

REVIEW ARTICLE

The importance of a good evaluation in order to prevent oral nerve injuries: A review

JUAN M. CÉSPEDES-SÁNCHEZ¹, RAÚL AYUSO-MONTERO^{1,2}, ANTONI MARÍ-ROIG^{1,2,3}, CARLOS ARRANZ-OBISPO^{1,2,3} & JOSÉ LÓPEZ-LÓPEZ^{1,2}

¹Oral Medicine, Oral Surgery and Implantology, ²Department of Stomatology, School of Dentistry, University of Barcelona, Catalonia, Spain, and ³Bellvitge Hospital. Barcelona, Catalonia, Spain

Abstract

Objective. Oral nerve injuries are a less frequent complication but they involve a decrease in the patient life quality. The purpose of the current review is to know the described risk factors to prevent injuries and to know the therapies against an established injury. **Materials and methods.** A Pubmed search of the English and Spanish language literature from 2000–2012 using the keywords ‘oral surgery’ or ‘trigeminal nerve injuries’ or ‘lingual nerve injuries’ or ‘mandibular nerve injuries’ was performed. Review articles were included and important articles from the references were added. **Results.** A total of 662 were obtained from the search, from which 25 were selected accomplishing the inclusion criteria. Moreover, seven important articles were selected from the references of the ones mentioned, obtaining a total of 32 articles for the review. **Conclusions.** There is a relationship between the position of the extracted tooth and the incidence of the inferior alveolar nerve and lingual nerve injuries; as well as the age of the patient, the intra-operative exposition of the nerve, the technique access for the lower third molar extraction and the surgeon’s inexperience. The radiological examination is useful to evaluate the nerve damage and to decide on the surgical technique.

Key Words: *lingual nerve injuries, mandibular nerve injuries, oral surgery and trigeminal nerve injuries*

Introduction

The vast majority of nerve injuries in oral surgery involve the fifth cranial nerve branches, especially the inferior alveolar nerve (IAN) and lingual nerve (LN) and with less frequency, the anterior palatal nerve, nasopalatine nerve and infraorbital nerve. These injuries can be produced during extraction of the third molar, orthognathic surgery, implantology surgery, pre-prosthetic surgery, salivary glands surgery, oral pathology surgery (such as cysts or tumours) and on some occasions after endodontic treatment or locoregional anaesthetic injection [1].

The extraction of the third molar is the most common surgical procedure in the oral cavity [2], this being the cause of 52.1% of nerve damage in oral surgery [1]. IAN lesions have an incidence of 0.26–8.4%, while the LN sensory deficit ranges from 0.1–22% [2]. Permanent lesions must be distinguished from transient ones. The first are those

that last more than from 6–12 months and in which no spontaneous recovery is expected. The classification of Seddon [3] in 1942 divides nerve damage into three categories, depending on its severity: neuropraxia, axonotmesis and neurotmesis. The first is characterized by the functional and temporal interruption of the nervous conduction. The second case would result in the anatomical interruption of the axons, but with conservation of the myelin sheaths of the nerves. Finally, neurotmesis means complete interruption, that is to say axon and sheaths ruptured. Later, in 1951, Sunderland [4] proposed an amendment to the previous classification based on the theory that the degree of sensory disturbance and subsequent recovery depended on the severity of the injury.

Changes in the sensitivity of the orofacial region may interfere with speech, chewing and social interactions. Even minor changes can significantly affect the quality-of-life of the patient. Trauma to a peripheral nerve can result in anything from a complete

Correspondence: Juan M. Céspedes-Sánchez, DDS, Master degree in Oral Medicine, Oral Surgery and Implantology. University of Barcelona, Catalonia, Spain. E-mail: juanmacesp88@hotmail.com

(Received 17 March 2013; accepted 23 May 2013)

ISSN 0001-6357 print/ISSN 1502-3850 online © 2014 Informa Healthcare
DOI: 10.3109/00016357.2013.812746

Table I. Aetiology of injury in the third branch of V cranial nerve as a percentage.

