Dental Local Anesthesia: Potential Risks and Risk Mitigation

A Clinician's Guide

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Introduction

Dentists administer quite literally thousands of local anesthetic injections every day[1,2] historically with few documented reports of complications. However, more recently, reports of paresthesia (prolonged anesthesia) subsequent dental local anesthetic injections have increased and even though rare, these incidents are proving to be compensatory. Patient complaints in some cases include dysesthesia (painful sensation) or hyperesthesia (increased sensation to noxious stimuli). Such sequalae can severely impact the quality of life for the individual affected. Paresthesia is an altered sensation of the skin and mucosa due to nerve trauma and manifesting as numbness, burning, or tingling. The etiology of nerve injury resulting in paresthesia is attributed to one of several factors, but primarily:

1. Mechanical trauma related to surgical technique and/or needle injury, or
2. Chemical trauma or anesthetic toxicity related to excessive dosage and/or high concentration of the anesthetic solution.

The lingual and inferior alveolar nerves are the most commonly[3,4,5] involved with lingual nerve injury, reported 70% of the time. The third most frequent site reported involves the mental nerve.

The dentist's best single course of action in the face of such potential complications is to minimize the chance of paresthesia occurring, and the dentist's expert knowledge of the anatomy of the head is key to limiting such complications. Misjudging the anatomy involved during local anesthetic administration can not only result in inadequate or incomplete anesthesia, but could lead to complications, such as nerve trauma.

Anatomy of the Pterygomanbibular Space (Infratemporal Fossa)

Patient complaints of paresthesia are primarily related to mandibular innervation. The dentist most often relies on block anesthesia for effectively anesthetizing mandibular teeth; the nerves involved are the inferior alveolar, lingual, and mental nerves.

Inferior Alveolar Nerve Block

The most common approach to inferior alveolar anesthesia is the traditional Halstead method.[6,7] In this method, the inferior alveolar nerve is approached in the pterygomandibular space, called the infratemporal fossa, via an intraoral route with the needle directed laterally toward the mandibular foramen (Figure 1). This space is entered through the buccinator muscle of the cheek passing between the anterior bony ramus, with its associated tendon of the temporalis muscle, anteriorly, and the

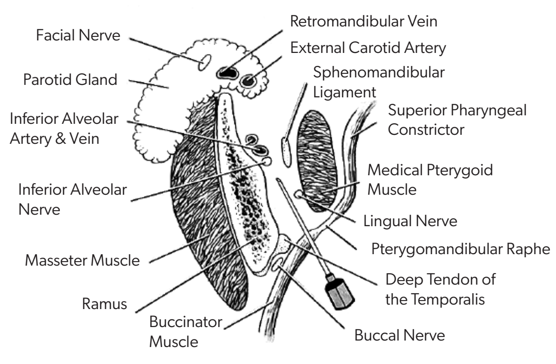

Figure 1: Cross-Sectional Anatomy- Inferior Alveolar Nerve Block

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pterygomandibular raphe and the anterior border of the medial pterygoid muscle, posteriorly. 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[8] 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). Afsar and colleagues suggested that dentists consider use of panoramic radiographs in locating the mandibular foramen rather than relying on bony landmarks.[10]

Occasionally, the Gow Gates method (Figure 2) is employed supplemental to the Halstead. This approach takes the needle higher in the infratemporal fossa to the level of the neck of the condyle of the mandible.

Figure 2: The Gow Gates Technique

It is important to note that the inferior alveolar nerve is vulnerable to the local anesthetic needle along its course from the mandibular condyle to the mandibular foramen. Dentists are encouraged, to assure the efficacy of the inferior alveolar nerve injection and to avoid bleeding complications, to direct the needle to the level of the mandibular foramen or to the level of the neck of the condyle of the mandible. The zone intermediate to these two levels is where the inferior alveolar nerve appears to be the most vulnerable to needle trauma.

Lingual Nerve Block

The lingual nerve courses through the infratemporal fossa anterior to the inferior alveolar nerve. The lingual nerve is typically anesthetized with a bolus of anesthetic solution injected during withdrawal of the needle after an inferior 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 mandibular alveolus just distolingual to the third molar (Figure 3).

