NERVE DAMAGE FOLLOWING THIRD MOLAR REMOVAL

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Dedication

To myself

CHAPTER ONE
INTRODUCTION

INTRODUCTION

Third molar surgery is one of the most frequently done procedures by oral & maxillofacial surgeons. Minor complications like pain, edema, bleeding & trismus are often seen. Damage to the inferior alveolar && guar nerves has been associated with decreased feeling, transient sensory loss, &permanent sensory loss in the inferior lips, jaw, & tongue. This issue persists despite advancements in preoperative evaluation & removal techniques for impacted lower 3rd molars, & it is often unexpected & unpleasant for patients, particularly when no previous warning has been provided (Bhat et al., 2020).

Third molars in the mandible are the most varied teeth in terms of architecture, root morphology, & root location relative to the inferior alveolar channel. This closeness, along with the surgical procedures used to remove these teeth, has a profound impact on the inferior alveolar nerve. Inferior alveolar nerve injury occurs in 0.2 to 4percentof surgically extracted 3rd molars, depending on a number of factors including age, sex, concomitant use of socket medications, surgeon skill & level, method & equipment used for tooth removal (Singh et al., 2020).

The lingual nerve may be damaged by a number of different causes. including oral & maxillofacial trauma, mouth cancer, & a range of illnesses & surgical procedures. Lingual nerve injury is most often caused via the removal of mandibular 3rd molars. Lingual nerve injury is an uncommon but severe consequence of mandibular 3rd molar extraction. According to Renton et al., lingual nerve damage occurs in between 0.02 & 2percentof patients having 3rd molar surgery (Tojyo et al., 2019).

Thus, it is essential to evaluate the 3rd molar's position & proximity to the mandibular channel during the preoperative phase in order to reduce the risk of nerve damage. Panoramic radiography is the most often used

diagnostic imaging modality for this purpose, since it provides only twodimensional information. Clinicians demonstrate the close connection between the 3rd molar & the mandibular channel by referring to a range of radiographic images (Del Lhano et al ., 2020).

Certain signals on panoramic radiographs have been associated with a high risk of nerve damage during mandibular 3rd molar extraction. The presence of one or more radiographic indications consistent with a tight connection between the mandibular channel & the 3rd molar, like a disruption of the mandibular channel wall's white line, darkening around the root(s), diversion of the mandibular channel, & narrowing of the molar channel (Kouwenberg et al ., 2016). Nerve disruption occurs about 3percentof the time after surgery on the lower impacted 3rd molar. However, in 0.3 percent of instances, permanent damage to the infraalveolar nerve (IAN) occurs. The risk of lingual nerve injury after impacted lower 3rd molar removal is about 0.4 percent, & the frequency of lasting damage is considerably lower (Nugere, 2018).

AIM OF STUDY

Reviewing the causes , risk factors, clinical and radiological assessment , and management of the inferior alveolar and lingual nerve damage associated with the extraction of mandibular 3rd molars.

CHAPTER TWO

REVIEW OF LITERATURE

REVIEW OF LITERATURE

1.Anatomy

The largest of the 3rd divisions of the trigeminal nerve is the mandibular or 3rd division. This kind of nerve is known as a mixed nerve. The mandibular division, like the ophthalmic and maxillary divisions, contains afferent fibers. The mandibular carries motor or efferent fibers to the mastication muscles, the mylohyoid and anterior digastric muscles, and the tensor veli palatini and tensor tympani muscles, in contrast to the tonner two divisions. Anatomists used to refer to the mandibular nerve as the dental nerve because of its significant connection with dentistry. After exiting the middle cranial fossa through the foramen ovale in the sphenoid bone, the mandibular division of the trigeminal nerve descends into the infratemporal fossa (Shankland, 2001). The MN descends into the infratemporal fossa through the foramen ovale (FO), where it attaches to the lateral pterygoid muscle (LPt). The buccal nerve (BN), masseteric nerve, posterior deep temporal nerves (DTN), and LPt nerve are all found in the anterior trunk. This trunk links the roof of the infratemporal fossa to the LPt. The auriculotemporal nerve (ATN), the inferior alveolar nerve (IAN), and the lingual nerve are the three major branches of the MN's broad posterior trunk. (LN) (Piagkou et al ., 2011).

The IAN is a sensory & motor fiber-containing branch of the mandibular nerve's posterior division. It travels via the mandibular foramen, the mandibular channel, & supplies blood to the mandibular teeth. It exits the mandibular channel through the mental foramen as the mental nerve. The nerve is about 3 millimeter in diameter & travels through the channel in a circular pattern. It may take a gentle curve toward the mental foramen, or it may climb or drop (Alhassani and AlGhamdi, 2010). The mental & incisive nerves are the inferior alveolar nerve's two terminal branches (Khalil, 2014).

It gives

route t0 branches that provide motor innervation to the

agastric muscle's mylohyoid & anterior belly, which are important for

rdising the hyoid & performing complicated jaw motions prior to entering

the mandibular foramen (speaking, swallowing, eating, & breathing)

the

(figure 1) (Ghatak and Ginglen, 2018).

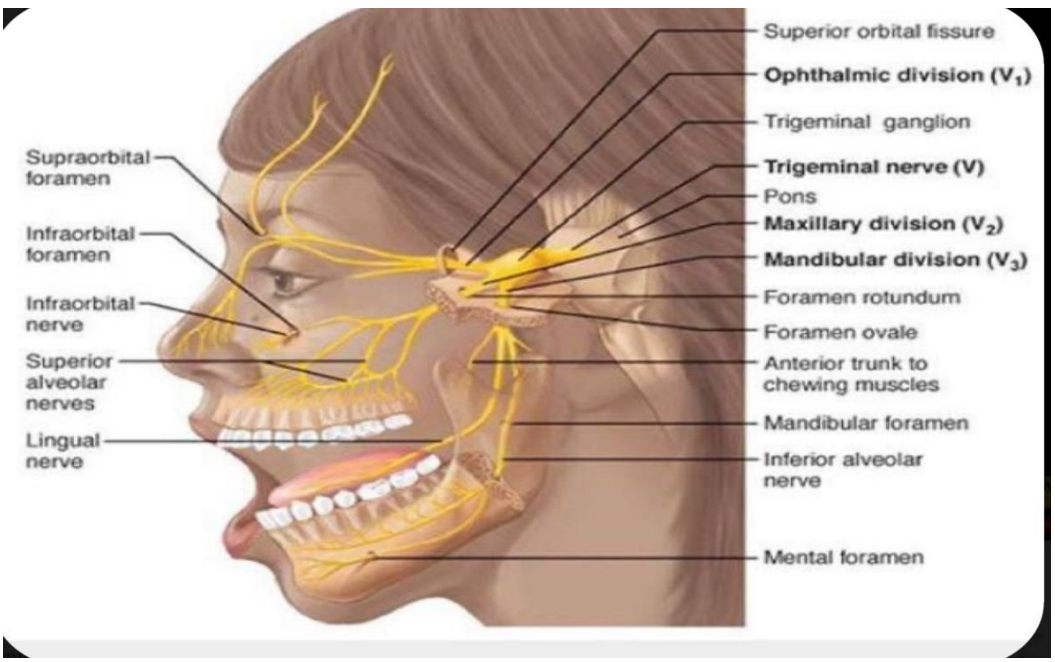


Figure. 1. Lateral view of the mandibular nerve branches in the infratemporal

fossa. ATN, auriculotemporal nerve; ADTN, anterior deep temporal nerve

PDTN, posterior deep temporal nerves; MsN, masseteric nerve; LPt, lateral

pterygoid muscle; BN, buccal nerve; LN, lingual nerve; IAN, inferior alveolar

nerve (Piagkou et al., 2011).

