MANANGING ANESTHESIA FAILURES IN ENDODONTICS

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Abstract
Local anesthesia is a safe, effective and reversible blocking of nerve impulses, with minor risks of irritation and allergic reactions, which produces a loss of sensation in order to control pain. The challenge increases particularly in endodontic practice, to achieve a deeper level of anesthesia that will last during the endodontic procedure. Successful management of pain and anxiety requires knowledge of the anesthetic agents and the neuro-anatomy as well as a good control of the techniques.
The present paper is a review of techniques and molecules used in clinical practice to ensure a lasting analgesia for a pain-free treatment.

Keywords: Anxiety - oral premedication - local anesthetic agents - intraosseous injection - inferior alveolar nerve block - intrapulpal injection.

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GESTION DE L'ÉCHEC DE L'ANESTHÉSIE EN ENDODONTIE

Résumé
L'anesthésie locale est un blocage sûr, efficace et réversible de l'influx nerveux, à risques mineurs d'irritation et de réactions allergiques, qui produit une perte de sensation, afin de contrôler la douleur. Le défi augmente en particulier dans la pratique endodontique, pour obtenir un niveau profond de l'anesthésie qui va persister toute la durée du traitement endodontique. Un contrôle réussi de la douleur et de l'anxiété nécessite la connaissance des propriétés des molécules anesthésiques, de la neuro-anatomie et des techniques d'anesthésie.
Le présent document est une revue des techniques et des molécules utilisées dans la pratique clinique afin d'assurer une analgésie durable pour un traitement sans douleur.

Mots-clés: anxiété – prémédiction – molécules anesthésiques – injection intra-osseuse – anesthésie intrapulpaire.

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Introduction

With the progression of the carious lesion and in the absence of treatment, the bacteria may invade the pulp of the tooth. Chronic inflammation spreads out and the breakdown of damaged cell membranes occurs releasing arachidonic acid (AA). An Acute exacerbation manifests with an influx of neutrophils and release of inflammatory mediators (such as prostaglandins and interleukins) and proinflammatory neuropeptides (such as substance P, bradykinin, and calcitonin gene-related peptide) [1]. These mediators sensitize the peripheral nociceptors within the pulp of the affected tooth, and increase pain production and neuronal excitability [2].

Lip numbness, probing the gingiva around the tooth in question, or simply starting treatment and waiting for a patient response are not very effective in confirming whether the anesthesia is achieved. Even when these symptoms were present, only 62% of the patients had pulpal anesthesia [3].

More objective tests such as electric pulp tester (EPT) and/ or the application of a cold refrigerant on vital tooth can be used before starting a clinical procedure. However, in a painful vital tooth (with an irreversible pulpitis (IP)), a negative response may not guarantee the pulpal anesthesia. A supplemental dose may be required if the patient experiences pain when accessing the pulp chamber.

In multi-rooted teeth or plural pulp systems in single rooted teeth, the patient may still report pain during treatment. Teeth with necrotic pulp chamber, but whose root canals contain vital tissue, may not be tested using the above means. Testing for pulpal anesthesia of the neighboring teeth may give the clinician an indication of the anesthetic status of the tooth to be treated [4].

Challenges exist in the mandibular and the maxillary teeth, and missed blocks (block failure) occurs because of the individual variations in response to the drug administered, operator differences, and variations of anatomy [5].

The most difficult teeth to anesthetize in case of IP are the mandibular molars followed by mandibular premolars, then maxillary molars and premolars, and then mandibular anterior teeth. Lesser problem in obtaining anesthesia is encountered with maxillary anterior teeth.

In addition to anesthetic success and failure, patients may also be subject to slow onset of anesthesia (more than 15min). It occurs about 19–27% of the time with the necessity to re-administer the injection before beginning treatment with no advantage for using a higher concentration (1 : 50,000) of epinephrine in an inferior alveolar nerve block (IANB) [6], or non-continuous anesthesia (episodes of anesthesia followed by a lack of clinically detected anesthesia probably related to the action of the anesthetic solution on the nerve membrane blocking and unblocking of the sodium channels). This occurs about 12–20% of the time in mandibular teeth [7].

When the clinician is confronted with the case of a severe IP in which the conventional techniques failed, the question arises about what strategies can be applied to achieve a pain-free root canal treatment.

Psychological treatment

Many patients suffer from anxiety when remembering an unpleasant injection or a painful root canal treatment. Anxiety is believed to play a negative role by lowering the pain threshold and thereby diminishing the anesthetic effect.