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[8,9] have placed this nerve within 5 mm of the crest of the non-resorbed 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. It is in this vicinity that the lingual nerve is most vulnerable to injury by the local anesthetic needle. Do not put a "cutting" instrument including the needle on the distolingual line angle of the last erupted molar and do not reflect a split-thickness flap lingual to the mandibular molars.

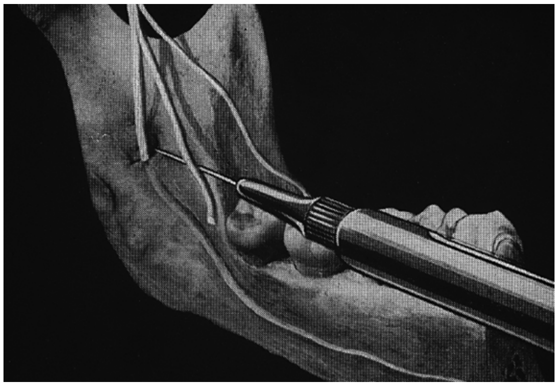

Figure 3: The Lingual Nerve Block

Mental Nerve Block

The mental nerve is the terminal branch of the inferior alveolar nerve that exits the mandible via the mental foramen (Figure 4). The position of this foramen varies greatly, making it difficult to predictably locate this nerve using intraoral landmarks. This task is even more daunting in a patient with a mutilated dentition or in the edentulous patient.

In a recent comprehensive study, Matheson and colleagues[11] 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 location for the mental foramen was reported to be apical to the mandibular first premolar (0.66 percent of cases).

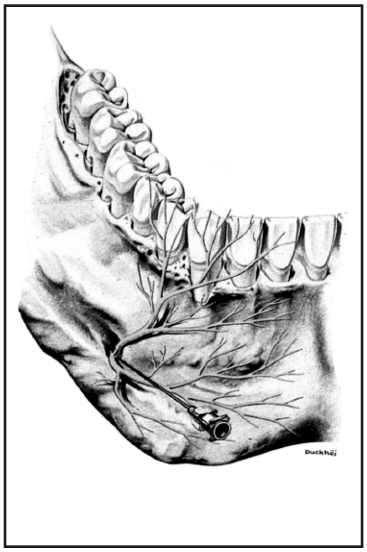

Figure 4: The Mental Nerve

Along the vertical axis, Matheson and colleagues 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. A quality periapical radiograph seems to provide a better indication of the location of the mental foramen relative to the apices of the mandibular teeth. In spite of the variable foramina 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 in the vicinity. 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 general 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 as well as the possibility of a significant arterial bleed. It is important to remember that the mental nerve supplies sensation to the lower lip, it does not innervate teeth. However, the foramen serves to provide incisor nerve anesthesia via the application of finger pressure over the foramen after local anesthetic solution is deposited there.

Mechanical Trauma Related to Surgery/ Needle Injury

Generally speaking, complications of an anatomical nature are of three types: injuries to nerves, injuries to blood vessels, and/or trauma to muscles. In the head and neck region, there is additional potential for intraglandular injections with associated sequelae.

Nerve Injury

Some dentists erroneously believe that the needle gauge used most often in dentistry precludes the risk of nerve damage. While it is true that 25- to 30-gauge needles are of insufficient diameter to sever a nerve trunk, contacting a nerve with such a needle apparently is all that may be needed to cause trauma that could result in paresthesia. In fact, there have been many reports of trauma to a nerve or nerve sheath produced by the needle during dental injections.[4,5,12-14]

Stacy and Hajjar[15] reported that nerve injury may occur during needle withdrawal. In a small study,[12] these authors noted that standard dental anesthetic needles can barb if they come into contact with bone during the injection. They found that a relationship existed between the pattern of such barbing and the likelihood of nerve injury occurring during withdrawal of the needle from the oral mucosa after injection. One study[12] reported that in addition to paresthesia (loss of sensation), hyperesthesia (increased sensitivity to painful stimuli), and even dysesthesia (pain following nonnoxious stimuli) may develop in some patients. Paresthesia resulting from nerve trauma during dental anesthetic injection can last for weeks or months and can lead to self-inflicted injury to oral tissues. These paresthesias commonly involve the tongue and lower lip. In cases involving the lingual nerve, mechanical (biting) and thermal trauma can occur without the patient's awareness and can result in significant pathology. When the lingual nerve is involved, the chorda tympani branch of the facial nerve also may be traumatized,[16] resulting in dysgeusia (impaired sense of taste) and xerostomia (reduced salivation). In some instances, dysesthesia may accompany paresthesia.

