The key to profound local anesthesia

Neuroanatomy

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First in an occasional series of articles about local anesthesia

ABSTRACT

Background. To achieve profound dental local anesthesia, it is necessary for the dentist to have a thorough knowledge of the details of sensory innervation to the maxilla and mandible. Since the early 1970s, dentistry has experienced a resurgence of interest in the neuroanatomical basis of local anesthesia, resulting in numerous scientific reports on the subject.
Overview. Current studies afford a more detailed knowledge of the branching of various divisions of the trigeminal nerve, the great sensory nerve of the head region. In this article, the authors provide an update of the peripheral distribution of the trigeminal nerve to enhance induction of safe and effective dental local anesthesia.
Conclusions and Practical Implications. An understanding of the potential variations in innervation should help the dentist improve his or her ability to induce profound local anesthesia.

The option of administering local anesthetic, one of the most common procedures performed in dentistry today, has been available to the dentist for more than 100 years. Occasionally, however, it can be one of the most frustrating procedures when the outcome is incomplete or ineffective anesthesia. To minimize anesthetic failure, the dentist must have a sound knowledge of the anatomy of the head region, particularly the neuroanatomy of the maxillary and mandibular regions of the face.

To achieve profound dental local anesthesia, dentists must have a thorough knowledge of the details of sensory innervation to the maxilla and mandible.

Current studies afford a more detailed knowledge of the branching of the various divisions of the trigeminal nerve, the great sensory nerve of the head region. To improve the incidence of safe and effective dental local anesthesia, we provide an update of the peripheral distribution of the trigeminal nerve.

ANESTHESIA OF THE MAXILLARY TEETH

From an anatomical perspective, maxillary injections generally are believed to be not only more predictable than mandibular injections, but also more benign and associated with fewer complications. However, this is not necessarily true, particularly for block injections. For example, the posterior superior alveolar, or PSA, or tuberosity block, infraorbital block and the second division block carry the needle into the depths of the midface and approximate to the base of the skull, the orbit and associated structures. Complications associated with such maxillary injections (such as arterial bleeding and temporary blindness [amaurosia]) can result in considerable difficulty and discomfort for the patient.[1,2]

In this section, we review innervation peculiarities of the maxilla, as well as anatomical considerations that relate to specific techniques of administering local anesthetic.

PSA nerve block. The outer cortical plate of the maxillary alveolus is almost always sufficiently thin and porous in the adult to allow for effective infiltration anesthesia. When subsequent buccal infiltration anesthesia is inade-

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quate, the alternative course of action for the dentist is to perform a PSA or tuberosity nerve block. With this block injection, the dentist directs the needle high onto the tuberosity of the maxilla to approach the PSA nerve before it enters the bony maxilla.

Occasionally, the PSA block will not result in complete maxillary molar anesthesia. This may occur because of displaced branches of the PSA nerves entering the palatal root of the molars, the lingual aspect of the premolars, or both.[3] In these instances, the dentist must remember that the greater palatine injection (discussed below) may add to the efficiency of a PSA injection.

Middle superior alveolar nerve block. Traditionally, researchers and clinicians have understood that there are three nerves (the anterior superior alveolar, or ASA, middle superior alveolar, or MSA, and the PSA) that carry sensation to the maxillary teeth. It is interesting that many patients have only two maxillary alveolar nerves; the MSA nerve, the innervation ascribed to the premolar teeth, often is missing.[4,5] In these instances, the PSA nerve innervates the premolar/canine region, and infiltration anesthesia in the region of the molars induces primary anesthesia for the premolars.

The clinician may have to modify his or her approach to infiltrating in the premolar area because of an occasional anatomical feature.

Unfortunately, there are no anatomical predictors of the pattern of innervation for an individual. When attempting to anesthetize the maxillary premolars, the dentist should understand that infiltration in the vicinity of the apexes of these teeth will induce anesthesia regardless of the origin of the dental nerves.

In addition, the clinician may have to modify his or her approach to infiltrating in the premolar area because of an occasional anatomical feature. In some patients, an extensive bony prominence, the zygomaticoalveolar crest, can approximate the apexes of the premolar teeth, which prevents the needle's approach to this vicinity. Because most, if not all, of the MSA fibers are incorporated into the PSA nerve, molar infiltration or a PSA nerve block would be the alternative choice in these cases.

