Local Anesthesia Strategies for the Patient With a "Hot" Tooth

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KEYWORDS

• Local anesthesia • Intraosseous injection • Irreversible pulpitis

Achieving profound pulpal anesthesia is a corner stone in endodontic practice and dentistry. Profound pulpal anesthesia during the root canal procedure benefits not only the patient, for obvious reasons, but also the dentist who will be less stressed worrying about patient reactions or sudden movement during therapy. Achieving adequate anesthesia in patients can, at times, be a challenge. But when one adds the condition of a "hot" tooth, the challenges increase. This article describes some strategies that the endodontist can use when treating patients with teeth having moderate-to-severe pain.

To begin, it is necessary to define what a "hot" tooth really is. In endodontic terms, it certainly does not mean a tooth of extreme attractiveness or even a tooth that is undergoing an exothermic reaction in which its temperature is well above normal body temperature. The term "hot" tooth generally refers to a pulp that has been diagnosed with irreversible pulpitis, with spontaneous, moderate-to-severe pain. A classic example of one type of hot tooth is a patient who is sitting in the waiting room, sipping on a large glass of ice water to help control the pain.

Inflammatory changes within the pulp progressively worsen as a carious lesion nears the pulp. Chronic inflammation takes on an acute exacerbation with an influx

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of neutrophils and the release of inflammatory mediators (such as prostaglandins and interleukins) and proinflammatory neuropeptides[1] (such as substance P, bradykinin, and calcitonin gene-related peptide). These mediators, in turn, sensitize the peripheral nociceptors within the pulp of the affected tooth, which increases pain production and neuronal excitability.[2] All of this leads to the pain that patients report as they sit in the dental chair.

In dealing with teeth diagnosed with irreversible pulpitis, determining whether adequate local anesthesia has been achieved before treatment is important. 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. However these techniques are not very effective in determining if pulpal anesthesia has been achieved.[3–6] Objective tests can be used 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 to accurately determine pulpal anesthesia in teeth with a normal pulp before 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 hot irreversible pulpitis, a failure to respond to the stimulus may not necessarily guarantee pulpal anesthesia.[7–9] The patient may still report pain during treatment. 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 tooth to be treated.[9]

When one considers the challenges of local anesthesia in dentistry, mandibular teeth pose the most severe challenge. The IANB must be delivered accurately (indicated by soft tissue and lip numbness) to attain pulpal anesthesia. Missed blocks (lack of lip numbness) occur about 5% of the time and should prompt the provider to re-administer the injection before beginning treatment. When dentists review the literature to determine what injection techniques or anesthetic solutions can offer, they need to be cognizant of the definition of anesthetic success that is used in the research. One way to define anesthetic success for mandibular anesthesia is by the percentage of subjects who achieve 2 consecutive EPT readings of 80 within 15 minutes and sustain these readings for 60 minutes. Clinically, this translates into being able to work on the patient no later than 15 minutes after giving the IANB and having pulpal anesthesia for 1 hour. This duration of anesthesia would be valuable to the endodontist and the restorative dentist. In the available clinical literature it is reported that after administration of a successful IANB (lip numbness achieved) using 2% lidocaine with 1:100,000 epinephrine, success occurs (1) 53% of the time for the mandibular first molar, (2) 61% of the time for the first premolar and (3) 35% of the time for the lateral incisor.[3–6,10–14] Anesthetic failure (the percentage of patients who never achieve 2 consecutive 80 readings with the EPT during 60 minutes 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 minutes following the IANB, which has been reported to occur in mandibular teeth approximately 19% to 27% of the time, with some patients (8%) having onset after 30 minutes.[3–6,10–14]

When the clinician is confronted with the case of a severe irreversible pulpitis in which the conventional IANB using 2% lidocaine with 1:100,000 epinephrine achieves lip numbness but not pulpal anesthesia (per testing), the question arises as to what strategies can be used to get the patient numb so that the root canal treatment can be done as comfortably as possible.

The first consideration could be to change the local anesthetic agents. Research comparing various local anesthetic agents such as 3% mepivacaine plain (Carbocaine, Polocaine, Scandonest),[4] 4% prilocaine (Citanest Plain),[4] 4% prilocaine with 1:200,000 epinephrine (Citanest Forte),[6] 2% mepivacaine with 1:20,000 levonordefrin (Carbocaine with Neo-Cobefrin),[6] and 4% articaine with 1:100,000 epinephrine (Septocaine)[15] 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. Clinical studies involving patients diagnosed with irreversible pulpitis also failed to show any superiority of 3% mepivacine[16] or 4% articaine with 1:100,000 epinephrine[17] over 2% lidocaine with 1:100,000 epinephrine for the IANB.

