

Prevention of neurological injuries during mandibular third molar surgery: technical notes

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Summary

Surgery to the mandibular third molar is common, and injuries to the inferior alveolar nerve and the lingual nerve are well-recognized complications of this procedure. The aim of these technical notes is to describe operative measures for reducing neurological complications during mandibular third molar surgery.

The following procedure should be used to prevent damage to the inferior alveolar nerve: a well-designed mucoperiosteal flap, to obtain appropriate access to the surgical area; a conservative osteotomy on the distal and distal-lingual side; tooth sectioning, to facilitate its removal by decreasing the retention zones; tooth dislocation in the path of withdrawal imposed by the curvature of the root apex; and careful socket debridement, when the roots of the extracted tooth are in intimate contact with the mandibular canal.

To prevent injury to the lingual nerve, it is important (I) to assess the integrity of the mandibular inner cortex and exclude the presence of fenestration, which could cause the dislocation of the

tooth or its fragment into the sublingual or sub-mandibular space; (II) to avoid inappropriate or excessive dislocation proceedings, in order to prevent lingual cortex fracture; (III) to perform horizontal mesial-distal crown sectioning of the lingually inclined tooth; (IV) to protect the lingual flap with a retractor showing the cortical ridge; and (V) to pass the suture not too apically and from the inner side in a buccal-lingual direction in the retromolar area.

Key words: inferior alveolar nerve injury, lingual nerve injury, intraoperative complications, third molar, oral surgery.

Introduction

Surgery to the mandibular third molar is common, but injuries to the inferior alveolar nerve (IAN) and the lingual nerve (LN) remain well-recognized complications. The reported incidence of nerve damage during this procedure has been reported to range from 0.26 to 8.4% for IAN and from 0.1 to 22% for LN (1). The wide variability of these values makes it impossible to provide a reliable estimate owing to differences in surgical technique, examined samples, follow-up and evaluation criteria used in the studies that have been reported in the literature.

The following risk factors for IAN injuries in third molar surgery have been reported in the literature: higher patient's age, pre-existing disease, deep impaction and close anatomic relationship between the tooth roots and the inferior alveolar canal (IAC), intraoperative exposure of the nerve trunk, less-experienced surgeon, use of the lingual split surgical technique, use of rotary instruments for bone removal or tooth sectioning and compression of the nerve during root elevation (1-5). In addition to increasing age, deep and distal impaction, and the use of the lingual split technique, the risk factors for LN involvement have been mainly related to iatrogenic causes such as poor flap design, using a periosteal elevator to raise and retract the lingual flap, clumsy instrumentation, and iatrogenic fracture of the lingual plate (1, 6-8).

Nerve damage may also be related to trauma during the injection of a local anaesthetic nerve block, intraoperative haemorrhage or post-operative complications including swelling, haemorrhage and perineural inflammation (5, 9). Damage to the IAN causes hypoaesthesia, anaesthesia, paraesthesia or dysaesthesia of the lower lip, chin, teeth and buccal mucosa on the homologous side, whilst altered sensations of