ASA nerve block. Some dentists consider the infraorbital or ASA nerve block to be a complicated injection fraught with risks and to be avoided. Accordingly, dentists do not use the ASA nerve block with the same frequency as they do the PSA block. This might seem to be primarily because of the dentist's lack of understanding of the anatomy involved, as well as a misconception regarding the dangers to the eye. Actually, the ASA nerve block can be extremely safe as well as highly successful when one adheres to a particular protocol based on a sound knowledge of the anatomy, specifically an awareness of the relative location of the infraorbital foramen.

In adults, the infraorbital foramen lies significantly below the infraorbital rim (8 to 10 millimeters), a safe distance from the cavity of the orbit. To locate the infraorbital foramen, the dentist can palpate a small depression in the infraorbital rim—the infraorbital notch—created by the zygomaticomaxillary suture. The clinician places his or her finger in this notch, and directs the needle through the vestibular mucosa over the first premolar tooth and toward the finger. The tip of the needle stays approximately 10 mm below the infraorbital rim.

The needle actually penetrates the soft tissue to a minimum depth of approximately 10 to 12 mm because of the height of the maxillary vestibule and the relative position of the foramen. The needle should stay adjacent to the periosteum to avoid engaging the overlying soft tissues of the face, where the facial artery could be encountered, creating significant bleeding. In addition, the clinician should be aware that with this injection, he or she may anesthetize peripheral branches of the facial nerve (VII) and render the patient with a partial facial paralysis. The dentist should advise the patient that this paralysis is transient and is of no lasting consequence.

In children and adolescents, the vertical growth of the facial skeleton is incomplete, and the infraorbital foramen is closer to the infraorbital rim than it is in adults. For this reason, the dentist should exercise more caution when administering an infraorbital block in the younger patient.

Palatal innervation. The mucosa of the hard palate and the palatal gingiva are supplied by the nasopalatine and greater palatine nerves. The boundary between the areas innervated by the two nerves corresponds roughly to a line drawn between the maxillary canines; however, the two areas are not so sharply delineated as such an imaginary line might suggest. By severing the nasopalatine nerve, Langford[6] showed that the greater palatine nerve may play a larger role in the innervation of the anterior palate than had previously been thought.

Nasopalatine nerve block. Fibers of the superior alveolar plexus occasionally join the nasopalatine nerve just below the nasal floor and travel with the nasopalatine nerve to reach the central incisor on the side of the mouth being innervated. It may be necessary to anesthetize the nasopalatine nerve to completely anesthetize the central incisors.[3,7,8] This is best accomplished by injecting immediately lateral to the incisive papilla, with the needle directed upward, backward and slightly medially.

Greater palatine nerve block. Most anatomy textbooks place the greater palatine foramen, which is accessed to administer a greater palatine nerve block or a second division nerve block, palatally opposite the second molar. More recent studies,[9-11] however, localize the greater palatine foramen farther posteriorly than is traditionally depicted. One study[10] showed this foramen to be opposite or slightly distal to the third molar or its extraction site (57 percent). The foramen has been shown to lie 1.9 mm in front of the posterior border of the hard palate and 15 mm from the palatal midline.[10] These measurements are useful for more easily locating the greater palatine foramen and enhancing the anesthetic injection technique in the posterior palate.

Trunk anesthesia immediately in the vicinity of the foramen is recommended to avoid complications such as postoperative ulceration or necrosis after palatal injections directed more anteriorly.

The greater palatine injection also may add to the efficacy of a buccal infiltration or PSA injection, if the latter does not render totally effective anesthesia. The greater palatine injection influences the nerves that enter the palatal root of the molars, the lingual aspect of the premolars, or both.[7,8] These nerves are displaced branches of the buccally located superior alveolar nerves, which enter the teeth from above.

ANESTHESIA OF THE MANDIBULAR TEETH

The buccal cortical plate of the mandible most often is sufficiently dense to preclude effective infiltration anesthesia in its vicinity. Therefore, the dentist must rely on block anesthesia for effectively anesthetizing mandibular teeth. It is interesting to note that various descriptions of the so-called usual innervation of mandibular teeth are generalized and incomplete. They do not accurately reflect the anatomical variability of various sensory nerves to the mandible. This could be one reason why the rate of failure in achieving adequate pulpal anesthesia via the inferior alveolar nerve block injection has been so high.[12,13]

The traditional approach to inferior alveolar anesthesia (that is, the Halstead method) has a reported success rate of only 71 to 87 percent, and incomplete anesthesia is not uncommon.[12-14] Several possible anatomical variations may explain this incomplete anesthesia. We discuss these variations below.