Nerve-related complications other than direct trauma can arise after anesthetic injection. The passive process of diffusion of the anesthetic through the orbit can ultimately result in ocular and extraocular symptoms, including paralysis of the extraocular muscles, with associated diplopia (double vision), and even amaurosis (temporary blindness). Also, Horner's syndrome-like manifestations can occur, including enophthalmos (recession of the eyeball), miosis (pupil constriction), and palpebral ptosis (drooping of the eyelid). Occasionally, temporary loss or blurring of vision unilaterally will occur. These ocular complications would most likely follow a posterior superior alveolar (PSA) or second-division nerve block. Such complications can arise when the needle either approaches the inferior orbital fissure at the height of the posterior maxilla or when an injection of too much anesthetic solution is delivered under excessive pressure, resulting in diffusion of the anesthetic through the inferior orbital fissure and into the orbit. The passive process of diffusion of the anesthetic solution through the orbit ultimately involves the optic nerve and results in temporary blindness. If this complication develops, the dentist should reassure the patient that this is a transient phenomenon, and vision will be restored as the effects of the anesthetic wear off.

Injuries to the inferior alveolar and lingual nerve caused by local anesthesia block injections have an estimated incidence of between 1:26,762 to 1:160,571.[4] These injuries are reportedly associated with a 34% [4] and 70%[21] incidence of neuropathic pain, high when compared with other causes of peripheral nerve injuries.

A recent settlement of 1.4 million dollars for lingual nerve injury caused by a local anesthetic block (IAN) highlights the significance of the associated disability and social repercussions of these injuries. If the nerve injury is temporary, recovery is reported to take place at 8 weeks for 85-94% of the cases.[22] IAN injuries are reported to have a better prognosis than lingual nerve injuries and if the duration of the nerve injury is greater than eight weeks, it is felt that permanency could be a risk.

Injury to Blood Vessels

The infratemporal fossa is a highly vascular area containing the largest artery of the external head, the maxillary artery, and its multiple named branches (Figure 5), as well as an extensive plexus of veins- known as the pterygoid plexus. When injecting into such a richly vascular area, the dentist faces the risk of intravascular injection, vascular damage, hemorrhage, and the possibility of hematoma formation.[2,8] Hematoma formation can lead to scar formation, resulting in pressure on the nerve and inhibiting healing in some instances contributing to the development of paresthesia.

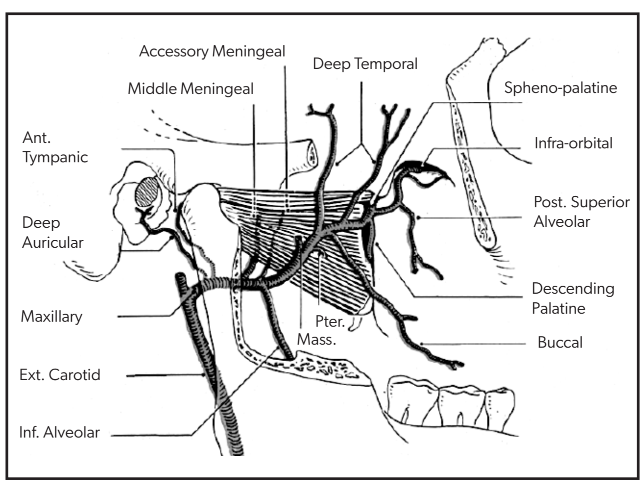

Figure 5: The Maxillary Artery

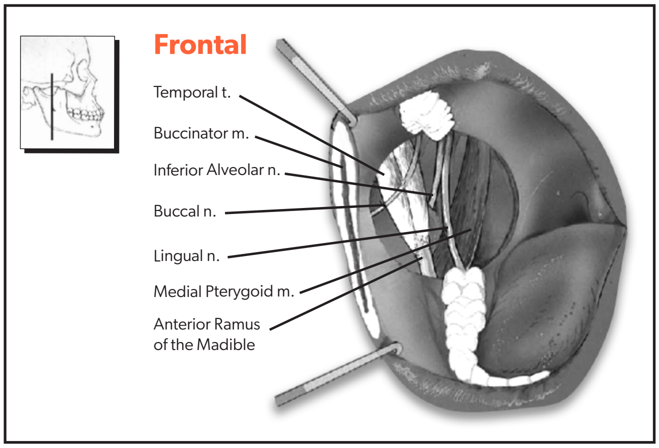

Figure 6: Avoiding muscle injury requires familiarity with the origins and insertions of the pertinent musculature in the vicinity. Pterygomandibular space. Cutaway intraoral view showing anatomic relationships of structures important in local anesthesia. (Redrawn from DuBrul with permissions.)