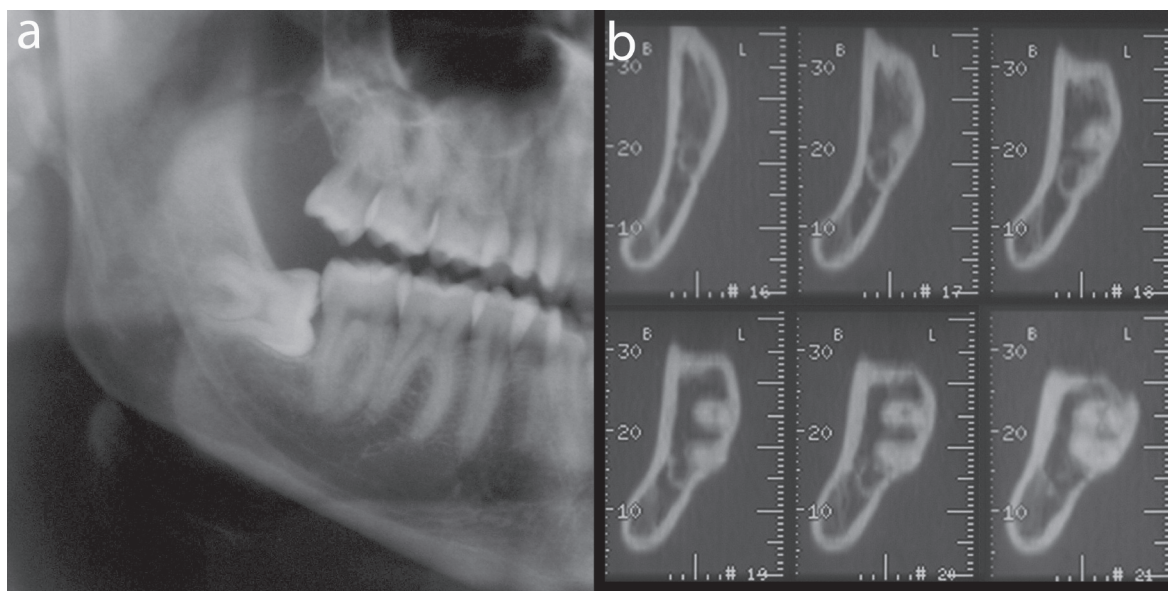


Figure 1. (a) Panoramic radiograph shows impaction of 4.8 in the presence of the overlap of root tips and inferior alveolar canal; (b) CT cross-sections demonstrate the exact course of the mandibular canal in contact with the roots of 4.8.

the tongue are due to LN lesions (1). Furthermore, depending on the involved nerve and the severity of the damage, there may be an association with functional deficits, such as burning sensation of the tongue, chewing and speech difficulties, involuntary biting of the lip and/or tongue, and dysgeusia (7, 9, 10). To minimize intra- and post-operative neurological complications, a preoperative radiological examination is mandatory for assessing the presence of risk factors and to decide on the most appropriate surgical technique. Panoramic radiography is most commonly used for this purpose, but this method does not reveal (I) the true relationship between the IAC and third molar in the presence of the overlap of root tips and IAC; (II) diversion, narrowing or interruption of the IAC; (III) curvature, darkening, deflection or narrowness of the roots; or (IV) a bifid root apex (Fig. 1a) (5, 10-14). Computed tomography is recommended in these cases for demonstrating the three-dimensional relationship between the two structures due to its sensitivity and specificity both being significantly superior to panoramic images (11). Indeed, the additional information provided regarding the position of the third molar and on the nerve and root anatomy makes it possible to improve the surgical approach and reduce the risk of injury (Fig. 1b) (5, 15-19). However, this method cannot be used to localize the LN.

The purpose of this article is to describe operative protocols that should minimize the risk of damage to the IAN and LN during mandibular third molar surgery.

Surgical technique

The surgical approach for removing the mandibular

third molar involves anaesthesia, incision and elevation of mucoperiosteal flap, osteotomy and tooth sectioning, elevation and avulsion according to the root axis, socket debridement, and suturing. These various procedures are described in detail below.

Local anaesthesia is generally preferred, and can be induced using an IAN block (mepivacaine 3% without epinephrine) and tissue infiltration (mepivacaine 2% with 1:100,000 epinephrine). General anaesthesia could be restricted to patients who are not cooperative, long or complex interventions, or when there is a high risk of intraoperative complications requiring further treatment, such as jaw fractures.

A well-designed *mucoperiosteal flap* for obtaining appropriate surgical access is the most important step in the removal of impacted mandibular third molars. A triangular or linear buccal flap is likely to be optimal. In this type of flap, to preserve the integrity of the LN, a distal releasing incision should be made in the retromolar area from the distal-buccal crown edge of the second molar slightly oblique in the vestibular direction, without involving the lingual side of the crestal mucosa. The mucoperiosteal flap must be elevated on the buccal surface of the mandible, and elevation of the lingual soft tissues, which is usually limited to a few millimetres, should be performed carefully in order to prevent accidental slippage of the periosteal elevator (Fig. 2).

When the third molar position requires a lingual flap, it should be wide enough to allow adequate access to the operating field, and the releasing incision should be located some distance from the site of inclusion, within the safety zone, to avoid unintended traction or lacerations of the LN. Before and after raising and retracting the subperiosteal lingual flap using a curved periosteal elevator, a lingual broad retractor with no