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Inferior alveolar nerve block. The most common approach to inferior alveolar anesthesia is the traditional Halstead method.[8,14,15] In this method, the inferior alveolar nerve is approached in the pterygomandibular space, called the infratemporal fossa, via an intraoral route located just before the nerve enters the mandibular foramen.[16] This space is entered laterally through the buccinator muscle between the anterior bony ramus, with its associated tendon of the temporalis muscle, and medially through the pterygomandibular raphe and the anterior border of the medial pterygoid muscle.

As the target site for the deposition of anesthetic solution in the conventional inferior alveolar block injection, the mandibular foramen is an essential structure to accurately locate. Nicholson[17] examined 80 dry adult human mandibles and used calipers to measure the position of the mandibular foramen relative to various landmarks. The rigorous demarcation and definition of the landmarks set this work apart from earlier studies of this foramen.[18] He found that the position of the foramen is indeed variable, and it is usually found anterior to the midpoint of the ramus of the mandible when the anterior border of the mandible is defined as the internal oblique ridge (that is, temporal crest).

Bremer[18] described the foramen as being slightly above the level of the molars; however, Nicholson could not confirm this. Nicholson[17] and Afsar and colleagues[19] found that the foramen was

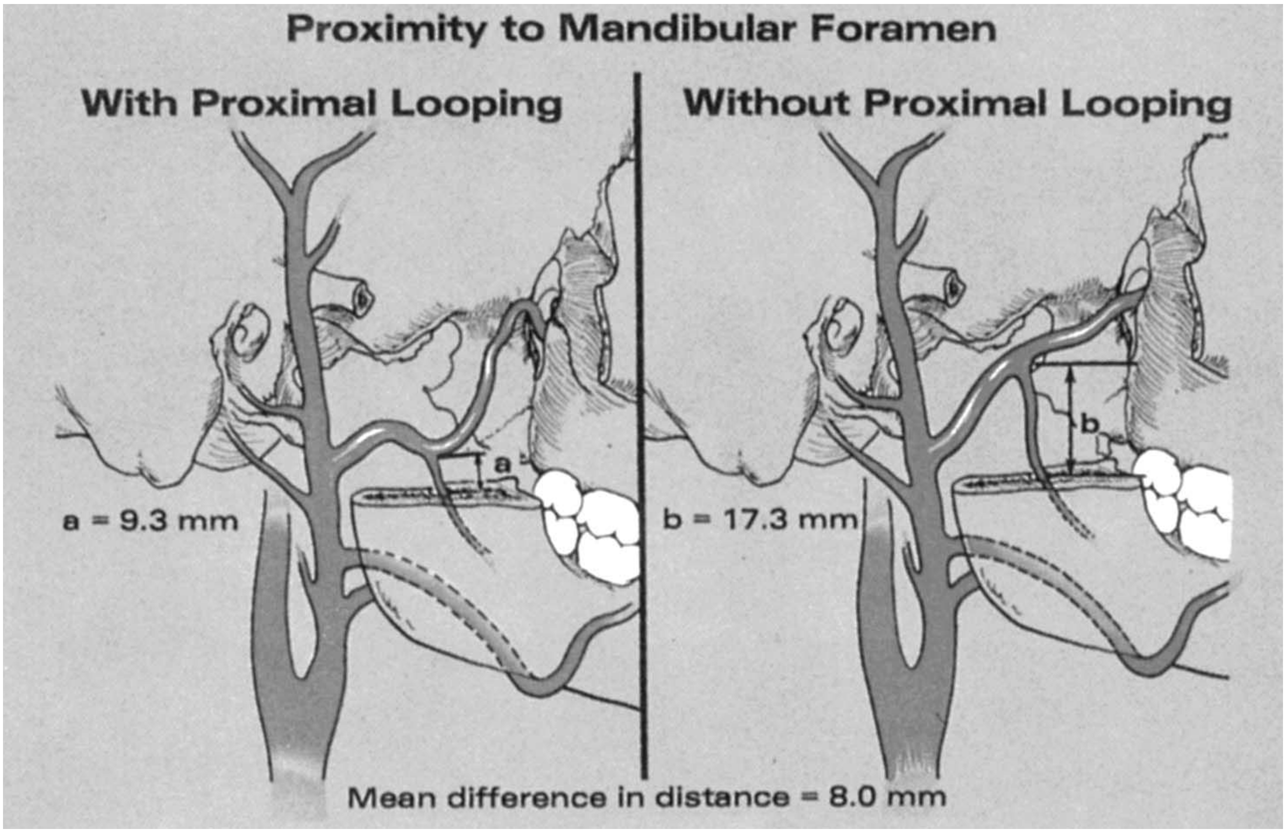

Figure 1. The proximity of the maxillary artery to the mandibular foramen can vary depending on whether the blood vessel loops inferiorly toward the mandible. Note the 8-millimeter difference illustrated in examples a and b. (Reprinted with permission of the publisher from Roda and Blanton.[21])

located below the occlusal surface of the molars in many cases. These authors concluded that clinicians should be aware of the variability in the location of the mandibular foramen when seeking to anesthetize the inferior alveolar nerve. In particular, Afsar and colleagues[19] suggested that dentists consider use of panoramic radiographs in locating the mandibular foramen rather than relying on bony landmarks.