A patient may not appreciate your sophisticated skills but he is expert in identifying a painless injection. Dentists' attitudes and behaviors should reduce anxiety and conveys professional competence [8]. Topical agents can be used to temporarily anesthetize the oral mucosa via the tiny nerve endings located on its surfaces for the aim of reducing the discomfort of dental injections. In general, it takes 1 to 5 minutes of contact time on a dry surface even with concentrations higher than those of injectable anesthetics [9]. Most of the widely used topical anesthetics contacts use 20% benzocaine in various forms - gels, ointments, sprays, and solutions - and flavors such as strawberry, mint, cherry, banana, and bubble gum. The 20% benzocaine has no systemic absorption and combination agents for more efficacies such as tetracaine, lidocaine, and prilocaine are neither regulated nor unregulated by the US Food and Drug Administration (FDA) [10].

Oral premedication to improve anesthesia

The administration of oral analgesics when treating patients suffering from an IP to improve the success rate of the anesthetic injection is a new trend. Ianiro et al. studied the effect of acetaminophen alone or combined to ibuprofen with placebo; oral doses were administered thirty minutes before the IANB injection. Success rate was 71.4% for the acetaminophen group, 75.9% for the acetaminophen and ibuprofen group, and 46.2% for the placebo group. No significant differences were noted between the medication groups, but a higher success compared to placebo [11].

Like nonsteroidal anti-inflammatory drugs (NSAIDs), acetaminophen has both central and peripheral effects on prostaglandin synthesis. While optimizing analgesia, acetaminophen-induced anti-nociception is derived from synergism between peripheral, spinal, and supra-spinal sites. Indiscriminate usage of this drug is not warranted, and its administration should be considered with great caution [12].

Galatin et al. used an intraosseous (IO) injection of 40mg of methylprednisolone (Depo-Medrol*) and found that it significantly reduced pain in untreated patients diagnosed with IP. Unfortunately, follow-up studies using similar doses of methylprednisolone failed to obtain the same results [13].

Another study in 2012 showed that a pre-medication with 800mg

Ibuprofen, 100mg Acetaminophen, and 1000mg Paracetamol resulted in a higher percentage of successful maxillary infiltration in case of IP [14]. The preoperative use of oral dexamethasone increased the anesthetic success rate of the inferior alveolar nerve block in patients having mandibular molars diagnosed with asymptomatic IP [15]. However, a combination dose of 1000 mg acetaminophen/10 mg hydrocodone given 60 minutes before the administration of the IANB did not result in a statistically significant increase in anesthetic success for mandibular posterior teeth in patients experiencing symptomatic IP [16].

The use of sedative agents and their effect on success of analgesia in patients diagnosed with IP was tested. Lindemann found no significant difference between a sublingual dose of Triazolam (0.25mg) and a placebo in the success rate of IANB in emergency cases of IP. He concluded that, with conscious sedation, profound pulpal anesthesia was still required to eliminate pain during endodontic treatment of teeth with IP [17].

Changing the local anesthetic agents

Various local anesthetic agents failed to show any difference in success rates in either patients with normal pulps or patients with IP [18], such as 3% mepivacaine (Carbocaine), 4% prilocaine, 4% prilocaine with 1:200,000 epinephrine, 2% mepivacaine with 1:20,000 levonordefrin and 4% articaine with 1:100,000 epinephrine to 2% lidocaine with 1:100,000 epinephrine, lidocaine hydrocarbonate.

Bupivacaine has slower onset compared to lidocaine but almost the double of the duration of pulpal anesthesia, i.e. approximately 4 hours.

Combined lidocaine/hyaluronidase solution showed significant increase in postoperative pain and trismus. The success rate was not significantly different between a 3.6-ml volume and a 1.8-ml volume of 2% lidocaine with 1:100,000 epinephrine to ensure complete pulpal anesthesia [19].

For mandibular posterior teeth, a 4% buffered lidocaine formulation did not result in a statistically significant increase in the success rate or a decrease in pain injection of the IANB in patients with symptomatic IP [20]. Adding fentanyl (opioid medication- narcotic) to conventional local anesthetic did not increase the effectiveness of infiltration in patients with IP [21]. Buffering the 2% lidocaine with 1:80,000 epinephrine with 8.4% sodium bicarbonate did not improve the success of the IANB in mandibular molars in patients with symptomatic IP [22].

Changing the injection technique

Failure of profound anesthesia is usually common in the IANB and especially when treating the first maxillary molar.

In the mandible, neither the Gow-Gates nor Vazirani-Akinosi (in case of closed mouth) techniques have shown an improved success rates when compared to the conventional IANB technique. Even though accurate injections could be achieved with the use of ultrasound to guide an anesthetic needle to its target, Hannan and colleagues [23] found that it did not result in more successful pulpal anesthesia. Needle deflection as related to the needle bevel direction has also been shown not to affect the anesthetic success rate of the IANB.

Accessory nerve block such as the incisive nerve block at the mental foramen when combined with the inferior alveolar nerve block demonstrated an increased success rate in the first molar.

