NEURAL COMPLICATIONS OF THIRD MOLAR SURGERY: REVIEW OF MANAGEMENT

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ABSTRACT
The surgical extraction of the mandibular third molar is one of the most common procedures performed by the oral and maxillofacial surgeon. It carries a risk of injury to both the lingual nerve (LN) and inferior alveolar nerve (IAN). Horizontal impaction is the most implicated in IAN damage while distoangular impaction in LN damage. LN complications occur at a prevalence of 0.1% to 22%, compared to IAN, which occurs at 0.26% to 8.4%. Complications to the IAN and LN can result in disturbances presenting as sensory loss, painful sensation, altered taste and speech, ultimately affecting the patient's quality of life.

Assessment of nerve injury subjective test or objective test. Objective tests for the IAN include two-point discrimination tests, brushstroke direction test, light touch test and thermal tests. While for the LN, an objective assessment includes the taste stimulation tests.

Treatment of nerve injuries involves both non-surgical and surgical therapy. Non-surgical therapy includes low-level laser therapy, acupuncture, and adjunct therapies. Adjunct therapy includes the use of vitamin and B complex, which promote neural regeneration as well as sensory re-education therapy, which is a cognitive behavioural technique which can partly compensate for some of the functional loss associated with nerve injury. Surgical therapies include direct suturing (neurorrhaphy), neurolysis and autogenous graft of nerve. Surgical therapies are the most preferred and optimal result is obtained when done within 3-6months after injury.

Introduction

The surgical extraction of the mandibular third molar is one of the most common procedures performed by the oral and maxillofacial surgeon.[1,2] Transient or permanent nerve damage are not uncommon complications during these procedures.[3-5] Hence, management of neurological complications following third molar surgery is requisite expertise for oral and maxillofacial surgeons.

Surgical extraction of third molars carries a risk of injury to both the lingual nerve (LN) and inferior alveolar nerve (IAN).[3,6,7,8]. The inferior alveolar neurovascular bundle travels within the inferior alveolar canal (IAC) in the mandible. During traumatic surgical extraction, injury to the IAN may occur when other injuries of the surrounding structures are transmitted to the IAN within the IAC. Kang et al.[9], in a systematic review assessing the incidence of IAN injury following 4,471 mandiular molar extractions, reported a 1.20% incidence of transient IAN deficit and 0.28% permanent IAN injury.

On the other hand, the LN is morphologically different from the IAN. It is not supported by a bony canal like the IAN; instead, it lies medial to and in front of the IAN and beneath the lateral pterygoid muscle.[9] The LN subsequently passes between the medial pterygoid muscle and the ramus of the mandible. When injured, the LN fibres retract and can become entrapped within surrounding soft tissue.[10] The commonest site of LN injury is the segment lying adjacent to the mandibular third molar. At this point, the nerve is covered with only a thin layer of soft tissue. Hence traumatic sectioning of the nerve during extraction may result in the ends retracting apart and becoming entrapped in scar tissue, particularly if the adjacent soft tissue is also distorted.[6] The presentation of neural complications following surgical extraction of mandibular third molars depend on the severity of inflammation and the type of injury-stretch, crush, and section.[10]

There is a wide range of symptoms characterizing neural complications following third molar surgeries. These neural complications may present as anaesthesia, hypoesthesia, hyperesthesia, or dysesthesia in the distributions of the IAN and LN. LN complications occur at a prevalence of 0.1% to 22%,[8] compared to IAN, which occurs at 0.26% to 8.4%.[11-16]The wide range in the incidence of neural complications reported in the literature may be explained by the difference in the time interval between tooth removal and the assessment of the sensory impairment.[6,8] For example, early evaluation of neural complication may result in many transient sensory changes that can potentially recover and may be missed if evaluation takes place after a relatively long period. Overall, 25% of patients with iatrogenic paraesthesia suffer permanent effects.[7]Further, a diagnosis of nerve injury may also be influenced by the mode of patient assessment.[6]

Complications to the IAN and LN can result in disturbances presenting as sensory loss, painful sensation, altered taste and speech, ultimately affecting the patient's quality of life.[9] Therefore, an understanding of management approaches for peripheral neural complications following mandibular third molar extractions is crucial for maxillofacial surgery trainees and attendings. We review the current evidence surrounding the management of peripheral neural complications following surgical extraction of mandibular third molars.