During administration of anesthetic to the inferior alveolar nerve, the clinician must be aware of the proximal extremity of the maxillary artery, as well as the course of the inferior alveolar artery. Lacouture and colleagues[20] found that the proximal portion of the maxillary artery crossed the posterior ramus of the mandible at a level that is closer to the level of the mandibular foramen than has been taught traditionally. This same study[20] showed a significant incidence of inferiorly directed looping of the maxillary artery immediately above the level of the mandibular foramen (Figure 1[21]).

During administration of anesthetic to the inferior alveolar nerve, the clinician must be aware of the proximal extremity of the maxillary artery, as well as the course of the inferior alveolar artery.

Another study[22] has shown that, in a high percentage of cases, the maxillary artery passes lateral to the inferior alveolar and lingual nerves in the superior region of the infratemporal fossa adjacent to the mandibular ramus. Fortunately, at the level of the mandibular foramen, the position of the inferior alveolar artery is such that it is protected from the dental needle. To prevent arterial complications in the event that the traditional approach to the foramen fails, the clinician should avoid moving the needle higher along the medial ramus than it was placed on original insertion—despite recent recommendations to the contrary[23]—to prevent significant hemorrhage. If the Halstead (inferior alveolar) block fails, pre-

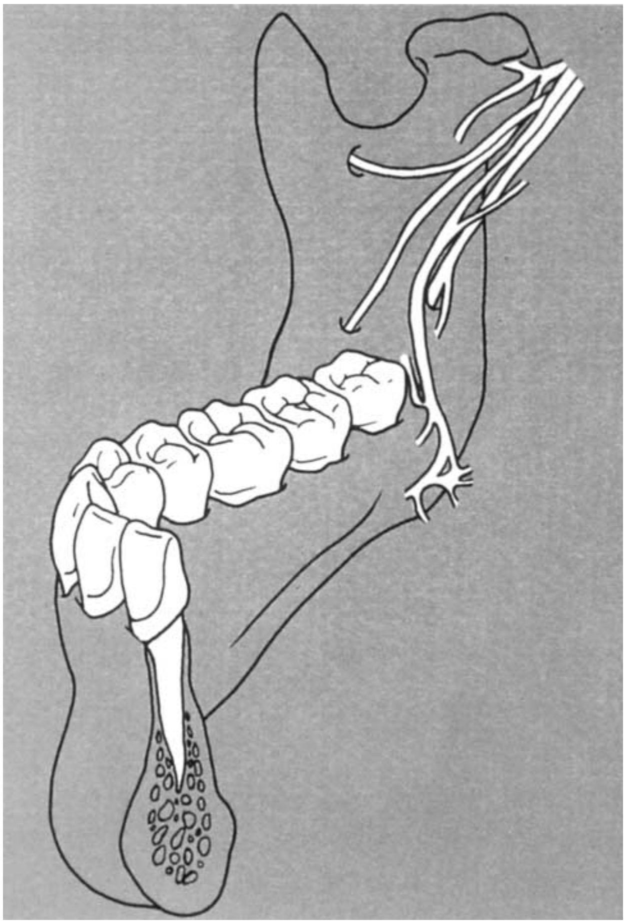

Figure 2. Accessory innervation of the mandibular molars can result from branching of the mandibular division of the inferior alveolar nerve. (Reprinted with permission of the publisher from Roda and Blanton.[21])

ferred alternative routes include accessory nerve blocks, the Gow-Gates block or the Vazirani-Akinosi technique.