The LN branches out from the trigeminal nerve under the oval

foramen, distally receiving the chorda tympani & distributes to the tongue

(Shinohara et al., 2010). The lingual nerve begins under the lateral

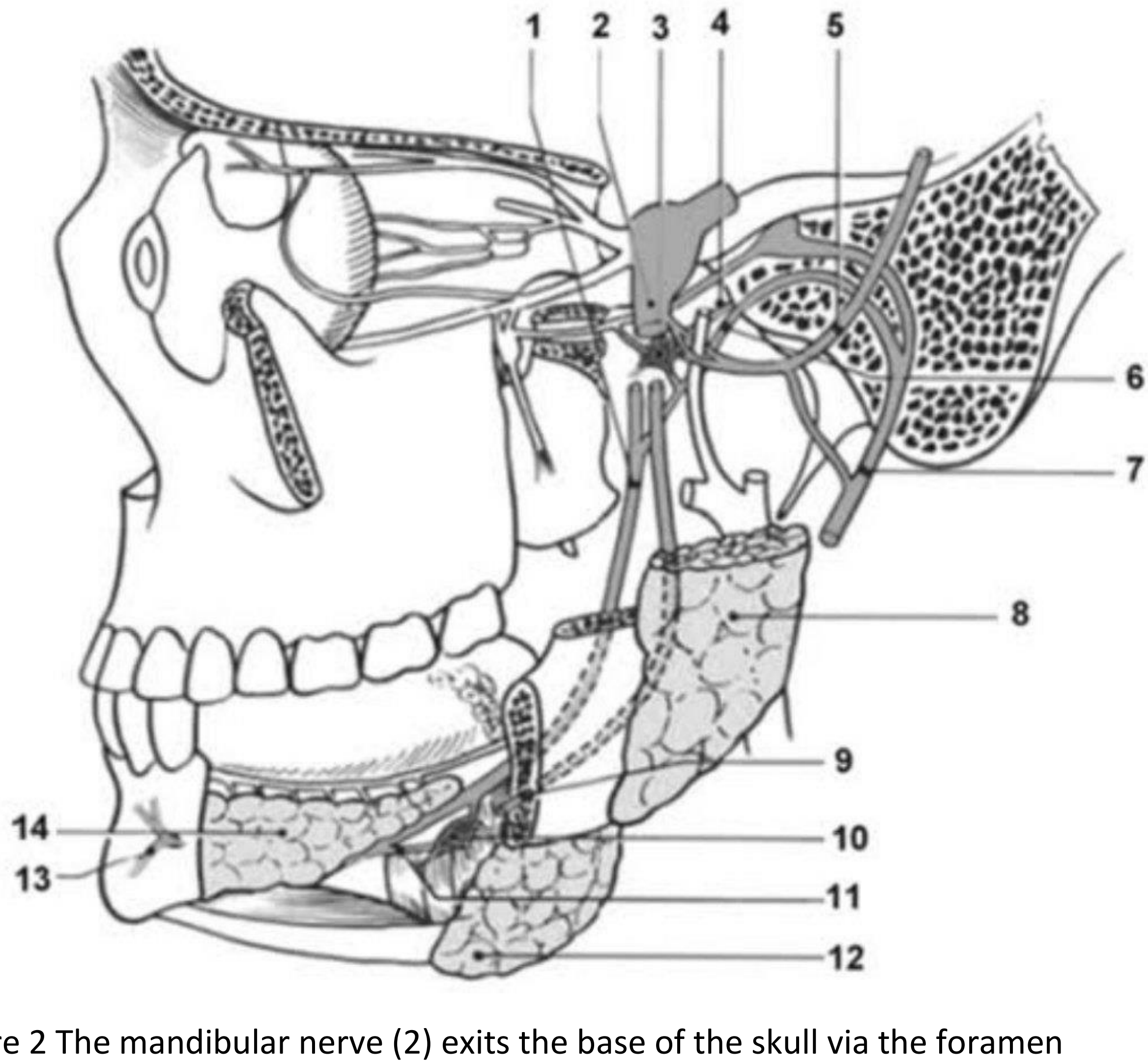
tip

pterygoid muscle, Just medial to & ahead of the inferior alveolar nerve.

A fter that, the nerve travels between the medial pterygoid muscle & the

mandible's ramus(Jerjes et al., 2010).

The lingual nerve leaves the pterygomandibular area in an oblique anterior & inferior direction, passing between the styloglossus & mylohyoid muscles & ending in the front portion of the mouth floor's mucous membrane (Esteves et al ., 2017). The lingual nerve (LN) supplies feeling to the mucosa of the floor of the mouth, the lingual gingiva, & the anterior two-thirds of the tongue, whereas the choda tympani, a branch of the facial nerve, supplies taste sensation to the front two-thirds of the tongue. The hypoglossal nerve innervates the posterior one-3rd of the tongue mucosa with general & taste sensations (figure 2) (Shinohara et al ., 2010).



igure 2 The mandibular nerve (2) exits the base of the skull via the foramen ovale,

With rami to the optical ganglion (3), then divides into threesensory branches:the auriculotemporal nerve (5) and lingual nerve (1), which give rami (11) to the submandibular ganglion (10), responsible for secretory innervation of the submaxillary (12) and sublingual glands (14), and participates in sensory innervation of the anterior two-thirds of the tongue, the inferior alveolar nerve (9), which penetrates the mandible at the mandibular crest, then, after giving many inferior dental rami, exits via the mental foramen for the sensory innervation of the chin (13). The mandibular includes an important motor contingent that exits the nerve root immediately above the foramen ovale and is distributed to the main masticatory muscles. Parotid (8), facial nerve (7), chorda tampani (6), small petrosal branch (4)(Leston, 2009)

2. Causes and risk factor

The complexity & degree of stress placed on the surrounding tissue varywhen the Oral & Maxillofacial Surgeon conducts more invasive or complicated surgery. Oral surgical methods differ in terms of complexity & degree of damage to surrounding tissue; when the Oral & Maxillofacial Surgeon conducts a more invasive or difficult procedure, both the surgical site & surrounding tissues will be exposed to greater trauma. The majority of 3rd molar surgeries go without a problem during or after the treatment, but this frequent procedure can occasionally result in many complications. Preoperative planning & the integration of surgical technique with surgical principles are critical in all surgical procedures to reduce the risk of complications(Daware et al ., 2021).

Several clinical & anatomic characteristics, including age, gender, forms of anesthetic, surgical procedures, Previous study has connected IAN damage to surgeon expertise & the anatomical connection between the inferior alveolar channel (IAC) & the 3rd molar roots. The natural

anatomical closeness of the lower 3rd molar roots to the IAN in particular may be the main cause & best predictor of IAN impairment after tooth extraction (Wang et al ., 2018).

Although nerve injury to the inferior alveolar nerve occurs seldom after surgical extraction of impacted lower 3rd molars, it is very unpleasant for the patient. It may occur in two ways: indirectly (infection in the postextraction region, pressure on the nerve from postoperative hematoma &/or oedema), or directly (injuries caused via close contact between the lower 3rd molar roots & the nerve).A permanent or transitory sensitivity disruption of different intensity in the area of nerve innervation manifests this injury. Sensory impairments are divided into two categories: paraesthesia (neuropraxia & axonotmesis) & anaesthesia (neurotmesis).

Neuropraxia is the mildest form of sensitivity disturbance, characterized by tingling, burning, & numbness in the neurological distribution area. It is frequently caused via ischemia or compression of the nerve, while the structure of the nerve remains intact. Axonotmesis is a severe sensory disorder that presents as hyperalgesia (overstimulationof stimuli) or allodynia (non-responsiveness to stimuli) (pain caused via harmless stimuli). It is caused via the interruption of particular axons in the nerve structure, resulting in Wallerian degeneration but with retained myelin coating. A total collapse of the morphological continuity of the nerve causes neurotmesis, which is a permanent & full loss of sensitivity

(Dubovina et al ., 2019).

According to Tay & Zuniga, the most frequent cause of IAN injury is trauma during 3rd molar surgery, accounting for 52percentof referrals. Some of the less common reasons include loco-regional anesthetic injections, endodontictreatment, orthognathic surgery, & implant surgery(Kang et al ., 2020).

Numerous factors, including the patient's age, the tooth's mesiohorizontal position, the depth of tooth impaction, the closeness of the roots to the IAN, the operator's surgical expertise, & surgical technique, have been suggested to be linked with an increased risk of IAN damage(Kang et al ., 2020).

Lingual nerve paraesthesia can be caused via a combination of circumstances, including the elevation of lingual flaps & the operator's experience. Paraesthesia is a sensory-only condition that does not result in muscle paralysis. In the majority of cases, nerve injury is discoveredafter the dental surgery, as a postoperative consequence. In the affected area, the patient will experience altered, decreased, or even complete lack of sensation. One or more senses may be impaired (taste, touch, pain, proprioception or temperature perception). That is, in the case of the mandibular or lingual nerves, some portion of the individual's lip, chin, mouth lining, or tongue .. Occasionally, the tooth itself, as it is pressed against the nerve. The most prevalent cause of lingual nerve paresthesia is improper instrumentation during the surgery (Sharanya and Sivakumar, 2018).

The less experience the operator has, the more likely the lingual nerve may be damaged as a result of the complex surgical process. Due toa totally bony impacted lower 3rd molar & severe flap retraction for an extended period of time, lingual nerve injury can result. Extensive bone cutting might also result in nerve injury (Khan et al ., 2016).

Unexpected & unexplained symptoms following a surgical treatment could be due to anatomical variations. Sensory disturbance of the lingual gingiva & mucosa may occur during floor of the mouth & tongue operations. Due to the involvement of the chorda tympani nerve, which runs inside the sheath of the lingual nerve, there will be a variable loss of taste after lingual nerve severance. Additionally, it may result in chronic numbness, loss of taste, & dysthesia of the anterior two-thirds of the tongue on the mandibular 3rd molar extraction side, resulting in a lifetime of discomfort. Because the lingual nerve's path varies significantly, particularly in the 3rd molar region, oral surgeons developed methods for 3rd molar extractions that restrict extractions to the buccal approach,giving the lingual nerve a wide surgical berth. These variations are said to stretch from the crest of the lingual bone to the floor of the mouth. Sometimes one of the differences is the lingual nerve going through the retromolar pad. Keeping the surgeon away from the lingual bone during extractions & the retromolar pad during incisions will keep the surgeon away from the different routes of the lingual nerve(Sharanya and Sivakumar, 2018).

Although the exact mechanism of lingual nerve injury during 3rd molar surgery is unknown, the most common causes are lingual plate perforation & lingual flap trauma during ostectomy or tooth sectioning, the use of a lingual flap retractor, & supra-crestal incisions because the nerve can be located & sectioned in this area in some cases (Lata and Tiwari, 2011). The lingual nerve may be damaged on the lingual or distal side of the 3rd molar if it is within 1 millimeter of the bone-basically in the periosteum-& is hurt when a lingual flap is reflected (Pichler and Beirne, 2001).