Peri-operative causes and classification

The risk factors for neural complications following third molar surgery may be anatomical or operator related. Anatomical factors include the radiographic relationship of the nerve with the tooth, impaction type, while operator factors include the duration of surgical extraction and the surgeon's experience.[17-24] Studies have shown that closer proximity between the root and nerve (<1mm), particularly with a diversion of the mandibular canal, the higher the risk of injury to the nerve during extraction.[9] Further, horizontally impacted teeth have the highest risk of inferior alveolar nerve injury. In contrast, distoangular impaction types have the highest risk of lingual nerve injury during surgical extraction. Trainee surgeons compared to senior specialist surgeons, coupled with longer duration of surgical extraction increase the likelihood of neural complications.[9]

The anatomical and operator factors mentioned above in contributing to the risk of neural complications, also influence the management of nerve injuries. Another important factor in management is severity of nerve injury which determines whether there is need for surgical intervention or not.

The severity of nerve injuries can be classified using the Seddon or Sunderland classifications.[25,26] Seddon proposed a classification based on the severity of nerve injuries in 1943.[25] The classification grouped nerve injuries into neuropraxia, axonotmesis, and neurotmesis. Sunderland modified this classification in 1951,[26] grouping neural injuries into five categories: Conduction block; transection of the axon with an intact endoneurium; transection of the nerve fibre (axon and endoneurial sheath) inside an intact perineurium; transection of nerve fibres and perineurium, nerve trunk continuity being maintained by epineural tissue and transection of the entire nerve trunk. Complete transection of the nerve tissues carries the worst prognosis and usually require direct interventions.[6,27]

Clinical neurosensory assessment

Determination of neural complications usually follows a neurosensory assessment during or after third molar surgeries. Neurosensory assessment of nerve injury complications includes subjective patient response, clinical tests and radiographic imaging.[24].

Assessment of nerve injury can be done as subjective test or objective tests. However, objective tests are more reliable. The objective tests are classified into three levels- A, B and C- to measure different types of nerves involved [Table 1]. Level A tests are used to determine slowly adapting larger myelinated Aα fibres. The tests involved are two-point discrimination and brushstroke direction tests.[6,24,25] On the other hand, the level B tests are used to determine rapidly adapting larger myelinated Aα fibres. The test involved is the Contact detection/light touch test.[24-27] While the level C tests are used to determine the small myelinated Aδ and C fibres. The tests involved are thermal, sharp-blunt discrimination and pin-prick tests.[6,28,29]

Further, the assessment of taste stimulation for LN injury, which will result in taste loss from the anterior aspect on the ipsilateral tongue, can be performed by drawing cotton wool pledgets soaked in 1M sodium chloride, 1M sucrose, 0.4M acetic acid or 0.1M quinine across the lateral aspect of the tongue. The patient is then asked to indicate the taste (salt, sweet, sour, bitter or no taste). Stimuli should be applied in random order, to each side of the tongue, and rinsing with tap water between tests advocated.[6]

Imaging techniques that can be employed include the panoramic radiograph, computerized tomography (CT scan), ultrasound, magnetic resonance imaging (MRI), magnetic resonance neuroradiography (MRN), and jaw reflex tracking can be used.[30-32] These imaging techniques have unique diagnostic capabilities to identify bony fragments impinging on the nerve or entrapment of nerve endings in adjacent scar tissue following surgical extraction

Careful monitoring of neurosensory recovery over three months can help determine the type of injury, with the most sensitive indicator of a deficit being ~~is~~ the patient's subjective response

Treatment

Surgical therapy

The timing of repair of the IAN and LN injuries is controversial. Most authors favour early repair of nerve injuries. . In a study where 51 lingual nerve and Inferior alveolar nerve microsurgeries where conducted, improvement was noticed in 88.9% of patients treated within 10 weeks when compared with 47.6% of patients treated $\geq$ 4 months after injury.[33] This prompts the idea that optimal result is obtained when repair is done between 3-6 months after injury.[33]

A variety of methods have been applied and reported in the management of IAN and LN injuries. Unfortunately, there is no way to effectively image nerves externally; thus, exploratory surgery is compulsory, and the treatment decision must occur intra-operatively. As a result, most studies include mixed results regarding the repair method. The various methods include:

Neurolysis

Neurolysis can be done to decompress the nerve when affected by a neuroma or scar tissue. The procedure can be an external (scar tissue surrounding the nerve) or internal neurolysis (scar tissue in the neural fascicles). Neurolysis is more commonly performed for injury related to LN, as it is surrounded by soft tissue and more prone to fibrosis and scar formation.[33]