Accessory innervation. Numerous studies[24-34] have provided sufficient evidence to support the concept of accessory innervation to the mandibular teeth (that is, there is more than one inferior alveolar nerve). Branches of the mandibular division of the inferior alveolar nerve can arise high in the infratemporal fossa and travel to the base of the coronoid process (high and anterior to the mandibular foramen) to enter the mandible (Figure 2[21]).[27] These branches carry sensory innervation to the second and third molars. Branches of the mandibular division or of its inferior alveolar or buccal branch also may enter the mandible in the retromolar fossa area and carry sensory fibers to the first and third molars.[27]

The better-documented of these accessory nerves include the mylohyoid nerve,[27,28,32] as well as branches of the mandibular division (V_3) of the trigeminal nerve, all of which arise high in the head and enter the mandible according to their own route.[26,29,35] The incidence of mylohyoid innervations to the mandibular teeth is approximately 60 percent.[26,28,34]

Branches of the mylohyoid nerve enter the mandible through retromental foramina, which are associated with the lingual cortical bone in the vicinity of the second premolar tooth (Figure 3). This nerve carries sensation from the premolar, canine and incisor teeth. One study also implicates the mylohyoid in innervation to the first molar.[34] The mylohyoid nerve may arise from the inferior alveolar nerve anywhere from 5 to 23 mm above the level of the mandibular foramen,[33,36] and enters the mandible at a point distant to the mandibular foramen. Therefore, deposition of local anesthetic in the vicinity of the mandibular foramen during administration of an inferior nerve block most often does not block the mylohyoid nerve. We recommend that dentists perform the mylohyoid nerve block in the vicinity of the retromental foramina.

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In addition to the challenges created by accessory innervation, the dentist should be aware that some studies have proposed that midline crossover of branches of the mental nerves in the mandible might allow innervation of the incisors of the contralateral side.[37-39] Because this crossover has been disputed on embryologic and developmental grounds,[40] if the traditional Halstead method (inferior alveolar nerve block), mental nerve block, or both prove ineffective, the dentist should attempt an ipsilateral mylohyoid nerve block or infiltration of the buccal aspect of the ipsilateral tooth before anesthetizing the contralateral incisor region.

Lingual nerve block. Branches of the lingual nerve supply the lingual gingiva and adjacent mucosa of the mandible. The lingual nerve courses through the infratemporal fossa anterior to the inferior alveolar nerve. This nerve typically is anesthetized with a bolus of anesthetic solution injected during withdrawal of the needle after an inferior