The lingual nerve is morphologically different from the inferior alveolar nerve in that it is not enclosed by a bone channel but rather by a thin layer of soft tissue & mucosa. As a consequence of sectioning a nerve, the cut ends retreat apart, become misaligned, & become restricted to the scar tissue (Bhat et al ., 2020). Similarly, Juodzbalys et al. discovered that lower wisdom teeth impacted distally had the greatest rate of lingual nerve damage (4.0%), followed by horizontal impaction (2.8%), mesial impaction (2.4%), & vertical impaction (1.9%). (Tojyo et al ., 2019).

Although the exact mechanism of lingual nerve injury during 3rd molar surgery is unknown, some of the most frequently cited causes include: lingual plate perforation & lingual flap trauma during ostectomy or tooth sectioning; use of a lingual flap retractor; chisel by a lingual approach associated with lingual plate fracture; & supra-crestal incision due to the nerve's location (Gomes et al ., 2005).

Age, unerupted teeth, deep impaction, specific radiographic symptoms, intraoperative IDN exposure, & use of the lingual split method have all been recognized as risk factors for IDN deficiency in lower wisdom tooth surgery. Age, unerupted teeth, distal impaction, elevation of the lingual flap, & use of the lingual split method all increased the likelihood of LN insufficiency after lower wisdom tooth surgery(Leung and Cheung, 2011

3. Preoperative Radiographical assessment of inferiro alvoelar and lingual nerve

Pre-operative radiological examination aids in predicting & avoiding post-operative problems, including paresthesia (Ghai and Choudhury, 2018). Radiological imaging is an important diagnostic & surgical tool. As aresult, before extracting the mandibular 3rd molar, a detailed preoperative radiographic examination is required. This evaluation should ideally aid the surgeon in determining the operation's difficulties & selecting the most appropriate surgical approaches, like where to remove bone, how to break the tooth, & which direction roots can be elevated (Saha et al ., 2019) . . Intraoral periapical radiography (IOPAR), orthopantomography, CT,

CBCT, & other diagnostic & imaging techniques are used to determine the proximity of impacted mandibular 3rd molar (IMTM) roots to the mandibular channel (Saha et al ., 2019). The overlaying of the channel by the molar roots provides separate pictures based on plain radiography alone (Gilvetti et al ., 2019). Although magnetic resonance imaging has been demonstrated to be capable of imaging the lingual nerve, it is not widely utilized in practice due to the high cost & difficulties in determining whether the nerve has been injured. Ultrasound is a low-cost method that may be performed rapidly, even in the office (Olsen et al ., 2007).

3.1 Panoramic radiograph

Panoramic radiography is the most often utilized radiographic method by oral & maxillofacial surgeons to see impacted mandibular 3rd molars & assess the risk of damage to the inferior alveolar nerve. When compared to periapical radiographic procedures, panoramic radiography has a number of advantages. When opposed to taking images using periapical procedures, patients prefer panoramic radiographs because they cover a larger region, which includes the structure of the jawbone & teeth. Images that are easily understood by viewers can be used for patients who are unable to open their mouths. The position of the film in periapical radiography can be painful for the posterior teeth. Holder placement in the lower 3rd molar area is difficult. Because it is near the border of the film, the apical region of the tooth is frequently not fully covered (Mulyani and Pratama, 2020).

produce a clinical dental image in a short scan time & with a minimal dose of radiation. Panoramic radiographs, on the other hand, include a number of flaws, including anatomical noise, superimposition, & geometric distortion (Zhu et al ., 2021) .

Before surgical removal of L3Ms, a panoramic radiograph is considering necessary (Mabongo and Thekiso, 2019).

Despite the fact that panoramic radiography produces twodimensional images, several radiographic signals indicate the IAC's intimate anatomical association with the IMTM. Rood & Shehab10 were the first to describe these radiographic findings, & they have been used as a reference since 1990. On the roots of the IMTM, four of these indicators can be seen: root darkening, a dark & bifid apex, root narrowing, & root deflection. The disruption of the IAC's cortical border, constriction of the IAC, & diversion of the IAC are the other three (figure 3) (Uzun et al .,2020).

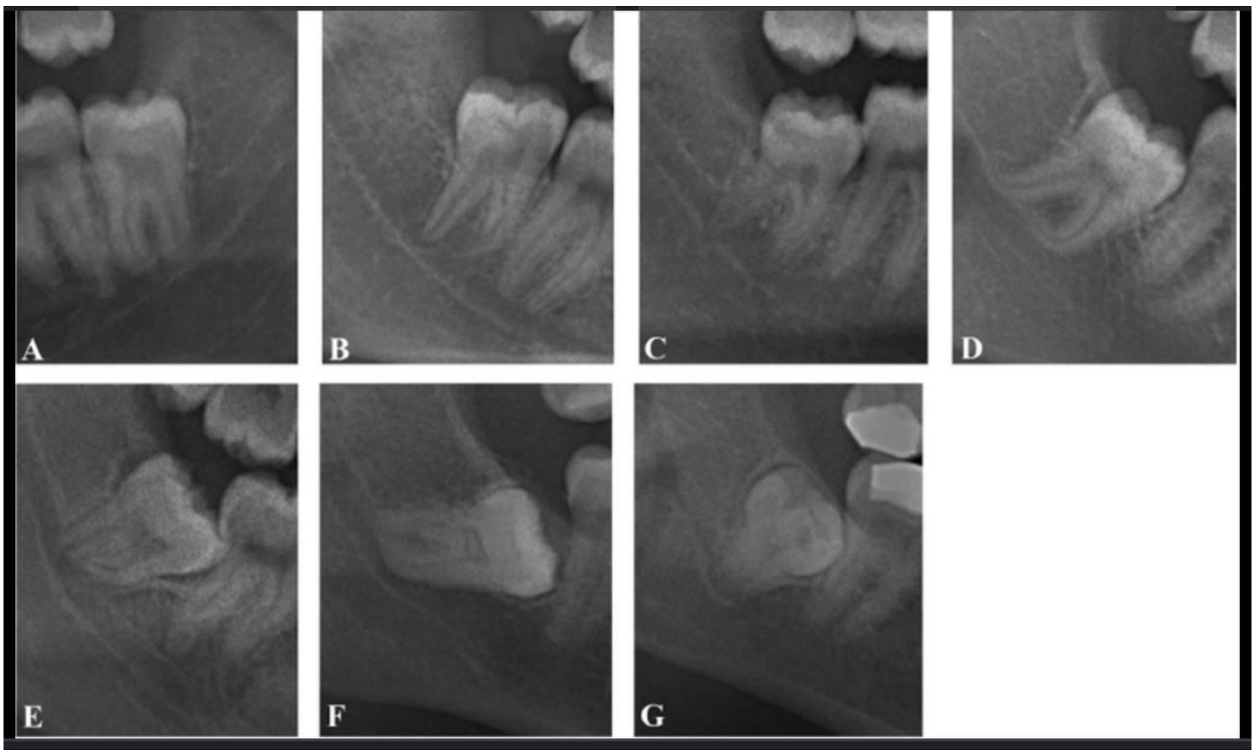


Figure 3. Appearance of radiographic signs considered to be indicative of the close anatomical relationship between the IAC and the MTM on the PR sections a) darkening of the root b) a dark and bitid apex c) narrow ing of the root d) deflection of the root e) interruption in the cortical border of the lAC) narrow ing of the IAC g) diversion of the IAC(Uzun et al., 2020)

However, OPG gives no information about the buccolingual dimension of MC in relation to the impacted MTM roots. Because the nature of riskcan vary with buccolingual position of the MC, & buccolingual position of the MC is associated with age & race, assessing

the buccolingual dimension of the MC relative to the impacted tooth roots is important in predicting risk of IAN damage during surgical removal of impacted MTM (Herath et al ., 2021).

3.2 cone beam computed tomography

Cone Beam Computed Tomography (CBCT) was developed for oral & maxillofacial applications &, like CT, enabled 3D exploration & more accurate imaging than 2D imaging. The low cost of CBCT technology has resulted in a rapid entry into the area of dentistry, necessitating the dedication of dental practitioners & academics to research the technology's applications (Venkatesh and Elluru, 2017)

Through the ability to obtain numerous successive crosssectional pictures, computed tomography (CT) was the first technique to provide viewing of both hard & soft tissues of the face bones (Ga?taAraujo et al ., 2020). Clinicians can now measure IAN risk using direct vision from various planes & 3-dimensional views thanks to the development of CT scans. Several CT radiographic characteristics, including IAC cortication status, IAC position, & form, have been linked to a higher risk of IAN damage (figure 4) (Wang et al ., 2018).