The next strategy would be to change the injection technique in attempting to block the inferior alveolar nerve. The Gow-Gates technique[18] has been reported to have a higher success rate than the conventional IANB, but controlled clinical studies have failed to prove its superiority.[19–23] The Vazirani-Akinosi technique (closed mouth) also has not been shown to be superior to the conventional IANB technique.[20,24–26] Therefore, replacing the conventional IANB injection with these techniques will 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 and colleagues[10] used medical ultrasound to guide an anesthetic needle to its target for the IANB. They found that although accurate injections could be attained by this method, it did not result in more successful pulpal anesthesia. Therefore, the accuracy of the injection technique (needle placement) was 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.[27]

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,[28] but the success rate was not as good as other supplemental anesthetic techniques. The mylohyoid nerve is the accessory nerve most often implicated as the cause for mandibular anesthesia failure.[29,30] However, Clark and colleagues,[31] 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.

Increasing the volume of the local anesthetic delivered during the IANB has also been found not to increase the incidence of pulpal anesthesia.[3,14,31–33] Increasing the concentration of epinephrine (1:50,000), with the hopes of keeping the anesthetic agent at the injection site longer, also showed no advantage in the IANB.[11,34]

So why then is it so difficult to achieve adequate pulpal anesthesia in mandibular teeth, even if the patient is asymptomatic? The central core theory may be the best explanation.[35,36] This theory states that the outer nerves of the inferior alveolar nerve bundle supply the molar teeth, whereas the nerves for the anterior teeth lie deeper. Anesthetic solutions that are currently used may not be able to diffuse into the nerve trunk to reach all the nerves and provide an adequate block, which explains the difficulty in achieving successful anesthesia for mandibular anterior teeth.[2–6,10–14,19]

Patients in pain as a result of a tooth diagnosed with irreversible pulpitis have additional 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 the anesthetic needed to penetrate the nerve sheath and membrane. Therefore, there is less ionized form of the anesthetic within the nerve to produce anesthesia. This theory may explain only the local effects of inflammation on the nerve and not why an IANB injection is less successful when given at a distance from the area of inflammation (the hot tooth). Another theory is that the nerves arising from the inflamed tissue have altered resting potentials and reduced thresholds of excitability.[37,38] It was shown that anesthetic agents were not able to prevent the transmission of nerve impulses because of the lowered excitability thresholds[37,39] of inflamed nerves. Other theories have looked at the presence of anesthetic-resistant sodium channels[40] and the upregulation of sodium channels in pulps diagnosed with irreversible pulpitis.[41]

SUPPLEMENTAL INJECTIONS

Failure of the traditional IANB in asymptomatic and symptomatic patients requires that a clinician have fall-back strategies to attain good pulpal anesthesia, especially when a patient complains of pain too severe for the clinician to proceed with treatment, as is often the case of patients with hot teeth. There are several supplemental injection techniques available to help the dentist/endodontist, which are reviewed in this article. It should be reiterated that these supplemental techniques are used best after attaining a clinically successful IANB (lip numbness).

Intraligamentary (Periodontal Ligament) Injection

Bangerter and colleagues[42] reported that the periodontal ligament (PDL) supplemental injection is still one of the most widely taught and used supplemental techniques. The success of supplemental PDL injections in helping achieve anesthesia for endodontic procedures has been reported to be 50% to 96%.[16,43,44] Often reinjection is required because of failure of the initial PDL injection. Walton and Abbott[43] reported an initial success rate of 71%, and when reinjection was used, the overall success rate was 92%. Smith and colleagues[44] also reported an increase in success when a second PDL injection was required. In patients with irreversible pulpitis, Cohen and colleagues[16] reported that the supplemental PDL injections were successful 74% of the time, whereas reinjection boosted success to 96%. The key to giving a successful PDL injection remains the attainment of back-pressure during the injection.[43,45] Failure to get back-pressure will most likely lead to failure.[43,46]

