of anesthetic (approximately 0.2 mL) is deposited on each surface.

Mechanism of Action

The PDL injection forces anesthetic solution through the cribriform plate (Fig. 8.13) into the marrow spaces and into the vasculature in and around the tooth (Figs. 8.14 and 8.15).[162-165] The primary route is not the PDL; the mechanism of action is not related to direct pressure on the nerves.[166,167]

Injection Discomfort in Asymptomatic Patients

When the PDL injection is the primary injection, needle insertion and injection may be painful about one third of the time.[166-168] In maxillary anterior teeth, the PDL injection may be quite painful[168] and should not be used. An infiltration is preferred. As a supplemental injection after an inferior alveolar nerve block, the PDL injection has a low potential to be painful.[129]

Onset of Anesthesia

The onset of anesthesia is rapid with a PDL injection; there is no waiting period to begin the clinical procedure.[166-168] If anesthesia is still not adequate, reinjection is necessary.

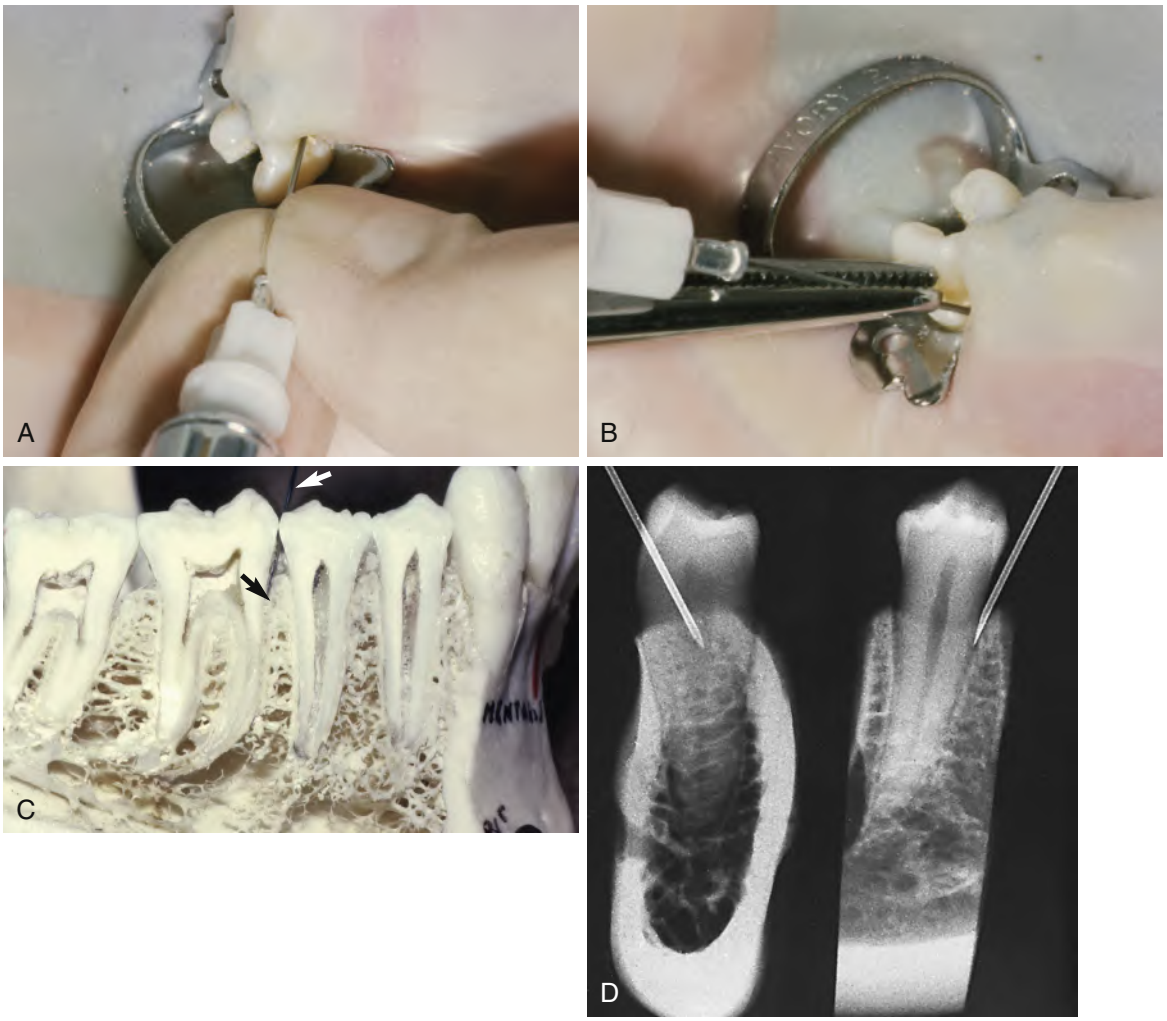
Success in Asymptomatic Teeth

Success rates for the PDL injection, when used as a primary injection, have been reported to be about 75% in mandibular and maxillary posterior teeth, with a duration of pulpal anesthesia of 10 to 15 minutes.[167,168] Success rates have been low in anterior teeth.[167-169] Anesthetic solutions without vasoconstrictors (3% mepivacaine) or with reduced vasoconstrictor concentrations (bupivacaine with 1:200,000 epinephrine) are not very effective.[167,170-172] Articaine is equivalent to lidocaine.[60]

When the PDL injection is used as a supplemental injection (standard techniques have failed to provide adequate anesthesia), good success rates are achieved, but the duration of pulpal anesthesia is approximately 23 minutes.[129]

Duration in Asymptomatic Teeth

The duration of profound pulpal anesthesia (either primary or supplemental) with PDL injections is approximately 10 to 15 minutes.[60,129,166-168]



• **Fig. 8.12** Intraligamentary Injection. **A,** Needle insertion using the fingers to prevent needle buckling. **B,** A hemostat may be substituted for the fingers to support and direct the needle. The injection may be given with or without the rubber dam in place. **C,** Note the direction and position of the needle *(arrows).* The tip of the needle will be wedged between the crestal bone and the root surface. **D,** Angle of the needle relative to the long axis of the tooth *(left).* With approximately a 30-degree orientation, the needle tip will be positioned close to the midline of the root.