External neurolysis has been detailed as a potential treatment for nerve injury following surgical extraction of third molars.[16,34-38] The indications for this approach include, involvement of LN, and persistent altered sensation along the nerve distribution without taste disturbance.[16,34] External neurolysis involves raising a lingual flap to enable visualization of the LN along the lingual aspect of the mandibular molars. The nerve tissue is then assessed for a neuroma, and if absent, freed from the surrounding scar tissue, and placed in healthy tissue where a scar reformation is unlikely to occur.[33] The procedure has a 25% success rate when used in cases of lingual nerve injury.[8,34]

Concerning external neurolysis for the inferior alveolar nerve, the indications include anaesthesia, recurring hypoesthesia, hyperesthesia; and dysesthesia of more than 12 months.[8] The procedure can be performed by decortication of the buccal plate of bone at the angle of the mandible to enable visualization of the IAN. The excision of neuroma is done, if present.[39] The entrapped nerve is then relieved from surrounding bony tissue. The procedure has been reported to have about 29% success rate.[39] Treatment outcome following external neurolysis is usually assessed after 12 months.

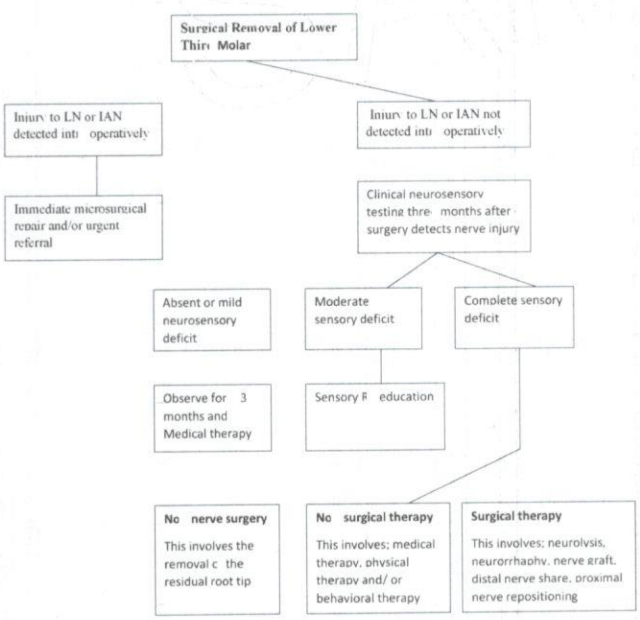
Direct suturing (Neurorrhaphy)

Studies have demonstrated direct suturing as a treatment option for nerve injury following mandibular third molars.[16,37,39-41] The procedure can be conducted when the post-surgical symptoms include anaesthesia, hypoesthesia, hyperesthesia, or dysesthesia of the anterior two-thirds of the tongue on the affected side with or without taste disturbance (in case of the lingual nerve). For the LN, the surgical repair involves raising a lingual flap, ~~if in LN,~~ to trace the course of the injured nerve, after which, a neuroma, if present, is excised. For IAN, a buccal decortication is done to expose the course of the nerve. The epineural tissue is then sutured using about four stitches of 8-0 or 10-0 non-resorbable nylon micro sutures with the proximal and distal nerve ends apposed without tension.[33,42,43] An absorbable collagen nerve cuff can be sutured around the anastomosed section of the nerve.[37] The principle for epineural repair in trigeminal nerve branches is because of the non-grouped, and different-sized pattern of the nerve fascicles (poly fascicular).[33,42,43] A review of cases detailed some neurosensory recovery in 5% to 55% of the cases reviewed after 12 months.[16,37,40,41] However, Susarla et al.[44] reported neuroma formation in association with LN repair using direct suturing (neurorrhaphy). In addition, Yamauchi et al.[45] stated that all LN defects repaired using direct suturing showed recovery; nonetheless, there was still evidence of partial sensory and taste impairment.

Autogenous grafts

Autogenous grafts used in managing neural defects can be divided into two categories: nerve grafts and vein grafts. The use of these grafts is indicated when neural injury or preparation during neurorrhaphy may cause a continuity defect (2-14mm after neuroma excision) or tension after repair.[33,46-48] Another indication is when the distal stump of the injured nerve can be salvaged, but the proximal stump cannot.[33]

Nerve grafts, procedure involves excision of the neuroma or surrounding scar tissue, (if present) and measuring the length of the defect. The graft should be about 10% longer than the defect gap to prevent contraction or shrinkage. The graft is sutured between the proximal and lateral stumps using two 8-0 to 10-0 nylon sutures passed through the epineurium,



The algorithm was adapted with modifications from Zuniga[24] and Loescher and colleagues[6].

