Iatrogenic trigeminal nerve injury

Minimising and managing injuries in relation to dental procedures

Tara Renton

Claims which are the result of nerve injuries are the third largest group of claims in terms of frequency, behind endodontics and crown and bridgework

They can also be very costly to resolve, especially when the patient's occupation is such that the consequences of the nerve injury interferes with the patient's employment or income. Some of these injuries can profoundly affect the patient's quality of life, and result in significant general damages for 'pain and suffering' and similar grounds for compensation. This article has been abstracted from an original paper written by Tara Renton, Professor Oral Surgery Kings College London Dental Institute who is a recognised and experienced authority in this field. It looks at the causes and management of trigeminal nerve injuries.

Trigeminal nerve injury is the most problematic consequence of dental surgical procedures with major dento-legal implications[1]. The incidence of lingual nerve injury has remained static in the UK over the last 30 years, however the incidence of inferior alveolar nerve (IAN) injury has increased; the latter being due to implant surgery and endodontic therapy.

Iatrogenic injuries to the third division of the trigeminal nerve remain a common and complex clinical problem. Altered sensation and pain in the orofacial region may interfere with just about every social interaction we take for granted[2]. These injuries can have negative effects on the patient's self-image and quality of life which can also produce significant psychological effects[3].

The trigeminal nerve is the largest peripheral sensory nerve in the human body and is represented by over 40% of the sensory cortex. The nerve supplies the face, eyes, mouth and scalp with general sensation in three divisions (ophthalmic, maxillary and mandibular) and supplies the mastication muscle. In addition the most commonly injured trigeminal nerve branches, the inferior alveolar and lingual nerves are very different entities in that the lingual nerve sits loosely in soft tissue compared with the IAN that resides in a bony canal.

Features of trigeminal nerve injury associated with dental procedures

- Both lingual and inferior alveolar nerve injuries are closed injuries; unlike the open sensory nerve injuries seen mainly on limbs due to trauma, that makes them accessible to immediate exploration and repair by orthopaedic or plastic surgeons. Paradoxically our profession has a 'sit and wait' policy for resolution of trigeminal nerve injuries unless it is known that section of the nerve has occurred.
- 88% of lingual nerve injuries associated with conventional (lingual access) third molar surgery resolve thus lulling dentists into a false sense of security believing that all nerve injuries get better. This misconception has also led to the assumption that most inferior alveolar nerve injuries resolve when in fact they are predominantly permanent[5].
- It would be difficult to traumatise a nerve with a drill without causing a multitude of events including;

a)direct mechanical trauma (tear, section, crush, stretch etc)

b) neural chemical trauma due to intracellular components released during trauma; haemoglobin irritates neural tissue

c) ischaemic injury within a bony canal (IAN) with continued bleeding or scar formation.

- It is unlikely that damage will be a simple 'cut'. It is more likely that it will involve a combination of events, providing a complex therapeutic challenge.
- If the patient suffers injury during an elective treatment that was supposed to improve their quality of life, any iatrogenic injury will distress both the patient and the clinician. The patient's frustration is often compounded by poor management (Hopefully something that this article will reduce).
- Sensory nerve injuries frequently cause pain rather than numbness. As the neuropathic area invariably involves the mouth and face the patients' ability to eat, speak, drink, sleep, kiss, shave or apply makeup is often severely compromised. Due to the chemical and neurophysical changes in the injured sensory nerve, light touch or drafts of air can cause debilitating neuralgic pain (allodynia) or in some instances the patient might experience constant background pain. All of which can add to the patient's distress.
- Complaints investigated by national registration bodies are predominantly related to implants and often involve IAN injury. Neuropathic pain can be very debilitating and, when compounded by poor management, may result in litigation.
- Current management of these nerve injuries is often inadequate. Although surgical correction may be offered there is little attention to medical or counselling intervention and there are often delays. A recent review of publications pertaining to trigeminal nerve repair highlights that the average time from injury to nerve exploration was 16 months; this is far too late to prevent central neural changes. Indeed after three months, permanent central and peripheral changes occur within the nervous system subsequent to injury that is unlikely to respond to surgical intervention[6].