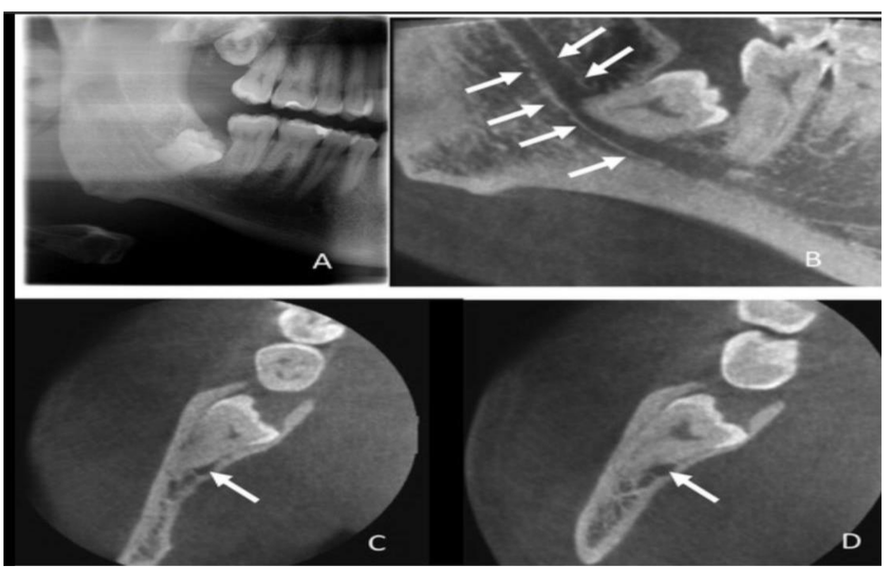


Figure 4 Example of a right side third molar that had a CBCT performed based on signs in the panoramic image (A). (B) Shows a CBCT-section

In the sagittal plane, and (C, D) show sections of the distal- and mesial root respectively in the axial plane. White arrows mark the mandibular

Canal with no bony separation to the third molar and narrowing of the canal lumen over the apical part of the roots. The treatment decision was coronectomy.(Matzen et al ., 2020)

3.3 MRI(magnatic resonance imaging)

All cranial nerves (CN) are visualized using magnetic resonance imaging (MRI), By utilizing certain MR sequences, each nerve segment may be viewed & studied in detail. Due to the intricacy of the CNs' path & surrounding anatomic structures, thorough study requirescarefulplanning & selection of the right MRI method. The imaging plane, coil selection, slice selection, in-plane resolution, & use of special methods may all be customized to the specific CN & region of interest in order to get the highest possible image quality (Miloro and Kolokythas, 2011).

Despite the fact that MRI may give comprehensive information, there is no regular presurgical evaluation of the LN& IAN route & integrity. Rather than that, MRI is the main imaging modality for evaluating the CNs' status, which is most often performed in the context of a disease process or after a brain injury (figure5) (Miloro and Kolokythas, 2011).

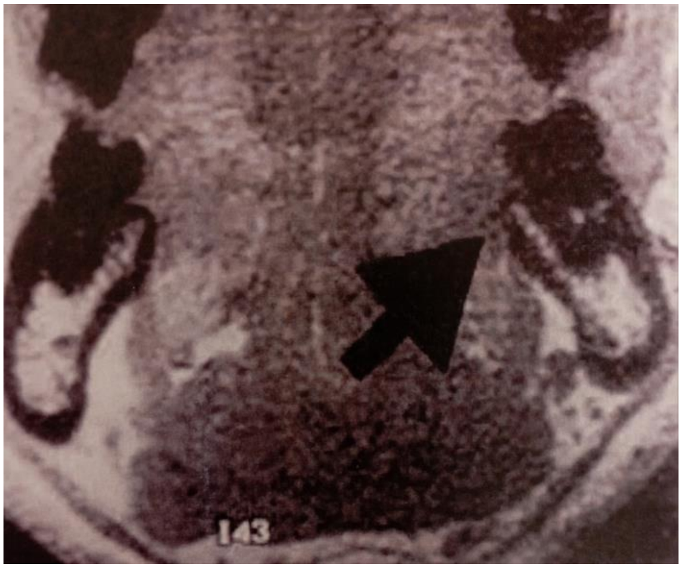


Figure 5. Coronal HR-MRI The position of the lingual nerve in the third molar region is seen in this figure (arrow). The nerve has an oval form.(MIiloro et al., 1997)

4. Clinical assessment

Trigeminal nerve injury is a dangerous complication of removing the lower 3rd molar surgically, & it is a clinically significant issue that needs to be addressed. After 3rd molar extraction, the frequency of inferior alveolar nerve (IAN) injury varies between 0.26 & 8.4 percent, whereas the frequency of lingual nerve (LN) sensory loss varies between 0.1 & 22 percent (Agbaje et al ., 2015).

A patient's lip or chin may go numb as a result of IAN injury. Orofacial sensory impairment may impede speech, chewing, & social interactions, all of which can have a significant impact on a patient's quality of life (Su et al ., 2017). If an IAN is damaged, the patient may experience tingling, numbness, burning, or pain in the ipsilateral lower lip, chin, gingivae, & teeth (Moosa and Malden, 2018)

Lingual nerve damage, a well-known consequenceof3rdmolar extraction,may result in a persistent lingual sensory deficit , manifesting as lost or altered feeling, accidental tongue biting, & the onset of severe neuropathie pain, all of which can result in a decreased quality of life (Atkins and Kyriakidou, 2021).

LND results in somatosensory (hypoesthesia, anesthesia, paresthesia, or dysesthesia) & taste (hypogeusia, ageusia, or dysgeusia) abnormalities of the ipsilateral half of the tongue. Inability to retain food or liquid in the oral cavity, involuntary tongue crushing while chewing, difficulty speaking, burning sensation, discomfort, & phonation abnormalities, as well as alterations in food & beverage taste perception (Pippi et al ., 2018).

It is more essential to use objective testing to evaluate nerve dysfunction than to depend on a patient's subjective description of neuropathie changes. Neurosensory clinical examinations or more sophisticated electrophysiologic investigations may give objective data (Bhat and Cariappa, 2012). Neurosensory testing may be divided into two types based on the specific receptors activated by cutaneous touch: mechanoceptive & nociceptive testing. Three kinds of mechanoceptive testing exist: two-point discrimination (TPD), static light touch, & brush directed stroke. Nociceptive testing may be classified into two types: pinprick & thermal discrimination (Poort et al ., 2009).

Neurosensory testing is used to determine the degree of sensory disturbance, the extent of sensory recovery, & the need of surgical intervention (Akal et al ., 2000).

- Two point discrimination:the two-point discriminator, alternatively referred to as an aesthesiometer, was used to evaluate two-point discrimination in the right & left quadrants. Gradually increase the distance between the spots by 2 millimeter until the patient can differentiate between two distinct & distinct points. The spots were moved closer together until the patient could only tell them apart by one or two. It quantifies the number of sensory receptors & afferent fibers that are functional as well as their density (Degala et al ., 2015).
- Light touch: The LT test was conducted with a wisp of cotton wool. The patient's perception of "touch" is evaluated via contact between the right & left quadrants. It is utilized to monitor the integrity of the Merkel cell & Ruffini ending, which are innervated by myelinated A beta afferent axons with a diameter of 5-15 m. These receptors adapt slowly, & their most likely sensory modality is pressure (Degala et al ., 2015)
- Brush directional strock: : the region was inspected with fine camel hairbrushes. The test site was stroked for 1 cm from right to left or left to right (on the operated side, the lower lip & chin). Sensory modalities for these quickly changing sensors include vibration, touch, & flutters (Degala et al ., 2015).
- Pinprik test: This test is done by pricking the right & left sides of quadrants with neurosensory impairments using a sharp probe held between the thumb & index finger. This test assesses nociceptive free nerve terminals as well as the small A delta & C fibers that innervate them (Degala et al ., 2015).
- Warm and cold test: For the warm test, a test tube was filled with

water at a temperature of 45°-50°. The cold test is performed by applying an ice cube to the test area. It is utilized to differentiate between myelinated & unmyelinated fibers with very small diameters

(Degala et al., 2015).

- Blunt discrimination: By placing the blunt end of a probe or a culture swab on the test region, blunt discrimination was enabled. Myelinated to a greater extent The blunt ends represent alpha afferent axons with a diameter of 5-15 m (figure 6) (Degala et al ., 2015).

Figure. 6 Neurosensory evaluation. a Two point discriminator. b Brush stroke test. c Pin prick test. d Blunt discrimination test. e Warm test. f Light touch test(Degala et al., 2015)

- ## 5. Prevention of nerve damage

in high-risk situations, various treatments have been recommended, including coronectomy with the roots left in place, stepwise surgical removal of the 3rd molar, modified coronectomy & grafting, orthodontic aided extrusion, & pericoronal ostectomy(Mukherjee et al ., 2016).

5.1 Coronectomy

The coronectomy procedure is an alternative to traditional tooth extraction for impacted teeth that tries to reduce the risk of IAN damage. This method entails removing the dental crown while keeping the residual roots in the alveolar bone. One of the possible effects of coronectomyis the migration of residual roots. This happens in 14-81 percent of patients, with an average migration of 2-4 millimeter toward the oral cavity after 2 years. The root migration is severe in the first six months after surgery, considerable in the first two years after surgery, & then stabilizes between the second & 3rd year. If a continuous migration occurs, it might cause irritation or localized infection in the oral cavity for up to 7 years after the surgery (Barcellos et al ., 2019). Because the IAN resides deep within the jaw, a coronectomy can reduce the chance of IAN damage(Tuk et al ., 2021).

The goal of a coronectomy is to remove only the crown of an impacted mandibular 3rd molar, preventing stress to the IAN. As a result, the roots are preserved, & the IAN is unaffected (Tuk et al ., 2021).