Figure 1. Algorithm for management of Neural

interfascicular epineurium, and perineurium.[33]

The nerves employed in for the autogenous repair of trigeminal branches (LN and IAN) are the greater auricular and sural nerves, because of the ease of harvesting, length, diameter as well as the fascicular pattern of these nerves.[33,42,49] Bagheri et al.[5] conducted nerve repairs on 19 patients using an autogenous nerve graft procedure (greater auricular and sural nerve) for the reconstruction of a nerve defect and demonstrated functional recovery. In another study, Bagheri et al.[50] observed functional recovery in 62 out of 71patients with IAN defects who received great auricular or sural nerve grafts. While greater auricular nerve grafts may be preferred due to proximity; nonetheless, when the gap extends beyond 2cm, a sural nerve graft is recommended.[50] The significant determinant of recovery was the time of repair (< 9 months), and the treatment option, when combined with a collagen cuff, yielded moderate success.[5] In LN repairs, nerve grafts are not used as often because the course of the nerve is tortuous, and tension-free mobilization is easier to perform.[5] However, when indicated, studies have recorded functional recovery using greater auricular and sural nerve grafts.[50,51] Further, surgeons should counsel patients about potential donor site morbidities such asloss of sensation on the lateral side of the foot and heel from harvesting the Sural nerve, or numbness in the ear, the skin covering the posterior part of the mandible, and the lateral aspect of the neck from harvesting the greater auricular nerve.[33] Another disadvantage is the potential formation of a neuroma.

Autogenous vein grafts using the saphenous vein (for LN) or the facial vein (for IAN) can be used to repair nerve injuries with a breach in continuity. Before repairing the defect with a graft, the epineurium on the nerve is removed, after which the harvested graft is dilated using forceps. The venous graft is then used to repair the neural defect with 8-0 nylon sutures to suture the proximal and distal ends to the graft.[46-47]

Pogrel and Magren[46] demonstrated that repair of LNs can be done using the long saphenous vein. The technique was useful for defects 5mm or less, while defects between 6 to 14mm showed no improvement after the procedure. They also demonstrated that the facial veins can be used to repair injuries to IAN though this procedure was more effective in defects 5mm in size or less.

Pogrel and colleagues[52] in a separate study demonstrated the use of Gore-Tex tube (polytetrafluorethylene) to bridge a neural defect of 2-15mm and 17-30 mm respectively in the LN and IAN nerves after neuroma excision. The Gore-Tex tube reported in this study[52] was 2cm long with an internal diameter of 3mm and served as a nerve conduit. The tube was approximated to the proximal and distal end of the neural defect using 8-0 nylon sutures. The procedures

Table 1. Classification of Objective Clinical neurosensory assessment tests

Objective Clinical neurosensory assessment tests		
Level A	Level B	Level C
Two-point discrimination test Two pointed, but not sharp, tips of a calliper touch the skin simultaneously with light pressure while the patient's eyes are closed. The separation of the two points is gradually reduced from 20 mm at the chin and 10 mm at the lips to the moment where the patient can feel one point only. The minimum separation at which two points can be reported is recorded.	**Contact detection/light touch test** The contact detection threshold, the minimum force of contact against the skin that is felt, is measured with the use of a monofilament mounted onto the end of a plastic handle	**Thermal testing** Perception of warmth is attributed to the integrity of A δ fibbers and cold to C fibers. Two small glass tubes containing water at 50°C (warm) and 15°C (cold) were used. The report of each stimulus, i.e. cold versus hot, is recorded.
Brushstroke direction test The sensory modalities for these receptors are vibration, touch and flutter. Moving stimuli is delivered with a soft brush at a fairly constant velocity (2 3 cm/s). Ten, two interval forced choice trials are then delivered to verify that the direction of motion is identified correctly.		**Sharp blunt discrimination** This is done by touching the test area randomly with a sharp or a blunt head of the mechanical probe. A rubber stopper is centred at the end of the dental probe so that when the tip is pressed to the skin, a constant degree of skin indentation was made.
		Pin prick test Consisted of repeating ten touches with an explorer tip on the skin of the chin skin.

were performed 30 months or less after nerve injury and assessed at least one year after the repair. In the LN cases, only one case showed significant improvement out of three cases, while one out of two cases showed improvement in IAN function. However, a disadvantage is that materials such as Gore-Tex can cause axonal conduction to decrease from localized compression, if in place for a long-term.[42] Other studies have used polyglycolic and absorbable collagen cuffs as nerve conduit materials to achieve functional sensory recovery.[5,37]

