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Strategies to Accomplish Effective Pulpal Anesthesia During Endodontic Therapy in Mandibular Molars

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KEYWORDS

Local anesthesia, inferior alveolar nerve block, supplementary anesthesia, acute irreversible pulpitis, intrapulpal anesthesia, intraosseous anesthesia, intraligamental anesthesia.

ABSTRACT:

Introduction: Fear of pain during endodontic treatment is a main cause of not seeking endodontic therapy among patients, which significantly affects patients' oral health and clinicians' dental practice. Hence, it is important for clinicians to know the cause of dental pain and various strategies for achieving profound analgesia during endodontic therapy. Moreover, achieving profound anesthesia in mandibular teeth is more difficult than maxillary because of the variations in the anatomical landmarks and compact bone of the mandible compared to porous bone of maxilla in the mandibular posterior region with irreversible pulpitis, is one of the challenging issues in endodontic practice.

Standard inferior alveolar nerve block (IANB) is the most common and frequently used anesthesia in endodontic therapy for mandibular molars. However, dentists can fail to achieve profound anesthesia during IANB for various reasons. Perhaps the most essential expertise a dentist can develop is to provide safe and effective local anesthesia (LA). Acutely inflamed pulp and periradicular tissues, acute periapical/periodontal abscess, trauma, altered landmarks, altered course of nerve, additional nerve supply, patient apprehension and lowered pain threshold, etc. can make the patient experience more painful during endodontic therapy. Almost all painful conditions can be managed by LA in endodontics. Hence, dentists' skill in administering LA is very important to obtain adequate analgesia.

The present narrative review describes the various techniques for anesthetizing mandibular teeth and reasons for the failure of IANB during endodontic therapy. Additionally, it reviews various supplementary anesthetic techniques to achieve profound pulpal anesthesia during root canal therapy, especially in cases of acute irreversible pulpitis.

Background:

Achieving profound pulpal analgesia is the keystone of successful endodontic therapy and a great challenge during endodontic therapy, especially in tooth with irreversible pulpitis.[1] The local anesthesia (LA) prevents the propagation of nociceptive nerve impulses temporarily to that region closer to the nerves that gives sensation to that region of operation to prevent pain during the clinical procedure. [2] Patients are apprehensive about endodontic therapy because of

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severe pain occasionally experienced during endodontic access preparation in tooth with acute pulpitis. Pain may persist due to dentists' inability to obtain profound anesthesia. Patients' apprehension, anxiety and fear of injection needles (trypanophobia) [3] significantly lower the pain threshold, which decreases the effectiveness of anesthetic solutions. [4]A study performed by Hargreaves *et al*. showed that patients with irreversible pulpitis had a failure rate of LA, eightfold higher, when compared to of healthy control patients. [5]

This narrative review describes the prevalence of failures of LA, various reasons for the failure of inferior alveolar nerve block during endodontic therapy, several concepts and protocols to be followed to control pain during the administration of LA, various techniques used in endodontics to achieve profound anesthesia in mandibular molar teeth.

Prevalence of failure of LA:

Many studies have reported with variations in prevalence of failure of LA. The mandibular right first molar was the most frequently treated tooth (approximately 9.12%), followed by the left mandibular first molar (approximately 7.07%).[5] Anesthetizing mandibular teeth sometimes associated with short comings such as trismus, positive aspirations, inadequate analgesia, lack of effect, pain at the injection site, prolonged anesthetic effect, various sensory disorders, infection, edema, hematoma, soft tissue injury, and ophthalmologic complications.[6]Various mandibular nerve block techniques have been suggested by many authors, such as conventional Inferior alveolar nerve block (IANB).[7-11]Various authors have estimated the failure rate of IANB as 15-25%. [12-14] Malamed describes the conventional technique of inferior alveolar nerve block by Halstead to have a failure rate of 31 – 41% in molars, 42%, in second, 38% in first premolars, and 46% in canines, [15] and 81% in lateral incisors. [16]