Venous bleeding is minimal in contrast to arterial bleeding and usually is observed a few days after the injection as bruising. In contrast, arterial bleeding occurs rapidly and can self-tamponade with hematoma formation. However, if the arterial bleeding continues into the soft tissue spaces and is not managed quickly, the situation can become life threatening. If recognized efficiently, the amount of hemorrhage with an arterial bleed can be reduced by applying significant pressure on the injection site. Patients with bleeding of arterial origin should be followed for several days as arterial bleeding can recur.

An additional interesting concern when injecting into a highly vascular area and depositing anesthetic solution in the vicinity of the arteries is the very real potential for anesthetizing sympathetic nerve fibers that travel in the company of arteries in the head region. The result is vasoconstriction which acts as an end-organ phenomenon such as blanching of the overlying skin evident on the patient's face.

Muscle Injury

An additional complication relates to muscle trismus. When inserting the needle into the pterygomandibular space for the inferior alveolar and lingual nerve blocks, the clinician should use caution to avoid injury to the temporalis and medial pterygoid muscles in particular (Figure 6). An intramuscular injection can not only result in trismus (that is, spasm of jaw muscles, which restricts mouth opening) but also can contribute to a needle "fracture" issue. The bony anterior ramus of the mandible offers a landmark for the temporalis muscle and usually is readily palpable. The pterygomandibular fold (obvious when the patient opens wide because it is elevated by the underlying pterygomandibular raphe) serves as a landmark for the medial pterygoid muscle. Superiorly, the muscle is lateral to the fold, but at the normal level of injection, the muscle is medial to it.

If the anesthetic needle is directed through the mucous membrane lateral to the pterygomandibular fold and medial to the greatest concavity of the anterior bony ramus, injury to these muscles and the resultant painful trismus usually can be avoided. In the event of a Gow-Gates injection, the needle is directed higher into the infratemporal fossa and, on rare occasions, may involve the lateral pterygoid muscle.[2]

Chemical Trauma (Neurotoxicity)

Haas and Lemmon were among the first to suggest that local anesthetic solutions have the potential for neurotoxicity. Johnson, et al 2002, provided evidence that the increased concentration of local anesthetic agents significantly impacts the survival rate of neurons in vitro. Both prilocaine (4%) and articaine (4%) are used in dentistry in higher concentration than the time-proven lidocaine (2%) anesthetic solution. Interestingly, lidocaine in higher concentrations than that traditionally used in dentistry has also been implicated in neurotoxic damage.[23]

Several subsequent studies (Figure 7) have shown higher per use incidence of injury with prilocaine and articaine as compared to lidocaine. Haas and Lemmon[23] reported that articaine was causing 21 times more nerve injury in Canada when compared with lower concentration drugs. Hillerup and Jensen[24] reported similar findings in Denmark, Pogrel in the United States, and Haas[23] more recently again in Canada.

There seems to be agreement that the reported injuries may not be related to the agent per se but rather the concentration (4%) of the agent that is used, Articaine is an amide anesthetic introduced to dentistry in 1998 and widely used in many countries for more than 20 years. Reported advantages of articaine include rapid onset of surgical analgesia compared with lidocaine;[26] better diffusion through hard and soft tissues;[27] and low toxicity subsequent inadvertent intravascular injection.[28] The diffusion feature of articaine has been implicated in reported incidences of ocular disturbances.

