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ANATOMICAL VARIATIONS – CRITICAL BLOCKERS TO INFERIOR ALVEOLAR NERVE ANAESTHESIA

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ABSTRACT

Pain management is both a challenge and an opportunity for the endodontist. Successful management of pain emergencies is a strong component of clinical excellence. Unlike in maxillary teeth where supra periosteal anaesthesia is effective anaesthetising the adult mandibular teeth for endodontic treatment by inferior alveolar nerve block has not always been successful especially in patients with irreversible pulpitis. Previous studies show a success rate of only 19-56% of inferior alveolar nerve block in cases of irreversible pulpitis. This local anaesthesia failure can occur in a substantial proportion of endodontic pain patients. Several studies have cited reasons for failure of inferior alveolar nerve anaesthesia in healthy or inflamed pulps. The reasons include pulpitis, concentration and volume of anaesthetic solution, patient anxiety, anatomical differences (such as accessory innervations, bifid inferior alveolar nerve, anatomic position of mandibular canal,) etc.

This article highlights the importance the clinician should give in understanding the role of various anatomical variations that may influence the success of an inferior alveolar nerve block.

Keywords: Pain, Mandibular canal, Interior alveolar nerve block, Supplemental anaesthesia

INTRODUCTION

Pain management is both a challenge and an opportunity for the endodontist. Successful management of pain emergencies is a strong component of clinical excellence. Local anaesthesia is the primary method used in dentistry for the management of procedural pain. Local anaesthetics work by blocking the entry of sodium ions into their channels thereby decreasing the permeability of the nerve membrane to sodium ions. This causes a lack of propagated action potential resulting in conduction blockade.[1]

Local anaesthetics administered by the infiltration route of injection are highly effective in producing clinical anaesthesia in normal tissues. For anaesthetizing maxillary teeth, local infiltration anaesthesia is commonly employed. Because of the ability of anaesthetic solutions to diffuse through periosteum and the relatively thin cancellous bone of maxilla, this method of pain control will prove effective in endodontic procedures. But supraperiosteal anaesthesia is rarely effective in the adult mandible because of the inability of the anaesthetic solution to penetrate the dense cortical bone.[1]

Inferior alveolar nerve block is the most frequently used mandibular injection technique for achieving local anaesthesia in endodontics. However, the IAN block does not always result in successful pulpal anaesthesia in patients with irreversible pulpitis.[1]

Previous studies have shown success rates of only 19% - 56% for inferior alveolar nerve blocks in patients with irreversible pulpitis. These patients had an eight – fold higher failure of local anaesthetic injections in comparison to normal control patients.[2]

It has been suggested that inflammation and infection lower tissue pH altering the ability of the local anaesthetic to provide clinically adequate procedural pain management. It has also been suggested that inflammation alters peripheral sensory nerve activity and can lead to inability of local anaesthetic to prevent impulse transmission.[2]

INFERIOR ALVEOLAR NERVE – ANATOMY

The inferior alveolar nerve (fig 1) also called the inferior dental nerve is the largest branch of the posterior division of mandibular part of trigeminal nerve.

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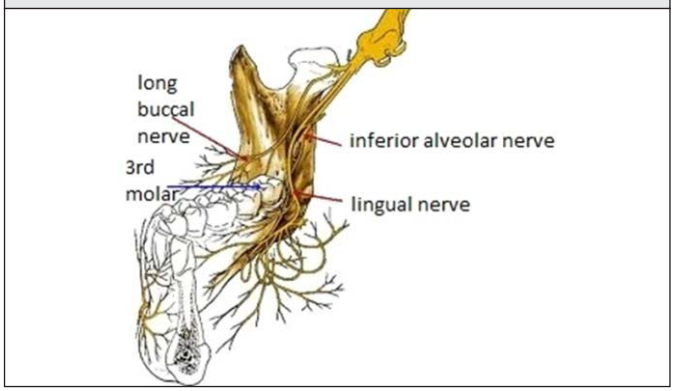
Before traversing the mandibular foramen, it gives off the nerve to the mylohyoid and then enters the mandible via the mandibular foramen, runs in the groove on the medial aspect.[1]