Preoperatively, the patients' demographic information (age & gender) as well as their tooth condition (eruption status, pattern & depth of impaction, root form, & radiographic signs) were documented (Leung and Cheung, 2018). The root complex migration is not a true complication of thecoronectomy treatment, but rather a result of the tooth's natural eruption pressures once coronal resistance is eliminated. However, if the root complex migrates into the oral cavity, intervention may be required (Pedersen et al ., 2019).

In general, the patient's age is the most important determinant in determining the degree of the migration. Root migration is likely to be larger in younger patients. Other parameters, including as sex, root complex shape, eruption state, & impaction depth, have not been demonstrated to affect the degree of root migration (Pedersen et al ., 2019).

The success of a coronectomy is contingent upon the residual root fragment containing viable, non-inflamed pulpal tissue & normal surrounding bone. As a consequence, there are a number of circumstances in which a coronectomy is contraindicated. Among them are caries with a pulpal involvement risk, mobility, apical disease, association with cystic tissue that is unlikely to resolve if the root is left in place, tumor, patients who have had an osteotomy, those who are immunocompromised, & those who have received treatment prior to radiotherapy (Gleeson et al ., 2012). Teeth that are horizontally affected along the course of the inferior alveolar nerve are contraindicated, since sectioning the tooth may jeopardize the nerve. As a consequence, the technique is more suited to vertical, mesioangular, or distoangular impactions in which the nerve is not jeopardized by the sectioning (figure7 ,8) (Ahmed et al ., 2011).

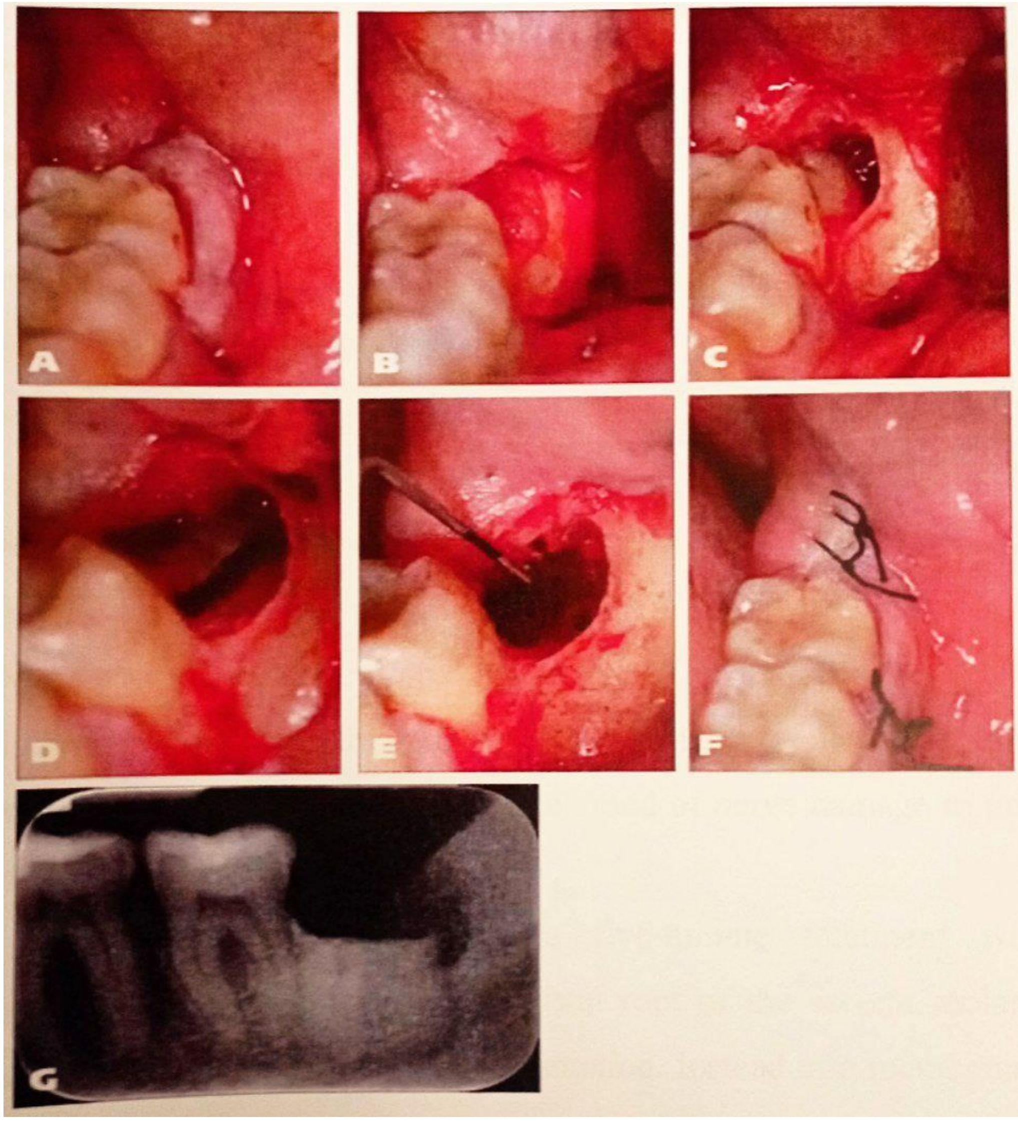


Figure 7. Surgical procedures. A. An envelope incision. B. A flap elevation. C. A imal buccal ostectomy. D, Mesiodistal toothsectioning. E. A lingual cut surface nsitionin relation to the lingual bony margin. F. Theprimary closure with 4-(0 sillk sutures. G. A pstoperative periapical radiograph showing a conplete crown removaflonac0.etal2012)

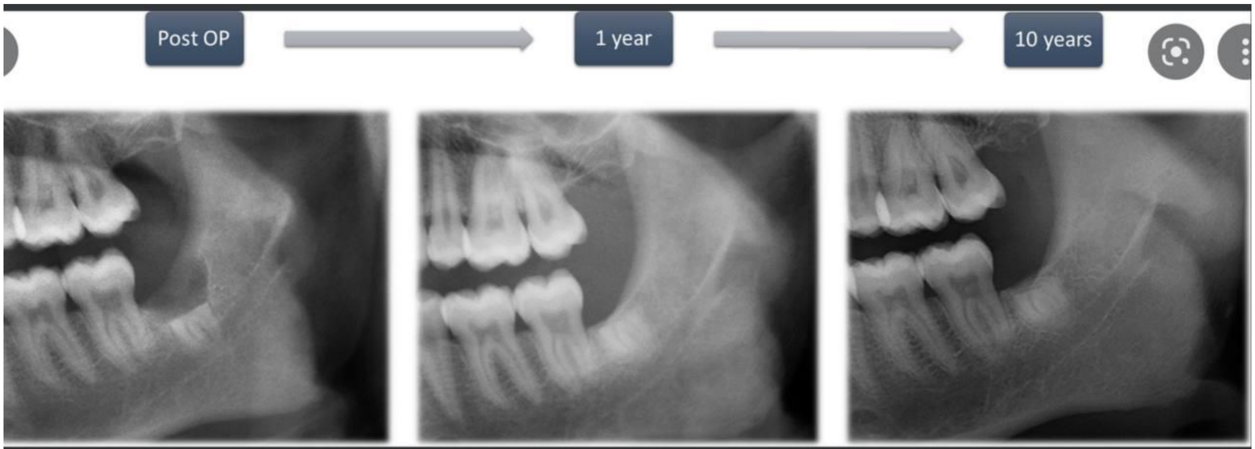


Figure. 8. Root migration documented by panoramic ra:. radiographs obtained postoperative, and at the 1-year and l0-year 1olloW-ups(Pedersen et al.. 2018)

Coronectomy with grafts & alterations (MGC) The technique's objectives are to reduce intraoperative root walkout, to reduce the risk of developing &/or preexisting periodontal pockets distal to the second molar, & toreduce the risk of delayed root migration necessitating a second surgical procedure, all while maintaining excellent IANI prevention. As a consequenceof the decreased pocketdepth,futureperiodontaltreatments may be avoided or limited. When the risk of IANI is significant, MGC involves the removal of the crown & a portion of the root/s of an afflicted MTM. As a result of this novel technique, efforts are being made to avoid inadvertent intraoperative root loosening. This is accomplished by stabilizing the radicular fragment during cutting & while separating the coronal portion, thus decreasing the likelihood of nerve damage in general (Leizerovitz and Leizerovitz, 2013). .

Using ultrasonic scaling & a five-minute treatment with a 25percentsolution of citric acid, the distal root of the second molar was detoxified & prepared for bone transplantation. Instead of a membrane, the bleeding location was treated with a resorbable hydroxyapatite (HA) graft. It was pushed before to suturing the flap using 4-0 Vicryl sutures to achieve complete graft coverage & primary closure(Leizerovitz and Leizerovitz, 2013)

5.1.1 Complication of coronctomy

The few hazards associated with coronectomy are often minimal & include postoperative infection, dry socket, & discomfort that may be managed with antibiotics & painkillers. Two additional issues include unsatisfactory healing & root eruption into the mouth cavity. Retention of enamel on the root surface may result in poor healing. Re-operation, or the removal of remaining roots, is a commonly performed procedure to correct coronectomy failure (Frenkel et al ., 2015).