Non-surgical therapy

Low-level laser therapy (LLLT)

An alternative to microsurgery is the use of LLLT. Ozenand colleagues[53] reported the use of this procedure on four cases of LN and IAN injury after extraction of mandibular third molars. The treatment procedure detailed a total of 20 LLLT sessions, and each patient received a session three times a week, with 2-day intervals between each session. A contact probe with a diameter of 0.5 cm, emitting a wavelength of 820-to-830 nm and irradiance of 6.0 J per treatment site was delivered by applying 5 mW in continuous wave mode for about 90 seconds. The treatment sites extra-orally were the region of the mental foramen, the lower lip and the chin. Intraoral sites were the mental foramen region, buccally in the region of the apices of the first molar, and lingually in the region of the mandibular foramen. There was a significant neurosensory recovery in the cases reported.[53] Low-level laser therapy promotes nerve regeneration by increasing collagen formation and reducing scar formation.[53,54] However, the findings on LLLT should be interpreted with caution, as the sample population was small. More research is therefore still needed to determine the efficacy of the approach.

Acupuncture

Another non-surgical treatment option is the use of acupuncture. Ka et al.[55] reported the use of acupuncture to treat six cases of LN injury and 27 cases of IAN injury. The procedure may be supplemented with heat treatment of the acupuncture needle at insertion (moxibustion). Neural recovery was assessed at six months after the procedure. Similar to LLLT, all LN cases experienced atleast some recovery, while over 90% of IAN injury cases experienced some recovery, with 14.7% recovering completely. Treatment with acupuncture was found to be significantly effective when commenced within 18 months after the nerve injury. The specialized skill necessary for acupuncture limits its use among maxillofacial surgeons. However, this technique may be promising in the management of neural deficits following third molar surgery.

Adjunct therapies

Adjunct treatment options include sensory re-education and palliative medical therapies, such as vitamin B_{12} and B complex, which promote neural regeneration. These commonly called "neurotropic" B vitamins play special and essential roles both in the central nervous system (CNS) and the peripheral nervous system (PNS).[56] Vitamin B_{12} is considered a coenzyme in folate metabolism and nucleotide biosynthesis, which makes it crucial in the metabolism of fatty acids and some amino acids and normal nervous system function.[57] Vitamin B12 is involved in the DNA synthesis of myelin producing oligodendrocytes and the synthesis of myelin.[56] Additionally, vitamin B_{12} was recently shown to be a superoxide scavenger contributing to neuronal cells axonal growth and reducing apoptosis of neuronal tissues after injury.[58]

Sensory re-education therapy is a cognitive behavioural technique which can partly compensate for some of the functional losses associated with nerve injury.[59] The technique can aid the meaningful interpretation of the altered neural impulses reaching the patient after the area with altered sensation has been stimulated. There is however, a dearth of evidence demonstrating its efficacy in treating nerve injury following mandibular third molar surgery. On the other hand, vitamin B_{12} and B complex have been shown to promote the regeneration of myelinated nerve fibres and proliferation of Schwann cells by increasing the number of Schwann cells, myelinated nerve fibres and the diameter of axons.[60]

Prognosis

The prognosis of neural complications following third molar surgery depends on the timing of repair and extent of the injury. Neural injury identified at the time of surgery and repaired immediately have the best prognosis.[60] This is followed by injuries identified in the first three months, but it decreases rapidly after six months such that there is less than 10% chance of recovery after nine months.[24]

Neural complications characterized by neuropraxia usually returns after four weeks. Injuries characterized by axonotmesis usually recover between 4 to 12 weeks whilst those with neurotmesis (which carries the worst prognosis), recover later than the third month or may require some surgical intervention to re-approximate the separated ends.[27,61]

Conclusion

The management of neural complications following third molar surgery depends mostly on the timing of diagnosis, the surgeon's expertise, and the extent of the injury. A diverse range of treatment options have been reported in the literature; however, their effectiveness varies,[8,16,33-35,40,46,48,52,53] and a majority require further empirical study.

The oral and maxillofacial surgeon should develop expertise in managing neural complications, as third molar surgeries are one of the most performed procedures in the field.[1] In addition, knowledge of when to make a specialist referral is important, in cases requiring microsurgical exploration, as this increases the likelihood of complete recovery in patients when done early. Further, well designed randomized control studies are needed to provide evidence supporting treatment approaches for neural complications following mandibular third molar surgeries.

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