The relative risk of neurosensory deficit following removal of mandibular third molar teeth: the influence of radiography and surgical technique

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Objective. The aim of this study was to identify the relative risk of damage to the inferior dental (ID) and lingual nerves in patients undergoing lower third molar removal.
Study Design. A single surgeon reviewed 1,000 patients.
Results. Temporary ID neurosensory deficit was highest (11%) when root apices were intimate to the ID nerve and lowest (0.9%) when close or distant from the nerve. Permanent ID neurosensory deficit was 0.4% per tooth but only when intimate to the canal. Bone removal, tooth division, and lingual split technique increase the risk of excessive hemorrhage which appears to be linked to the highest risk of temporary ID neurosensory deficit (20%). Permanent lingual nerve injury was rare (0.06%) and not related to lingual retraction.
Conclusions. Preoperative warning for lower third molar removal can be individually tailored depending on the intimacy of the ID canal to the root apices and the anticipated surgical technique. (Oral Surg Oral Med Oral Pathol Oral Radiol 2013; 115:18-24)

Damage to the inferior dental (ID) and lingual nerves is an uncommon but important complication in the surgical removal of impacted mandibular third molar teeth. The ID nerve runs in a bony canal within the mandible in a variable relationship to the root tips of the third mandibular molar tooth. Damage to this nerve manifests as a sensory disturbance of the lower lip and chin to the midline. The lingual nerve passes between the medial pterygoid muscle and mandibular ramus and then medially to the third molar immediately beneath the lingual periosteum, contacting the adjacent lingual plate in 62% of cases.[1] Damage to the lingual nerve results in altered sensation to the ipsilateral tongue with or without taste disturbance. The risk of ID nerve damage ranges from 0.26% to 8.4%,[2] and the risk of lingual nerve injury ranges from 0.1% to 22%.[2] When the ID nerve is injured, healing and recovery is relatively quick, because the nerve is usually contained within the bony canal. However, the lingual nerve is not supported by a bony canal and the damaged lingual nerve fibers often retract and become embedded in scar tissue. This latter phenomenon may explain why, in some studies, recovery from lingual nerve injury is far less predictable than for the ID nerve.[3,4] Nevertheless, most studies show that neurosensory deficit, when present, is temporary, resolving within 6 months. If the deficit persists >2 years, the altered sensation is considered to be permanent.[5–7]

Studies vary in size from <100 to >1,400 teeth, but most have been performed retrospectively, often enlisting multiple operators of varying experience and training, which can produce inconsistent and unreliable data.

Standard surgical practice involves a routine warning of potential damage to these nerves during surgery with the clinician having a duty of care to the patient to give adequate explanation and warning to permit consent.

The clinician should be able to inform the patient, before surgery, of the statistical likelihood of neurologic injury so that he/she may make a reasonable judgment whether or not to undergo surgery, especially because the removal of an impacted lower third tooth is an elective procedure. The exact etiology of ID nerve injury has been reported as imprecise and multifactorial. Kipp, Goldstein, and Weiss (1980)[8] consider that mechanical injury from chisels, burs, and elevators are most likely. Howe and Poyton (1960)[9] concluded that crushing or tearing of the nerve from movement of the tooth/root was more likely, particularly if the ID nerve

Statement of Clinical Relevance

This study of 1,000 patients highlights the variation in neurosensory deficit following third molar surgery directly attributable to the relationship of the root apices to the inferior dental neurovascular bundle.

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grooved or perforated the lower third molar tooth. Crushing of the bony roof of the inferior dental canal onto the nerve also has been implicated.