With the resurgence of interest in coronectomy, there is worry that the surviving root may get diseased later owing to the loss of pulpal vitality, or that the roots would migrate & cause symptoms. To reduce the risk of infection, coronectomy should be done only when there is no clinical or radiographic evidence of caries in the 3rd molar or pulpal, periodontal, or apical illness (Jowett et al ., 2016).

Deep periodontal pockets on the distals of second molars comparable to those following extractions in comparable circumstances, root migration necessitating a second procedure, dry sockets, local postoperative infections, postoperative pain, & inadvertent root removal, as well as root walk-out during surgery, all of which increase the risk of IANI, are all disadvantages of this technique (also known as a failed coronectomy)(Leizerovitz and Leizerovitz, 2013).

Mobilization of the root fragment (failed coronectomy) happens when the break between the root & the crown is insufficient, & excessive force is used to fracture the crown section, as well as when conical roots are used (Sureshkannan et al ., 2020).

5.2 Orthodontic extraction

In high-risk IAN injury patients, the "orthodontic extraction" procedureis a combination orthodontic-surgical strategy for removing impacted mandibular 3rd molars. There are two major ways that can be used depending on the technique. On the maxillary/mandibular molar, one method involves the use of orthodontic brackets & hooks, while the other requires the use of bone miniscrews(Wang et al ., 2019).

This orthodontic extraction technique enables quicker, simpler, & most significantly, safer extraction of mandibular 3rd molars with tight anatomic contact between the root & the mandibular channel. There is no danger of direct nerve damage because to the increased distance between the roots & the mandibular channel, as well as the decreased instrumentation required during extraction. Already luxated, the tooth is a more advantageous position for surgery. A more rapid & straightforward extraction leads in less postoperative edema & reduces the risk of direct nerve injury. Another serious complication linked with 3rd molar extraction that may be prevented via orthodontic extraction is mandibular fracture(Bonetti et al ., 2007).

The orthodontic-assisted removal includes surgical appear of the wisdom teeth crown, insertion of an orthodontic anchorage, & orthodontic eruption to move the roots far away from the IAC; the removal is completed three-six months later, when tooth has moved enough in the occlusal surface. Despite the fact that this therapy could be enhanced periodontal recovery distal to the second molar, it is difficult to apply, patients do not tolerate it well due to orthodontic device sensitivity, & it is time-consuming & costly (figure 9) (La Monaca et al ., 2017).

a Orthodontic extrusion. A, Distal movement of the third molar using 3-

. (arrow). B, Titanium-molybdenum alloy cantilever for third mol

extrusion (circle)(Bagheri et al., 2010)

5.3Pericoronal ostectomy

The 3rd molar is extracted in two stages. In stage one , bone is removed to remove bony interferences & establish suitable space for upright movement of the tooth, as well as slight luxated of to enhance its eruptive potential; stage two involves extraction a weeks later. The chance of LN injury in rare conditions requiring lingual exposure of the coronal surface as well as reduce risk of injury are all disadvantages of this technique (La Monaca et al ., 2017).

Local anaesthetic or intravenous sedation are also options for surgery. Using a 703 bur, the buccal bone is removed. after a normal buccal total thickness flap is mirrored to expose the damaged MTM's crown to the CEJ. All bone overhangs are removed & the crown of the tooth is entirely exposed. . It arise that at least three millimeters of distobuccal bone beyond the crown of the impacted tooth should be removed in order to provide an adequate "eruptive space" for tooth movement & to eliminate any bony interferences. It is essential to get a complete picture of the MTM crown & to ensure that the tooth's aprojected occlusal mobility is not restricted. After 6 to 8 weeks, the tooth that is more coronally situated may be readily pulled with little risk of nerve damage (figure10) (Tolstunov et al ., 2011).

Figure 10. Intraoperative photograph displaying the pericoronal ostectomy

10.

Technique with removal of all pericoronal bone and coronal exposure. At least 3 mm of distobuccal bone behind the erown of the mandibular third molar has to be removed to create an adequate "eruptive space" for upward tooth movement. (Tolstunov et al., 2011)

The ramus of the mandible appears to preclude distoangular impactions from erupting, while adjacent second molars preclude horizontal & steep mesioangular impactions from erupting, & the pericor-onal bone precludes vertical & slight (shallow) mesioangular impactions from erupting in the limited space between the second molar & the ramus. As a consequence, the PO technique is ineffective for horizontal, distoangular, or deep mesioangular impactions (55? angulation relative tothe second molar), but is very successful for shallow mesioangular & vertical MTM impactions (55? angulation related to the second molar)(Tolstunov et al ., 2011)

Another method that requires two surgical sessions is the staged approach, which includes eliminate mesial part of the wisdom tooth crown to create enough gap distal to the second molar to enhance root movement far away the IAN, which is removed during the second surgical technique. Because no intraoral appliances are required, we believe that using this strategy enhances Patient comfort is improved, & chair time & treatment expenses are reduced when compared to the orthodontic-assisted technique . Although other surgical procedures for removing mandibular 3rd molars have been offered, The classic surgical remove using a the buccal access the most common method is still performed around the world(La Monaca et al ., 2017).

Protecting the lingual nerves requires extreme care. Although many kinds of lingual retractors have been suggested, including those of Howarth, Ward, Meade, Hovell, Walters, & Rowe, there is little scientific evidence to support one being better to another, & the surgeon's personal experience seems to play a significant role in the decision. However, it has been shown that a broad & smooth active retractor surface, as opposed to a small & pointed active retractor surface, causes less stress on the lingual nerve during flap retraction (Pippi et al ., 2017).

While separating the lingual flap for retractor insertion is associated with a high risk of acute nerve injury, it may reduce the risk of permanent nerve injury by improving access to & visibility of the operative region, allowing for safer use of both manual & rotational tools(Pippi et al ., 2017).

Preoperatively, the flap design was determined by the extent of the inclusion & 3rd molar's location , The LN & facial artery must be kept out of the flap incision. The most crucial step in removing impacted mandibular 3rd molars is a good mucoperiosteal flap for gaining optimal surgical access, A three sided or linear buccal flap is likely to be the best option. A distal releasing incision should be made in the retromolar area, somewhat oblique in the vestibular direction, from the dista-buccal crown edge of the second molar, without touching the lingual side of the crestal mucosa. to protect integrity of the LN. On the buccal surface of the jaw, the mucoperiosteal flap must be raised, & the lingual soft tissues must be elevated a few centimetres, must be done with care to avoid unintentional periostealelevatormovement (Figure. 11) (La Monaca et al ., 2017).

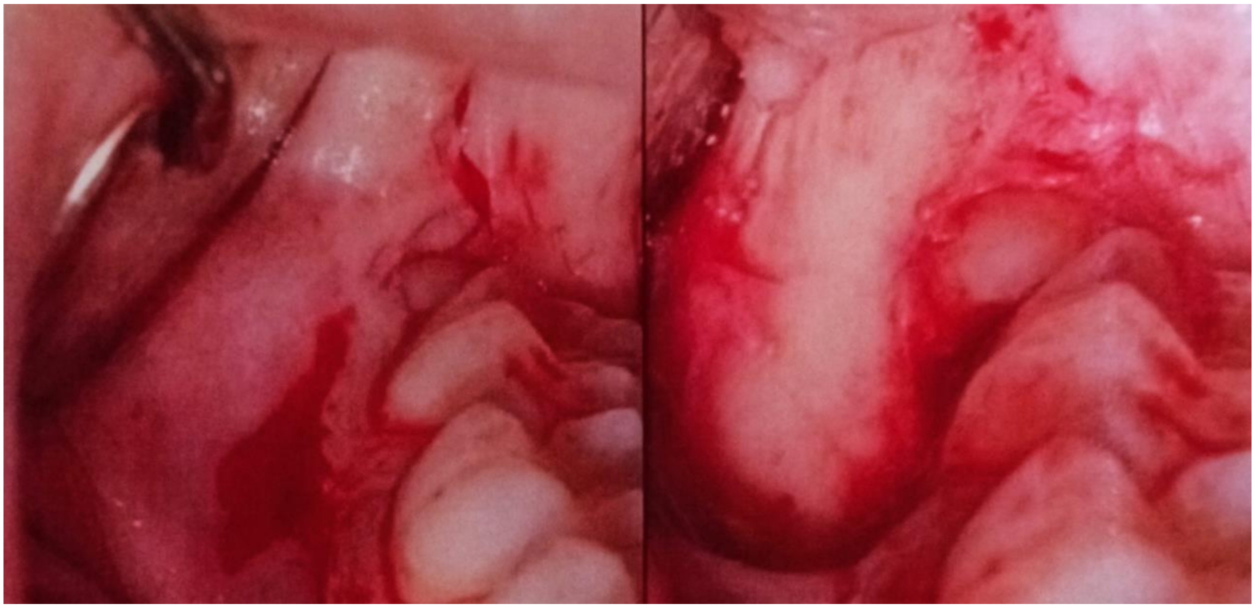


Figure 11. Mucoperiosteal flap: the distal releasing incision in the retromolar area Should not involve the lingual side of the crestal mucosa (La Monaca et al., 2017).

When a lingual flap is necessary for the 3rd molar position, it should be broad enough to enable good access to the operative site , & the releasing cut should be placed through safety zone, some distance from the inclusion site, to reduce inadvertent traction or LN injury (La Monaca et al ., 2017).