The anaesthesia of the mylohyoid nerve has been shown not to improve success rate of the IANB [24].To overcome this accessory innervation, the clinician has the options to deliver anesthetic solution higher in the pterygomandibular space using the Gow-Gates or the Akinosi techniques, or proceed with a lingual infiltration on the mandible regarding the tooth in question [25].

For supplemental anesthesia, intraosseous injection (IO) would be a conceivable choice [26] since the anesthetic solution is deposited right in the medullary space at the apices of the concerned teeth.

In the maxillary arch, failure of anesthesia can occur even though not frequently.

In the anterior teeth with long roots, infiltration should be administered high in the vestibule (especially canine – canine fossa). Palatal infiltration is desirable when the apices diverge in the palatal direction [19].

Palatal infiltration is advised in case of two-rooted premolars [19].

Palatal injection is always required for the palatal root in the maxillary molars. Shifting from maxillary buccal infiltrations with success rate ranging from 62% to 100% [27] to posterior superior alveolar nerve block (PSA) administered behind the zygomatic arch into the pterygomaxillary space or anterior or middle superior alveolar is not sufficient without an infiltration over the mesiobuccal root. The injection is characterized by a slow onset, and a declining duration of pulpal anesthesia over 60 minutes would not ensure predictable pulpal anesthesia (28).

Cross innervations from the contralateral nerves have been implicated in failure to achieve anesthesia in anterior teeth (incisors) in both upper and lower jaws.

Neither increasing the volume of the local anesthetic nor the concentration of anesthetic molecules in cases of a hot tooth showed any advantages. Many theories have been suggested but none is adopted or proved correct.

- The central core theory: outer nerves supply the molar teeth, while they lie deeper at the anterior teeth, which explain the difficulty in achieving successful anesthesia for mandibular anterior teeth.
- Ion trapping: lowered pH in the inflamed tissue reduces the amount of the base form of the anesthetic needed to penetrate the nerve sheath and membrane. This is true in local anesthetics and not in IANB injection given at distance from

the area of inflammation (the hot tooth).

Altered membrane excitability: The inflamed nerves arising from the tissues have altered resting potentials and lowered excitability thresholds, and thereby not preventing the transmission of nerve impulses.

Tetrodotoxin resistant channels (TTX-R): Increased expression of sodium channels by nociceptors that are resistant to anesthetic due to up-regulation in pulps diagnosed with IP [29].

No matter what causes the failure of anesthesia, when patient complaints of severe pain during the treatment procedure, the dentists/endodontists try to achieve a profound anesthesia and to obtain a sufficient working time using supplemental injections such as the periodontal ligament (PDL) injection, the intraosseous injection and the intrapulpal injection.

Mandibular buccal infiltration in IANB

As a supplementary injection, mandibular buccal infiltration injection increases the success of the IANB. Injection of 4% articaine with 1:100,000 epinephrine in asymptomatic patients reported a success rate of 91% [30]. Another study by Matthews testing buccal infiltration as a supplement in patients diagnosed with IP reported a success of only 58% [31]. This result was much less than the success attained with the IO and PDL injections.

Intrapulpal injection

Intrapulpal injection is a prime indication and the last resort when failure to produce adequate anesthesia. However, this technique requires the exposition of the pulp tissue. Pulpal exposure could be a painful procedure. Simply placing local anesthetic solution in the pulp chamber will not achieve adequate pulpal anesthesia; a strong back-pressure induces an immediate effect and a rapid onset [32]. The working time is of short duration (approximately15–20 minutes). The dentist should act quickly to remove all the tissue from the pulp chamber and debride the canals.

Before performing the intrapulpal anesthesia, the patient is warned of a moderate to severe pain during the initial phase, a pain that will last no more than one to two seconds. The relief occurs the instant the pain is perceived. The use of a small round bur to access quickly the pulp chamber is necessary to be able to introduce the needle.

Intraligamentary (periodontal ligament) injection

The periodontal ligament (PDL) additional injection is still one of the most widely taught and used supplemental techniques. In patients with IP, injections were successful 74% of the time, whereas reinjection boosted success to 96%. To avoid failure and to get successful PDL injection, the dentist should apply backpressure during the injection. PDL injections are usually given using either a standard dental anesthetic syringe or a high-pressure syringe [33]. Using the CompuDent (originally known as Wand system), primary PDL injection was successful 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 two solutions. The system was able to deliver 1.4 ml in approximately 4 minutes 45 seconds as slow rate or in one minute as fast rate of the anesthetic over the course of the injection. The duration of the anesthesia for the first molar averaged from 31 to 34 minutes [34]. The amount differs significantly from the periodontal ligament injection with a conventional syringe or pressure syringe.