	Third molar extraction	Local anaesthesia injection	Implant surgery	Orthognathic therapy	Trauma	Endodontics	Others
Tay and Zuniga [1]	52.5	15.3	11.9	8.5	1.7	1.7	6.8
Hillerup [19]	69	10	10			7	4
Caissie et al. [6]	66	12	5	10	2	3	1

loss of sensation (anaesthesia) to a reduction in the detection and perception capability of stimuli from mechanoreceptors and/or nociceptors (hypoesthesia). Some patients may experience dysesthesia, characterized by abnormal, painful sensations. This pain can be caused by a neuroma located in the injury, by changes in the autonomic nervous system (pain of sympathetic origin) or by alterations in the central nervous system (central neuropathic pain) [5]. Allodynia is a type of dysesthesia characterized by a painful response to a stimulus that is not usually painful [6]. Hyperalgesia is an exaggeration of the pain response to a stimulus, while hyperpathia is an exaggerated pain response that persists after removing the stimulus [5,6].

The damage to the LN or the IAN during extraction of third molars is among the most common causes of litigation in dentistry. Therefore, prevention is always the best method to avoid patient dissatisfaction with the received treatment [7,8].

Materials and methods

The literature review was performed in PubMed, focusing on the articles from 2000–2012, with the exception of five papers of particular interest prior to this date, chosen to clarify the aetiology of nerve damage and its radiographic and surgical management. The keywords used were oral surgery, trigeminal nerve injuries, lingual nerve injuries and mandibular nerve injuries. The inclusion criteria were articles written in English, clinical studies that included over 40 cases, except for the study by Karakas et al. [9], which was included for its study of the anatomical position of the LN in human cadavers.

Articles relevant to the study of wisdom tooth surgery and neurosensory deficit were selected. If there was inadequate information in the abstracts or the abstracts were missing, the articles were excluded.

Results

The result of the search yielded a total of 662 articles. Those items that had less than 40 patients or were not review articles were eliminated. A total of 260 abstracts which focused on assessing nerve damage in oral surgery were read. Finally, 25 items were included and significant references looked for in

them, which led to seven further articles. The final review was carried out on the resulting 32 articles.

Discussion

Aetiology and risk factors

Several studies have shown different causes of damage to the IAN and the LN. All coincided in the importance of pre-operative assessment to minimize intra-operative risks and post-operative sequelae. The frequency percentages of these authors are shown on Table I, where the importance of the third molar extraction can be appreciated in this type of injury. Jerjes et al. [5] conducted a prospective study of 3236 patients that evaluated the most significant risk factors leading to the production of these injuries, with three statistically significant factors in the permanent injury of the IAN: the horizontal inclusion of the third molar, patients treated by novice postgraduates and being in the age group ranging from 26–30. In this case, the horizontal inclusion is a risk factor since surgery is more complex with a greater need for bone removal. Furthermore, LN permanent injury was related to semi-included third molars, horizontal inclusion, patients treated by postgraduate students in the learning phase and the close relationship with the IAN channel. Tay and Go [10] found that exposure of the neurovascular pack during mandibular surgery increases the risk of paresthesia, with a 70% chance of recovery within a year. Leung and Cheung [11], in their literature review of seven case-control studies and 25 randomized prospective clinical studies, showed that the average age of patients with deficits in IAN was 32.3 years old, with unerupted and horizontal third molars extracted by specialists using lingual access flaps. This access is only defended by the British School, which claims that the visualization of the LN prevents injury to it, while other Schools do not defend its use due to the greater risk of injury during handling. Valmaseda-Castello et al. [12] found no significant differences between the different degrees of inclusion, although the highest percentage present is the intra-osseous inclusion of 2.2%. They give distal osteotomy as a risk factor in the IAN damage due to the close relationship between total bone impaction and damage to the IAN, as well as a longer than 20 min surgery time and