Pain control strategies during endodontic therapy:

Masoud Parirokha and Paul V. Abbott described the three basic pain management strategies during endodontic therapy by administration of LA while performing endodontic therapy as follows:[6]

- **Obstructing the nociceptive impulses** to reduce the pain of the injection by using topical anesthesia, cryotherapy performed by applying a cold stimulus, acupuncture and acupressure, etc.
- **Reducing nociceptive inputs** by selecting the appropriate anesthetic solution and by premedication with NSAIDs [17-19]
- **The perception of pain in the central nervous system can be prevented** by reducing nociceptive inputs by preventing the formation of prostaglandin at the injury site by using surface anesthetic gel/spray on using a smaller needle, controlling the speed of injection, concentration of epinephrine, volume of anesthetic solution. [20]

The reasons for the failure of IANB to achieve adequate anesthesia during endodontic therapy:

There are many reasons for the failure of IANB, such as variations in anatomical landmarks, pathological, pharmacological, patient's psychological, and clinician factors etc. [21]

Anatomical:

- Poor anesthetic technique followed and operator lacking the skill to administer IANB, variability in the anatomic landmarks. [21]
- The Mandibular block fail to anesthetize the region needed could be because of improper diffusion of solution near the intercepted sensory transmission at the lingula due to the inconsistent distribution of LA solution at the post-injection site in the pterygomandibular space. [11]
- The ascending branch of the nerve to mylohyoid may not be profoundly anesthetized during IANB, because of variations in the location of nerve branching or potential barriers caused by pterygomandibular fascia and the sphenomandibular ligament. Mylohyoid nerve may be anesthetized along with IANB depositing the anesthetic solution slightly at a higher level in the pterygomandibular space (e.g., Gow-Gates or Akinosi) with additional infiltration at lingual sulcus of the molar. [5,22-24]
- The presence of bifid and trifid mandibular canals (prevalence of 0.35–1%,) [25-28] and mandibular nerve branches that sometimes communicate with each other, may cause LA failures. During IANB, extra attention is needed on supplementary branches provided to the mandibular teeth by long buccal nerve and great

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auricular nerve, when they travel through the retromolar foramen.[29,30,31]

- If pulpal pain becomes a burning sensation, it indicates irreversible pulpal damage and involvement of C-fibers formed by core fiber. It is very difficult to anesthetize the tooth since anesthetic agents may not be able to reach those central core C-fibers. [32,33]
- According to the central core theory by de Jong *et al.*, the inferior alveolar bundle for the molar teeth is supplied by outer nerves, and the nerves for the anterior teeth lie deeper, which makes diffusion of anesthetic agents difficult and may not achieve adequate analgesia in the anterior region. [34]
- Variations in intraoral landmarks, patient skeletal patterns, extraoral landmarks, mandibular ramus dimensions and their degree of flaring should be considered. [35]
- According to You *et al.*, the failure rates of IANB in the retrognathic mandible (14.5%) were significantly higher than those in the prognathic mandible (9.5%) and normal mandible (7.3%). [36]

Pathological:

- Trismus, infection, inflammation, and previous surgery cause inability to open the mouth by the patients. Improper needle insertion and difficulty in injecting anesthetic solution will lead to anesthesia failure. [37,38]
- Acutely inflamed pulp of mandibular molars is very difficult to manage by the clinician during access preparation due to unsatisfactory analgesia following IANB. Although a proper technique of IANB is followed, block fails in approximately 30%-45% of cases in endodontics. [37,38]
- Acutely inflamed pulpal tissue induces acidosis in tissues with low pH, which may result in 'ion trapping' of LA. This lowered pH in the inflamed tissue leads to a greater proportion of the LA being trapped in the charged acid form of the molecule. This will prevent LA, such as lidocaine and bupivacaine, from crossing cell membranes, except for 3% mepivacaine, which is a preferred local anesthetic for use in patients with irreversible pulpitis because of its lower pKa values. [5]
- Failure of LA may occur during acute inflammation, and there is an increase in the anesthetic-resistant subpopulation of sodium channels that exist on pain neurons. This could be due to certain sodium channels found on these pain neurons, which appear to be less sensitive to LA. [5]
- Studies by Byers *et al.* have described nerve terminal sprouting of nerve terminals into inflamed pulpal and periradicular tissue, which increases the size of their receptive field, resulting in easily activating the pain neurons by a spatial summation of stimuli. [39,40]