Earlier publications have positively correlated specific radiographic findings with the risk of nerve injury. A panoramic radiograph (orthopantomogram [OPT]) is the radiologic investigation of choice before lower third molar surgery. The criteria for injury are identifiable on this radiograph, but like other conventional radiographs is unable to give complete information in 3 dimensions. Computerized tomographic (CT) scanning remains the most accurate preoperative investigation of predicting damage to the ID nerve.[10] However, this involves unnecessary radiation dosage to the patient, and the cost/benefit gain seems to be unjustified for such a routine and common procedure. Although Rood et al. (1990)[6] defined 7 radiologic markers that suggest an intimate relationship between mandibular third molar teeth and the nerve, 3 particular radiologic signs—1) diversion of the ID canal; 2) root darkening; and 3) deflected root apices by the canal—are now accepted as the most significant in predicting neurologic injury[2] and are used in assessing the likelihood of damage to the ID nerve. They also form the basis for obtaining consent from the patient particular to realistic risk of damage of the nerve and subsequent mental anesthesia. Additional factors implicated in nerve injury and subsequent recovery include the age of the patient and the local blood supply. Earlier studies[11] have also highlighted that unerupted, deeply impacted, and horizontally placed lower third molar teeth are at highest risk of ID nerve damage.

Certain operative findings are also linked to the likelihood of developing postoperative neurosensory deficit. Lingual split technique compared with buccal approach is 2.3 times more likely to induce lingual nerve damage, and intraoperative exposure of the ID nerve increases risk 15-fold,[2] with a 20% risk of postoperative anesthesia.[12] Because the ID vein lies superior in the canal, significant bleeding alerts the surgeon that the canal has been breached and neurologic injury is a realistic sequelae. More profuse bleeding usually indicates arterial injury which is intimately associated with the ID nerve.[5,8]

Interestingly, the experience of the operator appears to be a confounding variable in the incidence of ID deficit. Jerjes (2010)[11] in a large series of patients identified the surgical skills/experience of the operator as a main risk factor in developing permanent sensory deficit, and Leung (2010)[2] identified the highest incidence of neurosensory deficit in patients who underwent surgical removal by consultants/specialists compared with trainees and undergraduates. Cheung (2010),[13] however, cited increased technical difficulty in the consultants group as a rational explanation.

The aim of the present paper was to carry out a study identifying the relative risk of injury to the nerve when the tips of the roots are radiologically either "distant," "close," or "intimate" to the ID nerve. In addition, it endeavored to highlight additional risk factors, e.g., bleeding, that may be implicated in neurologic deficit. The paper allows a unique opportunity to study the caseload of a single experienced surgeon who uses a reproducible well established surgical technique predominantly under day case general anesthesia in an operating room environment to remove impacted lower third molar teeth.

MATERIALS AND METHODS

During the period of 2001-08, 1,000 consecutive patients were referred to the author for the removal of impacted mandibular third molar teeth. Patients were almost exclusively referred by general dental practitioners. The project was assessed by the Research and Ethics Department of Northampton General Hospital NHS Trust which acknowledged the study as service development.

A prospectively maintained custom-built database (Microsoft Access) was used to record patient demographics as well as a radiographic assessment of the impacted teeth. An up-to-date OPT was available on every patient during initial consultation and evaluated by the author for the relationship of the root tips of the impacted mandibular third molar tooth to the ID canal. The relationship was entered into the database before surgery. A simple practical classification relating the apices of the impacted third molar tooth/roots to the nerve was used:

1. *Distant from the canal*: There is a radiologic separation of >1 mm between the tips of the roots of the mandibular third molar and the ID canal within the mandible.
2. *Close to the canal*: The tips of the roots either abut the ID canal with no additional features or changes in radiologic appearance (see below). Alternatively, there is unchanged superimposition of the root apices over the ID canal.
3. *Intimate to the canal*: The tips of the roots are considered to be intimate to the ID canal when ≥ 1 of the following 3 criteria are met:
   a. Diversion of the ID canal.
   b. Darkening of the root.
   c. Deflected root apices.

All patients were treated under the UK Department of Health–NICE guidelines[14] for the management of impacted lower third molar teeth. When a patient required a general anesthetic, the contralateral mandibular third molar tooth was assessed and simultaneous extraction offered and performed only when the tooth was par-