In the inferior alveolar canal it gives off branches to the mandibular teeth that enter the apical foramina of the lower teeth to supply the dental pulps. Some of the fibres are distributed to the periodontal membrane of the various lower teeth. Other fibres pass through the walls of the alveoli to aid in supplying sensory fibres to the gingivae. As the inferior alveolar nerve reaches the region of the mental foramen it divides into two terminal branches – the mental and the incisive. These supply the cuspid tooth, incisor teeth, skin of chin and lower lip.[3]

Fig 1: Inferior alveolar nerve



INFERIOR ALVEOLAR NERVE BLOCK

Nerves Anaesthetised

1. Inferior alveolar nerve
2. Mental nerve
3. Incisive nerve
4. Lingual and buccal nerves

Areas anaesthetised

1. Body of mandible
2. Inferior portion of ramus
3. Mandibular teeth
4. Mucous membrane and underlying tissues

Anatomical landmarks

1. Muco buccal fold
2. Anterior border of ramus
3. External oblique ridge
4. Retro molar triangle
5. Internal oblique ridge
6. Pterygomandibular ligament and space

Needle pathway during insertion

The needle passes through the mucosa, a thin plate of the buccinator muscle, loose connective tissue and a variable amount of fat.[4]

Technique

Fig 2: Inferior alveolar nerve block

Fig 3: Intraligamentary injection

1. When the patient is in the dental chair the head should be positioned so that when the mouth is open the body of the mandible is parallel to the floor.
2. The mucobuccal fold should be palpated with the index finger or thumb, then moved posteriorly until contact is made with the external oblique ridge and the anterior border of the ramus of mandible.
3. When the finger contacts the ramus of the mandible it is moved up and down until the greatest depth of the anterior border of ramus is

identified. This area is called the coronoid notch.

4. The thumb is moved lingually across the retromolar triangle and onto the internal oblique ridge.
5. A 25 gauge needle is inserted parallel to the occlusal plane of the mandibular teeth from the opposite side of the mouth, at a level bisecting the finger and penetrating the tissues into the pterygomandibular depression.
6. During insertion the patient is asked to keep his mouth wide open. The needle is penetrated into tissues until gently contacting bone on the internal surface of the ramus of mandible (fig 2). This should be the area of mandibular sulcus which funnels into the mandibular foramen.
7. The needle is withdrawn about 1mm, and 1-1.8 ml of solution is deposited slowly to anaesthetize the inferior alveolar nerve.
8. The needle is now withdrawn to half its inserted depth, the remainder of the solution is injected into this area to anaesthetize the lingual nerve.
9. The long buccal nerve is anaesthetized by local infiltration.[3]

CAUSES OF FAILURE OF INFERIOR ALVEOLAR NERVE ANAESTHESIA[8]

These causes can be classified as:

Operator dependent

- Choice of technique and solution
- Poor technique

Patient dependent

- Anatomical
- Pathological
- Psychological

OPERATOR DEPENDENT VARIABLES

This really means poor technique, administration of insufficient solution or use of an inappropriate anaesthetic or method of administration. As a general rule, in adult patients about 1.0 ml of solution should be deposited for infiltration injections in the maxilla; for most regional block techniques 1.5 ml should be injected (palatal blocks and long buccal blocks however only require about 0.2–0.5 ml). An example of an inappropriate method is the use of infiltration anaesthesia to obtain pulpal anaesthesia in permanent mandibular molars in adults.[4]

CHOICE OF SOLUTION

The most appropriate local anaesthetic solution for most dental procedures is lignocaine with adrenaline. In some medically-compromised patients adrenaline-free solutions may be preferred, however for the majority of cases lignocaine with adrenaline is the 'gold standard'. The use of plain lignocaine does not give reliable pulpal anaesthesia and in addition its effect is short-lived.[4]