A review of 183 injuries

Renton and Yilmaz (2010)

- lingual nerve (n=93; 52%) LNI
- inferior alveolar nerve injuries (n=90; 47%) IANI
- buccal nerve (n=3; 1%) B.

Injuries were regarded as being permanent if the patient had their symptoms for more than 3 months. Many of the LNI and IANI patients had permanent injuries (63.4% and 54.8%, respectively) and females were more likely to suffer from permanent nerve injury ($p>0.001$). Only 12.9% and 5.4% of the LNI and IANI cases were temporary.

Third molar surgery (TMS) and local anaesthesia caused the majority of IANIs and LNIs Approximately 70% of all patients presented with neuropathic pain, despite the additional presence of anaesthesia and/or paraesthesia.

Causes of inferior alveolar nerve (IAN) injury in general practice

(Ablative surgery, trauma and orthognathic surgery have not been included here).

Local analgesia

Injuries to inferior alveolar and lingual nerves are caused by local analgesia block injections and have an estimated injury incidence of between 1:26,762 to 1:800,000 inferior alveolar nerve blocks[7 8]. More recently the incidence of nerve injury in relation to IDBs has been calculated as 1:609,000 but with a significant increase in injury rate with 4% agents[9].

Recovery is reported to take place at 8 weeks for 85-94% of cases[10]. IAN injuries may have a better prognosis than lingual nerve injuries but if the duration of nerve injury is greater than 8 weeks then permanency is a risk. However, the true incidence is difficult to gauge without large population surveys.

In the light of the current incidence of nerve injuries in relation to dental anesthesia warning of patients is not considered to be a routine requirement and indeed in the UK these iatrogenic injuries are not considered negligent.

However there is increasing evidence that higher concentration local anaesthetic agents may be associated with increased rates of neuropathy resulting in increasing litigation in the USA. A recent settlement of U$1.4 million dollars (Main USA) for lingual nerve injury caused by local analgesic inferior alveolar nerve block highlights the associated disability and social repercussions of these injuries.

Causes of damage

- Direct mechanical trauma by the needle
- Chemical nerve injury due to LA components.

The resultant nerve injury may be a combination of neural haemorrhage, inflammation and scarring resulting in demyelination.

Articaine

This amide analgesic was introduced to dentistry in 1998, however lignocaine (also an amide analgesic) remains the gold standard in the UK. Articaine is the most widely used local analgesic in many countries for over 20 years[11 12]. Articaine is said to have a number of advantages, namely; low toxicity subsequent to inadvertent intravascular injection which may be due to the rapid breakdown to an inactive metabolite (Articainic acid), rapid onset of surgical analgesia (2.5 =/-1.1 minutes) compared with conventional Lignocaine and better diffusion through soft and hard tissue. The conclusion drawn is that Articaine is a safe and effective local anaesthetic for use in clinical dentistry[13].

There is, however, some concern with regard using Articaine for inferior alveolar and lingual nerve blocks. Prolonged paraesthesia and altered sensation may be due to the high concentration of the local anaesthetic; however, the technique cannot be excluded as the cause for nerve injury (Haas and Lennon, 1995)[14]. Another report suggests that it is the type of anaesthetic that dictates the degree of inflammatory reaction to local anaesthetic; Lidocaine being the least irritant followed by Articaine, Mepivicaine and Bupivicaine.

Longstanding altered sensation or nerve pain associated with Articaine inferior alveolar nerve blocks for routine dentistry has been reported even though the product information sheet states that resolution usually takes place within 2 weeks (www.septodont.co.uk). As a result of these concerns inferior alveolar nerve blocks using Lignocaine remains standard care.