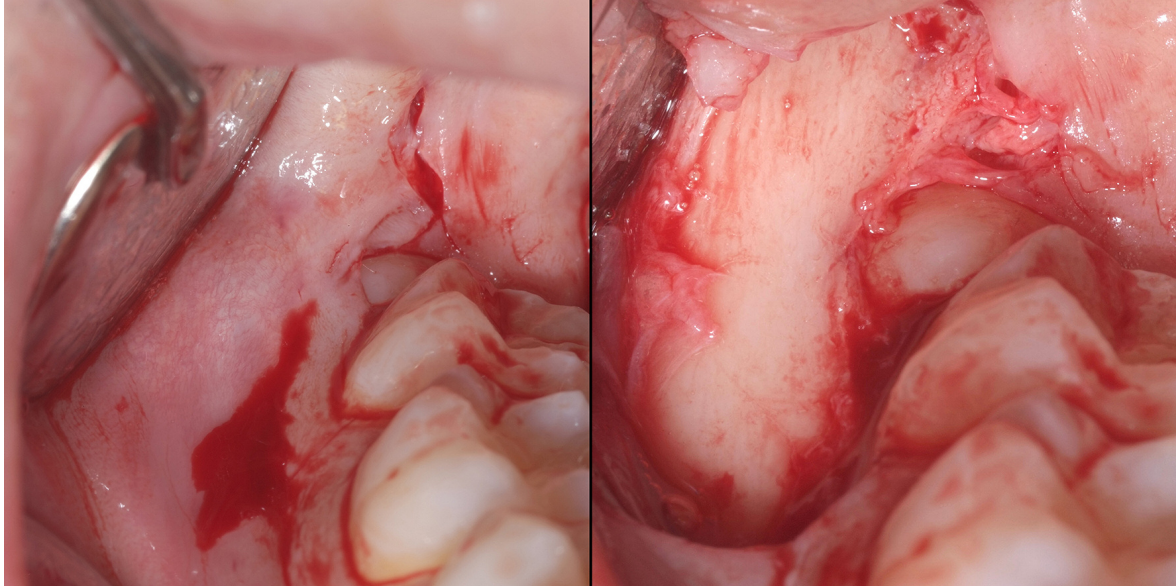


Figure 2. Mucoperiosteal flap: the distal releasing incision in the retromolar area should not involve the lingual side of the crestal mucosa.

sharp edges must be placed carefully in the periosteum and the bone plate in order to improve visibility and to protect the lingual soft tissue and the LN during osteotomy, tooth sectioning and elevation (20, 21).

Osteotomy is usually carried out from the occlusal plane down to the cemento-enamel junction of the mandibular third molar, and it should be as conservative as possible on the distal and distal-lingual side so as to not involve the IAN and LN (Fig. 3) (22). To avoid thermal trauma, the bone tissue should be removed using tungsten-carbide round and fissure burs mounted on a low-speed handpiece under copious refrigerated irrigation (4).

Tooth sectioning is designed to allow disengagement of the element by decreasing its zone of retention and to avoid compression or stretching of the IAN. The sectioning performed using a tungsten-carbide round bur mounted on a high-speed handpiece should not exceed the peripheral limits of the tooth, so as to leave a thin diaphragm of intact dental tissue near the nerve trunk. In order to complete the sectioning procedure, the diaphragm will be fractured in a cautious manner using elevators (Fig. 4).

Tooth removal should be performed with a root elevator, directing the force vector in the path of withdrawal imposed by the curvature of the root apex, to avoid the risk of nerve compression or stretching.

Socket debridement is performed after tooth extraction with extreme care, especially when removing the lingual portion of the follicular remnants from surrounding tissues to avoid tearing the lingual mucosa so as to not damage the LN. The socket was then irrigated with sterile saline solution at room temperature (Fig. 5).

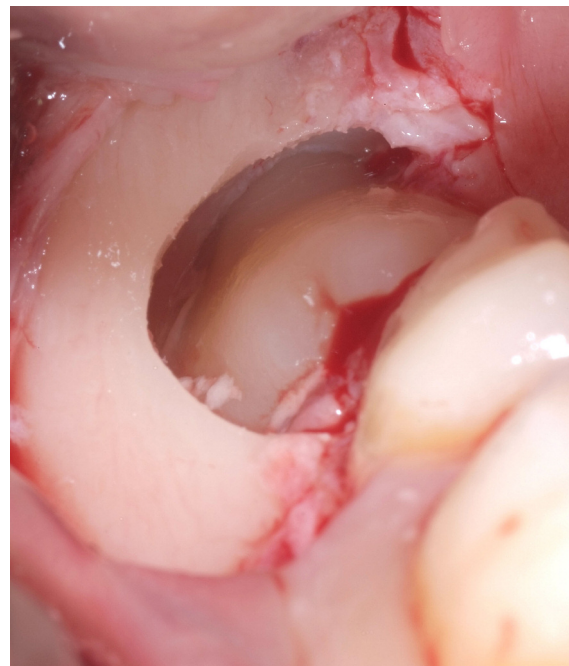


Figure 3. Osteotomy: should be as conservative as possible on the distal and distal-lingual side.