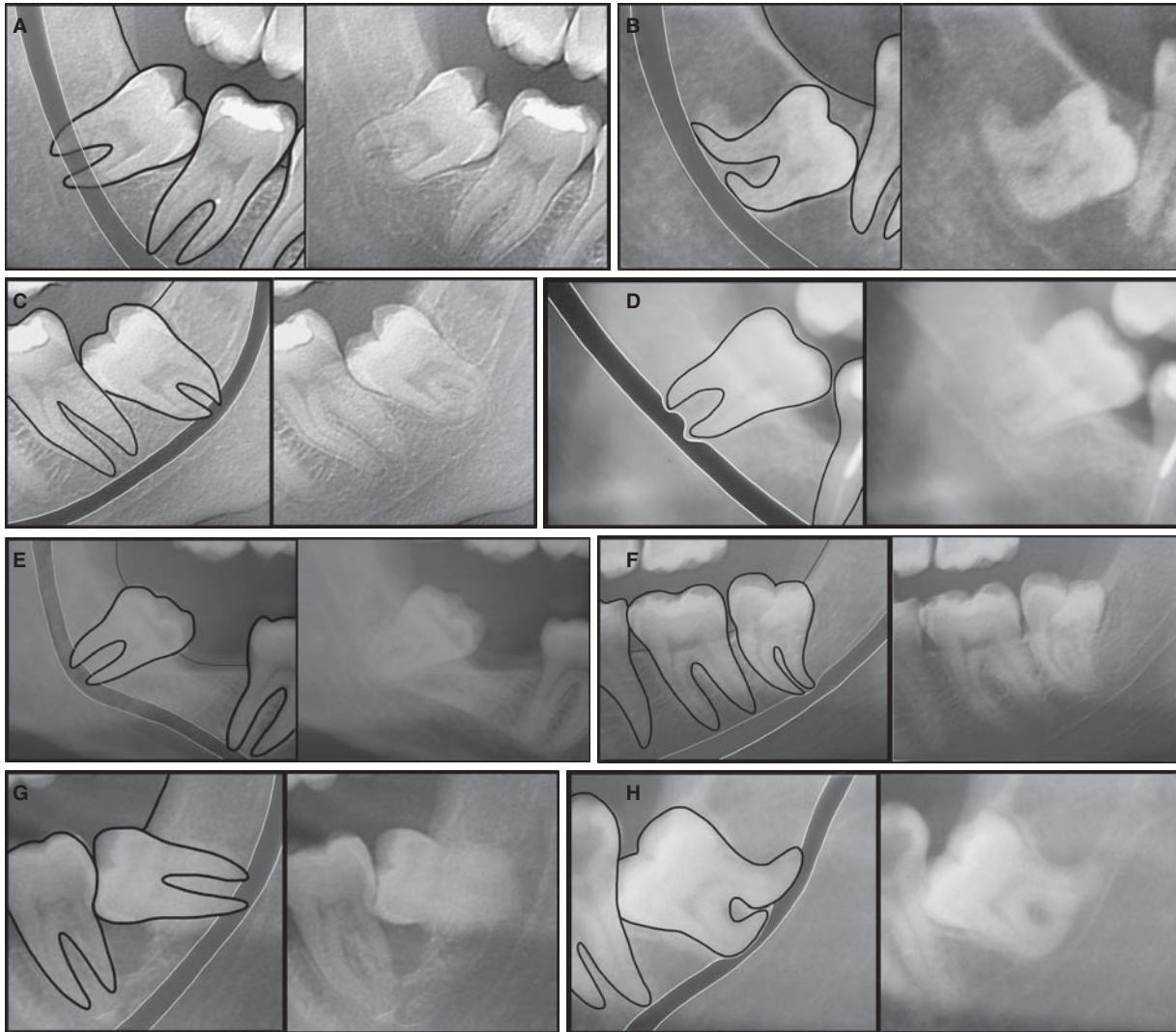


Figure 1. Possible signs of the channel are described according to the criteria described by Leung and Cheung [14] and Palma-Carrio et al. [15]. Four signs can be observed in the roots of the molars: darkening (A), deflection (B), narrowness of the root (C) and bifid root apex (D). Three signs can be detected in the channel: diversion (E), narrowing (F) and interruption of the channel cortical (G). On several occasions the signs can be found together (H), deflection, diversion, narrowing and interruption of the channel.

severe bleeding in the area. The prospective study of 4338 cases performed by Cheung et al. [2] showed no significant differences in gender and age among patients with or without lesions of the IAN, nor with the type of inclusion. As for the depth of the inclusion, a significant difference was found.

With respect to LN, it is important to note its inconsistent position in the retromolar region which means the injury may be a result of the different procedures used: during the incision, the flap elevation, the flap retraction, the odontosection, the avulsion and suture [5,13]. The work of Leung and Cheung [11] shows that LN injuries occurred in patients with an average age of 32.2 years, with unerupted third molars and also distalized with lingual flap elevation or access through the lingual flap. In contrast, Valmaseda-Castello et al. [8] showed an average of 5.4% of erupted third molars with LN lesions vs 1.8% of the rest, with a significant association with lingual angulation.