Neurotoxicity probably continues to be the most controversial theory of nerve damage due to anesthetic block injection. Many conclude that articaine is not only an effective but also a safe local anesthetic as used in

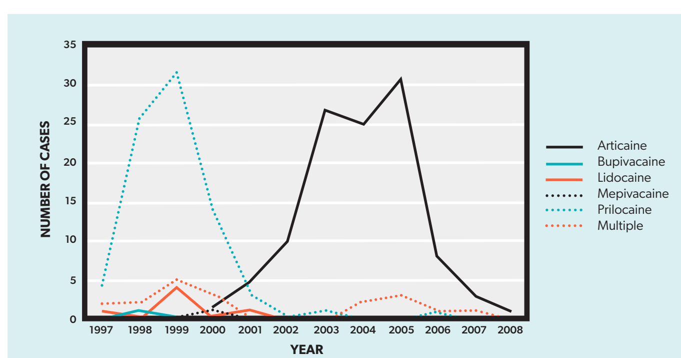

Figure 7: Reported number of cases of nonsurgical paresthesia, according to year and local anesthetic drug.

dentistry. However, there continue to be concerns with regard to using the higher concentration anesthetic agents for inferior alveolar and lingual nerve blocks. Studies on the comparative efficacy of articaine and lidocaine with conventional IAN block report neither is more effective than the other (Figure 8). Therefore, many authors recommend that the decision to use articaine instead of lidocaine for IAN blocks should be based on the risk benefit ratio.

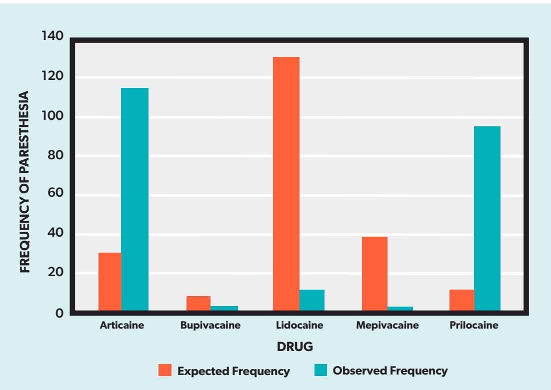

Figure 8: Expected versus observed frequency distribution per local anesthetic drug from November 1997 through August 2008.

Additionally, to avoid toxicity, dentists should keep in mind the maximum safe dose of anesthetic agents. In children and elderly patients, safe levels of anesthetics are lower than in the remaining population. The maximum safe dosages should be determined in accordance with Food and Drug Administration (FDA) established values and with consideration of whether a vasoconstrictor is included. The FDA creates and regularly updates the maximum recommended dosages (MRDs) for local anesthetic drugs. Some clinicians unaware of the FDA approved recommendations use dosages published in older editions of popular textbooks on local anesthetic usage and they espouse lower MRD values.

Nerve injury due to local anesthesia is complex. It may result from chemical or direct mechanical trauma by the needle. These etiologies have been the focus of most of the literature on the subject.

An Additional Consideration: Improper Use of The Existing Armamentaria

For years it was thought that mechanical trauma to the inferior alveolar and/or lingual nerve was the result of surgical trauma. However, more recently, the dental anesthetic needle has been implicated in trauma to the inferior alveolar and lingual nerves.

Needle selection and use are important to not only assure the efficacy of the anesthetic agent but to mitigate nerve trauma as well as other significant complications. Dental needles are available in two lengths: long and short. From hub to tip, a long needle is essentially 32mm (1.5 inches) and the short needle is about 20mm (1.0 inch). The long needle is recommended for mandibular blocks because of the depth of penetration which ranges from 20 to 25 mm for the average adult (IAN and Gow-Gates). This length accommodates the depth necessary for a successful injection and precludes insertion to the hub. It is strongly recommended that 5mm of the needle remain exposed. In the event of needle breakage, if not exposed, the needle is lost amongst numerous vital soft tissue structures, which would necessitate surgical retrieval. The short needle is reserved for infiltration injection. The gauge of the needle represents the diameter of the lumen and in dentistry, the common gauges include 25, 27 and 30. It is reported that patients are unable to distinguish among 25-, 27-, and 30-gauge needles. With the lower gauge (25 or 27) needles, there is more resistance to needle breakage, and less deflection as it advances through the deeper tissues supporting greater accuracy for reaching the desired target. More importantly, aspiration is more reliable. The 30-gauge needle is contraindicated for effective aspiration.

Over the past several years, more needle breakage with dental block injection is being reported. Reasons seen for needle breakage most often relate to the use of narrow-gauge needles, needles bent at the hub, needles injected to the hub, sudden movement of the patient or practitioner, and reuse of the needle.

