SELECTED READINGS

IN

ORAL AND

MAXILLOFACIAL SURGERY

INJECTION INJURY
TO THE THIRD BRANCH
OF THE
TRIGEMINAL NERVE

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Cognitive deficits are the common manifestation of systemic anesthetic toxicity, including sedation, mood alteration, and when severe, seizures, coma, and death. 

Syncope associated with a dental injection can manifest as loss of consciousness, elevated respiratory rate and loss of vascular tone. Patients and ill-informed practitioners can confuse this psychogenic reaction with an allergy. True allergies to amide local anesthetic agents are extremely rare. Most reactions mislabeled as allergies, are simply mimics of psychomotor reactions, vasovagal syncope and systemic toxic effects with excessive administration.

When there is suspicion of a true allergy, you must consider that today’s modern dental carpule contains additives other than the local anesthetic (e.g., vasoconstrictors, preservatives and pH modifiers). Allergies to the vasoconstrictors and pH buffers are essentially non-existent. The preservatives that minimize oxidation of dental carpule solutions are the focus for most dental local anesthetic allergies. Historically, methyl- and propyl-paraben have been used, however, bisulphite is now commonly used. Allergies to bisulphite are well documented in the literature.

With proper administration, and minor alterations for certain patient populations, local anesthetic delivery via a traditional dental syringe is safe and effective. The purpose of this paper is to present the theories of how trigeminal nerve damage results from the traditional inferior alveolar nerve block.

NERVE ANATOMY

The normal perioral nerve trunk is made up of organized collections of axons that are the peripheral extents of the cell bodies located within the trigeminal ganglion. Schwann cells (supporting cells of ectodermal origin that compose the neurolemma) envelop axons in a predetermined fashion and produce varying degrees of myelin (a complex lipid substance that enhances electrical conduction). In the peripheral nervous system, a single Schwann cell envelopes one axon, providing the axon with a myelin sheath. Unmyelinated axons
differ from myelinated axons in that several are ensheathed by one Schwann cell.

Surrounding the myelinated and unmyelinated axons are organized collagen fibers of the endoneurium. These fibers are organized so that the outermost layer is the basal lamina of the Schwann cell (band of Bungener) and essentially is the basal lamina tube running the entire length of the axon.

Many axons with their endoneurial sheaths are surrounded by a second organization of collagen fibers called the perineurium. The perineurium consists of layers of mesothelial cells and dense collagen that form the fascicle.

Fascicular patterns are designated by their organized collection as being mono-, oligo- or poly-fascicular. The fascicular pattern in perioral nerves is characterized by dramatic variations in number and direction throughout the proximal to distal extent of each nerve. For example, at and proximal to the third molar site, where an injection injury is likely to occur, the mean number of fascicles in the inferior alveolar nerve is 21.14 (S.D. = 7.05) and the lingual nerve is equally divided into oligofascicular (N= 2 to 10) and polyfascicular (N= 11 to 25) patterns.

The nerve trunk is completed by the following structures: (1) internal or interfascicular epineurium, connective tissue that surrounds the individual fascicles; (2) external or epifascicular epineurium, connective tissue that surrounds the entire nerve; and (3) the mesoneurium, loose connective tissue outside the nerve which contains the supplying blood vessels. Within the nerve trunk are capillaries, arterioles, venules, and occasional mast cells.

There is good evidence that axons branch after leaving the cell body and may supply several receptors. However, the system is generally somatotopically organized. For example, receptors that transmit pain are innervated only by unmyelinated or small myelinated fibers, carried to small cells that are localized in discrete cell groups in the ganglion according to the trigeminal region (e.g., mandibular versus maxillary), separated into terminal fields within the brain stem, and carried to higher CNS sites dedicated to the face. A disproportionate amount of the CNS is dedicated to the face (i.e., the homunculus), which illustrates the importance of trigeminal somatosensation in humans.