- TTX receptors, alterations in resting potentials, excitability of nociceptors isoforms, decreased excitability thresholds of neurons and their axons innervating the inflamed pulp tissue will alter the nerve fibers extending throughout the pulpal tissues. This altered capacity of these nerve endings to be anesthetized, may influence the concentration or volume of anesthetic agents currently used in endodontics. [41,42] Since tetrodotoxin-resistant (TTX-resistant) sodium channels mostly appear on deeper nociceptive C-fibers, neither negative nor positive responses to EPT and cold tests indicate the success of anesthesia following the administration of anesthetic agents. [18]
- Ion trapping of infiltration injections of LA due to the lowered pH of inflamed tissue reduces the amount of the base form of anesthetic to penetrate the nerve membrane. Consequently, there is less of the ionized form within the nerve to achieve anesthesia. However, IANB injections do not encompass acidotic tissues. [43,44] Decreased potency of the anesthetic agent due to tachyphylaxis which drastically reduces the anesthetic reaction due to 'ion trapping'. [45]
- Anesthesia failure can occur due to pulpal inflammation and infection. During pulpal inflammation, mediators of inflammation, such as substance P and calcitonin neuropeptides, are released. These mediators reduce the effect of local anesthetic agents. [46]
- In the case of chronic and slow onset inflammatory conditions of pulp, the central nervous system becomes sensitized and anesthetic agents may not act due to decreased nerves' excitability thresholds and increase in patients' anxiety due to pain. [47,4]
- In addition, damaging a second, or even third, neurovascular bundle can cause low analgesia along with complications such as paraesthesia, neuroma, or bleeding. [32]
- Nerve sprouting in inflamed tissues increases the volume of nerve tissue to be anesthetized. This may not result in adequate anesthesia. [40]

Clinician factor:

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Inadequate skill of the clinician, haste shown by the clinician to operate before LA acts, intravascular injections, and improper needle placement; and patient factors, such as fear, anxiety, psychological issues, inadequate mouth opening, and skeletal patterns. [11,42]

Pharmacological factors

Kaufman *et al* found the failure rate to be 13.7%, which varied when the different types of injection were administered and also despite newer anesthetic agents and advances in techniques, profound anesthesia may not be achieved in every case. [48]

Psychologic and patient factors,

- Fear, anxiety, psychological issues, inadequate mouth opening, and skeletal patterns can influence the outcome of anesthesia. [42]

Clinician factors

- Inadequate skill of the clinician, haste shown by the clinician to operate before LA acts, intravascular injections, and improper needle placement may affect to achieve profound anesthesia. [8]

Indications for IANB in endodontics

During the access cavity on vital inflamed teeth or teeth need to go for intentional root canal therapy, endodontic surgeries, and endodontic therapy on patients with fear, anxiety and apprehension and traumas.