Suturing in the retromolar pad area should be performed with the needle piercing the mucosa from the inner side in a buccal-lingual direction, because a passage in the opposite direction could expose the LN to the risk of a puncture lesion and to injury due to its shrinkage during the knotting procedure (Fig. 6).

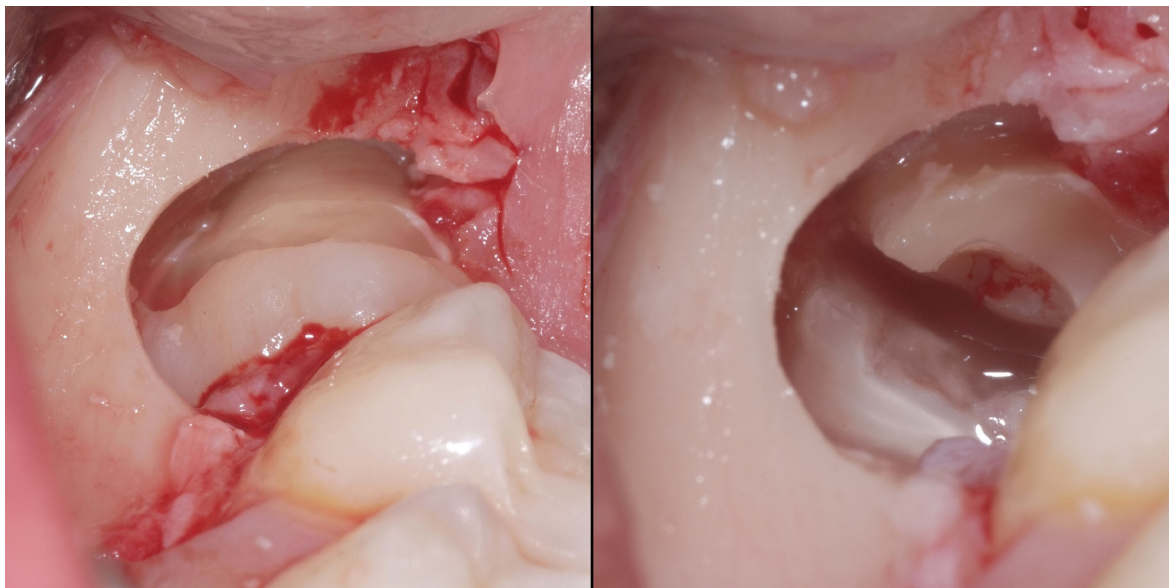


Figure 4. Tooth sectioning is designed to allow disengagement of the element by decreasing its zone of retention and to avoid compression or stretching of the IAN.



Figure 5. Socket debridement is performed with extreme care, avoiding to tear the lingual mucosa not to damage the LN.

Discussion

Different surgical techniques have been described for preventing neurological injury during mandibular third molar surgery. Coronectomy (partial odontectomy or root retention) consists of removing only the crown of an impacted mandibular third molar, leaving part of its roots at least 3 mm below the crestal bone, and

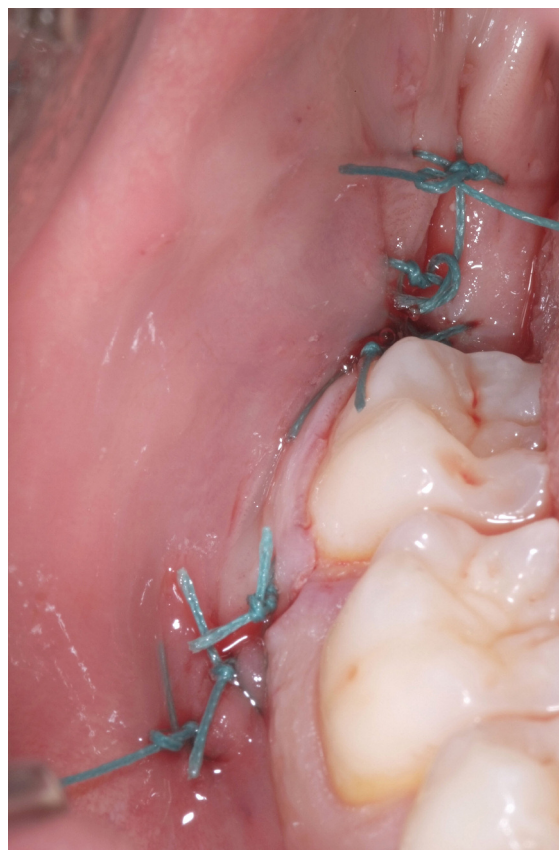


Figure 6. Suturing in the retromolar pad area should be performed with the needle piercing the mucosa from the inner side in a buccal-lingual direction not to expose the LN to the risk of puncture and shrinkage lesions during the knotting procedure.

