

Stumbling block for inferior alveolar nerve block in predoctoral students: An analytical observational study and review of literature of mandibular nerve block techniques

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ABSTRACT

Introduction: Dentists earnestly try to practice painless treatment. Conventional inferior alveolar nerve block technique is preferred by most of the dentists despite its various modifications. However its failure rate as per literature is quite high. Inexperienced dentists face difficulty in obtaining effective anesthesia. This may be due to limited access to inferior alveolar nerve, greater density of alveolar bone, bulky soft tissues, damage to nerve or due to risk of intravascular injection. **Aim:** The aim of this study is to review and clinically assess the factors causing difficulty or failure of inferior alveolar nerve block in predoctoral students and to review the mandibular nerve blocks. **Material and methods:** Dental interns of Riyadh Elm University were monitored during administration of inferior alveolar nerve block for difficulty factors influencing inferior alveolar nerve block. Onset of anesthesia, efficacy of anesthesia of inferior alveolar nerve, lingual nerve and long buccal nerve were ascertained. Difficulty index was used to assess the "item difficulty" with a score of 0.0 which indicates that none of the dental interns anesthetized correctly to 1.0 suggesting all the dental interns anesthetized correctly. **Results:** Complete failure of inferior alveolar nerve block was noticed in 2.4% of predoctoral students. The most common cause for inferior alveolar nerve block failure was attributed to the difficulty in palpating the landmarks (77%), 22% of the patients refused multiple needle penetrations, and 19% of inferior alveolar nerve block failure was due to the fear of potential complications by the predoctoral students. **Conclusion:** Clinical skill of predoctoral students need adequate training in nerve blocks. Revising the current literature on alternative inferior alveolar nerve block techniques or use of evidence based dentistry to update and practice alternative nerve block techniques would aid in improving the clinical skills and treatment outcome which would therefore enable to remove the stumbling blocks in successful anesthesia.

Keywords: Alternative techniques, Inferior alveolar nerve block, local anesthesia, students

Introduction

Various inferior alveolar nerve block (IANB) modifications have been reported in the literature. Teaching alternatives to IANB would be a worthwhile endeavor if dental teachers and students

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accept the advantages of alternative techniques. However, during predoctoral dental education, students are most often trained for the use of conventional nerve block technique.^[1] Attaining clinical competency in the predoctoral stage has been a challenge for both dental schools and the students. The addition of an extra programme other than the requirement is faced with resistance and skepticism. The paper evaluates the skill of predoctoral students of Riyadh Elm University in effectively administering IANB in the presence of experienced doctors.

Material and Methods

We included 123 dental house surgeons (interns) of Riyadh Elm University. Student's and patient's demographics were recorded. Interns were monitored by the authors in their respective specialities while performing the IANB. Seven variables were recorded: (1) students trained with conventional IANB only, (2) students trained in alternative IANB techniques, (3) IANB assessment, (4) number of IANB given per week, (5) number of successful IANB, (6) reasons for failure, and (7) steps taken to overcome failure. The patient variables included periodontal conditions, periapical lesion and radiographs of the tooth to be extracted. After obtaining patient consent, the technique used was recorded. Nerve blocks were performed using 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. A nerve block was deemed successful when a single application produced sufficient anaesthetic effect to extract the tooth with a score zero, assessed using the Verbal Rating Scale (VRS). Failure of anaesthesia of either lingual or long buccal nerve block was considered as total failure of IANB. Exclusion criteria included abscess, infection or inflammation, trismus, fear and apprehension.