Ostectomy of the mandibular 3rd molar is typically performed from the occlusal surface to the cementoenamel junction, & it should be performed conservatively on the distal-lingual sides to prevent contact with the IAN & LN. To reduce heat stress, tungsten-carbide round & fissure burs mounted on a low speed handpiece should be utilized to remove bone tissue while using sufficient cooled irrigation (figure12) (La Monaca et al ., 2017).

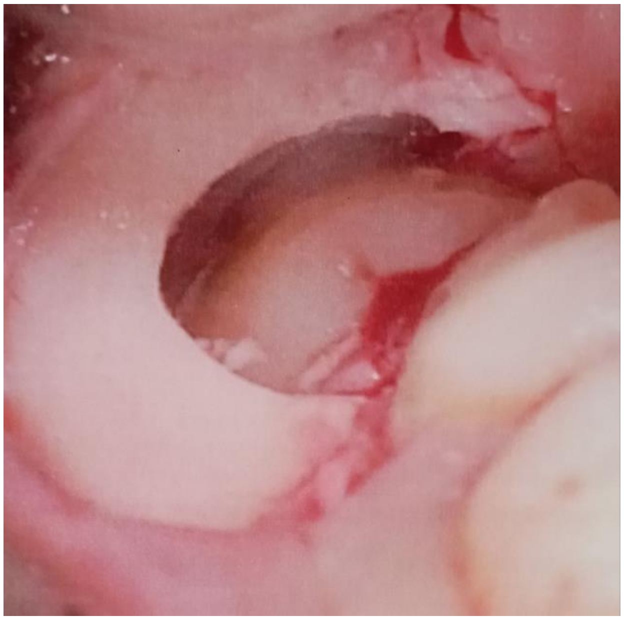


Figure 12. Ostectomy: should be distal and distal-lingual as conservative as possible on the side (La Monaca et al., 2017).

Tooth sectioning protects the IAN from crushing or stretching while enabling it to disengage by reducing its attachment zone. After sectioning using a tungsten-carbide round bur placed on a high-speed handpiece, a small surface of undamaged dental tissues next to the nerve root should be left. The diaphragm will be gently shattered utilizing elevators to finish the sectioning technique (Figure. 13) (La Monaca et al ., 2017).

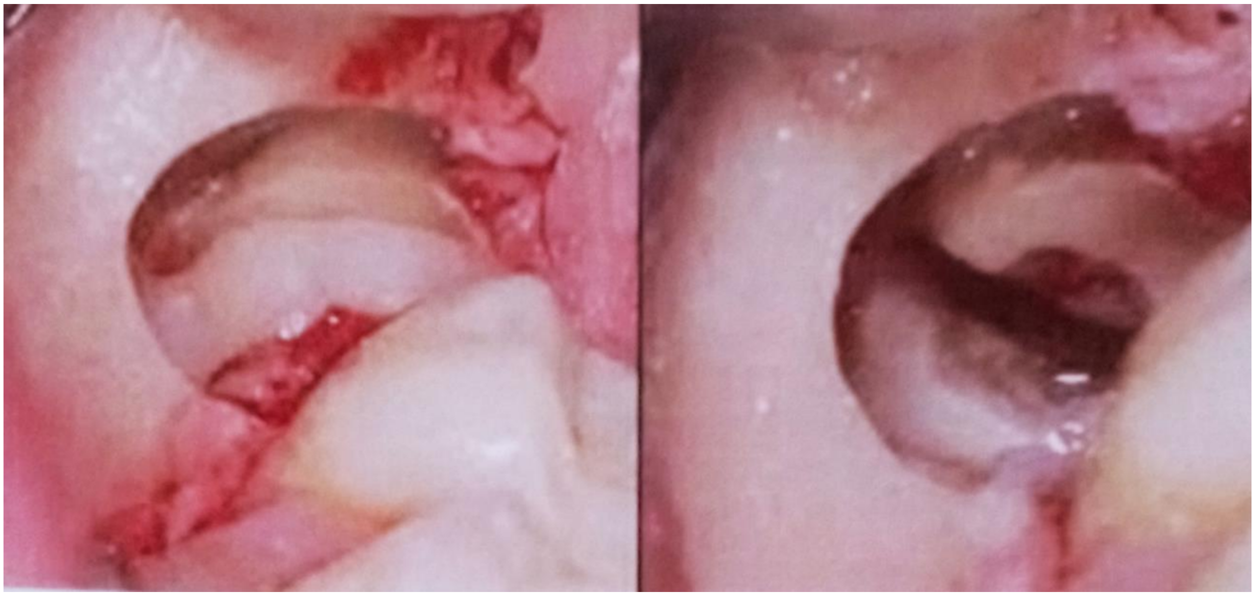


Figure 13, Tooth sectioning is designed to allow disengagement of the element by decreasing its zone of retention and to avoid compression or stretching of the A.N (La Monaca et al., 2017).

Tooth extraction should be done with a root elevator, with the force vector directed in the path of withdrawal indicated by the curve of the root apex, to avoid nerve compression or stretching. To prevent ripping the lingual mucosa & injuring the LN, socket debridement should be done with caution after tooth extraction, especially while separating the lingual section of the follicle remnants from the tissues. The site of extraction was irrigated with normal saline fluid at room temperature (Figure. 14) (La Monaca et al ., 2017)

Figure 14 .Socket debridement is performed with extreme care, avoiding to tear the lingual mucosa not to damage tlhe LN (La Monaca et al., 2017).

Stitching in the retromolar pad region should be performed with the needle entering from the inside in a buccal-lingual direction, as a passage in the opposite way may expose the LN to the danger of a puncture lesion & damage as a result of its contraction during the knotting process (Figure. 15) (La Monaca et al., 2017).

Figure 15. Suturing in the retrom01ar pad area should be performed with the 1celle piercing the mucosa from the inner side n a buccal-lingual direction not to Expose the LN to the risk of puncture and shrinkage lesions during the knotting procedure (La Monaca et al., 2017).

6. Treatment of nerve injury

To evaluate the possibility of recovery & design a treatment strategy, it is critical to first understand the process of nerve injury. The IAN or LN might be injured directly or indirectly by the tooth or surgical equipment during lower 3rd molar surgery(Leung, 2019).

The majority of occurrences of nerve damage following wisdom teeth removal are discovered in the post-operative period, rather than during the procedure. The comprehensive monitoring of sensory recovery over a three-month period aids in the differentiation of different types of injuries & the determination of whether the nerve is vulnerable to dangers & problems. If you don't heal, you'll have to have surgery. Paraesthesia does not necessitate surgical intervention. The delivery of stimuli to the numb area is used to monitor the recovery of sensation in the numb area. The first development of regenerated nerve ends, followed by the level of recovery, is shown by the patient's response & feedback (Shanmugapriyan and Ebenezer, 2020).

The great majority of these injuries (90%) are only transient & heal within eight weeks. However, if they last longer than six months, they are deemed permanent. (Coulthard et al ., 2014). The method of treatment for injured IANs/LNs was determined by the type of injury, the time of the injury, neurosensory abnormalities, & intra-operative observations. Nerve transections discovered during surgery should be corrected immediately; minor nerve injuries can be repaired later (Kushnerev and Yates, 2015).

When compared to LN repair, the technical requirements & surgical timeforIAN repair are higher. A sagittal split ramus osteotomy is required for IAN repair in order to expose the nerve's path. It is then followed by nerve mobilization to allow for tension-free healing. Mobilization is difficultdue to the nerve's location within the bone channel, & it usually Necessitates the laterlazation of the entire nerve all the way from the mental (leung,2019)

Figure 16. Lateralization of the inferior alveolar nerve from the mental foramen

allows mobilization of the nerve for reanastomosis (Leung, 2019).

.There are a variety of & nonsurgical therapies or treatments that can help with healing, including enhancing feeling. They can be categorized as follows:

1. Surgical - a wide range of procedures are available.

2. Laser treatment - partial loss of sensation has been treated with low-level laser treatment.

3. Medical - medication like antiepileptics, antidepressants, & pain relievers. (Coulthard et al ., 2014).

6.1 Surgical intervention

6.1.1 indications for microsurgical nerve repair

a. Nerve transection or laceration seen or suspected.

b. a lack of improvement in anesthesia three months after the injury

c. discomfort caused via a neuroma or entrapment of a nerve

d. discomfort caused via a foreign body or channel deformation

e. a gradual loss of feeling or an increase in discomfort (Akal et al ., 2000).

6.1.2 contraindications to microsurgical nerve repair.

A. neuropathic pain in the central nervous system
B. indications of improved anesthesia
C. praxia neuronale
D. a tolerable level of paresthesia
E. neuropathy due to metabolic dysfunction
F. patient with a medical condition
G. Age extremes
H. an extended period of time after an injury (Akal et al ., 2000).

External neurolysis: This treatment removes any restricting fibrous/scar tissue or bone from the nerve's connective tissue bed. Scar tissue may develop in response to an injury to the surrounding tissue, compressing or constricting nerves, blocking nerve communication, &, in certain cases, delaying nerve recovery(Coulthard et al ., 2014).

Decompression-treated IAN injuries healed faster than anastomosis treated IAN injuries, with sensation returning within three weeks & complete recovery taking two to three months (Kushnerev and Yates, 2015).

Internal neurolysis: is a technique for examining & releasing epineural fibrosis-affected nerve fascicles. It's employed when there's signs of nerve fibrosis & associated changes in the appearance of the nerve .. Some surgeons advise against this surgery since it may result in the production of more scar tissue (Coulthard et al ., 2014).