without performing pulpal treatment (23, 24). Coronectomy seems a reliable procedure for reducing the incidence of injuries to the IAN (0-9.5%) and LN (0-2%), with low rates of post-operative failure (on average less than 10%) and post-operative complications (pain, swelling, infection, dry socket and root migration) (23, 25, 26). In some cases, accidental intraoperative loosening or mobilization of the roots and post-operative root exposure made it mandatory to perform conventional surgical extraction. However, this technique is considered controversial by many oral surgeons due to the potential adverse effects of the retained roots. New randomized clinical studies involving larger samples and long follow-up periods are needed to accurately assess the long-term success of this approach.

The orthodontic-assisted extraction requires surgical exposure of the third molar crown, placement of an orthodontic anchorage and orthodontic extrusion in order to move the roots away from the IAC; the extraction is then performed after 3-6 months, when the tooth has moved sufficiently in the occlusal plane (27-29). Although this technique can improve periodontal healing distal to the second molar, it has disadvantages of being complex to perform, not well tolerated by the patient due to discomfort of the orthodontic device, time-consuming and expensive (25).

Another procedure requiring a double surgical intervention is the staged approach, which involves sectioning the mesial portion of the third molar crown to provide adequate space distal to the second molar to promote migration of the roots away from the IAN, which are extracted in the second surgical session (30). We consider that compared with the orthodontic-assisted technique, this technique improves patient comfort and reduces the chair time and procedural costs, since no intraoral appliances are required (30).

Pericoronal osteotomy also consists of two stages to complete the extraction of the third molar. In stage 1, the coronal bone is removed to eliminate bony interferences and create an adequate "eruptive space" to allow occlusal movement of the tooth, with light luxation (subluxation) of the tooth to improve its eruptive potential; this is followed some weeks later by extraction in stage 2 (31). The drawbacks of this procedure are the involvement of a staged operation, the possibility of LN injury in rare cases necessitating the full exposure of the coronal surface at the lingual aspect and a (low) risk of IAN injury (31). The use of this staged approach and pericoronal osteotomy is actually based on a very small sample with a short follow-up, and so its effectiveness and safety still need to be comprehensively assessed in randomized controlled trials involving large samples.

Alternative surgical techniques have been proposed for the removal of mandibular third molars, but the conventional surgical extraction with a buccal approach remains the most common procedure worldwide. We consider that the technical notes described in this article suggest intraoperative measures that

can reduce neurological complications.

Regarding the type of anaesthesia, some Authors have found the incidence of nerve damage to be lower and the neuropathic area to be larger when the surgery is performed under general rather than local anaesthesia (10, 32). This could be due to the increased difficulty of specific surgical procedures and to the aggressiveness of the surgeon when an intervention was carried out with the patient under general anaesthesia (10). In a single prospective study of 718 mandibular third molar extractions, Brann et al. found that the incidence of LN and IAN damage was five times higher when the surgery was performed under general anaesthesia (18%) than under local anaesthesia (3%). However, they found no significant associations between surgical difficulty, eruption status, age and preoperative pathology (32). In contrast, the prospective longitudinal study of Rehman et al. found no links between the choice of local (105 teeth) or general (474 teeth) anaesthesia and nerve damage during the removal of 614 mandibular third molars when the difficulty of surgery was taken into account (33).

Nerve damage can also occur as a complication of mandibular block anaesthesia, which affects the LN significantly more often than the IAN (34, 35). Although the reasons are unknown, the sensory alterations reportedly occur due to direct trauma by needle during penetration or retraction from bone contact, compression by intraneural bleeding or neurotoxicity of certain anaesthetic formulations (e.g. 4% articaine and 3-4% prilocaine). To prevent nerve injuries related to local anaesthesia, high concentrations of anaesthetic agent and multiple blocks should be avoided whenever possible (10).