Contraindications for IANB are

- Patients with allergy to an LA or any one of its ingredients.
- In patients with hepatic and renal impairment, no IANB or lower doses can be administered since anesthetics such as prilocaine are metabolized in the liver, kidneys and lungs. [2]
- Patients with cardiovascular disease. The maximum dose of adrenaline should be 0.04 mg, whereas the dose for healthy adults is 0.2 mg. [2]
- Even though IANB is safer in patients with anticoagulant therapy or bleeding disorders, it is preferred to administer infiltrations. For patients with inherited bleeding disorders, because of the risk of intramuscular bleeding and hematoma with potential airway compromise, the intraligamental technique or interosseous technique should be considered as a potential alternative to nerve blocks. [49,50]
- Geriatric patients with reduced liver and kidney functions. LA without adrenaline can be considered. [51]
- In pregnancy, even though lignocaine is a safer drug, the routine dental procedures can be avoided in the 1st and 3rd trimesters. Preventive, diagnostic and restorative dental treatment can be performed in pregnancy using LA with epinephrine (e.g., bupivacaine, lidocaine, mepivacaine). [52] However, prilocaine with felypressin and prilocaine alone can be avoided due to the risk of early labor induction and methemoglobinemia, respectively. [53,54]

IANB mandibular anesthesia protocol

- Prepare the patient by explaining the LA procedure according to the suggestions given by Wang YH *et al*. [47]
- According to a systematic review by Karapinar-Kazandag M *et al.*, in cases of irreversible pulpitis, the efficacy of mandibular anesthetic agents is partially enhanced by some premedication. [55] According to Shahi S, *et.al*. the premedication with NSAIDs (>400 mg/d) half an hour prior to therapy influences the success of anesthesia if the patient has no spontaneous pain, because of irreversible pulpitis. [56]
- Apply ice sticks (cryotherapy) and/or surface anesthetic gel at the site of injection and wait for 2 mins. [57]
- Anesthetic gels such as 2% lignocaine spray/gel and 20% benzocaine gels were applied at the injection site for 2 min to reduce pain perception and anxiety during LA needle insertion. [58]
- For the onset of action, wait for at least 8-10 minutes following inferior alveolar dental block. [41]
- Check for lip numbness with a blunt instrument by applying little pressure with a blunt instrument on the lip.
- Following establishing and confirming numbness, check for numbness on attached gingiva for buccal infiltration and lingual infiltration by applying little pressure with a blunt instrument. [59]
- Anesthetic efficiency can be evaluated through a cold test, electric pulp (EPT) test. [60,61] However, according to Sampaio *et al.*, the success of anesthesia following anesthetic agent administration cannot be assessed by negative or positive responses on the EPT or cold test. [62]
- If anesthesia is not adequate, supplementary anesthesia must be administered. [63]

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- If IANB fails, repetition of the block with different techniques or increasing the volume of local anesthetic agent will not improve the pulpal anesthetic effect, and the success rate is as low as 32%. [64]
- A systematic review by Amin Salem Milani *et al.* suggests that increasing the volume of anesthetic agent from 1.8 to 3.6 mL significantly increases the success rate of IANB in the irreversible pulpitis group. [65]

Alternate anesthesia to conventional IANB

- IANB described by Malamed [7]
- Mandibular nerve block by Gow-Gates [11]
- Closed mouth technique by Vazirani/Akinosi [11]
- A three-stage technique by Fischer [11]
- The alternative technique described and the technique using the internal oblique ridge by Thangavelu *et al.* [1, 66]
- The novel technique of Boonsiriseth *et al.*, 2012 [67]
- Palti *et al.*, 2011 suggested a new approach for IANB [68]
- IANB through the retromolar triangle [69]
- Modified indirect technique by Nooh and Abdullah. This technique is a modification of Malamed's indirect technique. [70]
- Injection into the pterygomandibular space technique.[71]
- Arched needle technique [72]

Various strategies to contribute to the success of anesthesia according to high-quality research evidence are as follows:

- Topical anesthesia: Application of anesthetic gel such as 20% Benzocaine or 2% Lignocaine along with cryotherapy by application of ice stick at the needle insertion, to prevent pain of needle insertion. Combining topical anesthetics such as 2.5% prilocaine and 2.5% lidocaine gels with other anesthetics is more effective than conventional topical anesthetic agents. [17, 18]
- Type of anesthetic solution: Several anesthetic solutions, such as lidocaine with different concentrations of epinephrine, articaine, bupivacaine, prilocaine, mepivacaine, bupivacaine, and ropivacaine, show efficacy in different clinical conditions. [73]
- Concentration of epinephrine and volume of anesthetic solution: Articaine with epinephrine at 1:200000 and 1:100000 will have a better success rate than other concentrations. [74]
- Size of the needle: Studies show that needle size has no influence on injection pain in adults during intraoral anesthesia injection. However, it may have some impact on pain perception at the injection site in children. [75]
- Evidence shows that there is no significant difference in the efficacy of LA between a bevel of the needle directed away from the ramus or a bidirectional needle rotation technique during IANB injection. [76]
- Speed of injection: Some studies have shown that LA injected slowly will have a better success rate than faster injections. [77] But, the evidence shows that the speed of injection has no significant effect on the success rate of anesthesia, but faster injections provide greater pain and discomfort for patients. [78]
- Premedication helps to reduce pain while administering LA and during endodontic treatment, especially in cases of acute irreversible pulpitis.
- Increasing the volume of the LA solution may help to assure the painless treatment procedure. However, more clinical studies are needed on teeth with irreversible pulpitis in this regard. [79]
- Studies show significantly higher success rates when either articaine alone or in combination with ketorolac is used. Mannitol and meperidine as additives showed anesthesia success. Hyaluronidase improved the duration of anesthesia when injected shortly after the anesthetic solution injection. [80]
- Following IANB, supplemental anesthetic techniques may be needed to increase the success rate of LA.

Supplemental pulpal anesthetic technique for mandibular teeth in endodontics:

<u>Lingual anesthetic infiltration:</u>

The mylohyoid nerve to the digastric and mylohyoid muscles passes through the mylohyoid groove in the lingual border of the mandible. This often carries sensory fibers to the mesial root of the first mandibular molar. To anesthetize it, lingual anaesthetic infiltration may be needed.[81]Gupta *et al.* found that if the failure of primary

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IANB increases, either a primary or a supplementary lingual infiltration technique needed to improve the efficacy of the IANB injection. [82]

Intraligamental anesthesia (ILI): [83]

Rapid onset of anesthesia is achieved with this technique in 30 seconds with 0.2 ml of solution. It is injected into the periodontium of each root. First, the lever was depressed to allow the solution from the cartridge to react, and the needle is inserted into the tissues for 5-10 seconds. It is computer-controlled anesthesia, and specialized delivery systems are needed. Eg: C-CLAD,Compudent system.

Method of administration:

Following the application of antiseptic solution to disinfect the injection site, needle is inserted at a 30° angle, to inject 0.2 ml of LA is injected into the periodontal ligament under back pressure against resistance for each root. Needle should be along the long axis of the tooth at the mesio-buccal part of the roots, between the tooth and the crestal bone until it is wedged with the bevel of the needle facing the alveolar wall. This increases the effect of the injection and prevents blockage. Anesthesia is achieved within 30 sec. The duration of pulpal anesthesia using ILI is <15 min for lower molars. It may be indicated for mandibular anesthesia in patients with bleeding disorders. The disadvantages are that it may produce bacteremia in patients with endocarditis. It may affect the cardiovascular system since it enters rapidly into the circulation. There may be postinjection discomfort and damage to periodontal tissues and pulp.

Intraosseous anesthesia (IOA): [84]

In this technique, LA containing a vasoconstrictor is directly injected into the cancellous bone adjacent to the tooth to be anesthetized. The onset of IOA ranges from 10-120 sec. It has a few disadvantages of rapid entry of local anesthetics and vasoconstrictors into the circulation, which may affect cardiac function. Specialized equipment may be needed to administer the injection. The Stabident® system (Fairfax Dental Inc., Miami, FL) and the X-tip® system (Dentsply, York, PA—the X-tip® system. Anesthesia for maxillary teeth is better achieved than that for mandibular teeth.