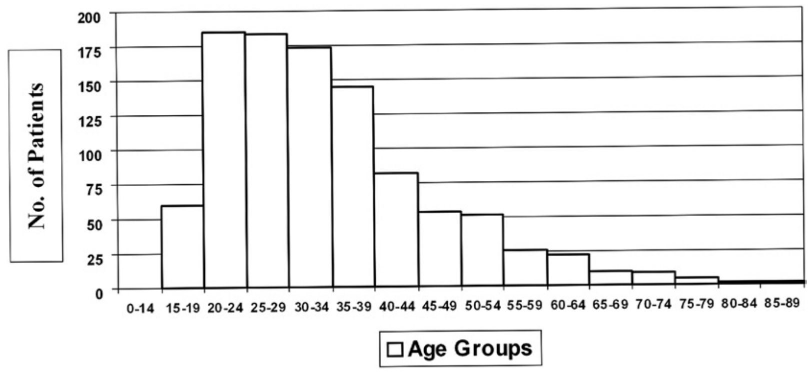

Fig. 1. Age distribution of 1,000 consecutive patients undergoing surgical removal of lower third molars.

tially erupted and likely to develop pathology in the future. Full written consent was obtained in every patient before surgery.

Surgical technique

Surgical removal was performed under a local anesthetic or a day-case general anesthesia in an operating theater. All patients under general anesthesia receive intravenous methylprednisolone (125 mg), intravenous antibiotics, and local infiltration of 0.5% bupivicaine and adrenaline to the operative sites to reduce postoperative analgesia requirements. Patients receiving local anesthesia (lignocaine with adrenaline) received oral antibiotics (3 g amoxil) within 1 hour before surgery.

Impacted mandibular third molar teeth were exposed using a buccal envelope mucoperiosteal flap. Bone removal was preferentially carried out with rotating burs. Lingual retraction was not used electively unless a significant amount of distal or distolingual bone removal was anticipated. The lingual tissues were released as far forward as the distal aspect of the lower second molar tooth to allow the subperiosteal insertion of a broad, e.g., Rowe, lingual retractor. Lingual split technique was used at the discretion of the author where the removal of distolingual bone would facilitate tooth delivery. When the tooth was deeply impacted, early elective decoronation and division of the roots was performed. Crown and roots were elevated separately. Coronectomy was not offered to any of the patients, because the procedure did not appear in the literature until after the commencement of the study. The socket was debrided, irrigated, and closed with resorbable sutures. Patients were prescribed postoperative antibiotics (Co-Amoxiclav or metronidazole) and appropriate analgesics, usually Ibuprofen (400 mg 3 times per day) unless contraindicated. Surgical techniques, including perioperative complications, were entered into the database on completion of surgery.

Two weeks later, the patient was reviewed by the author and postoperative complications entered into the database, including bleeding, dry socket, infection, retained root fragments and damage to the adjacent tooth. Bleeding was considered to be "excessive" when additional intervention, e.g., Surgicel pack and/or additional suturing was required to achieve hemostasis. Additional or repeated pressure packs did not constitute "excessive" bleeding.

All patients were reviewed and asked to volunteer any neurosensory symptoms. Sensory impairment in the distribution of the ID nerve was mapped by 2-point discrimination, pin prick, and light touch. The unaffected side was used as control. Any neurologic deficit was classified as one of the following: anesthesia (no response to any stimulus), paresthesia (partial response to $\geq$1 stimulus); or dysesthesia (a painful sensation triggered by nonnoxious stimuli).

The neurologic deficit was, when present, monitored at 3-month intervals until recovery had occurred. At every follow-up visit, the patient was questioned and the neurologic deficit objectively tested. The neurologic deficit was considered to be fully recovered if the patient did not report any impairment of sensation and the objective test returned to normal. Neurosensory deficit was considered to be permanent if symptoms and signs were present 2 years after surgery.

RESULTS

Surgery was performed for 1,000 patients in a hospital environment, removing 1,589 impacted lower third molar teeth. There was a slight female preponderance (58.5%). The median age of the patient was 31 years, with a range of 13-87 years. The mean age was 33.9 years (Figure 1).