Results

A total of 123 students were enrolled from peripheral clinics. Most common anesthetic techniques used for inferior alveolar nerve block is halstead techniques, a direct technique where inferior alveolar nerve is accessed intraorally near mandibular foramen. 6.50% of the students had an experience in alternative IANBs; 62.6% of the students successfully performed IANB; 34.15% of the students routinely used IANB as they were "not trained in alternative ianb techniques" Response rate of 13.82% of the predoctoral students was seen for "difficulty in practicing alternative IANB technique [Chart1]." Complete failure of IANB was noticed in 2.4% of predoctoral students [Chart 2]. We observed a strong association between the number of IANB and the success rate (successful IANB), Chi-square tests outcome $\chi^2 (9)=189.7, p=0.000$, was statistically significant [Table 1]. The most common cause for IANB failure was attributed to difficulty

in locating and palpating the anatomical landmarks (77%), 22% of the patients refused multiple needle penetrations, and 19% of IANB failure was due to fear of potential complications by the predoctoral students [Chart 3]. More than 50% of the students followed "wait and watch" method, following IANB failure if the nerve block was ineffective, anaesthesia was re administered; 10.6% of the students used an alternative IANB technique [Chart 4].

Discussion

The relevance of this study for family physicians and primary care is that whenever there is a need for an effective nerve block technique, a decision can be taken based on this review. The success or failure of anaesthesia has various contributing factors. This study assessed the efficacy of new entrants into the field of dentistry in the form of house surgeons compared to various previous studies that evaluated experienced practitioners. Martínez *et al.* combined two or more anaesthetic direct techniques (mandibular block and the Akinosi technique) and demonstrated a cent percent success.^[2] Kholer *et al.* reported the usage of 3.6 ml local anaesthetic, which resulted in quick and effective anaesthesia.^[3] Waikakul *et al.* in his study showed 60% success.^[4] Gallatin *et al.*^[5] reported the success rate of 81% with IANB as against 100% success rate when IANB was combined with intra alveolar injections. Hannan *et al.*^[6] and Reitz *et al.*^[7] from University of Ohio, showed a 76% and 60%-74% success rate, respectively, with conventional IANB. Kennedy *et al.* divided 64 patients into two groups: one anaesthetised with a conventional alveolar nerve block, the other with bi-directional alveolar nerve block. Both groups had a 50% success rate.^[8] Thangavelu *et al.* 2012, showed 95% success rate. However, keeping IANB as a standard, this technique may carry potential complications such as injury to the periosteum. Since the author advises contacting the medial aspect of the ramus with a needle, on two occasions the syringe has to be redirected making the technique painful.^[9] Suazo Galdames *et al.* introduced an alternative IANB technique through the retromolar triangle. This technique involves the deposition of local anaesthetic solution at the retromolar triangle which is a triangular area. Success rate of this technique was reported to be 72% with an onset time of 10 min. This technique is reported to be valuable in case of patients with blood disorders where the use of conventional IANB can present problems. The most common reason for IANB failure cited in the literature includes operator defective technique.^[9,10]

The various contributing factors include:
 Pathological: Trismus, infection, and inflammation.^[10,11]
 Anatomical: Mylohyoid ancillary nerve, bifid mandibular nerve, variations in the position of the retromolar foramen, and collateral innervation of teeth.^[10,12,13]
 Pharmacological: Use of: analgesics, antimicrobial agents, and anti-inflammatory agents.^[12]
 Psychological: Fear, anxiety, and apprehension.^[9]

Most common reason for failure of anaesthesia in our study too was difficulty in locating anatomical landmarks. Although house

Table 1: Chi square tests

	Value	df	Asymptomatic Sig (2 sided)
Pearson Chi square	189.725	9	0.000
Likelihood ratio	179.001	9	0.000
Linear by linear association	18.075	1	0.000
No of valid cases	123		