Neurorrhaphy: other names for this technique include coaptation & direct anastomosis. It is utilized in situations when the nerve has been transected & the two ends of the nerve may be sutured together without generating tension. Direct suture is typically sufficient to repair lesions smaller than 1 cmin length. When a nerve transection is detected, it is advised that this technique be used immediately to heal it. The repair is accomplished by connecting the two ends using epineural sutures (figure17) (Coulthard et

al., 2014).

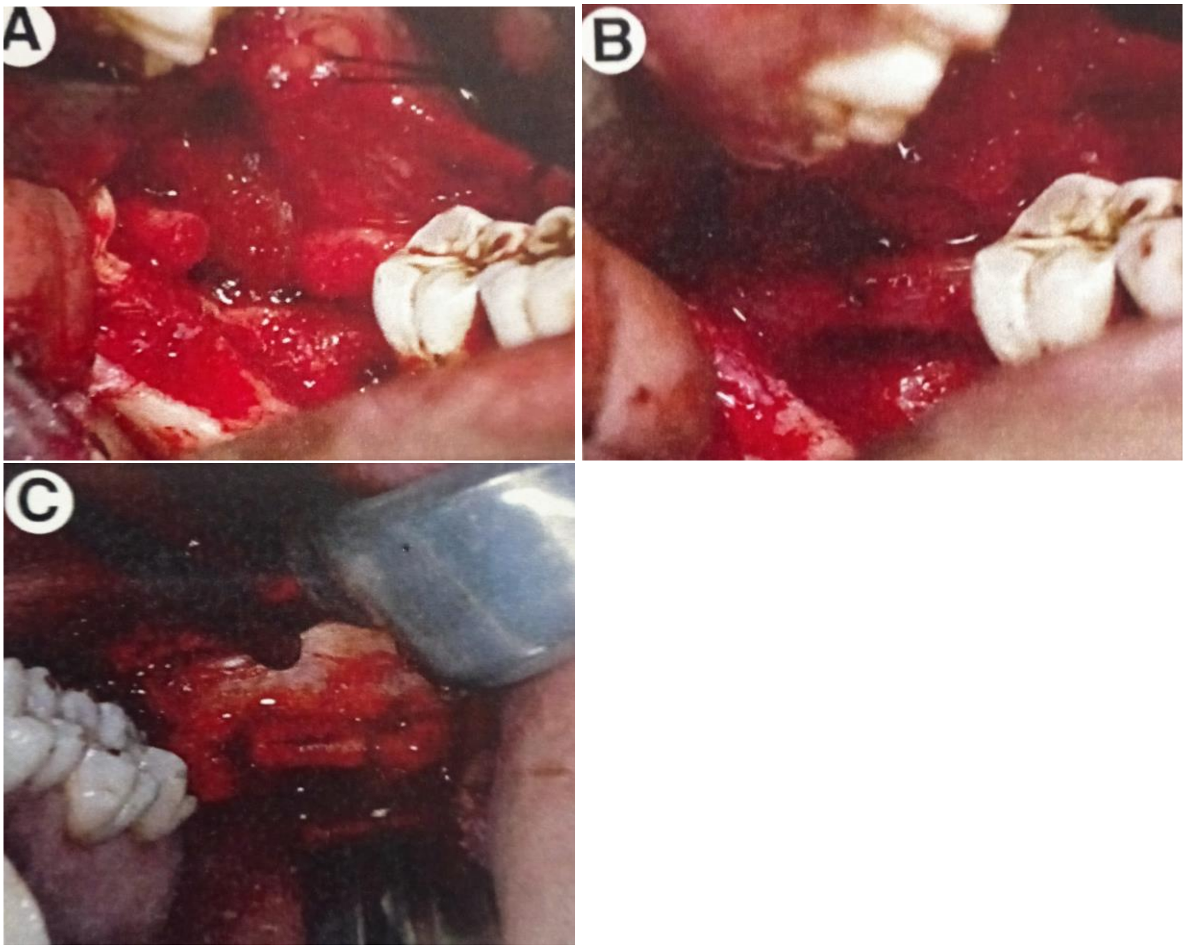


Figure 17 . A, Transected lingual nerve after external neurolysis. B. Primary neurorrhaphy with 8-0 prolene sutures. C, NeuraGen nerve guide in place (Farole and Jamal, 2008).

Neuroma excision: The formation of a neuroma is caused via axonal sprouting or disordered axonal regeneration at the damage site in an attempt to reach the distant stump. Crushed, abrasion, stretch, & the pathological effects of root tips, endodonticmedicaments, implants, & other objects could all be factors in the aetiology of this injury. An amputation neuroma, a lateral neuroma, or a continuity neuroma are all examples of neuromas. Sensory abnormalities like dysaesthesia can occur when nerve fibres in a neuroma exhibit irregular spontaneous activity or mechanical sensitivity. The preferred surgical treatment is resection of the neuroma, followed by direct approximate & stitching, or graft, based on whether the nerve ends can be approximated without pressure (figure 18.19 Coulthard et al., 2014).

Figure 18. Exposed LN neuroma in continuity (Bagheri et al., 2010)

Figure19, Excised neuroma showing distal and proximal nerve stumps (Bagheri et al., 2010)

Autologous nerve grafting : This approach provides for the filling of a gap between nerve ends in conditions where the is large defect prevents the neural endings from being directly approximated without tension. The sural nerve, larger auricular nerve, or medial antebrachial nerve are commonly used as donor tissue for interpositional grafts. However, donor site

morbidity is possible with autologous nerve graft procedures. Denatured skeletal muscle autografts can also be employed (Coulthard et al ., 2014).

Tubulization: When post-injury anomalies prevent direct apposition, a tubular conduit device may be utilized to aid nerve regeneration. It is possible to use both autologous & alloplastic materials. Repairing the lingual nerve with the saphenous vein & the inferior alveolar nerve with the facial vein. Alloplastic conduits like polyglycolic acid (PGA) bioabsorbable tubes, PGAcollagen tubes, collagen tubes (NeuraGen), & GoreTex tubes are used to restore lingual & inferior alveolar nerve deficiencies (Coulthard et al ., 2014).

Autogenous vein grafts have also been suggested as a conduit since they are autogenous, biocompatible, & may include nerve growth factors. Clinical outcomes were as least as excellent as those seen with autogenous nerve grafts when inferior alveolar nerve continuity deficiencies were repaired with vein grafts from the face vein. For lesions smaller than 5 millimeter in length, repair of lingual nerve discontinuity defects utilizing the long saphenous vein resulted in acceptable results (Pogrel and Maghen, 2001).

The NeuraGen nerve guide is an absorbable collagen tube that was initially designed to act as an interface between the nerve & surrounding tissues by providing a conduit for axonal development across a nerve gap. After external neurolysis, primary neurorrhaphy, & removal of neuroma (if present), a 4-millimeter diameter NeuraGen nerve guide was brought to the field, split longitudinally, & encased the nerve damage site with at least a 1.5-cm margin (Farole and Jamal, 2008).

When employed as conduits or protective cuffs, permanent alloplastic materials like as silicone & Gore-Tex have been shown to have

adverse effects. Compression neuropathy has been reported as a side effect of these therapies, & when used to repair other peripheral nerves, it resulted in the development of neuromas & extrusion from the repair sites. the NeuraGen nerve guide, which is a collagen nerve cuff that is bioabsorbable When placed over a nerve gap, it has been shown to achieve functional recovery levels similar to those obtained with direct suture repair (Farole and Jamal, 2008).

6.2 Laser treatment

Low-level laser treatment has been utilizedto repair partialsensory loss in patients with iatrogenic inferior alveolar nerve injuries. Laser therapy, both before & after surgical treatments like sagittal split osteotomy, has been shown to enhance recovery(Coulthard et al ., 2014).

One of the potential mechanisms of LLL activity has been reported to be the penetration of laser light at the proper wavelength (820-830 nm) through tissues to the axons & Schwann cells in the region of the injured nerve segments. According to current theories, LLL effects occur at the cellular metabolic level, resulting in activation of light-sensitive fibers or axon enzyme degradation (a rhodopsin-kinase-type enzyme). Nerve segments that have been damaged may be encouraged to produce proteins that aid in neural healing(Miloro and Repasky, 2000).

6.3 Medical treatment

A peripheral nerve damage may result in central nervous system changes. Neuropathic pain may be caused via neuron malfunction in the peripheral & central nervous systems. Antiepileptics, antidepressants, & analgesics are only a few of the medications utilized to pharmacologically treat this issue. These medicines may be used orally or topically (Coulthard et al ., 2014).

To reduce inflammatory responses in the damaged nerve, a course of steroids may be given. An option would be to take a high dosage of nonsteroidal anti-inflammatory medications (e.g ., 800 mg ibuprofen) three times day for three weeks. The feelings of pain & temperature are usually the first to return, while other sensations may take longer (Alhassani and AlGhamdi, 2010).

Oral dexamethasone 4 mg, twice daily for three days, then once daily for three days, or oral prednisolone 1 mg per kilogram daily (maximum 80 mg) may be given. Antihistaminic medicines (loratadine 10 mg daily) & acido alpha-lipoic acid (superala 800 mg once daily for four weeks) were given(Scarano et al ., 2017)