PDL injections are usually given using either a standard dental anesthetic syringe or a high-pressure syringe. The development of computer-controlled anesthetic delivery systems (the Wand or the Single Tooth Anesthesia [Milestone Scientific, Livingston, NJ, USA] devices) have been found to be able to deliver a PDL injection. Berlin and colleagues,[47] using the Wand, found that with a primary PDL injection, successful anesthesia (2 consecutive 80/80 readings) was attained in mandibular first molars 86% of the time with 4% articaine with 1:100,000 epinephrine and 74% of the time with 2% lidocaine with 1:100,000 epinephrine. No significant difference was found between the 2 solutions. The Wand system was able to deliver 1.4 mL of the anesthetic over the course of the injection. When this system was used, the duration of anesthesia for the first molar averaged from 31 to 34 minutes, which was longer than the 10 minutes reported by White and colleagues[48] when they used a pressure syringe and delivered only 0.4 mL of 2% lidocaine with 1:100,000 epinephrine. No research on the Single Tooth Anesthesia device is currently available for review.

In patients diagnosed with irreversible pulpitis and experiencing moderate-to-severe pain, when a supplemental PDL injection was delivered using the Wand, the rate of success of the injection was 56%.[49] Success in this study was defined as no pain or mild pain on access and instrumentation of the canals of the affected tooth. The PDL injections used 2% lidocaine with 1:100,000 epinephrine and were limited to mandibular posterior teeth after successful IANB injections (lip numbness only).

Intraosseous Injection

The use of the intraosseous (IO) injection allows the practitioner to deliver local anesthetic solutions directly into the cancellous bone surrounding the affected tooth. There are several IO systems available in the market, including the Stabident system (Fairfax Dental Inc, Wimbledon, UK), X-Tip system (Dentsply, York, PA, USA), and IntraFlow handpiece (Pro-Dex Inc, Santa Ana, CA, USA). The Stabident system consists of a 27-gauge beveled wire that is 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 2-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 for injecting the anesthetic solution. The guide sleeve is then removed with a hemostat at the end of the appointment. The IntraFlow handpiece holds and drives a perforating needle and an anesthetic cartridge, which is engaged via an internal clutch to deliver the local anesthetic through the perforation.

One of the benefits of the IO injection is the reported immediate onset of anesthesia.[50–58] The injection is recommended to be given distal to the tooth to be anesthetized.[50–58] The exception to this rule would be the maxillary and mandibular second molars, for which a mesial site injection would be needed. The perforation site for the IO injection should be equidistant between the teeth and in the attached gingiva to allow for the perforation to be made through a minimal thickness of tissue and cortical bone and to prevent damage to the roots of the teeth. Perforation in the attached tissue also allows for easier location of the perforation site with the Stabident system. The X-Tip could be used in a more apical area below the mucogingival junction if needed because the guide sleeve remains in place and therefore, there is no difficulty in locating the perforation hole. This may also be attempted with the IntraFlow system. The apical location of the injection would be advisable if the patient has no attached tissue around the affected tooth, if there is a lack of interproximal space between adjacent roots, or if the Stabident IO injection did not achieve adequate anesthesia.

Research on the supplemental IO injection for patients diagnosed with irreversible pulpitis has shown good results. Nusstein and colleagues[8] found that a supplemental mandibular IO injection using 1.8 mL of 2% lidocaine with 1:100,000 epinephrine had a 91% success rate in attaining complete pulpal anesthesia when used after the IANB injection failed. Parente and colleagues[59] reported a success rate of 79% when they used 0.45 to 0.9 mL of 2% lidocaine with 1:100,000 epinephrine. The addition of a second IO injection increased their reported success to 91%. Reisman and colleagues[60] used 1.8 mL of 3% mepivacaine as a supplemental injection in mandibular, posterior teeth diagnosed with irreversible pulpitis. They reported 80% success with an initial IO injection and 98% success when a second IO injection of mepivacaine was delivered. Bigby and colleagues[61] studied 4% articaine with 1:100,000 epinephrine as an IO supplemental injection in posterior mandibular teeth diagnosed with irreversible pulpitis and reported an 86% success rate when the IANB injection failed. The Stabident system was used in all these 4 studies.