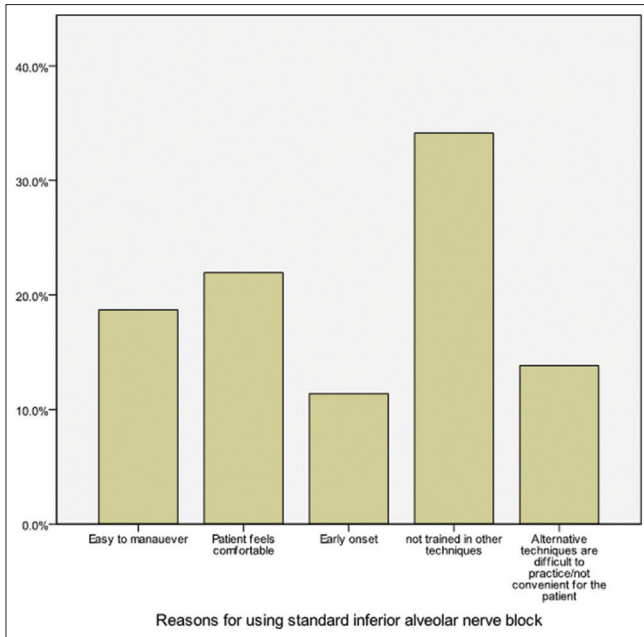


Chart 1: Reasons for using a standard IANB

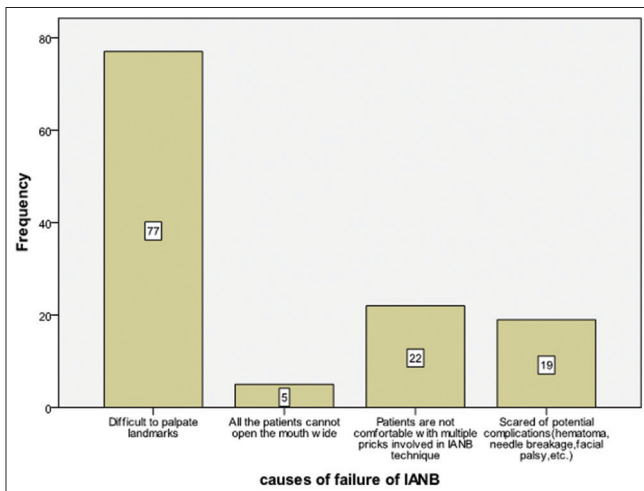


Chart 3: Causes of failure of IANB

surgeons were verbally able to describe the landmarks, applying the knowledge clinically posed a hindrance for select few. Percentage of complete failure of anaesthesia was 2.4. However, most of the patients were injected a second time on failure of first attempt and that explains the high rate of success. House surgeons did not limit themselves to a single attempt as the patients need to be anaesthetised to carry out the procedure on hand.

Alternative techniques of IANB

The Gow-Gates nerve block

The Gow-Gates technique was first described in 1973.^[2,3] The GGNB delivers anesthetic to the neck of the condyle to achieve close proximity to the mandibular branch of the trigeminal nerve as it exits the foramen ovale.