Alternatives to inferior alveolar nerve blocks with Articaine have been suggested for implant surgery and it is becoming routine practice for orthodontic extraction of premolars and restorative treatment of premolars and molars in adults using Articaine local analgesic infiltrations rather than inferior alveolar nerve blocks[15].

Preventing problems

- Avoid multiple blocks where possible
- Avoid IAN blocks by using Articaine infiltrations only
- Avoid high concentration LA for ID blocks (use 2% Lidocaine as standard)
- Document any unusual patient reaction during local analgesic blocks (such as sharp pain or an electrical shock–like sensation).

Management

The clinician need to be be sympathetic to the patient's concerns which can lead to distrust of future dental treatment and a real fear of similar problems arising on the contralateral side. Management usually involves counselling and medication for any pain if present. In addition the patient needs to be reassured and given realistic expectations of recovery. An explanation of why they were not warned of this complication may also be required. If injury persists more than 6 weeks with more than 50% of the dermatome affected, recovery is unlikely.

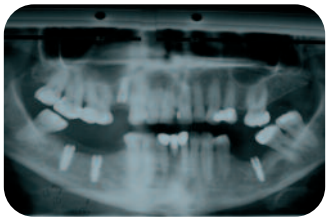
Implants

The literature shows that the incidence of implant related inferior alveolar nerve (IAN) nerve injuries varies from 0-40%. In addition the 25% incidence of edentulous patients presenting with a degree of altered IAN function, reinforces the need for a preoperative neurosensory evaluation.

Great care must be taken when selecting the patient and possible sites for implant placement. Appropriate radiographic evaluation of the implant site is a given. Cone beam CT Scanning, now introduced to many specialist practises and dental hospitals, provides lower radiation dosage compared with conventional CT and improved imaging for planning implant treatment. However several papers have drawn attention to the weakness of CT evaluation in identifying the IAN canal when compared with a panoramic radiograph.

Many practitioners use software to assist in the planning of implants and for the identification of the IAN canal position, with the specific aim to place the implants with a safety zone of more than 2mm from the IAN canal[16]. Because it is the clinician who 'draws in' the IAN canal, the assessment will be subjective. Increasingly practitioners in the USA now recommend a safety zone of a minimum of 4mm. More recently[17] the necessity for cross-sectional imaging, even for surgical procedures in the symphyseal region, has been recommended to prevent unforeseen nerve injuries. Most cases of iatrogenic paraesthesia can be prevented. However, when this problem occurs, follow-up must be initiated quickly, since the first few months significantly influence the degree of nerve healing.

Figure 1
Illustrating a case with bilateral IAN injury resulting from inadequate safety zone provision



A sudden 'give' during preparation may be indicative of protrusion through the lingual or buccal plate but may also be associated with fracturing of the IAN canal roof which will increase the risk of haemorrhage into the canal and subsequent compression of the nerve. It will, furthermore, increase the likelihood of extrusion of preparation debris or alkaline solutions being introduced into the canal causing potential harm to the nerve.

If there is an inferior alveolar arterial or venous bleed it may be advisable not to place the implant and to wait 2-3 days to ensure that no nerve damage has occurred before placing the implant in granulation tissue. Whilst this should not compromise success there is, as yet, no evidence to support this practice.

If a nerve injury is suspected, the clinician should perform a basic neurosensory examination and ascertain whether the patient experiences pain, altered sensation or numbness and document the results later that day when the effects of the anaesthetic should have worn off. A phone call six hours post surgery will enable the surgeon to ascertain this.