For purposes of this article, the normal anatomy is important to explain the proposed sensory deficits associated with needle injection or chemical injuries of the trigeminal nerves. As opposed to mechanical injuries that can affect the entire dermatome (somatotopic field) due to truncal injury (involving the epineurial, perineurial and endoneurial structures described above), an injection injured patient frequently complains of partial dermatome deficits. The partial, incomplete somatotopic field effect may be explained by fascicular injury (perineurial and endoneurial injury only) specific to the chemical exposure (e.g., local anesthetic, steroid, etc. injected into the nerve) with intact epineurium. Those fascicles not exposed to the chemical are typically spared. For example, if 50% of the 21.14 fascicles in the inferior alveolar nerve and 5 to 10 fascicles in the lingual nerve are affected by
the chemical exposure, then half of the lip/chin/oral mucosa and teeth and half of the tongue on the affected side will be reported as altered whereas the remaining half will be normal.

Because we don’t know the number of fascicles required to result in subjective deficits or the dilution spreading affect of the various chemicals on fascicle preservation or damage, we would expect a great variation in sensory-deficit reporting in most chemical injuries due to injection. This is frequently noted in patient’s reports and clinical neurosensory testing.

MECHANISMS OF LOCAL ANESTHETICS

It is important to review the mechanism of local anesthetics. Baart and contributing authors described the basic mechanism of neural transmission and local anesthetic action. Each neuron cell is generally impermeable to everything except water. It is this barrier that helps maintain the ion gradient created by the sodium, potassium, chloride pumps and channels. There is a negative charge within the cell. Pain, sensory, and motor transmission is based upon the depolarization of the internal cell charge from negative to positive. The prevention of this negative to positive charge is the basis of local anesthetic mechanism. The reversible inhibition of the sodium channel is the primary method of preventing this depolarization.

TRIGEMINAL NERVE INJURY

Oral and maxillofacial surgery presents a huge potential for injury to the mandibular branch of the trigeminal nerve. Orthognathic surgery, dentoalveolar surgery, 3rd molar removal, pathology, maxillofacial trauma and dental implants all provide obvious mechanical causes of nerve trauma. Tay and Zuniga showed that neurosensory disturbance is most commonly a result of dental extraction (52.5%), but local anesthetic delivery was the 2nd most common cause, at 15.3%. The incidence of dental injection-related nerve damage is varied and sometimes difficult to estimate due to reporting variables by different authors. The estimates range from 1: 26,762 to 1:785,000 when accounting for reporting differences of total injections vs. mandibular blocks.

“Neuropathic pain is defined as pain caused by lesions of the peripheral or central nervous system.” This nerve damage to the trigeminal nerve can be mechanical, infectious, chemical or metabolic in nature. It is important to determine the cause of the neuropathic pain because interventions vary substantially.

The injuries can be defined as temporary or permanent. In dentistry, the term paresthesia is used to describe the cluster of abnormal nerve function. Dysesthesia is reserved to described symptoms of pain or discomfort to a normally non-noxious stimuli. Hyperesthesia is an exaggerated pain response to normally noxious stimuli. Anesthesia describes partial or total loss of that nerve branch’s sensory function.

Distribution

The distribution of trigeminal nerve...
injury as a result of dental treatment is inconsistently reported in the literature. In what is likely the most substantial study in terms of study time period and patient population, Haas’s 21-year retrospective study utilizing Ontario’s Professional Liability Program found no difference due to age, sex, and gauge of needle. Animal models have shown differing responses to nerve injury based upon sex. The most common anatomically defined complaint is in the tongue, followed by the lip. These conclusions are not universal, many authors have cited a greater incidence of damage in female patients.

Chemical Causes of Nerve Damage During Dental Injection

The most common local anesthetics in use today can be estimated from Canadian and Danish studies. Although evidence exists showing local anesthetics of all types can be neurotoxic, more attention has been focused on the local anesthetics articaine and prilocaine. This is based upon observational increases in paresthesias after the release of these drugs. This observation was backed up by Haas’s 21-year Canadian study showing articaine (p<.002) and prilocaine (p<.025) had increased the incidence of paresthesias beyond their relative frequency of use in the study population.

Evidence that local anesthetics are neurotoxic is available from animal models and clinical studies. Lidocaine has been shown to be directly neurotoxic in a rat model in a paradoxical excitotoxic manner and release of intracellular Ca++. An additional theory of local anesthetic toxicity has been presented by Cherng et al. They demonstrated, in a rat model, that intrathecal spinal injections of lidocaine and bupivacaine resulted in a dose-dependent release of the excitatory neurotransmitter glutamate. The resulting toxicity was monitored via tail-flick latencies. A dose dependent response was found for lidocaine but not for bupivacaine. This suggests that increased glutamate release may be one cause of lidocaine induced chemical toxicity to nerves. The theory of glutamate toxicity is not new and many authors have demonstrated neurotoxicity from elevated glutamate levels.