Cheung et al. [2] found a statistically significant relationship in those third molars with a distoangular inclusion. For the other variants, with respect to the LN, no significant differences were found.

Regarding radiographic evaluation of the risk of nerve injury in surgery of the lower third molars, their close proximity to the IAN channel is the cause most directly related to injury to the IAN. The radiographic image is the only method available to detect this close relationship, particularly orthopantomography (OPG). Predicting IAN exposure during surgery may be helpful to explain to the patient the risk of nerve injury and avoid apical pressure during root avulsion or even to perform odontosection to reduce stress during dental elevation [14]. Four signs can be observed in the roots of the molars (darkening, deflection and narrowness of the root and bifid root apex) and three in the channel (diversion, narrowing and interruption of the cortical of the channel) (Figures 1A–H) [14,15].

Table II. Relationship between radiographic findings in relation to the real contact between 3rd molar and the IAN channel according to the study of Khan et al. [17].

	Panoramic radiograph	CT
Root darkening	74.19%	43.4%
Channel narrowing	25.8%	50%
Radiolucency between root and channel	41.93%	30%
Cortical channel interruption	54.83%	30.8%
Channel Diversion	12.9%	50%

Leung and Cheung [14] conducted a study on 178 third molars, finding a prevalence of 5.1% of injuries to the IAN. In their work, 65.7% of third molars studied had only one radiographic sign, 27.5% had two, 5.1% had three and 1.7% had four. The darkening of the lower third molar root was the only radiographic sign that showed a high risk of injury to the IAN after surgery and the risk increased when the third molar had two or more radiographic signs. This agrees with the suggestion of Howe and Poyton [16], who in 1960 estimated that the 93% of third molars showing a darkening of the roots had a 'real relationship' with the IAN. Khan et al. [17] showed a 43.4% presence of a 'real relationship' when overlay existed. In the same study, they found the horizontal tilt of the third molar with a 'real relationship' in 85.7% of cases. Other authors have found that the channel diversion was the only sign statistically related to injury [12]. Sedaghatfar et al. [18] observed four radiographic signs statistically associated with the IAN exposure during extraction (darkening and narrowing of the root, interruption of the cortical and channel diversion), while for Gomes et al. [19] no statistically significant association with radiographic signs was found.

As a second step in the pre-operative evaluation of nerve injury computer tomography (CT) is available. In CT the absence of cortical bone in the alveolar channel involves contact with the lower third molar root and is associated with radiographic signs in orthopantomography such as the narrowness, diversion and interruption of the cortical of the channel and the root darkening [15]. In the study of Khan et al. [17] the relationship between orthopantomography and CT findings was used to determine a 'real relationship' between the roots of the third molar and the IAN channel (Table II).

Signs and symptoms

Although nerve damage can cause permanent sensorineural damage that is clinically reflected by a loss of function (anaesthesia, hypoesthesia), often accompanied by neurogenic distortion (paresthesia, dysesthesia, allodynia), many cases have shown potential for at

Table III. Clinical evaluation of paresthesia, as in Caissie et al. [6].

Clinical evaluation of the affected area
Mapping the affected area with a pen
Sensitivity test with cotton swab applied to the affected area
Detecting the motion direction over a wide area
Testing sensation with a 27 diameter needle when applied to the affected region with enough pressure to mark the skin, but without penetrating it
Electrodiagnostic methods (evoked potentials, action potentials)

least partial recovery [20]. Hypoesthesia means numbness, stiffness or tension. Paresthesia brings a sense of tingling, vibration and burning. Finally, dysesthesia is associated with stinging, burning, electric-like pain, sensitivity to heat or cold, intense pain or intense burning. Moreover, according to Tay and Zuniga [1], the presence of dystrophic changes with paleness or loss of fungiform papillae is a sign of LN injury. Upon regaining sensitivity these fungiform papillae reappear. This allows evaluation of the course of nerve regeneration to take place. Renton et al. [21], in their study of NDI and LN injury, concluded that the tongue with LN damage works with less accuracy, so speech and eating were significantly more problematic for these patients. The information transmitted in the nervous system is poor, producing changes in the sound of some vowels.