POOR TECHNIQUE

The most likely defect in technique is faulty needle placement. Failure to aspirate before injection, which could lead to intravascular deposition of solution might also lead to failure of anaesthesia although this has never been proven. Success may be related to the speed at which the solution is deposited. It is easy to imagine the anaesthetic being directed away from a nerve trunk during forceful injection. There is evidence in the surgical literature that the success of some techniques is increased with slower injection speeds.[4]

As far as conventional methods of local anaesthesia are concerned poor technique usually relates to mandibular anaesthesia, specifically failed inferior alveolar nerve block injections. The success rate for inferior alveolar block injections with lignocaine and adrenaline is more than 90%. Practitioners who regularly fail with this method should reassess their technique. The best way to achieve success with the inferior alveolar nerve block is to use the direct technique[4]

In most cases the dentist who experiences the odd failure rectifies the problem with a repeat injection, perhaps at a slightly higher level. An orthopantomogram may help in locating the position of the mandibular foramen. In those cases where a second injection has not overcome the failure, an alternative approach to the inferior alveolar nerve should be considered.[4]

ANATOMICAL CAUSES OF FAILURE OF ANAESTHESIA

Individual variations in the position of nerves and foramina

The foramina of importance in regional block anaesthesia in dentistry do not have a consistent location between patients. Available radiographs may be helpful in anticipating this situation.[2]

Factors affecting the relative position of the mandibular foramen:

1.Width of ascending ramus:

The greater the width of the ascending ramus, then the farther back the mandibular foramen will be situated and thus the deeper the needle will have to be inserted.[2]

2. Width of arch of the mandible: The wider the arch then the farther back the body of the syringe will have to be placed on the opposite side to the injection in order to allow the needle to clear the internal oblique ridge and still reach the mandibular foramen.[2]

Obliquity of angle of mandible:

The more oblique the angle of the mandible then the farther forward and the higher up the mandibular foramen will be and thus the injection technique will need to be modified accordingly.[2]

Accessory nerve supply

Accessory nerve supplies to the teeth

Tooth	Main supply	Accessory supply
Maxillary	Superior alveolar nerve	Greater palatine/ Naso-palatine
Mandibular	Inferior alveolar Nerve	Long buccal nerve
		Lingual nerve
		Mylohyoid nerve
		Auriculo-temporal nerve
		Upper cervical nerves

Accessory nerve supply can lead to failure of anaesthesia following both infiltration and regional block methods. Pulpal supply to upper molar teeth may arise from the greater palatine nerves and a buccal infiltration is unlikely to affect transmission by this source. Similarly maxillary anterior teeth can receive innervation from the naso-palatine nerve. The solution for both these cases is a palatal injection.[2]

The long buccal nerve will occasionally provide innervation to the lower molar pulps and a long buccal block or mandibular buccal infiltration may be necessary for complete anaesthesia in such cases. The lingual nerve may also contribute pulpal supply to the mandibular teeth but this will normally be counteracted by the lingual nerve block given in association with the inferior alveolar nerve block. However it will not be affected by the mental and incisive nerve block.[2]

Further accessory supplies innervate mandibular teeth. Such supply can be derived from the mylohyoid nerve, the auriculotemporal nerve and the upper cervical nerves.The mylohyoid branch leaves the main inferior alveolar trunk more than a centimeter superior to the mandibular foramen so may not be affected by a conventional approach to the latter nerve. However, it may be anaesthetised using the techniques of Gow-Gates and Akinosi. Alternatively, a lingual infiltration adjacent to the tooth of interest may be effective.[2]

The auriculotemporal nerve occasionally sends branches to the pulps of the lower teeth through foramina high on the ramus. This supply, like the mylohyoid branches, is countered by a 'high' block such as the Gow-Gates or Akinosi.[2]