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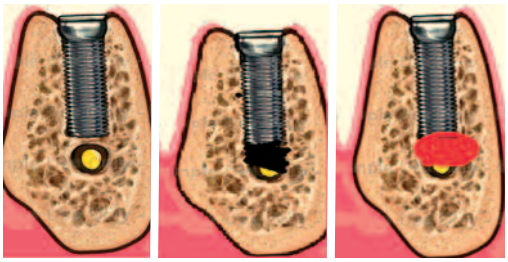
Figure 2
Possible aetiology of nerve injury. The nerve injury may be due to direct mechanical trauma by the preparation bur or implant which is prevented by adequate safety zone (A), extrusion of debris into the canal (B), breach of the lamina dura around the canal may cause heammorhage during preparation which continues after implant placement and results in nerve compression and ischemia (C)



A B C

Preventing problems

- Adequate work up and planning >4mm safety zone.
- Do not place implant if there is a bleed during implant bed preparation – place the implant 2-3 days later.
- If an implant is potentially violating the canal (a sudden give experienced during preparation) then its depth in the bone could be decreased by unscrewing it a few turns 'back up'. However if there is haemorrhage the nerve will will be compressed within the bony canal and removal is preferred. Back up may also leave excessive implant exposed coronally thus preferably remove the implant, check for haemorrhage and if none replace with a shorter implant.
- Document all unusual patient reactions occurring during implant bed preparation or placement (such as sharp pain or an electrical shock–like sensation) and IAN vessel bleed.
- Routinely check on patient early post operatively at 6 hours.
- If patient has neuropathy immediately after local analgesia has worn off:
  – Consider removing the implant in less than 24 hours
  – Steroids and NSAIDS
  – Refer to specialist (an appropriately trained micro-neurosurgeon if necessary).

Late removal of implant

To optimise neural recovery the potential harmful implant must be removed very early on if there is persistent neuropathy after the LA has worn off. Even doing this within 36 hours may still be too late.

Endodontics

- The risk factors for endodontic inferior alveolar nerve injury include;
- Proximity of the tooth to the mandibular canal
- Over instrumentation
- Overfill
- Chemical nerve injury (including sodium hypochlorite)

Similar to extracting mandibular teeth proximal to the IAN canal, root treatment of these teeth has the same potential for nerve injury. If the apex of the tooth is adjacent or intrudes into the IAN canal, any material leakage or overfilling may compromise the nerve. Assessment of the proximity of the tooth apex to the IAN canal has become significantly improved with cone beam CT scanning (CBCT). However the risk of additional radiation and may not provide significantly more information than a standard long cone radiograph.

Any tooth requiring endodontic therapy that sits in close proximity to the IAN canal needs special care. If the canal is over-prepared and the apex opened, then chemical nerve injuries from irrigation of canal medicaments are possible. In addition physical injury precipitated by overfilling using pressurised thermal filling techniques can occur. Postoperative radiographs must be arranged on the day of completion and the presence of any materials in the vicinity of the IAN canal should be reviewed carefully. If nerve function is compromised after the local anaesthetic has worn off then immediate arrangements should be made to remove the over-fill.

The optimum pH of an endodontic medicament is as close as possible to that of body fluids, (pH 7.35.) If the pH is higher or lower cellular necrosis is possible for any tissue in direct contact with the medicament.

Commonly used endodontic medicaments

- Formocresol
pH 12.45 +/- 0.02
- Sodium hypochlorite
pH 11-12
- Calcium hydroxide (Calyxl).
pH 10-14
- Antibiotic-corticosteroid paste (Ledermix)
pH 8.13 +/- 0.01
- Neutral
pH 7.35-7.45
- Eugenol
pH 4.34 +/- 0.05
- Iodoform paste
pH 2.90 +/- 0.02

Chemical nerve injuries are commonly permanent and can cause severe neuropathic pain. If the patient is suffering from neuropathy after the LA has worn off and the postoperative radiographs confirm that there is no radio-opaque material in the canal, chemical nerve injury may be presumed. Because the injury is likely to be irreversible, any subsequent removal of the obturation or extraction of the tooth extraction is unlikely to reverse the damage.