This technique presents many limitations such as:

- Bacteremia in endocarditis;
- Cardio-vascular effects;
- Discomfort due to injection;
- Damage to periodontal tissues.

Intraosseous injection (IO)

It' the only technique that allows the practitioner to deliver local anesthetic solutions directly into the cancellous bone surrounding the concerned tooth. It improves the anesthetic efficacy of the IANB in mandibular posterior teeth with irreversible IP.

Success of IO in achieving pulpal anesthesia in patients with IP has been reported to be 82-98% [15] and 83.33% [35].

There are several available IO systems: Stabident system (Fairfax Dental Inc., Miami) (Fig. 1), X-tip system (X-tip Technologies, Dentsply, Maillefer) (Fig. 2), IntraFlow (Intra Vantage, Plymouth, MN), the Comfort Control Syringe® (Dentsply International, York, PA) and the Quicksleeper (DHT, Cholet, France).

All devices consist of a 27-gauge needle driven by a slow-speed air motor handpiece (Fig. 3).

The injection should be done distal to the tooth in question with the only exception at the maxillary and mandibular second molars, for which a mesial site injection would be needed [35].

The perforation site is selected 2-4 mm apical to the alveolar crestal bone level in the attached gingiva to allow a minimal thickness of tissue and cortical bone. The level of crestal bone is determined by sounding with a periodontal probe. In 2-4 seconds, the drill perforates a small hole through the cortical plate into the cancellous bone. The needle perforates the cortical bone in order to deliver a standard anesthetic syringe into the cancellous bone. The solution is delivered over a 1 minute time period after administration of anesthetic solution, the guide sleeve is removed using a hemostat.

Results have shown success rate up to 98% in attaining complete pulpal anesthesia especially when a second IO injection is delivered.

The advantages of this technique are:

- Immediate onset of anesthesia [7].
- Higher successful rates than periodontal injection due to the greater amount delivered of anesthetic solution.

Fig. 1: Stabident perforator, a solid 27-gauge wire with a beveled end that is placed in a slow-speed handpiece.

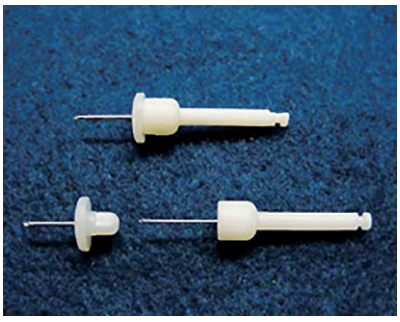

Fig. 2: The X-tip delivery system made of an X-tip (top)that separates into two parts: the drill (a special hollow needle) and the guide sleeve component.

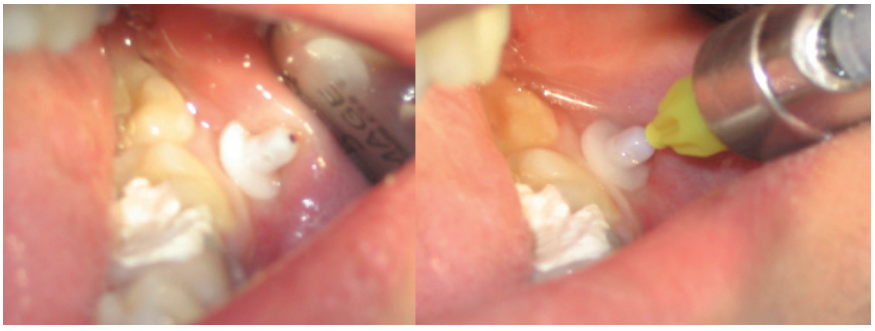

Fig. 3: Intraosseous injection using the X-tip system.

- Shorter duration of anesthesia compared to mandibular block or infiltration [6].

However, this technique presents cardiovascular risks with the rapid entry of anesthetic and vasoconstrictor causing tachycardia [6].

In both the IO and the PDL injections, the dentist should respect these obligations:

- Administration of the minimum quantity needed to assure profound anesthesia.
- No injection and anesthesia delivery into an actively acute abscess site.
- Differentiate IP from a symptomatic necrotic tooth with apical pathosis since, in this condition, intraosseous and intrapulpal injections may not be effective and there exists the possibility of forcing bacteria into the periradicular tissues.

Conclusion

Achieving adequate pulpal anesthesia in patients diagnosed with an irreversible pulpitis is a great challenge. When the inferior alveolar nerve block fails to provide profound pulpal anesthesia, it is necessary for the clinician to develop a plan to deal with failures. This plan needs to include different approaches, skills and mastering supplemental techniques like the PDL or the IO injections proven effective in achieving pulpal anesthesia under such conditions. The main objective is to provide relatively pain-free treatment.

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