Postoperative Discomfort in Asymptomatic Teeth

When the PDL injection is used as a primary technique, postoperative pain occurs in one-third to three-fourths of patients, with a duration of 14 hours to 3 days.[60,129,166-168,173,174] There is no difference between articaine and lidocaine.[60] The discomfort is related to damage from needle insertion rather than to the pressure of depositing the solution.[173] About one-third of patients report that their tooth feels "high."[167,168]

Selective Anesthesia

It has been suggested that a PDL injection may be used in the differential diagnosis of poorly localized, painful irreversible pulpitis.[175] However, adjacent teeth are often anesthetized with PDL injection of a single tooth.[166-168] Therefore this injection is *not* useful for differential diagnosis.

Systemic Effects

Although some authors[176] have found that the PDL injection raises the heart rate, human studies have shown that these injections do not cause significant changes in heart rate.[174,177]

Other Factors

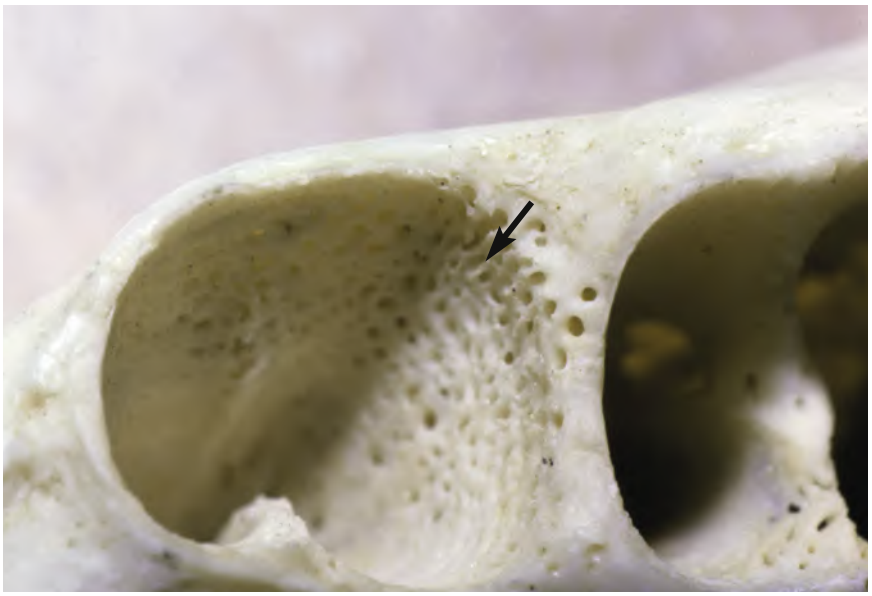
Different needle gauges (25-, 27-, or 30-gauge) are equally effective for PDL injections.[178] Special pressure syringes have been marketed (Fig. 8.16) but have not proved to be more effective than a standard syringe.[167,168,178]

Damage to the Periodontium

Clinical and animal studies have demonstrated the relative safety of the PDL injection.[166-169,174,178-184] Minor local damage is limited to the site of needle penetration (Fig. 8.17); this damage subsequently undergoes repair.[179] In some instances, periodontal infections have occurred.[167,168] The clinician should be aware that this may happen. Histologic areas of root resorption after PDL injections have also been reported, but they heal with time.[183,184] Damaging effects from injecting into an area of periodontal disease are unlikely.[185]

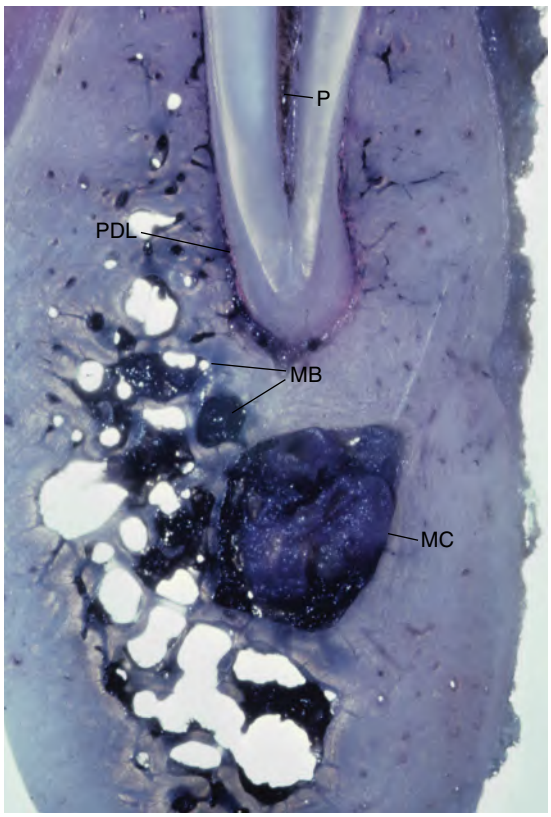
Damage to the Pulp

Clinical and animal studies have shown no adverse effects on the pulp after PDL injections.[166-168,186,187] However, physiologic