Using the X-Tip system for the supplemental IO injection in patients diagnosed with irreversible pulpitis, Nusstein and colleagues[50] reported an 82% success rate when using 1.8 mL of 2% lidocaine with 1:100,000 epinephrine in mandibular posterior teeth. In this study, the injection site was 3 to 7 mm apical to the mucogingival junction. The failures of the injection were attributed to backflow of the anesthetic out of the guide sleeve during the injection. This backflow usually indicates an incomplete perforation or blockage of the guide sleeve. Remmers and colleagues[62] used the IntraFlow system as a primary IO injection in 15 patients diagnosed with irreversible pulpitis and reported an 87% success rate. Their definition of success was 2 consecutive 80/80 readings with the EPT. They reported that failures were because of clogging of the perforating needle and subsequent leakage of the anesthetic around the transducer assembly. However, the study sampled a very small number of patients, and further research is needed on the Intraflow system.

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 minutes.[8,49,60] The duration will be shorter with the 3% mepivacaine solution.[59]

One of the concerns when using the IO injection is the reported transient increase in heart rate with both the Stabident and X-Tip systems when injecting epinephrine- and levonordefrin-containing anesthetic solutions.[8,50–57,61,63] Replogle and colleagues[63] 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 used. The increase in heart rate ranged from 12 to 32 beats per minute.[51,53,61,63,64] The use of 3% mepivacaine has been reported not to cause any significant increase in the heart rate[63,65] and may be an excellent alternative when a patient's medical history or drug therapies contraindicate the use of epinephrine or levonordefrin.

Mandibular Buccal Infiltration Injection with Articaine

Recent 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. In asymptomatic patients, the use of the articaine solution was found to be superior to the lidocaine solution (88% vs 71%, respectively, when success was defined as achieving 2 consecutive readings of 80 with the EPT and maintaining anesthesia for 60 minutes).[66] Kanaa and colleagues[67] reported a success rate of 91% (2 consecutive readings of 80 during the test period) with 4% articaine with 1:100,000 epinephrine. However, when the buccal infiltration injection was used as a supplement to the IANB in patients diagnosed with irreversible pulpitis, success was reported as only 58%.[68] This result was much less than that attained with the IO and PDL injections.

Intrapulpal Injection

In approximately 5% to 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.

The intrapulpal injection works well when it is given under back-pressure.[69,70] 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 minutes). 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 because the pain of treatment may begin when the dentin is exposed.[8,50,60,61,70] The injection 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.

Preemptive Strategies to Improve Success of the IANB Injection

Recent clinical studies have looked at the use of oral medications before treatment of a patient with a tooth diagnosed with irreversible pulpitis in hopes of improving the success rate of the IANB injection. Ianiro and colleagues[71] used pretreatment oral doses of acetaminophen or a combination of acetaminophen and ibuprofen versus placebo in patients undergoing endodontic therapy. They reported a trend toward higher success rates (defined as no pain upon entering the pulp chamber) of 71% to 76%, respectively, as compared with placebo (46%). These differences, however, were not found to be significant. Galatin and colleagues[72] used an IO injection of 40 mg of methylprednisolone (Depo-Medrol) and found that it significantly reduced pain and use of medication in untreated patients diagnosed with irreversible pulpitis when compared with patients who received a placebo injection. Unfortunately, follow-up studies by Agarwala and colleagues[73] and Stein and colleagues[74] using similar doses of methylprednisolone failed to improve the success of the IANB injection.

Anxiety is believed to play a role in lowering pain thresholds, and the use of a sedative agent to help increase the success of the IANB injection in patients diagnosed with irreversible pulpitis was studied by Lindemann and colleagues[75] This group used sublingual triazolam and found that a dose of 0.25 mg given 30 minutes before treatment failed to improve the success rate of the IANB as compared with placebo. They concluded that, with conscious sedation, profound pulpal anesthesia was still required to eliminate pain during endodontic treatment of a hot tooth.

SUMMARY

The dentist who treats patients diagnosed with a mandibular hot tooth (irreversible pulpitis) will often find achieving adequate pulpal anesthesia to be a challenge. It behooves each provider to develop a plan to deal with the eventual failures found with the IANB injection. This plan needs to include the use of supplemental anesthesia techniques. Whether the clinician's training or preference is the PDL or IO injection, these supplemental techniques have been shown to be quite effective in achieving pulpal anesthesia for teeth with irreversible pulpitis. Being able to fall back on both sets of techniques provides the dentist the confidence to provide relatively pain-free treatment for the patient having a hot tooth.

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