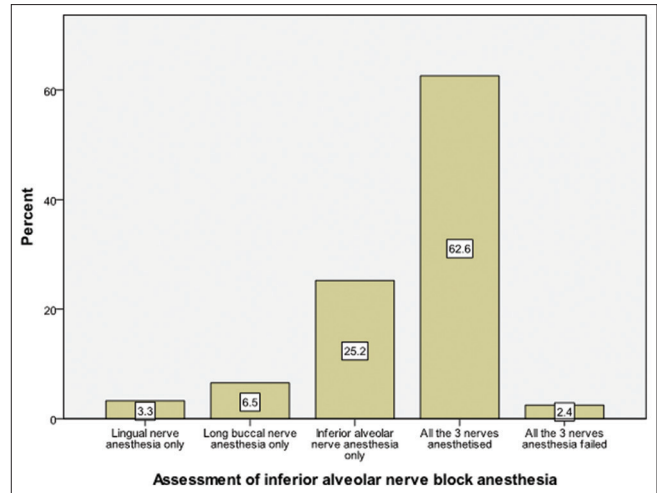


Chart 2: Assessment of IANB anaesthesia

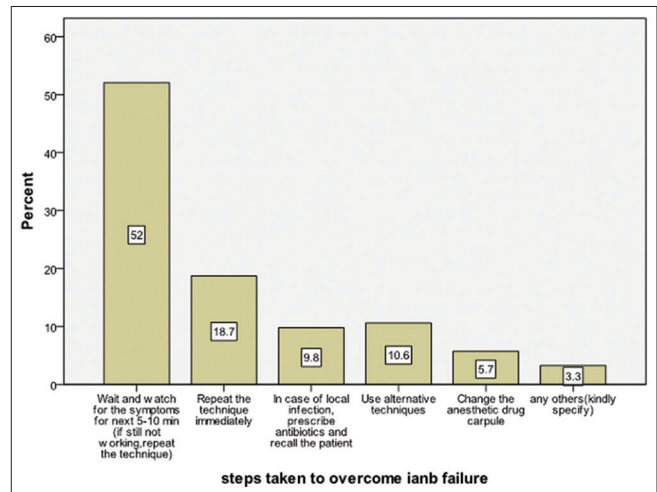


Chart 4: Steps were taken to overcome the failure of IANB

Gow gates mandibular nerve block is usually a preferred technique among dentists after IANB failure, anatomical variability or evidence of accessory innervation.^[14]

With this technique, the syringe is aligned parallel to an imaginary line drawn between the intertragic notch and the commissure of the mouth. Intra-orally, the external oblique ridge of the anterior surface of the ramus is located and the thumb is moved superiorly until the coronoid process is palpated. The barrel of the syringe should be over the contralateral premolars. The needle is inserted just medial to the attachment of the temporalis muscle and advanced until the condyle is reached at 25 mm depth. The syringe is retracted 1 mm and anaesthetic is given, pending negative aspiration.^[15] A wide opening is essential for success, concomitant with staying open for 20 seconds post injection to keep the IAN close to the injection site.^[16]

A successful CCNB will anaesthetize the IAN in combination with the buccal nerve, the mylohyoid nerve and the auriculotemporal nerve. This may resolve concerns regarding accessory innervation

of the dentition, and will also anaesthetise the buccal gingivae of the mandibular molars without the need for a separate buccal nerve block.^[16]

The CCNB was shown to have a success rate between 38% and 83.9% on healthy first permanent molar pulps using two consecutive EPT readings as an outcome measure.^[17] Other studies using the VAS, or that anaesthetised inflamed molar teeth, had success rates between 12.5% and 87.5%.

The Akinosi-Vazirani nerve block (AVNB)

The AVNB was introduced independently by two dentists. The block was initially published by Vazirani in 1960 but was brought to the attention of educators by Akinosi in 1977.

The indications for the AVNB are listed below:

1. Limited mouth opening
2. The presence of trismus due to spasm of muscles
3. Difficulty seeing intra-oral landmarks for an IANB.
4. Macroglossia

This technique is unique in that the patient has their mouth closed throughout. Intra-orally, the external oblique ridge of the ascending ramus is palpated. The thumb is then moved superiorly to the coronoid process. Lateromedially, the point of insertion of the needle is lateral to the maxillary tuberosity and medial to the coronoid process. Superoinferiorly, the point of insertion is at the height of the mucogingival junction of the maxillary teeth. The needle is advanced 25 mm, being mindful to stay parallel to the maxillary occlusal plane, and anaesthetic is delivered post negative aspiration. There is no contact with bony landmarks. A successful AVNB will anaesthetise the IAN in combination with the lingual, mylohyoid and buccal nerves.^[2]

The AVNB was shown to have a success rate of 27% on healthy first permanent molar pulps using two consecutive EPT readings as an outcome measure.^[6]

Other studies using the VAS, or that anaesthetised inflamed molar teeth, had success rates between 16% and 41%.

The intra-osseous technique

A variant of the intra-osseous technique was first published in 1910. Many specialised devices, such as the Stabident system, X-Tip and the IntraFlow, have since been introduced to aid intra-osseous injections. The technique is performed by creating a small perforation into the thick cortical plate of the mandible and providing a route of access to the cancellous bone beneath, and hence, to the nerve supply of the dentition.

The technique may be used to anaesthetise one or more teeth in the arch depending on the injection site and the amount of anaesthetic used.

Technique

After applying topical anaesthesia, the area intended to work on

is anaesthetised with 0.2 mL local anaesthetic for 50-60 seconds prior to perforating the cortical bone. The perforation site should be located distal to the tooth being treated. The point of perforation is 2 mm below the intersection of a line running vertically from the bisection of the interdental papilla and a horizontal line running along the buccal gingival margins of the teeth. At this intersection a specialised delivery system is used to gain access to the cancellous bone. A sudden loss of resistance during perforation indicates penetration of the cortical bone to the desired location.^[18]

The anaesthetic is then delivered through the hole created in the bone, anaesthetising the tooth of interest and the teeth mesial and distal to that tooth in most cases.