When using regional block anaesthesia structures in the mid-line may not be satisfactorily anaesthetised as they receive bilateral innervation. A classic example is the failure of inferior alveolar or mental and incisive nerve blocks to anaesthetise a lower central incisor. The solution is to block the contralateral nerve with an inferior alveolar nerve block, incisive nerve block or buccal infiltration. Alternatively, an infiltration, intraligamentary or intra-osseous injection may be administered at the outset in this area.[2]

Barriers to anaesthetic diffusion

The most obvious barrier to anaesthetic diffusion is the

thick cortical plate of the mandibular alveolus which precludes infiltration anaesthesia in adults with the possible exception of the mandibular mid-line. The first molar region in the adult maxilla occasionally presents a similar problem. In this region the thick zygomatic buttress can prevent passage of the anaesthetic to the dental apices. The answer to this problem is to inject mesial and distal to the first molar away from the buttress (as the first molar can obtain supply from both posterior and middle superior alveolar nerves a posterior superior alveolar nerve block may be unsuccessful).[4]

PATHOLOGICAL CAUSES OF FAILURE OF ANAESTHESIA

Factors precluding access

Factors which can preclude access include trismus (because of a number of causes) and anatomical changes because of trauma or surgery. Trismus is the most likely factor in practice and this is often because of an infective cause. Buccal infiltrations in the maxilla are still possible with the mouth closed. A way to anaesthetise the palatal tissues in the patient with trismus is to inject while advancing a needle toward the palate through the mesial and distal gingival papillae from the buccal side.

The best way to achieve inferior alveolar anaesthesia in the patient with trismus is to use the Akinosi closed-mouth technique described above. There are extra-oral approaches but these are not recommended in practice.

Although methods of anaesthetising the nerve supply to the teeth are possible in the patient with trismus the practitioner must question the appropriateness of administering the injection. It may be that half-completed treatment is worse than none at all. It may be prudent to allow the trismus to resolve prior to dental treatment.[4]

Inflammation

It is apparent to all practitioners that teeth with inflamed pulps can be difficult to anaesthetise. The classic explanation for this is that the low tissue pH in areas of inflammation affects the activity of the local anaesthetic solution by decreasing the concentration of the unionised (lipophilic) fraction which diffuses through nerve sheaths. Similarly areas of inflammation have an increased blood supply due to vasodilatation and this might increase anaesthetic 'wash-out'. However, these answers do not explain the failure of regional block techniques where the solution may be deposited 4 or 5 cm from the area of inflammation. The most plausible explanation is that inflammation makes nerves hyperalgesic.[2]

Minimal stimulation results in conduction. However, no tooth is resistant to local anaesthesia. The practitioner therefore has to decide on the maximum volume of local anaesthetic he is willing to inject for that patient and be prepared to use up to that maximum to anaesthetise that tooth. This may mean limiting treatment to only one tooth but if it takes the maximum safe dose — so be it. On no account should the predetermined safe maximum dose be exceeded. In healthy patients there is usually sufficient room for manoeuvre to administer a dose sufficient to halt conduction in the tooth without producing generalised central nervous system effects.[2]

The use of higher concentrations of local anaesthetic solutions (such as 5% lignocaine), although effective, is not a viable option in practice. The answer is to inject more solution. This does not have to be at the same site, eg the combination of infiltration and regional block anaesthesia can be used in the maxilla (eg infiltration at the apex of an upper lateral incisor plus an infra-orbital nerve block). This can be supplemented with intraligamentary or intra-osseous injections if required.[5]

PSYCHOLOGICAL CAUSES OF FAILURE

There are undoubtedly patients who do not do well with local anaesthesia but in whom the local anaesthetic appears to have been effective. This may be because of fear and apprehension. In such patients the use of sedative techniques can be helpful as successful anaesthesia is easier to achieve in the relaxed patient Benzodiazepines offer the added bonus of reducing local anaesthetic toxicity which is useful when multiple injections are being administered.[4]