Preventing problems

- Preoperatively identify teeth proximal to the IAN and take special care in preventing apical breech with over instrumentation.
- Recognise and record certain events during treatment including;
  – Pain during irrigation
  – Pain during preparation and filling
  – If Inferior alveolar vessel bleeds during preparation, delay filling.

- If nerve injury is suspected, the postoperative radiograph must be scrutinised for evidence of breach of apex and deposition of endodontic material into the IAN canal. The patient should be informed that the material, apex and or tooth must be removed within 48 hours of placement in order to maximise recovery from nerve injury.
- Routinely contact patients postoperatively to ensure patient is comfortable once local analgesia has worn off. If nerve injury is suspected at this stage, the clinician must inform the patient and also consider removing any overfill of endodontic material, or apicect or extract the tooth within 48 hours.

Figure 3
Radiographs illustrating over fill of endodontic material into the IAN canal

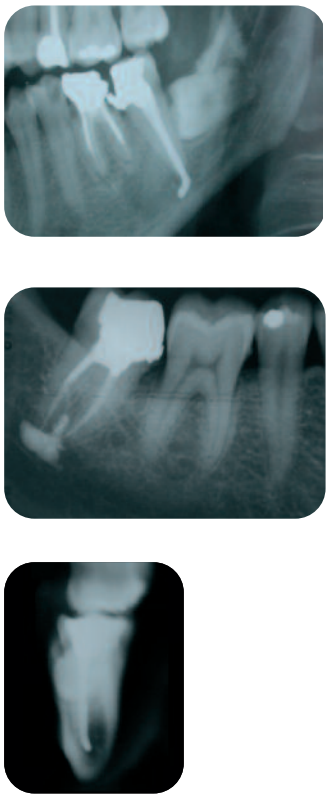
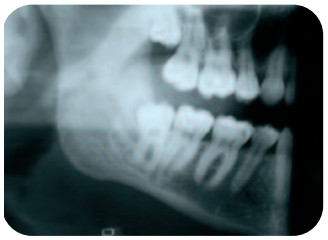


Figure 4
DPT radiographs illustrating 2 cases of 'high risk' mandibular third molars.

In both cases the lower third molar is crossing the IAN canal completely, there is darkening of the tooth roots and loss of lamina dura of the canal roof and banding



- If pain persists and no evidence of overfill is present, residual symptoms could result from;
  – apical inflammation (neuritis) confirmed by prescription of antibiotics
  – chemical nerve injury from irrigant or endo material
  – thermal damage.

In any event once neuropathy is identified the clinician should reassure the patient, prescribe steroids (Prednisolone step down 15mg/ 5 days, 10mg/ 5 days and 5mg/ 5 days and high dose NSAIDs, 600mg Ibuprofen QDS if not contraindicated) and make a timely referral to an appropriately trained specialist if necessary.

Lower third molars

The risks for lingual nerve injury during mandibular third molar surgery are well established. A recent systematic review concluded[18] that there was a significant increase in lingual nerve injury when using a lingual split technique with lingual flap or a lingual flap on its own when compared with a buccal approach. The paper concludes that lingual flap 'protection' of the lingual nerve is not necessary and also potentially harmful.

Prevention of lingual nerve injuries may be possible if undergraduate and postgraduate training promoted the use of the buccal technique. There is still a reluctance to change from traditional techniques (lingual split/lingual retraction) as in some experienced hands these techniques involve minimal morbidity. However, if the buccal technique is adhered to there is no risk to the lingual nerve. Avoidance of the envelope flap minimises the necessity of a long distal extension of the flap which exposes the distal bone adjacent to the third molar and thus may 'tempt' the surgeon to remove distal bone which would compromise the lingual nerve.