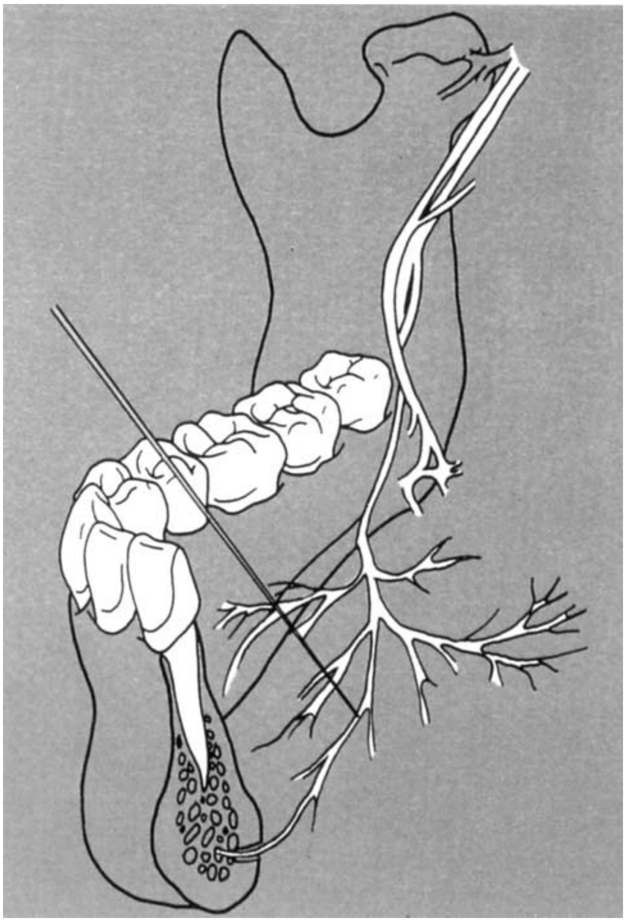

Figure 3. Branches of the mylohyoid nerve showing the needle placement required to block this nerve. (Reprinted with permission of the publisher from Roda and Blanton.[21])

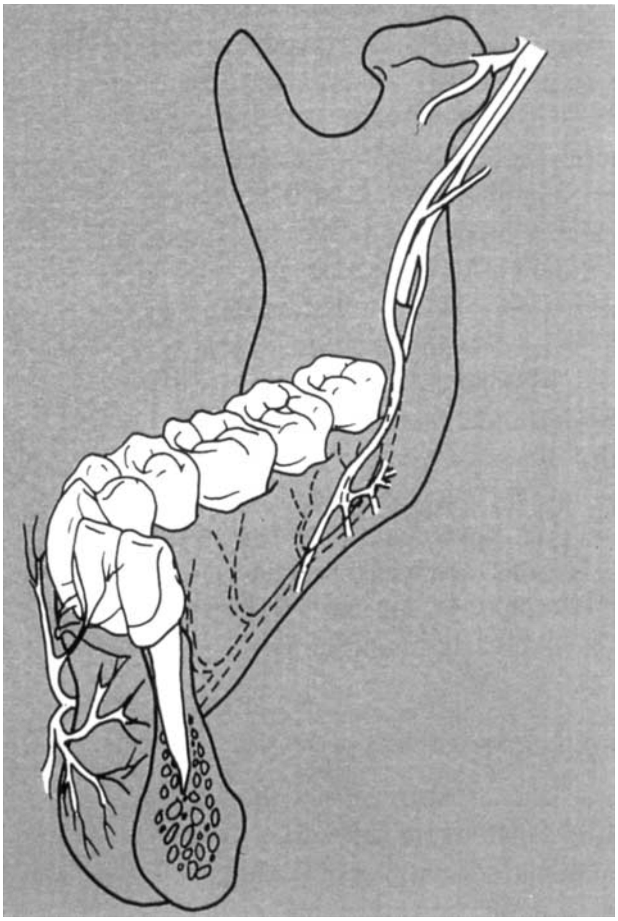

Figure 4. Course of the lingual and inferior alveolar nerves. Note the proximity of the lingual nerve to the lingual aspect of the third molar region. (Reprinted with permission of the publisher from Roda and Blanton.[21])

alveolar nerve block. Although the lingual nerve is frequently anesthetized during the inferior alveolar nerve block, the bolus delivery ensures lingual nerve anesthesia.

The lingual nerve passes from the infratemporal fossa into the floor of the mouth close to the alveolus just distolingual to the third molar (Figure 4). Along its course, adjacent to the alveolar process in the vicinity of the second and third molars, the lingual nerve is quite vulnerable to trauma. Two studies[41,42] have placed this nerve within 5 mm of the crest of the nonresorbed alveolus. These researchers found that it touched the lingual alveolar cortical plate of the third molar in 62 percent of the dissections, and was at or above the level of the alveolar crest 17.6 percent of the time.

Buccal nerve block. Traditionally, the buccal nerve block injection is delivered to the anterior ramus of the mandible at the level of the mandibular molar occlusal plane in the vicinity of the retromolar fossa.

The long buccal nerve supplies general sensation to the buccal gingiva and mucosa of the mandible for a variable length, from the vicinity of the third molar to the canine. The long buccal nerve arises quite high in the infratemporal fossa and crosses the anterior border of the ramus to give rise to its multiple branches. More current studies show that with the mouth wide open, this nerve crosses the ramus at a level corresponding to the occlusal surfaces of the maxillary molars,[20] not the mandibular molars, as has been promulgated traditionally.[43] This is some distance above the plane of injection for the mandibular block, and it is at this point that the long buccal nerve can be reached to induce block anesthesia. The conventional approach at the level of the mandibular occlusal plane will, however, produce satisfactory local anesthesia of the buccal aspect of the lower molars.