SUPPLEMENTAL INJECTION TECHNIQUES[7]

1. INTRALIGAMENTARY

2. INTRAPULPAL
3. INTRAOSSEOUS

THE INTRALIGAMENTARY APPROACH[7]

- Provides pulpal and soft-tissue anesthesia in a localized area (one tooth) of the mandible without producing extensive soft-tissue (e.g. Tongue and lower lip) anesthesia.
- Without the extensive soft tissue anesthesia, patients may be concerned that they are not adequately anesthetized.
- Local anesthetic is diffused apically and into the marrow spaces surrounding the teeth.
- The solution in not forced apically through the periodontal tissues because of the increased hydrostatic pressure being exerted in a confined space. This could cause avulsion of a tooth.
- The most frequent post-injection complications reported include mild discomfort and sensitivity to biting and percussion for 2 or 3 days.
- The most common causes of post-injection Discomfort:
  - Too rapid injection (producing edema and slight extrusion of the tooth sensitivity on biting)
  - Injection of excessive volumes of local anesthetic into the site.

Nerves anaesthetised[1]

Terminal nerve ending at the site of injection and at the apex of the toot

Areas anaesthetized

Bone, soft tissue, and apical and pulpal tissues in the area of injection

Indications[1]

1. Pulpal anesthesia of one or two teeth in a quadrant
2. Treatment of isolated teeth in 2 mandibular quadrants
3. Patients for whom residual soft-tissue anesthesia in undesirable
4. Situations in which regional block anesthesia is contraindicated
5. As a possible aid in diagnosis of pulpal discomfort
6. As an adjunctive technique after nerve block anesthesia if partial anesthesia is present

Contra-indications

1. Infection or inflammation at the site of injection
2. Primary teeth, when the permanent tooth bud is present
   a. Enamel hypoplasia has been reported to occur in a developing permanent tooth when a PDL injection was administered to the primary tooth above it
   b. There appears to be little reason for use of PDL technique in primary teeth because infiltration anesthesia and the incisive nerve block are effective
3. Patient who requires a "numb" sensation for psychological comfort

Injection technique

Area of insertion: along the long axis of the tooth to be treated

Target area: depth of gingival sulcus

Landmarks

- Root(s) of the tooth
- Periodontal tissues

Procedure[8]

- Stabilize the syringe along the long axis of the root to be anesthetized
- With the bevel of needle on the root, advance the needle apically until resistance is met (fig 3)
- Deposit 0.2 ml of local anesthetic solution in a minimum of 20 sec
- If tooth is multi-rooted, remove the needle and repeat the procedure on the
- other roots

Advantages

1. Prevents anesthesia of the lip, tongue, and other soft tissues, thus facilitating treatment in multiple quadrants during a single appointment.

2. Minimum dose of local anesthetic necessary to achieve anesthesia (0.2 ml per root)
3. An alternative to partially successful regional nerve block anesthesia
4. Rapid onset of profound pulpal and soft-tissue anesthesia (30 seconds)
5. Less traumatic than conventional block injections
6. Well suited for procedures in children, extractions, and periodontal and endodontic single-tooth and multiple quadrant procedures

Disadvantages

1. Proper needle placement is difficult to achieve in some areas
2. Leakage of local anesthetic solution into the patient's mouth produces an unpleasant taste
3. Excessive pressure or overly rapid injection may break the glass cartridge
4. A special syringe may be necessary
5. Excessive pressure can produce focal tissue damage
6. Post injection discomfort may persist for several days
7. The potential for extrusion of a tooth exists if excessive pressure or volumes are used.