Reusage of needles in contemporary dental practice should generally be avoided. This occurs most often when giving additional doses of anesthetics to the patient that reports that they are not yet anesthetized. It has been demonstrated that repeated injections with the same needle is associated with metal fatigue which increases the likelihood of needle breakage. Additionally, it is prudent to evaluate all needles prior to initial use and certainly prior to subsequent use.

Aggressive insertion techniques are to be avoided in general. Injecting to the hub without bony contact increases the risk of needle separation. This is where your dentist's knowledge of the anatomy is crucial to effective and safe anesthetic administration. Aggressive injection techniques also increase the likelihood of unanticipated patient and/or provider movement and the potential for therapeutic misadventure. Finally, bending of the needle is generally to be avoided.

The American Dental Association has recently supported a new uniform cartridge color coding system for those dental anesthetic agents in the ADA Seal of Acceptance program. Such rigorous standardization of the dental anesthetic cartridge will allow for easier recognition by the practitioner and enhanced safety for the patients. However, the new coding system is intended only as an adjunct; the dentist must not use it as a substitute for carefully verifying the label. As a side note, not all products commercially available on the market participate in the ADA Seal of Acceptance program and other color-coding systems exist.

Summary

During the more than 100 years since Halstead introduced the inferior alveolar nerve block, a number of myths and misconceptions have permeated the practice of inducing local anesthesia. Perhaps one of the most profound myths involves the perceived benign nature of dental local anesthetic injections. Such a myth could lead to less than-full appreciation of the anatomical complexity and variability of the head and neck region. We have attempted to dispel this myth and encourage the dentist to consider the potential for anatomical complications discussed above when administering any dental local anesthetic. Failure to do so can result not only in less -than-optimal local anesthesia but, more significantly, in minor—perhaps even major—consequences in the form of local and systemic complications.

Dentists can avoid most of these complications by remaining cognizant of the potential risks associated with oral injections and by establishing a routine protocol to be followed before administering any local anesthetic. Such preparation should include the following: a complete preoperative review of the patient's medical history; preoperative recording of blood pressure and pulse; attempts to help the patient relax before administering local anesthetic injections by addressing any anxiety or apprehension he or she may have; placement of the patient in a supine position for injections; in addition, the dentist should assume a position that will allow him or her to administer the injection comfortably; use of disposable needles to prevent infection transmission and use of aspirating syringes in an attempt to avoid intravascular injections; attention to delivering painless injections; use of a minimum volume of anesthetic solution, injected slowly and only after the dentist performs aspiration on two planes; and observation of the patient during and after administration of the local anesthetic.

Fortunately, most paresthesia resolves without intervention within approximately eight weeks. Only if the damage to the nerve is severe might the paresthesia become permanent and this is a rare occurrence. If the clinician is faced with a case of suspected permanent paresthesia, it is important to manage the patient as well as the complication(s). First, the dentist should reassure the patient by informing him/her that transient loss of sensation can and does occur and that it may persist for several months "with gradual improvement." The patient's neurological deficit should be monitored by "mapping" the extent of the skin involvement over time as well as noting the degree and duration of the paresthesia. The postoperative protocol is divided into week one for the initial treatment and followed for twelve weeks. Corticosteroids and NSAIDS are prescribed after surgery as part of the initial treatment protocol. Also, it is prudent and appropriate for the dentist to consult with an oral and maxillofacial surgeon. Peripheral nerve changes subsequent to direct trauma are unlikely to respond to surgical repair if not referred within the first 2 to 3 months after the injury. It is interesting to note that paresthesia is one of the most frequent causes of dental malpractice litigation.

Conclusions

Most complications associated with dental local anesthetic injections are transient in nature, but some are persistent or have permanent ramifications. If complications do occur, it is incumbent on the dentist to make the proper diagnosis and act swiftly to manage the problem, inform and assure the patient, and minimize the consequences.

Dentists administer thousands of local anesthetic injections every day with few reports of serious complications. However, we cannot allow our successes to lull us into complacency. Whenever local anesthesia is called for, we must remind ourselves of the anatomical and pharmacological considerations that could result in complications, ranging from temporary discomfort for the patient to death.

Provided by Eastern Dentists Insurance Company (EDIC), June 2021. The information contained is only accurate to the day of publication and could change in the future.

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