The flap design was planned preoperatively according to the depth of the inclusion and the position of the third molar. During flap incision it is important to avoid both the LN and facial artery. In the mandibular third molar region, the LN runs about 2.5 mm medially and inferiorly to the alveolar ridge, although in some cases it may lie above the bone or within the soft tissues of the retromolar pad area (36, 37). These variations in the position of the LN predispose it damage throughout the surgical procedure, and injuries are not always avoidable (6).

Once flap incision and dissection are completed, it is important to keep the soft tissue retracted and protected during osteotomy, tooth sectioning and dislocation. Several studies have shown that while the use of a lingual flap and the placement of a lingual retractor can cause transient LN damage, this procedure does not appear to be a cause of permanent LN damage (38, 39). Many studies have criticized the use of a Howarth elevator, since although this can be used to retract the lingual tissue, it does not adequately protect the LN, and the bur can slip in front or behind the elevator and still damage the LN (40). Moss et al. proposed that the key to successful lingual retraction was creating an area of "tissue freedom" before inserting a retractor in order to avoid unnecessary

stretching of the nerve. This theory suggests extending the lingual flap to the distal side of second molar to allow the insertion of a wider retractor, a technique that reportedly resulted in a lower incidence rate in a single operator series (41). Where necessary, the use of a lingual retractor provides the surgeon with better visualization of the third molar, better access and the ability to remove distal bone, distal-lingual bone and even lingual bone, since protection is provided by retractor. Raising a lingual flap and using a lingual retractor for selected indications is therefore felt to be an acceptable protocol during the removal of mandibular third molars (6, 24). Note that the lingual retractor must be broad and have no sharp edges to ensure that the LN is protected and not damaged (2). The ostectomy was always performed under copious irrigation to prevent overheating and using new and sharp burs. There are some reports of higher rates of IAN and LN damage after extraction of third molar with total bone impaction, because damage to these nerves is significantly related to the technique used for bone removal (3, 6, 9, 41).

To reduce surgical morbidity caused by manipulation and to minimize damage during ostectomy, the tooth-sectioning technique is a standard procedure that facilitates the removal of the impacted tooth by decreasing its zone of retention (4). Ultrasound bone surgery may also be useful in selected cases for reducing the risk of nerve damage during ostectomy and tooth sectioning. This technique can be used to make micrometric, precise and smooth cuts into mineralized tissues while adjacent soft tissues are preserved, provided that very low pressure is applied (42-44). Nevertheless, the operating time is much longer compared to when using conventional rotary instruments.

It must also be remembered that inappropriate tooth dislocation may cause the displacement of the entire tooth or part thereof into the sublingual or submandibular space due to internal fracture of the alveolar wall, possibly resulting in injury to the LN. Horizontal and distal-angulated positions expose patients to the highest risk of neurological injury for the IAN, while a lingual position exposes the patient to the risk of LN damage as well as adding complexity to the surgery (45).

A careful surgical approach must be employed for those patients having a mandibular third molar with recurrent pericoronary infection disease, since the risk of nerve paraesthesia has been found to be seven times higher (46). As described previously, repetitive infections probably increase the susceptibility of nerve sheaths to surgical traction or pressure movements (46).

Finally, once the impacted tooth has been extracted, great care is needed when cleaning the surgical site so as to avoid direct damage of the vascular nervous bundle. Similar care is needed during the subsequent wound suturing to avoid the needle puncturing the LN, and also to avoid injury due to narrowing during the knotting process.

Conclusion

Minimizing intra- and post-operative neurological complications requires a good knowledge of anatomy in order to identify the presence of risk factors and to decide on the most appropriate surgical technique. The role of expertise and professional experience in the incidence of complications associated with third molar removal should also not be underestimated, since complications reportedly occur more often among inexperienced surgeons than among those with experience related to IAN and LN injury (6, 20, 38-40, 45, 47). However, some Authors have also found higher rates of IAN deficits in surgery performed by specialists/consultants than surgical trainees/residents or undergraduates (1, 33, 45). Leung and Cheung assumed that the greater involvement of specialists/consultants in post-operative IAN deficits could be due to them encountering more difficult and deeply impacted third molars compared with the operators having less surgical experience (1). This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest and source of funding statement

The Authors have stated explicitly that there are no conflicts of interest in connection with this article.

Authors Declarations

All Authors gave final approval and agree to be accountable for all aspects of the work.