The intraosseous technique was shown to have a success rate between 45% and 100% on healthy first permanent molar pulps using two consecutive EPT readings as an outcome measure.^[14]

A meta-analysis published in 2003 investigated the efficacy of the 10 techniques and concluded that it was a suitable primary method to achieve mandibular pulpal anaesthesia.^[19]

The intra-ligamentary (IL) technique

The IL injection is based on the ability of the anaesthetic to reach the apex of a tooth via small perforations in the socket wall when delivered into the periodontal ligament (PDL). This technique regained popularity in the 1970s in conjunction with the advent of new delivery systems such as high-pressure dental syringes. Today, there are computer-aided devices such as the Wand handpiece and the 5TA system, which help control injection rate and pressure. However, the choice of syringe does not affect the efficacy of anaesthesia.

Technique

To perform the technique, the needle is inserted at 30° to the long axis of the tooth at the mesio-buccal aspect of the roots. The needle is advanced until it is wedged between the tooth and crestal bone.^[16] The amount of solution required is minimal at 0.2 mL per root. 3 The most critical factor to success is that this technique is performed against resistance.

The IL technique was shown to have a success rate between 74% and 86% on healthy first permanent molar pulps using two consecutive EPT readings as an outcome measure. A meta-analysis published in 2014 concluded that the IL technique was neither superior nor inferior to the IANB and reported methodological flaws in the literature.^[20]

Mandibular buccal infiltrations (BIs)

Traditionally, BIs in the mandible have been disregarded, as practitioners believed the dense cortical bone prevents the dissolution of anaesthetic to the IAN. However, there has been a renewed interest in this technique since the legalisation of articaine in the UK and US in 1999 and 2000, respectively.

Articaine has a unique chemical structure, being the only amide analgesic to contain an ester group. It also contains a thiophene ring, making it more lipophilic and potent.^[5] This allows articaine to diffuse more readily through both hard and soft tissue.

The less successful outcomes are reported from studies using 2% lidocaine as a local anaesthetic agent.^[5] Those using 4% of articaine showed success rates between 54% and 87%. One recent systematic review comparing Buccal infiltration with articaine to an IANB with lidocaine to achieve mandibular pulpal anaesthesia concluded that they had similar outcomes.^[15] There is a plethora of research, including a systematic review and meta-analysis, investigating BI with articaine as an adjunct to an IANB with lidocaine, showing greater success rates with a longer duration of anaesthesia.^[17]

Wand-assisted PDL injection

The Wand was introduced as a new method for local anaesthetic delivery to alleviate pain and anxiety in dental patients. The Wand accommodates a conventional local anaesthetic cartridge that is linked by microtubing to a disposable, lightweight, pen-like handle with a Luer lock needle (Milestone Scientific) attached at the end. The manufacturer claims that the Wand greatly reduces fear and anxiety in patients by using a sterile, disposable handpiece that does not look like a syringe. The computer-activated foot control automates the delivery of local anaesthetic from the cartridge at a precise pressure and volume ratios. Constant pressure and volume ratio can be maintained regardless of variations in tissue resistance. This system eliminates the variability of a thumb-operated plunger. Maintaining an ideal flowrate of anaesthetic solution is probably the major factor in achieving a comfortable anaesthetic injection. In clinical instances, when a single mandibular tooth needs to be anaesthetised or multiple teeth require anaesthesia for a brief period, the intraligamentary or PDL injection may be warranted. Although this injection has been investigated thoroughly and is often used to augment an IANB, it is usually ignored as a viable alternative to an IANB.^[21,22]

Equipment

The Wand-assisted PDL injection was administered with a 30-gauge, extra-short (12-mm) needle. The Wand has two delivery modes (slow and fast) controlled by an air-activated foot pedal. Only the slow one was used in this study. For the mandibular inferior alveolar block, 1.2 mL of Lidocaine with 1:100,000 epinephrine was administered with a metallic, breech-loading, aspirating syringe.