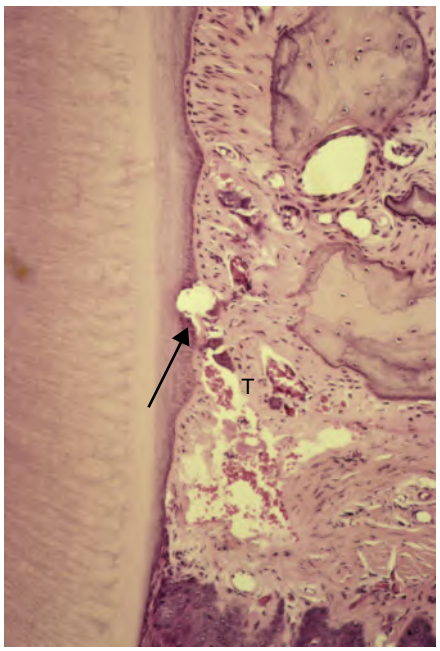
• **Fig. 8.13** Extraction Socket of a Second Molar. The bone of the cribriform plate is very porous, particularly in the cervical region *(arrow).* During the intraligamentary injection, this is the region of passage of most anesthetic solution into the medullary space.

• **Fig. 8.14** A single intraligamentary injection of carbon dye adjacent to a dog's tooth demonstrates the distribution of dye particles. Particles are concentrated at the injection site *(I)* and in the medullary bone *(MB),* the apical foramen *(AF),* and the pulp *(P)* of the injected tooth. Dye particles have spread through the periodontal ligament *(PDL)* of both the injected and adjacent teeth.



• **Fig. 8.15** A single injection of dye was made in the distal periodontal ligament. This frontal section, including the tooth apex and surrounding structures, shows that dye distributes to the pulp *(P),* periodontal ligament space *(PDL),* medullary bone space *(MB),* and mandibular canal *(MC).* The widespread distribution of solutions from the intraligamentary injection may anesthetize the adjacent teeth.

• **Fig. 8.16** Example of a special syringe used for the intraligamentary injection. Although these devices are capable of injecting with more pressure, they have not been shown to be superior to the standard syringe.



• **Fig. 8.17** The Injection Site at the Time of Injection. The needle tract *(T),* which ends in a gouge in cementum *(arrow),* is apparent in the connective tissue. No tissue changes are evident outside the penetration site, including the more apical tissues.

changes in the pulp do occur, including a rapid and prolonged marked decrease in blood flow caused by epinephrine.[188] This vascular impairment has no demonstrated damaging effect, even in conjunction with restorative procedures.[189] The PDL injection probably would not result in severe pulpal injury, although this event has not been studied with extensive (crown) preparations or in teeth with significant caries.

Damage to Primary Teeth

Minor enamel hypoplasia of succedaneous teeth has been seen after PDL injections in primary teeth.[190] However, this effect was caused by the cytotoxicity of the local anesthetic rather than by the actual injection. Therefore this injection may be used for anesthetizing primary teeth.

Precautions

The PDL injection should not be used with necrotic pulps and periapical pathosis or with cellulitis or abscess formation. This would be very painful and likely would not provide profound anesthesia.

Anesthesia Difficulties in Endodontics

The following is a classic scenario: The diagnosis is irreversible pulpitis. The dentist administers the standard inferior alveolar nerve block. The patient reports classic signs of anesthesia (lip numbness and a dull feeling of the tooth or quadrant). After isolation, access preparation is begun. When the bur is in enamel, the patient feels nothing. Once the bur enters dentin or possibly not until the pulp is exposed, the patient feels sharp pain. Obviously, pulpal anesthesia is not profound and additional anesthetic is required. The following are some of the theories as to why this problem occurs.

1. The anesthetic solution may not completely penetrate to the sensory nerves that innervate the pulp, especially in the mandible.
2. The *central core theory* states that nerves on the outside of the nerve bundle supply molar teeth, whereas nerves on the inside supply anterior teeth (see Fig. 8.6). The anesthetic solution may not diffuse into the nerve trunk to reach all nerves to produce an adequate block, even if deposited at the correct site. This theory would explain the higher experimental failure rates in anterior teeth with the inferior alveolar nerve block.[40-50,52]
3. *Local tissues change* because of inflammation. This popular theory states that the lowered pH of inflamed tissue reduces the amount of the base form of the anesthetic available to penetrate the nerve membrane.[14] Consequently, there is less of the ionized form within the nerve to achieve anesthesia. Although this theory may have some validity for regions with swelling, it does not relate to anesthesia difficulties in the mandible.[40] It does not explain the major problem, which is the mandibular molar with pulpitis that is not anesthetized by an inferior alveolar injection. The injection site is distant from the area of inflammation; changes in tissue pH would be unrelated to the anesthesia problem.
4. *Hyperalgesia.* Change in nociceptor (pain receptor) pathways is a more plausible explanation. This theory states that the nerves arising in inflamed tissue have altered resting potentials and decreased excitability thresholds. These changes are not restricted to the inflamed pulp itself but rather affect the entire neuronal membrane, extending to the central nervous system.[5,6] Local anesthetic agents are not sufficient to prevent impulse transmission, owing to these lowered excitability thresholds.[5]
5. *Apprehension.* Patients in pain often are anxious, which lowers the pain threshold. A vicious cycle may be established in which initial apprehension leads to a decreased pain threshold, which leads to anesthesia difficulties, which lead to increased apprehension, which results in loss of control and confidence, and so on. Therefore, if this cycle becomes evident, the practitioner should stop treatment immediately and regain control, schedule another appointment, or consider referral to an endodontist. Most patients will endure some pain during the initial stages of root canal treatment if they have confidence in the dentist. However, they will not tolerate being hurt repeatedly!

6. *Insufficient time allowed after injection.* The dentist may not allow adequate time for the anesthetic to diffuse and to block the sensory nerves. Onset may be very slow, particularly with the inferior alveolar block.