THE INTRAPULPAL APPROACH[7]

- Deposition of local anesthetic directly into the pulp chamber of a pulpally involved tooth provides effective anesthesia for pulpal extirpation and instrumentation
- The intrapulpal injection may be used on any tooth when difficulty in providing profound pain control exists
- Provides pain control both by the vpharmacological action of the local anesthetic and the applied pressure

Nerves Anesthetized [2]

Terminal nerve endings at the site of injection in the pulp chamber and canals of the involved tooth

Areas anesthetized [2]

tissues within the injected tooth

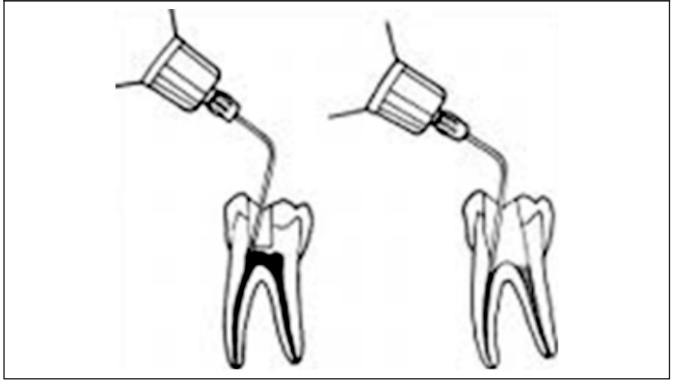
Indication

When pain control is necessary for pulpal extirpation or other endodontic treatment the absence of adequate anesthesia from other techniques

Technique[1]

1. Insert a 25 or 27-gauge short or long needle into the pulp chamber or the root canal
2. Wedge the needle firmly into the pulp chamber or root canal
3. Deposit anesthetic solution under pressure
4. Resistance to the injection of the drug should be felt
5. Bend the needle, if necessary, to gain access to the canal
6. When the intrapulpal injection is performed properly, a brief period of pain may accompany the injection. Relief usually immediate
7. Instrumentation may begin ~30 seconds after the injection

Fig 4: Intrapulpal injection technique



Advantages

1. Lack of lip and tongue anesthesia (fig 4)
2. Minimum volumes of anesthetic solution necessary
3. Immediate onset of action
4. Very few postoperative complications

Disadvantages

1. Traumatic
   - The intrapulpal injection is associated with a brief period of pain as the anesthetic is deposited
2. Bitter taste of the anesthetic

3. May be difficult to enter certain canals
4. Need a small opening into the pulp chamber for optimum effectiveness - Large areas of decay make it more difficult to achieve profound anesthesia with the intrapulpal injection

Complication[5]

Discomfort during the injection of anesthetic.

The patient may experience a brief period of pain as the injection of the anesthetic drug is started.

Almost immediately, the tissue is anesthetized and the pain ceases

THE INTRAOSSEOUS APPROACH[6]

Deposition of local anesthetic solution into the interproximal bone between two teeth

Nerves anesthetized [1]

Terminal nerve endings at the site of injection and in the adjacent soft and hard tissues

Areas anesthetized

Bone, soft tissue, and root structure in the area of injection

Indication [2]

Pain control for dental treatment on a single or multiple teeth in a quadrant

Contraindications

Infection or severe inflammation at the injection site

- ❖ Because the intraosseous injection site is relatively vascular, it is suggested that the volume of local anesthetic delivered be kept to the recommended minimum to avoid possible overdose
- ❖ Because of the high incidence of palpitations noted when vasopressor-containing local anesthetics are used, a "plain" local anesthetic is recommended

Technique[7]

Stabident System[7]

– 2 parts: a perforator, a solid needle that perforates the cortical plate of bone with a conventional slow-speed contra-angle handpiece (fig 5A), and an 8 mm long, 27-gauge needle that is inserted into this predrilled hole (fig 5B) for anesthetic administration

Fig 5: Stabident system

5A - Perforator 5B - Needle

X-tip[7]

– Composed of a drill and guide sleeve. The drill leads the guide sleeve through the cortical plate (fig 6A) , after which it is separated and withdrawn. The guide sleeve remains in the bone (fig 6B) and accepts a 27-gauge ultrashort needle (fig 6C)

Fig 6: X-tip system

6A – Drill 6B – Guide sleeve 6C – Ultrashort needle

Fig 7: Intraflow system

Intraflow[7]

-The anesthetic cartridge is attached to a standard four-hole air hose and controlled by a rheostat.