References

1. 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.
2. Bataineh AB. Sensory nerve impairment following mandibular third molar surgery. *J Oral Maxillofac Surg.* 2001;59:1012-1017.
3. Blondeau F, Daniel NG. Extraction of impacted mandibular third molars: postoperative complications and their risk factors. *J Can Dent Assoc.* 2007;73:325.
4. Genù PR, Vasconcelos BCE. Influence of the tooth section technique in alveolar nerve damage after surgery of impacted lower third molars. *Int J Oral Maxillofac Surg.* 2008;37:923-928.
5. Szalma J, Lempel E, Jeges S, Szabó G, Olasz L. The prognostic value of panoramic radiography of inferior alveolar nerve damage after mandibular third molar removal: retrospective study of 400 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010;109:294-302.
6. 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;109:335-345.
7. Lata J, Tiwari AK. Incidence of lingual nerve paraesthesia

- following mandibular third molar surgery. *Natl J Maxillofac Surg.* 2011;2:137-140.
8. Charan Babu HS, Reddy PB, Pattathan RK, Desai R, Shubha AB. Factors influencing lingual nerve paraesthesia following third molar surgery: a prospective clinical study. *J Maxillofac Oral Surg.* 2013;12:168-172.
 9. Fielding AF, Rachiele DP, Fraizer G. Lingual nerve paresthesia following third molar surgery: a retrospective clinical study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1997;84:345-358.
 10. 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;41:1509-1518.
 11. Tantanapornkul W, Okouchi K, Fujiwara Y, Yamashiro M, Maruoka Y, Ohbayashi N, et al. A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2007;103:253-259.
 12. Flygare L, Öhman A. Preoperative imaging procedures for lower wisdom teeth removal. *Clin Oral Investig.* 2008;12:291-302.
 13. 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;15:886-890.
 14. Friedland B, Donoff B, Dodson TB. The use of 3-dimensional reconstructions to evaluate the anatomic relationship of the mandibular canal and impacted mandibular third molars. *Oral Maxillofac Surg.* 2008;66:1678-1685.
 15. Céspedes-Sánchez JM, Ayuso-Montero R, Mari-Roig A, Aranz-Obispo C, López-López J. The importance of a good evaluation in order to prevent oral nerve injuries: a review. *Acta Odontol Scand.* 2014;72:161-167.
 16. Umar G, Obisesan O, Bryant C, Rood JP. Elimination of permanent injuries to the inferior alveolar nerve following surgical intervention of the "high risk" third molar. *Br J Oral Maxillofac Surg.* 2013;51:353-357.
 17. Matzen LH, Christensen J, Hintze H, Schou S, Wenzel A. Influence of cone beam CT on treatment plan before surgical intervention of mandibular third molars and impact of radiographic factors on deciding on coronectomy vs surgical removal. *Dentomaxillofac Radiol.* 2013;42:9887034.
 18. Di Bari R, Coronelli R, Cicconetti A. An anatomical radiographic evaluation of the posterior portion of the mandible in relation to autologous bone harvest procedures. *J Craniofac Surg.* 2014;25:475-483.
 19. Tuzi A, Di Bari R, Cicconetti A. 3D imaging reconstruction and impacted third molars: case reports. *Ann Stomatol (Roma).* 2012;3:123-131.
 20. Pogrel MA, Goldman KE. Lingual flap retraction for third molar removal. *J Oral Maxillofac Surg.* 2004;62:1125-1130.
 21. Haug RH, Abdul-Majid J, Blakey GH, White RP. Evidenced-based decision making: the third molar. *Dent Clin North Am.* 2009;53:77-96.
 22. Valmaseda-Castellon E, Berini Aytès L, Gay-Escoda C. Inferior alveolar nerve damage after lower third molar surgical extraction: a prospective study of 1117 surgical extraction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2001;92:377-383.
 23. Long H, Zhou Y, Liao L, Pyakurel U, Wang Y, Lai W. Coronectomy vs. total removal for third molar extraction: a systematic review *J Dent Res.* 2012;91:659-665.
 24. Gleeson CF, Patel V, Kwok J, Sproat C. Coronectomy practice. Paper 1. Technique and trouble-shooting. *Br J Oral Maxillofac Surg.* 2012;50:739-744.
 25. Martin A, Perinetti G, Costantinides F, Maglione M. Coronectomy as a surgical approach to impacted mandibular third molars: a systematic review. *Head Face Med.* 2015;10:11-9.