Haas provided a unique data interpretation by comparing the overall incidence of observed nerve injury from local anesthetic blocks to the rate of anesthetic type (articaine, bupivicaine, lidocaine, mepivacaine, prilocaine) used in the population. The expected number of nerve injuries for each anesthetic type was estimated by applying the total number of injuries in a weighted manner to each type and comparing them to the true rates. Evaluation with chi-square test showed that the expected and actual rates of nerve damage were not congruent, and that certain anesthetics likely have greater neurotoxic effects. 

Mechanical Causes of Nerve Damage During Dental Injection

Nerve damage from dental injection has been thought to result from direct contact between the injection needle and the nerve. However, Haas’s Canadian study showed no impact of needle gauge size on incidence of
Trigeminal Nerve Injury

The electric shock phenomenon felt by patients during some mandibular injections has been used in an attempt to associate direct needle-to-nerve contact with nerve damage. However, the results are not convincing. Haas showed that only 31 of 143 patients reporting shocks ultimately had nerve damage. In a larger study, 856 of 12,104 mandibular injections had electric shock, however, none had damage.

In an attempt to anatomically define the relationship between dental nerve block needles and the lingual nerve during a standard injection, Morris et al. performed 44 standard inferior alveolar and lingual nerve blocks as described anatomically by Malamed. Dissection showed that 16% of injections resulted in the needle passing within 0.1mm of the nerve and 4.5% penetrated the nerve. The authors concluded that the 4.5% that contacted the nerve is consistent with rates of “electric shock phenomenon” found in many other studies. They concluded a more lateral approach may benefit the practitioner in avoiding the lingual nerve during mandibular block injections.

A clinical study of 100 single inferior alveolar injections found that under microscopic examination, 60% of used needle tips had barbs, with a decrease in incidence in faculty vs. student injections. In the same study the authors also completed a bovine study in which inward facing barbs, outward facing barbs and undamaged needles were purposefully drawn a single time over freshly removed nerves. Electron microscopic examination of the nerves was done in serial sections to assess any damage. The study had to be repeated multiple times in order to demonstrate damage to the epineurium, and damage only occurred with the outward facing barbs.

Hematoma

A rat sciatic nerve experiment showed electrodiagnostic and histological changes as a result of hematoma formation within the nerve sheath. Immediate evacuation of the blood, prior to hematoma formation, produced slightly less damage. However, in patients that elected to undergo surgical repair of injuries presumed to be due to injections, no damage could be found during inspection with surgical exposure.

Prognosis and Evolution of the Injury

Hillerup et al’s Danish study followed 52 patients with 42 lingual and 12 inferior alveolar nerve injuries that occurred as a result of anesthetic injection. Their study included an interview, neurosensory exam with point discrimination, temperature, light touch and painful stimulus. An additional gustatory clinical evaluation was also done. The follow-up neurosensory exam after 13 months showed little improvement in these injuries. There was no difference among the types of anesthetic and the amount of improvement. The gustatory exam had equally poor outcomes. In those who had gustatory perception injury, there was no significant improvement after 13 months. Ultimately the authors found no significant impact of injection volume, repeat injections, the perception of electric shock on injury on the outcome and prognosis. The authors
agreed with other studies that showed a predilection for injury to female patients. Pogrel’s cohort showed that neurosensory abnormality persistent after 3 weeks has a poor prognosis, with complete recovery occurring in only 33% of the patients.

IMPACT ON PATIENTS

Pogrel studied the long-term impact of trigeminal nerve injuries due to dental treatment, and not limited to just local-anesthetic related injuries. The 145 patients who responded to the telephone surveys reported a striking amount of life changes as a result of this injury. Functional problems with eating (43%) and speaking (38%) were the most common. Psychologic impacts included depression (37%), relationship changes (14%), and adverse effects on employment (13%). Coping mechanisms provided mild relief for most, however, a minority pursed surgical and medication based treatment. Nerve injuries to the inferior alveolar nerve and lingual nerve can be so distressing that it is a leading cause of malpractice complaints against oral and maxillofacial surgeons.