Eg: The stabident system, The X-tip anesthesia delivery system, Intraflow system

Method of administration:

The needle is penetrated through the attached gingiva into the thickness of the cortical plate in the mandible. The point of entry of the needle is determined by 2 mm apical to the bisecting two imaginary lines running perpendicular to one another or on attached gingiva coronal to the bisecting point. The horizontal line passes along the buccal gingival margins of the teeth, and the vertical line bisects the distal interdental papilla of the tooth to be anesthetized. This allows direct access to the cancellous bone. Using specialized equipment, the perforator is advanced through the anesthetized gingiva and cancellous bone. The perforator is removed, a 27-gauge short needle is inserted into the cancellous space through the perforation, and 1.0 ml of solution is injected slowly over 2 min. This technique is effective in anesthetizing the target tooth and often ensures anesthesia to mesial and distal parts of that tooth. However, there will be postinjection discomfort.

Intrapulpal anesthesia (IPI) [85]

When the conventional techniques fail during canal access preparation, intrapulpal anesthesia which relies on anesthetic solution or saline injected directly into the coronal pulp under pressure to be given. It can be performed only on exposed pulp to insert the needle. The systemic effects of intrapulpal anesthesia appear to be negligible. This technique may be very painful for a few seconds but helps provide profound pulpal anesthesia within a few seconds. It is used as a supplementary technique by infiltration of articaine after a clinically successful IANB (lip numbness) if the patient has pain during entry into the pulp chamber.

Method of administration:

In this technique, access cavity to be prepared as small as the small round bur to snugly fit the needle into the pulp chamber. Pulp chamber to be deroofed. Bleeding, if any, should be controlled by using a cotton wool pledge soaked with hemostatic agent or sodium hypochlorite (NaOCl). A 10- or 20-mm short, 30-gauge needle then advanced into the pulp chamber as far apically as possible until the snug needle fit to the canal walls and 0.2-0.3 ml. of LA solution is to be injected with pressure, into the pulp chamber to provide effective anesthesia while extirpating pulp tissue. The exposed pulp should be flushed in a small amount of LA solution for one minute. However, due to the vascular distension of the

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tissues and engorgement of the blood vessels, it is highly painful. To proceed with painless, successful endodontic therapy, this supplementary anesthesia for IANB in pulpectomy procedures is very useful. [86] Topical application of 20% benzocaine gel mixed with hyaluronidase may be applied to the exposed pulp before injecting IPI to reduce the pain intensity during IPI. [87]

Transcutaneous electronic nerve stimulation (TENS): Meechan *et al.* preferred the use of intraoral TENS over the use of topical anesthetics to reduce the discomfort of IANB injections. [88] Supplementary anesthesia and some adjuvant therapies can be tried to provide painless root canal therapy, especially in inflamed mandibular posterior teeth. [89]

Adjuvant therapies to achieve analgesia during endodontic therapy:

Influence of music therapy on anxiety and pain perception:

Bhawna Jethani *et al.* evaluated the influence of music as an aid to reduce anxiety and pain perception as well as to control physiological parameters (heart rate, systolic blood pressure, and diastolic blood pressure) during endodontic therapy. Music as a nonpharmacologic aid was found to significantly decrease pain perception and control physiological parameters during endodontic therapy. [90]

Virtual reality (VR) is an effective distraction tool and another adjuvant therapy to alleviate the anxiety of the patient during endodontic therapy while, administration of LA. [91]

Conclusion:

Pain in endodontics practice is a dreaded factor which is initially managed by LA. Achieving adequate analgesia in teeth with inflamed pulp is a difficult task. It is important to know the reasons for anesthetic failure, technical aspects of various alternative and supplementary techniques to administer anesthesia, and developing skills for appropriate techniques.

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