Preventing problems

- Identify 'high risk' teeth. Pre-operative x-rays are essential to assess the proximity of the IAN canal. Radiographic signs (Figure 4) indicative of possible IAN risk include;
- Diversion of the canal
- Darkening of the root
- Interruption of the canal LD
- Juxta-apical area (Figure 5)
- Narrowing of the roots or canal

The patient must be informed about any elevated risk and should be offered a suitable referral if this is thought necessary. If the tooth is high risk with these radiographic features the risk is elevated from 2% temporary to 20% temporary and from 0,5% permanent to 2% permanent ID nerve injury.

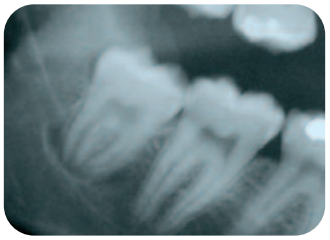
- The clinician must identify mandibular teeth at high risk of IAN injury based on radiographic features. If deemed at high risk the patient must be made aware of the increased nerve injury incidence and perhaps offered alternative procedures that may in course reduce the risk of injury.

- If the tooth is in close proximity to the IAN on plain film then cone beam CT scanning may further elucidate the relationship between IAN and tooth roots. If the tooth is non vital, or pathology associated with it, then tooth removal has to take place and the roots should be sectioned appropriately to minimise trauma to the adjacent IAN.

Other teeth

If a mandibular tooth (lower 8,7,6,5 or 4) crosses the IAN canal, and displays radiographic signs associated with an increased risk of IAN injury if the (if the tooth was removed) then the patient must be assessed accordingly, consented and treated in a similar manner to a patient with a high risk lower third molar.

Figure 5
Juxta-apical area



Socket medications

There is limited availability of information on the relative alkalinity or acidity of various dental compounds used for socket medication including; Alvolgyl, Whiteheads varnish, Corsodyl and Surgicel. However, a previous study highlighted the relative neurotoxicity of Carnoy's solution, Surgicel, Whiteheads varnish and bismuth iodoform paraffin paste (BIPP) reporting that Carnoys is likely to cause permanent nerve damage and Surgicel along with Whiteheads varnish can cause temporary sensory disturbances. BIPP was the least neurotoxic[19]. Bone wax is a neutral pH however excessive packing or pressure can lead to nerve compression and injury.

Management of trigeminal nerve injuries

We now know that up to 70% of patients with iatrogenic trigeminal nerve injuries present with post traumatic nerve neuropathy which is painful. This is reflected by the wide variety of functional problems that can arise from nerve damage created by a dental intervention helps to explain why the claims and helps to explain why the claims that arise from thesesometimes be extremely high.

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Iatrogenic trigeminal nerve injury

- Disability associated with difficulty with; eating, drinking, speaking, tasting, sleeping, tooth brushing, kissing, applying makeup or shaving.
- Interference with work ability and type of occupation are important features.
- Social problems such as embarrassment with eating or speaking in public are common. Problems with personal relationship (pain in kissing, resulting in avoidance of personal contact).

Significant psychological distress can develop in these patients particularly when the injury proves troublesome or exhibits a painful neuropathy resulting in limited daily and social function. Most importantly the clinician must manage the patients' expectations since sensation is unlikely to return to normal if it is still abnormal after 3-6 months with or without intervention.

Reassurance counselling

Surgical intervention has limited success in reversing nerve damage and these cases may have to be managed symptomatically. Alongside drug interventions with analgesics and anti-inflammatory medications, amongst others, counselling provides a very useful tool. It is helpful therefore if the referring dentist is aware of what this might involve.

A counsellor trained in this field would normally consult the patient in depth, reaffirm that the nerve injury is permanent and provide reassurance and an explanation. Often patients who can manage their pain but have associated functional difficulties are successfully managed by an explanation of their symptoms.

The permanency of their condition must be explained with realistic expectations. The patient can also be reassured that these injuries do not predispose them to cancer or any other disease process and indeed will never worsen.