Success of the Inferior Alveolar Nerve Block with Symptomatic Irreversible Pulpitis

Fowler and coauthors determined the success of the inferior alveolar nerve block in first and second molars and premolars using 2% lidocaine with 1:100,000 epinephrine in emergency patients presenting with symptomatic irreversible pulpitis.[191] They found success (no or mild pain upon endodontic access or instrumentation) was 28% for the first molars, 25% for the second molars, and 39% for the premolars. These success rates for the inferior alveolar nerve block of the molars and premolars would not be high enough to ensure profound pulpal anesthesia.

For patients presenting with irreversible pulpitis, success was not significantly different between a 3.6 mL volume and 1.8 mL volume of 2% lidocaine with 1:100,000 epinephrine.[51] The success rates (28% to 39%) with either volume were not high enough to ensure complete pulpal anesthesia.[192]

Gow-Gates and Vizarani-Akinosi Techniques

Neither the Gow-Gates[85] (see Fig, 8.5) nor the Vizarani-Akinosi[86] (see Fig. 8.5) technique is superior to the standard inferior alveolar nerve block injection.[87-92] These techniques are not replacements for the inferior alveolar nerve block, and both require a two-cartridge volume. The Vizarani-Akinosi is a closed-mouth technique and is useful for patients presenting with trismus. However, patients with trismus should be referred to an endodontist because patient management is complicated (Videos 8.4 and 8.5).

Neither the Gow-Gates nor Vazirani-Akinosi technique provides adequate pulpal anesthesia for mandibular posterior teeth in patients presenting with symptomatic irreversible pulpitis.[93] Both injections would require supplemental anesthesia.

Do Buffered Lidocaine Formulations Increase the Success of the Inferior Alveolar Nerve Block in Patients with Symptomatic Irreversible Pulpitis?

Two systems are commercially available to buffer local anesthetics. Onset (Onpharma, Los Gatos, California, USA) buffers a local anesthetic solution using a unique dispensing system. The other system is Anutra (Anutra Medical Inc., Morrisville, North Carolina, USA), which consists of a dispenser, a 5-mL multiple-dose syringe, and cassette.

Two studies evaluated a buffered 2% lidocaine with 1:80,000 epinephrine formulation, or buffered 4% lidocaine with 1:100,000 epinephrine formulation for inferior alveolar nerve blocks in patients presenting with symptomatic irreversible pulpitis.[79,83] Both studies concluded that buffering did not statistically improve the success of the inferior alveolar nerve block or decrease injection pain.

Effect of Preemptive Nitrous Oxide in Irreversible Pulpitis

Nitrous oxide is the most commonly used inhalation anesthetic in dentistry.[34] It has an impressive safety record and is excellent for providing conscious sedation for dental patients. Moreover, nitrous oxide provides a mild analgesic effect. The most common estimate of analgesic efficacy suggests 30% nitrous oxide is equivalent to 10 to 15 mg morphine.[34] Nitrous oxide has significant benefits because of its sedation and analgesic effects.

Two studies have found administration of 30% to 50% nitrous oxide resulted in a statistically significant increase in the success of the inferior alveolar nerve block in patients presenting with symptomatic irreversible pulpitis.[34,36]

Success of Maxillary Molar Infiltration with Irreversible Pulpitis

Clinical studies of maxillary posterior buccal infiltrations in patients presenting with irreversible pulpitis reported successful infiltration 54% to 85% of the time with an average rate of 64%.[193-195] There does not appear to be a difference between articaine and lidocaine formulations.[196,197]

Asymptomatic Irreversible Pulpitis Versus Symptomatic Irreversible Pulpitis

Patients who have spontaneous pain (symptomatic irreversible pulpitis) have less successful anesthesia after an inferior alveolar nerve block than patients who do not have spontaneous pain or who have pain only when the tooth is stimulated by the application of cold (asymptomatic irreversible pulpitis).[198] It is important to distinguish between these patients when evaluating clinical success, because the success rates differ.

Use of Preoperative Analgesic Medications to Increase the Success of the Inferior Alveolar Nerve Block

Many studies have used analgesic medications (for example, ibuprofen, acetaminophen, hydrocodone, and combinations of these medications) given 60 minutes before administering an inferior alveolar nerve block to try to increase the success of the inferior alveolar nerve block. There are varying results but, currently, it appears that preoperative analgesic medications may not show a significant advantage.[199-201] If any increase in success is seen, it is not enough to prevent the use of supplemental anesthesia.

Adjunctive Pharmacologic Therapy

Anxious patients may benefit from sedation (oral, inhalation, intravenous). However, even with conscious sedation, profound local anesthesia is required to eliminate pain during dental treatment.[33-35] Nitrous oxide administration helps reduce pain during treatment in patients presenting with symptomatic irreversible pulpitis.[34,36] A discussion on agents that control anxiety is included in Chapter 9.

Reversing Soft-Tissue Numbness

Patients may feel that residual soft-tissue numbness interferes with their normal daily activities in three specific areas: perceptual (perception of altered physical appearance); sensory (lack of sensation); and functional (diminished ability to speak, smile, drink, and control drooling). Patients often do not want to have lip and tongue numbness for hours after the appointment. Phentolamine mesylate (0.4 mg in a 1.7 mL cartridge, OraVerse; Septodont, Lancaster, Pennsylvania, USA) is an agent that shortens the duration of soft tissue anesthesia.

Fowler and coauthors studied the use of OraVerse for reversal of soft-tissue anesthesia in asymptomatic endodontic patients.[202] They found it shortened mandibular and maxillary soft tissue sensations. Postoperative pain and complications were minimal. Many patients may benefit from the use of a reversal agent when

they have speaking engagements or important meetings or perform in musical or theatrical events.