Mental nerve block. The mental nerve is the terminal branch of the inferior alveolar nerve and exits the mandible via the mental foramen. The position of this foramen varies greatly, making it difficult to predictably locate this nerve using intraoral landmarks in a patient with an intact dentition. This task is even more daunting in a patient with a mutilated dentition or in the edentulous patient.

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In a recent comprehensive study, Matheson and colleagues[44] determined the location of the mental foramen in relation to intraoral anatomical landmarks. Along the horizontal axis, they confirmed that the foramen was located near the apex of the mandibular second premolar 52.8 percent of the time, and rested between the premolars 32.0 percent of the time. These authors found that the foramen was posterior to the second premolar in 13.9 percent of cases, and was apical to the first molar in 1.2 percent of cases. The least likely area to find this structure was apical to the mandibular first premolar (0.66 percent of cases). Along the vertical axis, Matheson and colleagues[44] found that the average distance of the foramen from the inferior border of the mandible was 7.0 mm, and from the cementoenamel junction of the second premolar was 15.0 mm.

In spite of the limitations inherent with the variable foramen locations, the success rate of a mental block injection approaches 100 percent, possibly because of the wider diffusion of the anesthetic solution in the soft tissues. Because of the variation in location of this nerve, when anesthetic procedures are performed, we recommend that the tip of the needle be directed to approximate the position of the foramen, but not to enter the foramen.

By approximating the foramen, rather than entering it, the dentist is more likely to avoid potential nerve trauma and the resultant paresthesia, as well as the possibility of a significant arterial bleed. It is important to remember that the mental nerve does not innervate teeth, but it can be used to provide incisive nerve anesthesia via the application of finger pressure over the foramen after local anesthetic solution is deposited there.

CONCLUSION

We have attempted to present a detailed description of the complexities and variability of trigeminal innervation to the mandible and the maxilla. A thorough understanding of these neuroanatomical concepts is necessary for dentists to induce profound dental local anesthesia on a more consistent basis. ■

1. Malamed SF. Handbook of local anesthesia. 4th ed. St. Louis: Mosby; 1997:143-258.
2. Laskin DM. Diagnosis and treatment of complications associated with local anesthesia. Int Dent J 1984;34:323-37.
3. DuBrul EL. Sicher's oral anatomy. 7th ed. St Louis: Mosby; 1980:453.
4. Loetscher CA, Walton RE. Patterns of innervation of the maxillary first molar: a dissection study. Oral Surg Oral Med Oral Pathol 1988;65:86-90.
5. Heasman PA. Clinical anatomy of the superior alveolar nerves. Br J Oral Maxillofac Surg 1984;22:439-47.
6. Langford RJ. The contribution of the nasopalatine nerve to sensation of the hard palate. Br J Oral Maxillofac Surg 1989;27:379-86.
7. Phillips WH. Anatomic considerations in local anesthesia. J Oral Surg 1943;1:112-21.
8. DuBrul EL. Sicher & DuBrul's oral anatomy. 8th ed. St. Louis: Ishiyaku EuroAmerica; 1988:269-84.
9. Slavkin HC, Canter MR, Canter RC. An anatomic study of the pterygomaxillary region of the cranium of infants and children. Oral Surg Oral Med Oral Pathol 1966;21:225-35.
10. Westmoreland FF, Blanton PL. An analysis of the variations in position of the greater palatine foramen in the adult human skull. Anat Rec 1982;204:383-8.
11. Slavkin HC. Anatomical investigation of the greater palatine foramen and canal. Alpha Omegan 1965;58:148-51.
12. Kaufman E, Weinstein P, Milgrom P. Difficulties in achieving local anesthesia. JADA 1984;108:205-8.
13. Gow-Gates G, Watson JE. Gow-Gates mandibular block: applied anatomy and histology. Anesth Progr 1989;36:193-5.
14. Malamed SF. Handbook of local anesthesia. 3rd ed. St. Louis: Mosby; 1990:160-218, 245-57.
15. Reams GJ, Tinkle JJ. Supplemental anesthetic technique. J Oreg Dent Assoc 1989;58:34-9.
16. Jastak JT, Yagiela JA. Regional anesthesia of oral cavity. St. Louis: Mosby; 1981:155.
17. Nicholson ML. A study of the position of the mandibular foramen in the adult human mandible. Anat Rec 1985;212:110-2.
18. Bremer G. Measurements of special significance in connection with anesthesia of the inferior alveolar nerve. Oral Surg Oral Med Oral Pathol 1952;5:966-88.
19. Afsar A, Haas DA, Rossouw PE, Wood RE. Radiographic localization of mandibular anesthesia landmarks. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;86(2):234-41.
20. Lacouture C, Blanton PL, Hairston LE. The anatomy of the maxillary artery in the infratemporal fossa in relationship to oral injections. Anat Rec 1983;205:104A.
21. Roda RS, Blanton PL. The anatomy of local anesthesia.