Patients with paresthesia after surgery should be evaluated as soon as possible following instructions summarized in Table III [6]. After obtaining the necessary information it will be easier to establish a diagnosis, the degree of nerve injury, prognosis, choose the appropriate treatment and evaluate the recovery from injury.

Treatment

Treatment with corticosteroids in patients with post-operative nerve injury minimizes the inflammatory response (prednisone 50 mg, every 24 h for 7 days) [6], although Tay and Go [10] do not associate the use of steroids with a decrease in nerve damage. The medication proposed by Jerjes et al. [5] (dexamethasone and dipyrone) administered pre-operatively in patients with a high risk of nerve injury can reduce sensory hypersensitivity.

In the Pogrel et al. [22] study, 145 patients were interviewed after nerve injury and it was found that that older patients had higher pain levels than the younger ones. According to Queral-Godoy et al. [23], this could be because older patients suffer more severe damage or due to decreased nerve regeneration and neuronal plasticity. Pogrel et al. [22], in contrast, found that long-term NL has a greater potential for recovery than the IAN. This finding contrasts with the findings of other studies that examined short-term

Table IV. Evolution of nerve injuries based on the criteria established by Jerjes et al. [5] and Cheung et al. [2].

Time evolution	Jerjes et al. [5]		Cheung et al. [2]	
	IAN Paresthesia	LN Paresthesia	IAN Paresthesia	LN Paresthesia
1 month	1.5%	1.8%	0.35%	0.58%
3 months			0.21%	0.49%
6 months	1.4%	1.6%	0.19%	0.30%
1 year			0.16%	0.24%
2 years	0.6%	1.1%	0.13%	0.20%

injury. The injuries that are recovered from within the first 3 months are probably neurapraxia, while injuries that continue over time may be an axonotmesis [23]. Hillerup [20] claims a faster recovery during the first 6 months after injury. Thus, the prospective studies conducted by Jerjes et al. [5] and Cheung et al. [2] show the evolution of nerve damage after 1, 3, 6 months and 1 and 2 years in patients with surgical trauma. They show a progressive cure of either IAN or LN paresthesia and that the risk of nerve failure that occurs after third molar extraction is low (Table IV). Caissie et al. [6] recommend microsurgery in the following cases: confirmation of nerve transection, anaesthesia of the affected area 2 months after the trauma, loss of protective reflexes 2 months after trauma or dysesthesia. According to Hillerup and Stoltze [24], microsurgical repair of nerve damage with persistent total or near total loss of function should be carried out within 3–6 months post-injury. This prompt repair of the lesion makes nerve endings remain intact and be easy to anastomose. Besides, the presence of a neuroma worsens the outcome. The surgical techniques used are decompression, direct suture of the nerve, neuroma excision with direct suture, external neurolysis and simple excision of the neuroma with or without flap replacement [25,26]. After these surgeries, there may be a functional improvement, but a full recovery of sensation is not possible [6]. Thus, the diagnosis of nerve damage should include at least a detailed history, clinical examination and an objective test of sensory function.

Prevention

According to the AAOMS (American Association of Oral and Maxillofacial Surgeons) the extraction of third molars in adults is a safe surgical procedure with minimal morbidity, no mortality and no long-term negative impact on the life quality of the patients [27]. All patients should be warned of the risks of third molar surgery, including possible damage to the IAN and LN, and informed consent must be obtained before surgery [5,21]. Furthermore, the prediction of intra-operative IAN exposure may be useful to explain the risk of nerve injury. There are a number of signs that appear with orthopantomography and computed tomography which

indicate this [14]. The lingual approach should be avoided because of the high risk of injury in the LN and IAN. Coronectomy or withdrawal of the crown of a third molar intentionally without removing the roots minimizes the risk of nerve injury [11]. This technique used in the study of Cilasun et al. [28] shows that in the coronectomy group the post-operative complications were minimal (less pain and infection), with 4.5% vs 4.6% in the control group. After the removal of the crown, root canal treatment was not carried out because it has been shown that there is pulp survival with live retention of the roots. Cases have been reported of delayed eruption or migration from the root to the surface up to 10 years after the coronectomy [29]. On the other hand, other authors do not recommend this technique due to the potentially harmful effects that the unremoved roots can cause [12].