The intraflow (fig 7) is a modified slow-speed handpiece that consists of 4 main parts

A needle or drill that makes the perforation through the bone and delivers the local anesthetic

A transfuser that acts as a conduit from the local anesthetic cartridge to the needle or drill

A latch tip or clutch that drive and governs the rotation of the needle or drill

A motor or infusion drive that powers the rotation of the needle or drill and, while holding the local anesthetic cartridge in place, powers the infusion plunger

Advantages

- Lack of lip and tongue anesthesia
- Atraumatic
- Immediate (<30 seconds) onset of action
- Few postoperative complications

Disadvantages[2]

- Requires a special syringe
- Bitter taste of the anesthetic drug (with leakage)
- Occasional difficulty in placing anesthetic needle into predrilled hole
- High occurrence of palpitations when vasopressor-containing local Anesthetic is used

Complications[2]

- Palpitations
- Post-injection pain unlikely, but NSAIDS may be used for post-injection discomfort
- Fistula formation
- Separation of the perforator or cannula
- Perforation of the lingual plate

SUMMARY

A study was conducted in the department of Conservative dentistry and Endodontics as a clinical trial to evaluate the anaesthetic efficacy of an intra-osseous injection (X-TIP technologies, Dentsply, Maillefer, Switzerland) in patients with irreversible pulpitis in mandibular posterior teeth when the conventional inferior alveolar nerve block failed.

Thirty patients with the diagnosis of symptomatic irreversible pulpitis of mandibular posterior teeth were included in the study. The adjacent teeth in the same quadrant were selected as controls to evaluate the efficacy of primary anaesthesia. After cold and electric pulp test of the affected and control teeth, inferior alveolar nerve block injection along with long buccal injection, was administered using 1.8ml of 2% lidocaine with 1:800000.

A standard endodontic access preparation was started after a waiting period of 15 minutes. Each patient was evaluated for subjective science of clinical anaesthesia consisting of lower lip and tongue numbness. Once the subjective science appeared, teeth were tested with ice sticks and electric pulp tester to evaluate the effect of primary anaesthesia. If the control teeth showed response to the cold test or electric pulp test, the anaesthesia was considered as failure and inferior alveolar nerve block was repeated.

Fifteen minutes after re-administration of local anaesthesia, these patients were re-checked with cold and electric pulp test to confirm the adequacy of anaesthesia. If the teeth did not show response to cold test or maximum output of the pulp tester at two or more consecutive time points, the teeth were isolated with rubberdam and access preparartion started.

The patients were instructed to rate any discomfort felt during access into dentin, when entering the pulp chamber or with initial file placement using Heft-Parker visual analogue scale.

86.7% of patients had either no pain or mild pain. Only 7% patients had moderate pain. Moreover in the case of success 73.3% patients had no pain and 23.3% had mild pain. Out of the failure cases 3.3% had moderate pain and no patient had severe pain.

The following observations were drawn from the study.

- There was a high success rate (86.7%) of an intra-osseous injection for achieving profound pulpal anaesthesia for a successful endodontic treatment when the conventional inferior alveolar nerve block failed.

- Most of the patients had no or mild pain following intra-osseous injection.
- Majority of the patients reported mild or no discomfort during various stages of this technique.

The results of this study showed that supplemental intra-osseous injection has statistically significant influence in achieving successful pulpal anaesthesia in patients with irreversible pulpitis.

CONCLUSION

Supplemental injection techniques could be used to increase the likehood of pain free endodontic treatment and ensure successful management of pain emergencies in endodontic field. Also a thorough knowledge of the anatomy and its possible variations would enable a practitioner perform virtually painless root canal therapy. A basic aspect of providing care is a dentist's ethical obligation to render it painlessly.

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