Supplemental Techniques for Mandibular Teeth in Endodontics

Supplemental Buccal Infiltration of Articaine After an Inferior Alveolar Nerve Block in Patients Presenting with Symptomatic Irreversible Pulpitis

Fowler and coauthors determined the anesthetic success of a supplemental, articaine buccal infiltration after a failed inferior alveolar nerve block, in premolars and first and second molars, in emergency patients presenting with symptomatic irreversible pulpitis.[191] Success was defined as the ability to access and instrument the tooth with mild to no pain. They found success was 42% for the first molars, 48% for the second molars, and 73% for the premolars. Therefore supplemental anesthesia should be considered.

This result should be compared with the finding in asymptomatic (nonpainful) teeth where the buccal infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine after an inferior alveolar nerve block was successful 88% of the time.[124]

Supplemental Intraosseous Injections

For use as a supplemental injection with irreversible pulpitis, high success rates (about 90%) have been reported for IO injections.[193,199,203,204] There is no difference between lidocaine and articaine.[204] Three percent mepivacaine has an 80% success rate, which increases to 98% with a second IO injection of 3% mepivacaine.[205]

Although some studies[206,207] have suggested that an IO injection alone can successfully anesthetize patients presenting with irreversible pulpitis, it is doubtful that this would be successful.[193,199-201,208]

Supplemental Periodontal Ligament Injections

Supplemental PDL injections are not as successful as supplemental IO injections.[151,209] For example, in patients with irreversible pulpitis, use of a computer-controlled local anesthetic delivery system (see Fig. 8.1) for supplemental PDL injections was successful in about half of patients with irreversible pulpitis.[209] Others have reported success in about three-quarters to half of patients.[151,210] Reinjection increases the success rate.[178,210]

Supplemental Intraseptal Injection

Intraseptal anesthesia is the deposition of the anesthetic solution directly into the interdental septum, allowing solution to flow through the porous crestal alveolar bone and hence into the medullary bone surrounding the tooth.[211]

A study in endodontics determined the anesthetic efficacy of the supplemental intraseptal technique in mandibular posterior teeth diagnosed with symptomatic irreversible pulpitis when the conventional inferior alveolar nerve block failed.[212] Success was defined as the ability to perform endodontic access and instrumentation with mild to no pain. The supplemental intraseptal injection provided success in 29% of patients and would not provide a predictable level of anesthesia.

Supplemental Intrapulpal Injection

Besides the supplemental infiltration, IO, and PDL injections discussed previously, the intrapulpal (IP) injection is used when other methods fail (Video 8.6).

Indications

After the inferior alveolar nerve block, on occasion IO and PDL injections do not produce profound anesthesia, even when repeated, and pain persists when the pulp is entered. This occurrence is an indication for an IP injection. However, the IP injection should not be given without first administering an inferior alveolar block plus an IO or PDL injection. The IP injection is very painful without some other form of supplemental anesthesia.

Advantages and Disadvantages

Although the IP injection is somewhat popular, it has disadvantages as well as advantages, making it the last supplemental injection of choice. The major drawback is that the needle is inserted directly into a vital and very sensitive pulp; thus the injection may be exquisitely painful. Also, the effects of the injection are unpredictable if it is not given under pressure. Once anesthesia has been obtained, the duration is short (5 to 15 minutes). Therefore the bulk of the pulp must be removed quickly and at the correct working length to prevent recurrence of pain during instrumentation. Another disadvantage is that the pulp must be exposed to permit direct injection; often problems with anesthesia occur before pulpal exposure.

The advantage is the predictability of profound anesthesia if the IP injection is given under back-pressure. The onset of anesthesia is immediate, and no special syringes or needles are required, although different approaches may be necessary to attain the desired back-pressure.

Mechanism of Action

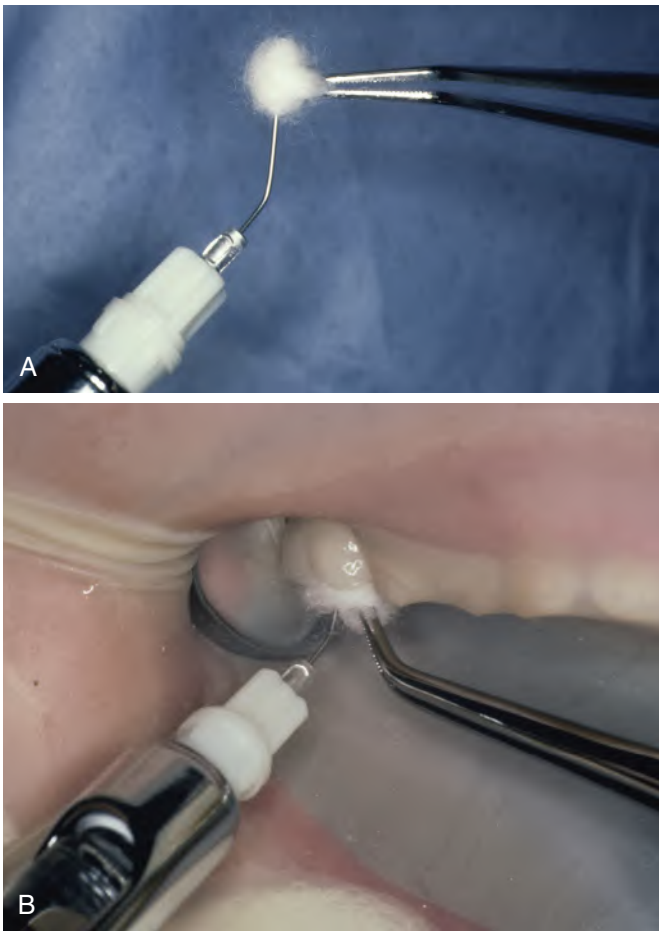
Strong back-pressure has been shown to be the major factor in producing anesthesia.[212,213] Depositing anesthetic passively into the pulp chamber is not adequate; the solution will not diffuse throughout the pulp. Therefore the anesthetic agent is not solely responsible for IP anesthesia; it also depends on pressure.