Prevention of damage to the IAN or LN must be achieved through a profound knowledge of the anatomy, a full consideration of its variants and a detailed surgical plan, avoiding root compression and avoiding damage to the nerves with surgical instruments. Risk factors should be identified before surgery and the relationship with the third molar, the need for osteotomy and the age of the patient must be seriously taken into account [12].

According to Robert et al. [30], in their retrospective study, the reported average of nerve injury in the IAN was four in 1000 third molar extractions. In the case of LN the frequency was one in 1000 extractions (with respect to temporary and permanent injury). This article also shows that permanent nerve damage has a frequency of one in 2500 extractions in the case of IAN and one in 10,000 extractions in the LN.

Subsequent nerve damage and sensory distortion can occur after direct or indirect trauma. That is why the surgeon must decide whether the risks of surgery outweigh the expected benefits. Thus, Caissie et al. [6] give some indications and contraindications for carrying out the extraction of third molars. They refer to the prevention and treatment of infection, dental disease (caries and pulpitis), periodontal cysts and odontogenic tumours and orthodontic considerations. Furthermore, the contraindications refer to age (over 30 or below 12), damage to adjacent structures, the possibility that the tooth will erupt or serve

as an abutment for a prosthesis, orthodontic considerations and, most importantly, that the patient does not accept the risks associated with extraction.

In the case of LN, the position of a periosteal elevator lingual area can protect the nerve from direct trauma. However, when this technique is used by inexpert surgeons, there is a likelihood of injury to the LN. Other injuries of this nerve can occur after an infection in the area, the forming of a haematoma, a swelling and after troncular anaesthesia [5]. The anatomical location of the LN is variable and is an important factor in the aetiology of the nerve injury. In dissections made by Karakas et al. [9] the mean horizontal distance from the lingual cortical to the LN was 4.19 mm, whereas the vertical distance to the lingual ridge was 9.56 mm. Tay and Zuniga [1] found IAN injuries more frequent than LN injuries. However, the latter are more severe than those of the IAN [27]. Pogrel et al. [22] suggest the possibility of a greater recovery from NDI because it contains a channel that acts as a guide. Cheung et al. [2] found no association between the pattern of inclusion and the incidence of sensory deficit in LN (not in the IAN). Valmaseda-Castellon et al. [8] give the status of the lingualized molar as a statistically significant risk factor; this may be due to the amount of distal bone that must be removed [11] and the inexperience of the surgeon. Furthermore, the same authors suggest that a possible cause of nerve damage is the use of general anaesthesia and the aggressiveness of surgical procedures when the patient is unconscious. However, local anaesthesia can cause mechanical nerve damage by causing an intra-neuronal haemorrhage through the needle or compressive damage through the injection of anaesthetic liquid with the application of excessive force [12]. With respect to the IAN, neuropraxia or axonotmesis can happen at any point of surgery. If the nerve passes directly through the roots of the tooth, when this is avulsed the IAN can be sectioned, resulting in neurotmesis. Several risk factors for IAN lesion have been examined by various studies, the inclusion and the proximity of the tooth to the channel being the most obvious ones.

With respect to radiography, Leung and Cheung [14] suggest that any deeply impacted lower third molar shows radiographic darkening of the root or two or more of the radiographic signs described above, with a significant risk of post-operative deficit of the IAN. Therefore, CT is recommended when these signs appear in the OPG to reveal the true relationship between these two anatomical structures. However, there is no study showing that the use of CT significantly reduced nerve injury during the inferior third molar surgery [15]. To reduce the rate of this injury, we have already described surgical techniques such as coronectomy, with a success rate of 96.5% in 87 cases performed by Cilasun et al. [28].

Thus, many cases of paresthesia can be prevented, but, when this problem occurs, monitoring should be initiated rapidly in the first months to determine the degree of nervous healing. Many patients recover without treatment [6]. The work presented by Hillerup [20] suggests that improved sensory recovery occurs gradually after the first 6 months but not after 2 years, due to the possible formation of neuromas which make nerve conduction difficult. According to Tay and Go [10], this may be due to the interruption of the continuity of the nerve trunk. Thus, they show the persistence of sensory alteration in 28.9% of the area after a year, which suggests the presence of a grade IV Sunderland classification [4]. In this study, the number of areas with paresthesia was reduced by ~60% after 3 months and by over 70% in terms of area 1 year after surgery. Between the first and second year, there was a slight decrease of 18%. They also suggest that the identification of the IAN neurovascular bundle pack during surgery increases the risk of injury by 20%, although this identification can be difficult due to inadequate access to see the area. Leung and Cheung [11] correlate the increased risk of LN injury in unerupted teeth to the need of use lingual retractors during surgery. With respect to injury to the IAN, this is due to the close proximity of the roots. According to Hillerup and Stoltze [7], nerve microsurgery should be carried out in lesions with Sunderland grade V and VI.