 26. Patel V, Gleeson CF, Kwok J, Sproat C. Coronectomy practice. Paper 2: complications and long term management. *Br J Oral Maxillofac Surg.* 2013;51:347-352.
 27. Checchi L, Alessandri Bonetti G, Pelliccioni GA. Removing high-risk impacted mandibular third molars: a surgical-orthodontic approach. *J Am Dent Assoc.* 1996;127:1214-1217.
 28. Alessandri Bonetti G, Bendandi M, Laino L, Checchi V, Checchi L. Orthodontic extraction: riskless extraction of impacted lower third molars close to the mandibular canal. *J Oral Maxillofac Surg.* 2007;65:2580-2586.
 29. Hirsch A, Shteiman S, Boyan BD, Schwartz Z. Use of orthodontic treatment as an aid to third molar extraction: a method for prevention of mandibular nerve injury and improved periodontal status. *J Periodontol.* 2003;74:887-892.
 30. Landi L, Manicone PF, Piccinelli S, Raia A, Raia R. A novel surgical approach to impacted mandibular third molars to reduce the risk of paresthesia: a case series. *J Oral Maxillofac Surg.* 2010;68:969-974.
 31. Tolstunov L, Javid B, Keyes L, Nattestad A. Pericoronar osteotomy: an alternative surgical technique for management of mandibular third molars in close proximity to the inferior alveolar nerve. *J Oral Maxillofac Surg.* 2011;69:1858-1866.
 32. Brann CR, Brickley MR, Sheperd JP. Factors influencing nerve damage during lower third molar surgery. *Br Dent J.* 1999;186:514-516.
 33. Rehaman K, Webster K, Dover MS. Links between anesthetic modality and nerve damage during lower third molar surgery. *Br Dent J.* 2002;192:43-45.
 34. Hillerup S, Jensen R. Nerve injury caused by mandibular block analgesia. *Int J Oral Maxillofac Surg.* 2006;35(5):437-443.
 35. Pogrel MA. Permanent nerve damage from inferior alveolar nerve blocks: a current update. *J Calif Dent Assoc.* 2012;40:795-797.
 36. Kiesselbach JE, Chamberlain JG. Clinical and anatomic observations on the relationship of the lingual nerve to the mandibular third molar region. *J Oral Maxillofac Surg.* 1984;42:565-567.
 37. Robinson RC, Williams CW. Documentation method for inferior alveolar and lingual nerve paresthesia". *Oral Surg Oral Med Oral Pathol.* 1986;62:128-131.
 38. Gomes ACA, Cavalcanti do Egito Vasconcelos B, Dias de Oliveira e Silva E, Ferreira da Silve LC. Lingual nerve damage after mandibular third molar surgery: a randomized clinical trial. *J Oral Maxillofac Surg.* 2005;63:1443.
 39. Pichler JW, Beirne OR. Lingual flap retraction and prevention of lingual nerve damage associated with third molar surgery: a systematic review of the literature. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2001;91:395-401.
 40. Robinson PP, Smith KG. Lingual nerve damage during lower third molar removal: a comparison of two surgical methods. *Br Dent J.* 1996;180:456-461.
 41. Moss C, Wake M. Lingual access for third molar surgery: a 20-years retrospective audit. *Br J Oral Maxillofac Surg.* 1999;178:140-144.
 42. Pippi R, Alvaro R. Piezosurgery for the lingual split technique in mandibular third molar removal: a suggestion. *J Craniofac Surg.* 2013;24:531-533.
 43. 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;39:320-326.
 44. Cristalli MP, La Monaca G, Sgaramella N, Voza I. Ultrasonic bone surgery in the treatment of impacted lower third molar associated to a complex odontoma: a case report. *Ann Stomatol (Roma).* 2012;3:64-68.
 45. Barone A, Marconcini S, Giacomelli L, Rispoli L, Calvo JL

- Covani U. A randomized clinical evaluation of Ultrasound bone surgery versus traditional rotary instruments in lower third molar extraction. *J Oral Maxillofac Surg.* 2010;68:330-336.
46. Costantinides F, Biasotto M, Gregorio D, Maglione M, Di Leonarda R. Abscess as a perioperative risk factor for paresthesia after third molar extraction under general anesthesia. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2009;107:8-13.
47. Sisk A, Hammer W, Shelton D, Joy E. Complications following removal of impacted third molars: the role of the experience of the surgeon. *J Oral Maxillofac Surg.* 1986;44:855-859.