Nurhan and Dogan evaluated a total of 25 comparisons between PDL injections with the Wand and IAN injections with the traditional syringe.

They concluded that (1) The PDL injections with the Wand resulted in significantly lower pain scores during injection when compared with the traditional IAN injection. (2) Pain scores during the treatment with PDL injections were found to be

significantly higher than those with IAN injections, indicating that the Wand did not produce profound anaesthesia. (3) When patients were asked their preference of technique, the majority favored PDL injection.

Several techniques have been developed to provide mandibular anaesthesia. When deciding which technique prevails as the primary method of achieving mandibular pulpal anaesthesia, one must assess the benefits and drawbacks associated with each technique.

From the patient's perspective, painless injection techniques should be prioritised. One randomised controlled trial concluded that there were no statistically significant differences between the discomfort associated with the classical inferior alveolar technique, Gow-Gates or Akinosi-Vazirani.^[23]

A recent systematic review of the literature concluded that computer-controlled local anaesthetic delivery, with devices such as the Wand, Comfort Control Syringe, Quick Sleeper and CT, resulted in less discomfort during administration.^[24]

The choice of technique depends upon the clinical scenario. Patients presenting with trismus may require a closed-mouth technique such as the Akinosi-Vazirani technique if nerve block anaesthesia is required, or the intraosseous or BI techniques if pulpal anaesthesia is necessitated.^[25]

A study was conducted to assess the knowledge, attitude, and awareness about the Gow-Gates technique among dental students. Their knowledge about the Gow-Gates technique is less than adequate.^[26]

Dental universities across the UK and Ireland teach the IANB as the primary method of achieving mandibular pulpal anaesthesia. Some clinicians may be reluctant to use new local anaesthetic techniques as they may not have been taught how to do so during their undergraduate dental training. Furthermore, the intraosseous technique requires further technical skill with additional equipment, which students may also not have had exposure to during their undergraduate training.

The most significant observation in the study was the failure of many interns to locate the anatomical landmarks. Halstead method describes penetration of syringe anterior to pterygomandibular raphe. Even though verbally the interns were able to describe the key anatomical landmarks, most interns failed to pinpoint the exact location of pterygomandibular raphe and most were unable to mention the recommended height of syringe above the mandibular occlusal plane. Literature also mentions that syringe should be 6-10 mm above the mandibular occlusal plane. Many interns were unsure about the exact position of the syringe.

Conclusion

The use of models to demonstrate conventional and alternative techniques of IANB during student days could probably instill confidence in the budding doctors going forward. Revising the current literature on alternative IANB techniques or the use of evidence-based dentistry to update and practice alternative nerve block techniques would aid in improving the clinical skills and treatment outcome which would therefore enable to remove the stumbling blocks in successful anaesthesia.

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Conflicts of interest

There are no conflicts of interest.