Several drugs have been evaluated for the treatment of nerve damage, including vitamins B1, B6 and B12 administered every 12 h. However, although these substances improve peripheral nerve regeneration in animals, their effects in humans have not been demonstrated. Low level laser therapy has been shown to lead to an increase in axonal density after repair of the IAN in rats and improved the regeneration of IAN after orthognathic surgery, but further studies are needed to assess its effectiveness [23].

Several studies have confirmed that only 30–50% of the information given to patients before surgery is recalled after 7 days [31]. Therefore, written informed consent, which reflects the possible complications, is of great important to prevent subsequent disputes, which are ever increasing in number. Pogrel and Thamby [32] found that 40% of patients who experienced nerve injuries had sued the professional they believed responsible. Lydiatt [31] in his study highlights the fact that 79% of the legal complaints related to dentistry in the US concerned extractions and, in 46%, a lack of informed consent.

In conclusion, this literature review found that there is a relationship between the incidence of nerve injury in the inferior alveolar nerve and lingual nerve and the anatomical position of the tooth to be extracted, the age of the patient, intra-operative nerve exposure, the access technique for extraction of lower third molars and the inexperience of the surgeon.

Radiographic evaluation is useful in assessing nerve damage and deciding on the surgical technique. All patients should be made aware of the risk through informed consent.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