Quintessence Int 1994;25(1):27-38.
22. Pretterklieber ML, Skopakoff C, Mayr R. The human maxillary artery reinvestigated, I: topographical relations in the infratemporal fossa. Acta Anat 1991;142:281-7.
23. Wong MK, Jacobson PH. Reasons for local anesthesia failures. JADA 1992;123:69-73.
24. Shiller W, Wiswell O. Lingual foramina of the mandible. Anat Rec 1954;119:387.
25. Carter RB, Keen EN. The intramandibular course of the inferior alveolar nerve. J Anat 1971;108:433-40.
26. Casey DM. Accessory mandibular canals. N Y State Dent J 1978;44:232-3.
27. Haveman CW, Tebo HG. Posterior accessory foramina of the human mandible. J Prosthet Dent 1976;35:462-8.
28. Madeira MC, Percinoto C, Silva MG. Clinical significance of supplementary innervation of the lower incisor teeth: a dissection study of the mylohyoid nerve. Oral Surg Oral Med Oral Pathol 1978;46:608-14.
29. Frommer J, Mele FA, Monroe CW. The possible role of the mylohyoid nerve in mandibular posterior tooth sensation. JADA 1972;85:113-7.
30. Sutton RN. The practical significance of mandibular accessory foramina. Aust Dent J 1974;19:167-73.
31. Chapnick L. A foramen on the lingual of the mandible. J Can Dent Assoc 1980;46:444-5.
32. Chapnick L. Nerve supply to the mandibular dentition: a review. J Can Dent Assoc 1980;46:446-8.
33. Wilson S, Johns P, Fuller PM. The inferior alveolar and mylohyoid nerves: an anatomical study and relationship to local anesthesia of the mandibular anterior teeth. JADA 1984;108:350-2.
34. Pyle MA, Jasinevicius TR, Lalunandier JA, Kohrs KJ, Sawyer DR. Prevalence and implications of accessory retromolar foramina in clinical dentistry. Gen Dent 1999;47:500-3.
35. Jablonski NG, Cheng CM, Cheng LC, Cheung HM. Unusual origins of the buccal and mylohyoid nerves. Oral Surg Oral Med Oral Pathol 1985;60:487-8.
36. Wilson S, Johns P, Fuller PM. Accessory innervation of the mandibular anterior teeth in cats: a horseradish perioxidase study. Brain Res 1984;298:392-6.
37. Rood JP. The nerve supply of the mandibular incisor region. Br Dent J 1977;143:227-30.
38. Rood JP. Some anatomical and physiological causes of failure to achieve mandibular analgesia. Br J Oral Surg 1977;15:75-82.
39. Younchak T, Reader A, Beck M, Myers WJ. Anesthetic efficacy of unilateral and bilateral nerve blocks to determine cross innervation in anterior teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;92:132-4.
40. Barker BC, Davis PL. The applied anatomy of the pterygomandibular space. Br J Oral Surg 1972;10:43-55.
41. Kiesselbach JE, Chamberlain JG. Clinical and anatomic observations on the relationships of the lingual nerve to the mandibular third molar. J Oral Maxillofac Surg 1984;42:565-7.
42. Wilson C, Rivera-Hidalgo F, Blanton PL, et al. Lingual nerve: its relationship to the mandible (abstract 1504). J Dent Res 1992;65:336.
43. Phillips WH. Anatomical considerations in local anesthesia. J Oral Surg 1943;1:112-21.
44. Matheson BR, Blanton PL, Rivera-Hidalgo F, et al. Utilization of an intraoral landmark to localize the mental foramen. J Dent Res 1986;63A:278.