Technique

The patient must be informed that a "little extra" anesthetic will ensure comfort and that there will be "a sharp sensation" as the injection is given.

One technique creates back-pressure by stoppering the access with a cotton pellet to prevent backflow of anesthetic (Fig. 8.18).[213,214] Other stoppers, such as gutta-percha, waxes, or pieces of rubber, have been used. If possible, the roof of the pulp chamber should be penetrated by a half-round bur, which allows the needle to fit snugly in the bur hole.

Another approach is an injection into each canal after the chamber has been unroofed. A standard syringe is usually equipped with a bent short needle. With fingers supporting the needle shaft to prevent buckling, the needle is positioned in the access opening and then moved down the canal, as the anesthetic is slowly expressed, to the point of wedging. Maximum pressure is then applied slowly on the syringe handle for 5 to 10 seconds. If there is no back-pressure, anesthetic flows out of the access opening. The needle is then wedged deeper or withdrawn and replaced with a larger diameter needle (or stoppered with a cotton pellet), and the injection is repeated. This procedure may be necessary in each canal.



• **Fig. 8.18** Intrapulpal Injection Technique. **A,** A 45-degree bend is placed on the needle. To stopper the injection site, a cotton pellet is pulled over the needle and the needle is placed in the opening in the pulp (the patient is forewarned of discomfort!). **B,** The cotton pellet is packed *tightly* and held in the access opening, and the syringe handle is pushed *slowly.* The patient often feels sharp pain with resistance on the syringe handle; this resistance usually indicates successful anesthesia.

What Is the Effect of No Endodontic Débridement on Postoperative Pain for Symptomatic Teeth with Pulpal Necrosis?

Patients without a dentist or access to care often present to hospital emergency departments with painful teeth. These patients are typically prescribed pain medication and an antibiotic. If they do not seek immediate dental treatment, what postoperative pain do they experience?

Sebastian and coauthors compared the effect of complete endodontic débridement (cleaning and shaping of the root canal system) versus no endodontic débridement on postoperative pain in emergency patients with symptomatic teeth, a pulpal diagnosis of necrosis, and a periapical radiolucency.[215] Success was defined as mild or no postoperative pain and no use of narcotic medication. Patients receiving débridement or no débridement had a decrease in postoperative pain over the 5 days. However, débridement resulted in a statistically higher success rate than no débridement.

Therefore an important consideration is that if there is not time or ability to perform complete débridement, an option is to refer the patient to an endodontist or defer treatment until the patient is asymptomatic.

Anesthetic Management of Pulpal or Periapical Pathoses

Symptomatic Irreversible Pulpitis

With irreversible pulpitis, the teeth most difficult to anesthetize are the mandibular molars, followed in order by the mandibular and maxillary premolars, maxillary molars, mandibular anterior teeth, and maxillary anterior teeth. The vital inflamed pulp must be instrumented and removed. Also, pulpal tissue has a very concentrated sensory nerve supply, particularly in the pulp chamber. These factors, combined with others related to inflammatory effects on sensory nerves and failures that occur with conventional techniques, make anesthetizing patients with painful irreversible pulpitis a challenge.

Different clinical situations present surprises. In some cases, inflamed vital tissue exists only in the apical canals, and the tissue in the chamber is necrotic and does not respond to the cold refrigerant or electric pulp testing. Obviously, in this situation the chamber is entered with no problem, but when the operator attempts to place a file to length, severe pain results. IO or PDL injections are helpful, and an IP injection may be used. However, irreversible pulpitis must be differentiated from a symptomatic necrotic tooth with a distinct radiographic apical abscess, because IO, PDL, and IP injections are contraindicated in the latter condition.

General Considerations

A conventional anesthetic using primary techniques is administered to the patient, and after signs of soft tissue anesthesia occur, the pain abates and the patient relaxes. Frequently, however, on access opening or when the pulp is entered, pain results because not all sensory nerves have been blocked. A useful procedure is to test the pulp of the tooth with cold (cold refrigerant) before the access is begun.[193,209] If the patient responds, an IO or PDL injection is given. However, no response does not ensure complete anesthesia.[193,209] The patient is always informed that the procedure will be immediately discontinued if pain is experienced during treatment or if there is a "premonition" of impending pain. Appropriate supplementary injections are then used. Occasionally, all attempts fail, and in that case, it is best to place a temporary restoration and refer the patient to an endodontist.

Mandibular Posterior Teeth

For mandibular posterior teeth, a conventional inferior alveolar nerve block is administered, usually in conjunction with a long buccal injection for the molars. The tooth is tested with cold refrigerant. If the result is negative, the clinician may proceed with access; if the result is positive, an IO or PDL injection is administered before access is begun. Before the supplemental IO injection, buccal infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine is given over the tooth to reduce the pain of the injection. If pain is felt during access, the IO or PDL injection may be repeated, or an IP injection is given if the pulp is exposed. Usually, once the pulp has been removed, further pain is minimal, owing to the longer duration of mandibular anesthesia.[43-48,193]

Mandibular Anterior Teeth

For mandibular anterior teeth, an inferior alveolar injection is given. The tooth is tested with cold refrigerant. If the result is negative, the clinician may proceed with access; if the result is positive, an IO injection is administered before access is begun (the PDL injection does not work well in mandibular anterior teeth). Before the supplemental IO injection, labial infiltration of a cartridge of 4% articaine with

1:100,000 epinephrine is given over the tooth to reduce the pain of the IO injection. If pain is felt upon access, the IO injection is repeated. If this is unsuccessful, an IP injection is added.