- [1] Tay AB, Zuniga JR. Clinical characteristics of trigeminal nerve injury referrals to a university centre. *Int J Oral Maxillofac Surg* 2007;36:922–7.
- [2] Cheung LK, Leung YY, Chow LK, Wong MC, Chan EK, Fok YH. Incidence of neurosensory deficits and recovery after lower third molar surgery: a prospective clinical study of 4338 cases. *Int J Oral Maxillofac Surg* 2010;39:320–6.
- [3] Seddon HJ. A classification of nerve injuries. *Br Med J* 1942;2: 237–9.
- [4] Sunderland S. A classification of peripheral nerve injuries produced by loss of function. *Brain* 1951;74:491–516.
- [5] Jerjes W, Upile T, Shah P, Nhembe F, Gudka D, Kafas P, et al. Risk factors associated with injury to the inferior alveolar and lingual nerves following third molar surgery-revisited. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;109:335–45.
- [6] Caissie R, Goulet J, Fortin M, Morielli D. Iatrogenic paresthesia in the third division of the trigeminal nerve: 12 years of clinical experience. *J Can Dent Assoc* 2005;71:185–90.
- [7] Hillerup S, Stoltze K. Lingual nerve injury II. Observations on sensory recovery after micro-neurosurgical reconstruction. *Int J Oral Maxillofac Surg* 2007;36:1139–45.
- [8] Valmaseda-Castellon E, Berini-Ayres L, Gay-Escoda C. Lingual nerve damage after third lower molar surgical extraction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;90: 567–73.
- [9] Karakas P, Uzel M, Koebke J. The relationship of the lingual nerve to the third molar region using radiographic imaging. *Br Dent J* 2007;203:29–31.
- [10] Tay AB, Go WS. Effect of exposed inferior alveolar neurovascular bundle during surgical removal of impacted lower third molars. *J Oral Maxillofac Surg* 2004;62:592–600.
- [11] Leung YY, Cheung LK. Risk factors of neurosensory deficits in lower third molar surgery: an literature review of prospective studies. *Int J Oral Maxillofac Surg* 2011;40:1–10.
- [12] Valmaseda-Castellon E, Berini-Ayres L, Gay-Escoda C. Inferior alveolar nerve damage after lower third molar surgical extraction: a prospective study of 1117 surgical extractions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001;92: 377–83.
- [13] Gomes AC, Vasconcelos BC, de Oliveira e Silva ED, da Silva LC. Lingual nerve damage after mandibular third molar surgery: a randomized clinical trial. *J Oral Maxillofac Surg* 2005;63:1443–6.
- [14] Leung YY, Cheung LK. Correlation of radiographic signs, inferior dental nerve exposure, and deficit in third molar surgery. *J Oral Maxillofac Surg* 2011;69:1873–9.
- [15] Palma-Carrio C, Garcia-Mira B, Larrazabal-Moron C, Penarrocha-Diago M. Radiographic signs associated with inferior alveolar nerve damage following lower third molar extraction. *Med Oral Patol Oral Cir Bucal* 2010;15:886–90.
- [16] Howe G, Poyton HG. Prevention of damage to the inferior dental nerve during the extraction of mandibular third molars. *Br Dent J* 1960;109:355–63.
- [17] Khan I, Halli R, Gadre P, Gadre KS. Correlation of panoramic radiographs and spiral CT scan in the preoperative assessment of intimacy of the inferior alveolar canal to impacted mandibular third molars. *J Craniofac Surg* 2011; 22:566–70.
- [18] Sedaghatfar M, August MA, Dodson TB. Panoramic radiographic findings as predictors of inferior alveolar nerve exposure following third molar extraction. *J Oral Maxillofac Surg* 2005;63:3–7.
- [19] Gomes AC, Vasconcelos BC, Silva ED, Caldas Ade F Jr, Pita Neto IC. Sensitivity and specificity of pantomography to predict inferior alveolar nerve damage during extraction of impacted lower third molars. *J Oral Maxillofac Surg* 2008;66: 256–9.
- [20] Hillerup S. Iatrogenic injury to the inferior alveolar nerve: etiology, signs and symptoms, and observations on recovery. *Int J Oral Maxillofac Surg* 2008;37:704–9.
- [21] Renton T, Yilmaz Z, Gaballah K. Evaluation of trigeminal nerve injuries in relation to third molar surgery in a prospective patient cohort. Recommendations for prevention. *Int J Oral Maxillofac Surg* 2012;41:1509–18.
- [22] Pogrel MA, Jergensen R, Burgon E, Hulme D. Long-term outcome of trigeminal nerve injuries related to dental treatment. *J Oral Maxillofac Surg* 2011;69:2284–8.
- [23] Queral-Godoy E, Valmaseda-Castellon E, Berini-Ayres L, Gay-Escoda C. Incidence and evolution of inferior alveolar nerve lesions following lower third molar extraction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;99:259–64.
- [24] Hillerup S, Stoltze K. Lingual nerve injury in third molar surgery I. Observations on recovery of sensation with spontaneous healing. *Int J Oral Maxillofac Surg* 2007;36:884–9.
- [25] Gregg JM. Surgical management of inferior alveolar nerve injuries (Part II): the case for delayed management. *J Oral Maxillofac Surg* 1995;53:1330–3.
- [26] Pogrel MA. The results of microneurosurgery of the inferior alveolar and lingual nerve. *J Oral Maxillofac Surg* 2002;60: 485–9.
- [27] Haug RH, Perrott DH, Gonzalez ML, Talwar RM. The American Association of Oral and Maxillofacial Surgeons Age-Related Third Molar Study. *J Oral Maxillofac Surg* 2005;63:1106–14.
- [28] Cilasun U, Yildirim T, Guzeldemir E, Pektas ZO. Coronectomy in patients with high risk of inferior alveolar nerve injury diagnosed by computed tomography. *J Oral Maxillofac Surg* 2011;69:1557–61.
- [29] Renton T, Hankins M, Sproate C, McGurk M. A randomised controlled clinical trial to compare the incidence of injury to the inferior alveolar nerve as a result of coronectomy and removal of mandibular third molars. *Br J Oral Maxillofac Surg* 2005;43:7–12.
- [30] Robert RC, Bacchetti P, Pogrel MA. Frequency of trigeminal nerve injuries following third molar removal. *J Oral Maxillofac Surg* 2005;63:732–5.
- [31] Lydiatt DD. Litigation and the lingual nerve. *J Oral Maxillofac Surg* 2003;61:197–200.
- [32] Pogrel MA, Thamby S. The etiology of altered sensation in the inferior alveolar, lingual, and mental nerves as a result of dental treatment. *J Calif Dent Assoc* 1999;27:534–8.