Increasingly there is evidence for successful treatment of chronic conditions using Cognitive Behavioural Therapy (CBT). Within our field chronic temporo-mandibular pain conditions can be successfully treated and CBT. Formal counselling may have an increasing role particularly for patients whose nerve damage leaves them unable to cope with the impact either socially or at work.

Medical intervention

Wil be indicated for many patients to control their chronic pain. This may require systemic drugs or topical anaesthetic patches.

Surgical intervention

If a suspected section of the nerve has occurred, immediate surgical exploration, with the potential for effecting, repair is indicated. Also patients with IAN injuries with retained roots or obvious disruption of the IAN canal are candidates for early intervention. With regards IAN injuries without immediate indications for surgery and lingual nerve injuries several authors recommend referral to a micro-neurosurgeon within two months. Ideally the patient should be referred immediately to allow the surgeon to make their own assessment and measure the lack of functional recovery over a period of two months before intervening. There is increasing evidence that surgical intervention is best undertaken within 3 months. Although considerable functional improvement is seen in many patients after surgery regaining normal sensation is not possible; all patients who undergo surgery will have some permanent sensory deficit. It is unhelpful to be over optimistic about the suggested benefits of microsurgery[20].

Dento-legal issues

With regard to lingual nerve injuries related to third molar surgery, most patients recover normal sensation without treatment but those with permanent damage often have severe disability, which is reflected in the high proportion of lawsuits in such cases.

Increasingly complaints relating to nerve injury are implant related. More than half of lawsuits are associated with invalid consent for implant surgery and most were associated with premolar implants[21]. Of claims made against American Dental Insurance companies (Fortress and OMSNIC) 34% of patients were unhappy with the aesthetics and 24% related to nerve injury.

24% of dental implant claims have an average payment of $89,000 per patient while 37% of the general dental implant claims had an average payment of $63,000. Implant nerve injuries average payouts are higher than the average payout for IAN injury related to third molar surgery. Implant cases in the USA involved oral surgeons more frequently than general dentists; this may reflect the increased complexity of cases and the greater volume of dental surgery undertaken by oral surgeons.

Improved consent

All patients must be given realistic expectations of the likely outcomes of treatment and should be warned of Inferior Alveolar Nerve (IAN) or Lingual Nerve Injury (LNI) injury when appropriate. Assessment of the risk to the nerve tissue must be undertaken if the patient is to be correctly advised regarding any alternative treatment plans. The information should be explicit to ensure that the patient is aware that any nerve injury will often cause pain (with or without altered sensation) and that this could be intermittent or constant, temporary or even permanent.

By performing a neurosensory examination prior to treatment it is possible to determine whether there is a pre-existing altered sensation as up to 24% of patients with edentulous mandibles may present with IAN neuropathy (Walton 2000). If the tooth is high risk (crossing both IAN canal LD on plane film) then the patient should be advised of increased risk of nerve injury and offered alternative surgical techniques that may minimise nerve injury.

Improved management

Commonly the anger and frustration following iatrogenic injury is compounded by poor patient management by the clinician involved. After causing the injury many patients complain that the treating clinician refuses to even communicate with them or remains in denial about the injury. Furthermore, particularly in secondary care, the patients are reviewed for many months or even years, by consecutive junior staff providing them with unrealistic false hope and reassurance that their nerve injury will resolve.

Early recognition and referral of trigeminal injuries is fundamental in the improvement in treating these patients.

Summary

The most desirable outcome after nerve injury is the spontaneous return of normal sensation. The likelihood of this occurring depends on both the severity of the injury, the age of the patient and the nerve involved. When nerve injury occurs it is imperative that the clinician recognises the injury immediately and advises the patient appropriately.

Many injuries can be prevented through better patient selection, planning and execution of procedures. In addition patient management can be optimised by adopting a consent process that is based on a good risk assessment and improved postoperative care with early referral for nerve injuries. In addition to outlining several strategies to help prevent trigeminal nerve injuries it is important to remember that there is no 'silver bullet' for treating these patients.

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