Maxillary Posterior Teeth

The approaches for maxillary posterior teeth are the same as those outlined under "General Considerations" *except* that the initial dose of 2% lidocaine with 1:100,000 epinephrine is doubled (3.6 mL) for buccal infiltration, and a palatal infiltration is given for the rubber dam retainer. The tooth is tested with cold refrigerant. If the result is negative, the clinician may proceed with access; if the result is positive, an IO or PDL injection is administered before access is begun. If pain is felt during access, the IO or PDL injection is repeated. In some cases, an IP injection may be needed.

The duration of anesthesia in the maxilla is less than in the mandible.[131-139] Therefore if pain is experienced during instrumentation or obturation, additional primary and/or supplemental injections are necessary.

Maxillary Anterior Teeth

In the maxillary anterior teeth, anesthetic is administered initially as a labial infiltration and occasionally as a palatal infiltration for the rubber dam retainer. The tooth is tested with cold refrigerant. If the result is negative, the clinician may proceed with access; if the result is positive, an IO injection is administered before access is begun (the PDL injection is not effective[168]). Rarely is an IO injection needed. The duration of anesthesia may be less than 1 hour, requiring additional infiltration.[131-139]

Symptomatic Pulp Necrosis

A diagnosis of symptomatic pulp necrosis indicates pain and/or swelling and therefore periapical inflammation. Because the pulp is necrotic and apical tissues are inflamed, anesthesia problems are different. These teeth may be painful when manipulated during treatment.

For the mandible, an inferior alveolar nerve block and a long buccal injection (for the molars) are administered. For maxillary teeth, if no swelling is present, the anesthetic is given with a conventional infiltration. If soft-tissue swelling is present (cellulitis or abscess), infiltration is administered on either side of the swelling. Occasionally a regional block may be necessary. Access is begun *slowly.* Usually the pulp chamber is entered without discomfort if the tooth is not torqued excessively during use of the high-speed handpiece. File placement and débridement also can be performed without much pain if instruments are used gently.

Occasionally, conventional injections do not provide adequate anesthesia. IO, PDL, and IP injections are *contraindicated.* Although effective for vital pulps, these injections are painful and ineffective with apical pathosis. Rather, the patient should be informed that profound anesthesia is not present, owing to inflammation in the bone. Therefore an important consideration is that if the pain is too severe to perform complete débridement, an option is to refer the patient to an endodontist or defer treatment until the patient is asymptomatic.

In patients with severe preoperative pain without drainage from the tooth (or when no swelling can be incised), a long-acting anesthetic (e.g., bupivacaine) may help control postoperative pain in mandibular teeth; however, this is not very successful in maxillary teeth.[132,140] The duration of analgesia in the mandible is usually not so long as to preclude the prescription of oral analgesics.[48]

Asymptomatic Pulp Necrosis

Asymptomatic teeth are the easiest to anesthetize. Although it may be tempting to proceed without anesthesia, vital sensitive tissue (ingrowth of periapical tissue into canal) may be encountered in the apical portion of canals, or placement of files may cause pressure and extrusion of fluid periapically.

The conventional injections are usually administered: inferior alveolar nerve block and long buccal injection (molars) for mandibular teeth and infiltration in the maxilla. Usually the patient remains comfortable. Rarely, there may be some sensitivity during canal preparation that requires an IO or IL injection. IP injection is not indicated, because bacteria and debris may be forced periapically. In the maxilla, an additional infiltration may be necessary during longer procedures.

Anesthesia for Surgical Procedures

Incision for Drainage

Patients tolerate the procedure better when adequate anesthesia is present before incision and drainage (I&D) of a swelling. However, obtaining profound anesthesia is difficult, which should be explained to the patient. In the mandible, an inferior alveolar nerve block plus a long buccal injection (for molars) and an inferior alveolar nerve block plus labial infiltration away from the swelling (for premolars and anterior teeth) are administered. In the maxilla, infiltration is given mesial and distal to the swelling. For palatal swellings, a small volume of anesthetic is infiltrated over the greater palatine foramen (for posterior teeth) or over the nasopalatine foramen (for anterior teeth). With swelling over either foramen, lateral infiltration is indicated.

Injection directly into a swelling is contraindicated. These inflamed tissues are hyperalgesic and difficult to anesthetize. Traditionally it has been believed that the anesthetic solution may be affected by the lower pH of these tissues and rendered less effective and that direct injection "spreads the infection," although neither belief has been proved. Nevertheless, reasons for avoiding injection into a swelling are the pain from the injection pressure and the ineffectiveness of this technique. Theoretically, the area of swelling has an increased blood supply; therefore the anesthetic is transported quickly into the systemic circulation, diminishing its effect. Also, edema and purulence may dilute the solution.

Incision and Drainage—Buffered Anesthetics

In dentistry, I&D of an odontogenic facial swelling is an emergency procedure. Adequate pain control during the I&D procedure is difficult. Buffered local anesthetics have been purported to reduce pain particularly during painful procedures such as I&D. The reasoning behind buffering of local anesthetics is logical according to the Henderson-Hasselbalch equation: if a local anesthetic solution is buffered to a pH that is closer to its pKa, more of the free base form will be available upon injection to enter the nerve sheath. The most common method for buffering local anesthetics is by the addition of sodium bicarbonate.

Two investigations studied the pain of local anesthetic infiltration (mesial and distal to the swelling) and the pain of the I&D procedure of a buffered versus a nonbuffered formulation in symptomatic emergency patients presenting with a diagnosis of pulpal necrosis, associated periapical area, and an acute clinical swelling.[81,84] Moderate to severe pain was experienced in a large number of patients with both the infiltrations and during the I&D procedure. Buffering did not significantly decrease the pain of infiltrations or significantly decrease the pain of the I&D procedure.