References

- Johnson TM, Badovinac R, Shafer J. Teaching alternatives to the standard inferior alveolar nerve block in dental education: Outcomes in clinical practice. *J Dent Educ* 2007;71:1145-52.
- Reitz J, Reader A, Ninst R, Beck M, Meyers WJ. Anesthetic efficacy of the intraosseous injection of 0.9 mL of 2% lidocaine (1:100,000 epinephrine) to augment an inferior alveolar nerve block. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998;86:516-23.
- Kholer BR, Castellón L, Laisle G. Gow-Gates technique: A pilot study for extraction procedures with clinical evaluation and review. *Anesth Prog* 2008;55:2-8.
- Waikukul A, Punwutikorn J. A comparative study of the extraoral landmark technique and the direct technique for inferior alveolar nerve block. *J Oral Maxillofac Surg* 1991;49:804-8.
- Gallatin E, Stabile P, Reader A, Nist R, Beck M. Anesthetic efficacy and heart rate effects of the intraosseous injection of 3% mepivacaine after an inferior alveolar nerve block. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;89:83-7.
- Hannan L, Reader A, Nist R, Beck M, Meyers WJ. The use of ultrasound for guiding needle placement for inferior alveolar nerve block. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1999;87:658-65.
- Haas DA. Alternative mandibular nerve block techniques: A review of the Gow-Gates and Akinosi-Vazirani closed-mouth mandibular nerve block techniques. *J Am Dent Assoc* 2011;142(Suppl 3):8S-12S.
- Kennedy S, Reader A, Nusstein J, Beck M, Weaver J. The significance of needle deflection in success of the inferior alveolar nerve block in patients with irreversible pulpitis. *J Endod* 2003;29:630-3.
- Madan GA, Madan SG, Madan AJ. Failure of inferior alveolar nerve block: Exploring the alternatives. *J Am Dent Assoc* 2002;133:843-6.
- Wong JK. Adjuncts to local anesthesia: Separating fact from fiction. *J Can Dent Assoc* 2001;67:397-7.[27]Auluck A, Ahsan A, Pai KM, Shiety C. Anatomical variations in developing mandibular nerve canal: A report of three cases. *Neuroanatomy* 2005;4:28-30.
- Yonchak T, Reader A, Beck M, Meyers WJ. Anesthetic efficacy of unilateral and bilateral inferior alveolar nerve blocks to determine cross innervation in anterior teeth. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001;92:132-5.
- Desantis J, Liebow C. Four common mandibular nerve anomalies that lead to local anesthesia failures. *J Am Dent Assoc* 1996;127:1081-6.
- Malamed, S. *Manual de Local Anesthesia*. 5 ed. Madrid España: Elsevier Mosby; 2006. p. 3-297.
- Gallatin J, Reader A, Nusstein J, Beck M, Weaver J. A comparison of two intraosseous anesthetic techniques in mandibular posterior teeth. *J Am Dent Assoc* 2003;134:1476-84.
- Bartlett G, Mansoor J. Articaine buccal infiltration vs lidocaine inferior dental block-A review of the literature. *Br Dent J* 2016;220:117-20.
- Dreyer WP, van Heerden JD, de V Joubert JJ. The route of periodontal ligament injection of local anesthetic solution. *J Endod* 1983;9:471-4.
- Kanaa MD, Whitworth JM, Corbett IP, Meechan JC. Articaine buccal infiltration enhances the effectiveness of lidocaine inferior alveolar nerve block. *Int Endod J* 2009;42:238-46.
- Meechan JG. Supplementary routes to local anaesthesia. *Int Endod J* 2002;35:885-96.
- Kleber CH. Intraosseous anaesthesia: Implications, instrumentation and techniques. *J Am Dent Assoc* 2003;134:487-91.
- Shabazfar N, Duablander M, Al-Nawas B, Kammerer PW. Periodontal intraligamentary injection as alternative to inferior alveolar nerve block-meta-analysis of the literature from 1979 to 2012. *Clin Oral Investig* 2014;18:351-8.
- Krochak M, Friedman N. Using a precision metered injection system to minimize dental injection anxiety. *Compendium* 1998;19:137-48.
- Friedman MJ, Hochman MN. A 21st century computerized injection system for local pain control. *Compend Contin Educ Dent* 1997;18:995-1000, 1002-3; quiz 1004.
- Jacobs S, Haas DA, Meechan JG, May S. Injection pain: Comparison of three mandibular block techniques and modulation by nitrous oxide: oxygen. *J Am Dent Assoc* 2003;134:869-76.
- Kwak E-J, Pang N-S, Cho J-H, Jung B-Y, Kim K-D, Park W. Computer-controlled local anaesthetic delivery for painless anaesthesia: A literature review. *J Dent Anesth Pain Med* 2016;16:81-8.
- Akinosi JO. A new approach to the mandibular nerve block. *Br J Oral Surg* 1977;15:83-7.
- Natarajan K, Ganapathy D, Visalakshi RM. Knowledge, attitude and awareness about Gow-Gates technique among dental students. *Drug Invent Today* 2019;12:1095-9.