MANAGEMENT

Zuniga has described non-surgical management of trigeminal nerve injuries. The most common inferior alveolar and lingual nerve injuries are the result of extraction, orthognathic surgery, dental implants, and injection injuries. Realistically, there are no surgical options for needle injection injuries. Non-surgical options such as physiological therapies, behavioral/physical therapies, and pharmacological therapies are used individually and together. Physiological therapies include cryotherapy, immobilization, short-wave diathermy and microwave radiation, ultrasound, and electro-iontophoresis.

The application of ice to an area will theoretically lower edema and inflammatory tissue around the nerve. However, this would be difficult to apply long term near an inferior alveolar or lingual nerve injury. Immobilization applies primarily to fracture or osteotomy sites, and does not apply to injection nerve injuries. Diathermy, microwave, ultrasound, and electro-iontophoresis require access to the area of injury and likely would not be of benefit for a needle stick injury.

Physical therapy techniques primarily take the form of sensory retraining. This involves teaching a patient to interpret sensations that have been altered due to the injury. Basic techniques involve delivery of specific evolving light-touch stimuli to the affected area. A complete discussion of the non-surgical management of trigeminal nerve injuries can be found in Selected Readings in Oral and Maxillofacial Surgery, Vol. 14, #1 (2006).

Pharmacological interventions involve either supplement or nerve transmission alteration. Supplements include vitamin B6, B12, and chondroitin sulfate, based on the idea that deficiency in these three can lead to neuropathy or deficiency in nerve cell membranes. Nerve transmission altering drugs include anticonvulsant, anti-arrhythmic and topical agents. The anticonvulsants are gabapentin, pregabalin, baclofen, clonazepam
and tegretol. Specific dosing can obtained from the literature.

Topical agents capsaicin and lidocaine have also been used to control neuropathic pain. Capsaicin works by depleting substance P neurotransmitter, but can be extremely uncomfortable to deliver. Topical lidocaine is also effective for peripheral neuropathic pain. Both topical applications are limited by anatomical diffusion. Lastly, botulinum toxin has been used for the treatment of neuropathic pain via an unknown mechanism. It is important to remember that injection injuries are unlikely to benefit from any form of surgical intervention, and the above mentioned non-surgical interventions are the only reasonable methods of patient subjective improvement.

CONCLUSION

It is a true gift that dentistry can offer patients treatment complimented by local anesthetics that are safe and effective. The rate of nerve injury attributable to local anesthetic injections is very low. Laboratory-based studies show that local anesthetics at dental carpule concentrations are capable of causing neuro-conduction disturbance, however, the toxicity becomes more obvious as the concentration increases. Concentration differences are thought to be one contributing factor to the increase in observed incidence of nerve damage following the introduction of 3% and 4% solutions. In large retrospective studies injury rates are indeed higher than predicted. Mechanical injury has not been shown to directly contribute, however, animal studies show that an intact neural sheath gives reasonable protection against chemical injury.

Cadaver studies show that mandibular blocks place the lingual nerve at reasonable risk of direct contact. The prognosis of injury from dental injection is very poor. Neurosensory and gustatory sensation improve very little following immediate complete sensory injury. The impact on patients suffering from altered sensation to the mandibular and lingual branch of the trigeminal nerve is substantial and those displaying residual long-term symptoms have few treatment options.

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was awarded the 1998 Daniel Laskin award for Most Outstanding Publication in the Journal of Oral and Maxillofacial Surgery. He has been the Principal Investigator or co-Investigator in 20 grants and contracts from federal, industry or foundation sources and is currently funded through the NIH/NIDCR for clinical trials examining the genetic determinants of clinical response to opioid analgesia and genetic risk factors associated with chronic TMD with investigators from the University of North Carolina. Dr. Zuniga is active locally, nationally and internationally in the specialty of oral and maxillofacial surgery. He is a diplomate of the American Board of Oral and Maxillofacial Surgery where he served 6 years on the Examination Committee. He serves on the Editorial Board of several journals and is an ad hoc reviewer for several journals in Neuroscience and Oral and Maxillofacial Surgery. He serves on several committees for the American Association of Oral and Maxillofacial Surgeons and is a voting member of the Dental Products Panel of the Medical Devices Advisory Committee for the Center for Devices and Radiological Health of the Food and Drug Administration.

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**REFERENCES**