Although the theory of buffering local anesthetics is logical, in reality the presence of a buffer in the local anesthetic may not be enough to overcome the lowered excitability thresholds and peripheral sensitization associated with such significant inflammatory and infectious conditions of a patient with pulpal necrosis and associated acute swelling.[84]

Outcome of an Incision and Drainage Procedure

Endodontic textbooks recommend I&D to treat swollen endodontic patients. The rationale is that I&D prevents further spread of the infection, relieves pressure and pain, and allows introduction of oxygen, which may aid in reducing the number of anaerobic bacteria. However, there is no evidence-based research to support that the outcome of an endodontic I&D procedure is related to these factors.

One recent study found there was more postoperative pain when an I&D procedure was performed.[216] This result may have been related to tissue damage caused by the surgical wounding of the infected and inflamed tissue by the incision and dissection of the swelling.[216] The authors also found that whether an I&D was performed or not, patients had a decrease in postoperative pain and medication use over the 4 days.

Regardless, patients with facial swelling should be closely monitored and possibly referred to an endodontist because clinical management of these patients requires special care.[216]

Periapical Surgery

Most periapical surgery should be performed by an endodontist, because these practitioners have received advanced training in surgical procedures, the periapical bone anatomy of the mandible and maxilla, the use of magnification technologies, the complex canal anatomy, and advanced microsurgical techniques for retrograde preparation and filling.

Additional considerations in periapical surgery involve anesthesia of both soft tissue and bone. Also, inflammation is usually present. In the mandible the inferior alveolar injection is reasonably effective. Additional infiltration injections in the vestibule are useful to achieve vasoconstriction, particularly in the mandibular anterior region. In the maxilla, infiltration and block injections are generally effective, and larger volumes usually are necessary to provide anesthesia over the surgical field.

If the area of operation is inflamed or the patient is apprehensive, anesthesia may not be totally successful. Additionally, the effectiveness of surgical anesthesia is decreased by half compared with anesthesia for nonsurgical procedures. With flap reflection and opening into bone, the anesthetic solution is diluted by bleeding and removed by irrigation.[217]

Use of a long-acting anesthetic has been advocated.[14,69,218] In the mandible, use of a long-acting anesthetic is reasonably effective. In the maxilla, long-acting agents have decreased epinephrine concentrations, which result in more bleeding during surgery.[219] After periapical surgery, administration of a long-acting anesthetic has been suggested.[14] However, postsurgical pain is usually not severe and can be managed by analgesics.[219]

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Study Questions

1. Giving a thorough explanation of the procedure and how to converse if there is any discomfort is an example of exercising which of the 4 Cs?
   a. Control
   b. Communication
   c. Concern
   d. Confidence
2. Why do we use topical anesthesia?
   a. Decreases pain of depositing the anesthetic solution for the IAN block
   b. Decreases pain of depositing the anesthetic solution for infiltrations
   c. Provides an increase in pulpal anesthesia
   d. Demonstrates to the patient that the doctor is doing everything possible to prevent pain
3. Which of the following statements is true?
   a. One way to determine working length is by not administering anesthesia.
   b. Anesthesia is not necessary for teeth with pulpal necrosis.
   c. Anesthesia is not necessary for obturation appointments.
   d. The "eye-blink response" should not be used as an assessment of working length.
4. Which of the following has been shown to increase the success of the inferior alveolar nerve block in asymptomatic patients?
   a. Slow injection
   b. Buffered anesthetic
   c. Increased epinephrine concentration
   d. Increased volume (1.8 mL versus 3.6 mL)
5. Articaine is best used for which type of injection?
   a. Inferior alveolar nerve block
   b. Mandibular infiltration after an IANB
   c. PDL injection after an IANB
   d. Intraosseous injection after an IANB
6. If a patient's lower lip is numb but she or he feels pain when their mandibular tooth is prepared, the next step is to administer
   a. Another inferior alveolar nerve block
   b. A solution with more epinephrine
   c. A mylohyoid nerve injection
   d. Supplemental anesthesia
7. Which type of maxillary anesthesia is preferred for endodontic treatment of maxillary canines?
   a. Infiltration of the tooth
   b. Second division nerve block
   c. Palatal–anterior superior alveolar nerve block
   d. Infraorbital nerve block
8. Which of the following statements is true?
   a. After infiltration anesthesia, performing an incision & drainage procedure is painless.
   b. Cold testing for anesthesia should be done before beginning endodontic therapy.
   c. A repeat inferior alveolar nerve block should be used when patients have pain during endodontic treatment.
   d. Infiltrations should be given directly into a swelling to have the best anesthesia for an incision & drainage procedure.
9. Which of the following should be used for an intraosseous injection:
   a. Both lidocaine and mepivacaine
   b. Only mepivacaine
   b. Only lidocaine
   d. Only bupivacaine
10. A supplemental intraosseous injection is more successful than a supplemental PDL injection because it is administered
    a. In a more apical site
    b. With more anesthetic
    c. More slowly
    d. In the cancellous bone

ANSWERS

Answer Box 8

1 b. Communication
2 d. Demonstrates to the patient that the doctor is doing everything possible to prevent pain
3 d. The "eye-blink response" should not be used as an assessment of working length.
4 a. Slow injection
5 b. Mandibular infiltration after an IANB
6 d. Supplemental anesthesia
7 a. Infiltration of the tooth
8 b. Cold testing for anesthesia should be done before beginning endodontic therapy.
9 a. Both lidocaine and mepivacaine
10 b. With more anesthetic

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Video 8.0: Supplemental Injections Introduction
Video 8.1: Gow-Gates Injection
Video 8.2: Akinosi Technique
Video 8.3: Intraosseous Injection
Video 8.4: Periodontal Ligament Injection
Video 8.5: Intrapulpal Injection