Ninety percent of patients underwent the surgical removal of impacted molar teeth under a day-case general anaesthetic. Nine percent underwent surgery under local anesthetic alone and 1% with the use of local anesthesia supplemented with intravenous sedation. The types of impaction of the mandibular molar

Table I. Types and incidence of impaction of lower third molars

Impaction	Left	Right	Total (%)
Distoangular	253	231	484 (31)
Mesioangular	250	261	511 (32)
Horizontal	100	113	213 (13)
Vertical	171	160	331 (21)
Orthognathic	8	8	16 (1)
Other	8	13	21 (1.3)
Soft tissue only	7	6	13 (0.7)
Total	797	792	1,589

teeth are outlined in Table I, with mesioangular and distoangular impaction accounting for >60% of cases.

The indications for removal are outlined in Table II, with pericoronitis (49%) being most common and 18% of extractions performed on the asymptomatic partially erupted contralateral lower third molar tooth.

Of the 1,589 lower third molar teeth removed, 466 (29%) demonstrated a distant relationship of their apices to the ID canal, 869 (55%) were close to the canal, and only 254 (16%) were deemed to be intimate to the canal. There appeared to be no predominance between the left (n = 797) and right (n = 792) sides regarding this anatomic relationship.

Incidence of neurosensory deficit

Thirty-nine patients (3.9%) reported neurosensory disturbance over the distribution of the ID nerve in 40 extractions (Table III). Seven patients (0.7%) sustained permanent sensory loss. Nineteen patients with ID nerve damage had undergone a left lower wisdom tooth extraction, whereas 21 patients had undergone a right lower wisdom tooth extraction. Bilateral injury was observed in 1 case. The incidence of ID neurosensory deficit was highest with horizontal impaction (4.7%) and lowest when the tooth is vertically impacted (0.9%; Table III). However, the difference between each type of impaction is not statistically significant. Forty teeth produced mental anesthesia, of which 33 (83%) required both bone removal and tooth division, whereas only 6 teeth (15%) removed by bone removal alone resulted in neurologic deficit. One extraction (0.06%) produced mental anesthesia after simple elevation. The overall incidence of ID nerve damage was 2.5% per tooth removal. Thirty-three (85%) of the 39 patients experiencing mental anesthesia reported resolution of anesthesia within 6 months. Seven (0.7%) of the 1,000 patients reported permanent mental anesthesia, and the incidence per tooth removal was 0.4% (7/1,589).

Lingual anaesthesia occurred in 5 (0.3%) of the 1,589 procedures, of which 134 (8.4%) procedures necessitated lingual flap release and concomitant nerve protection. Lingual flap release (134 procedures) produced 2 cases (1.5%) of temporary lingual anesthesia, and a further 3 patients developed lingual anesthesia in the absence of lingual nerve protection, one of which proved to be permanent (0.06%).

Table II. Indications for surgical removal of lower third molars

Indication	Left	Right	Total (%)
Pericoronitis	379	396	772 (49)
Caries	152	145	297 (19)
Cyst	27	35	61 (4)
Contralateral	157	139	296 (18)
Pain	54	49	103 (6.5)
Periodontal	10	10	20 (1.2)
Orthodontic	8	8	16 (1)
Orthognathic	4	4	8 (0.5)
Resorption	4	4	8 (0.5)
Fracture	4	2	6 (0.3)
Total	797	792	1,589

Table III. Incidence of mental anaesthesia and type of impaction

Impaction	Left	Right	Total
Vertical	1/171 = 0.5%	2/160 = 1.3%	3/331 = 0.9%
Mesioangular	9/250 = 3.6%	10/261 = 3.8%	19/511 = 3.7%
Distoangular	5/253 = 2.0%	2/231 = 0.9%	7/484 = 1.4%
Horizontal	3/100 = 3.0%	7/113 = 6.2%	10/213 = 4.7%
Other	1/23 = 4.3%	0/27 = 0%	1/50 = 2%
All	19/797 = 2.4%	21/792 = 2.7%	40/1,589 = 2.5%

Anatomic relationship and neurosensory deficit

The overall incidence of mental anesthesia was 3.9% per patient and 2.5% per tooth. However, when the cohort was subdivided by the anatomic relationship of the ID nerve to the root apices, a variation in the incidence exists. The lowest incidences were seen when the nerve was either "distant" (0.8%) or "close" (0.9%), and highest when the nerve was classed as "intimate" (11%; Table IV).

The difference between the "distant" group compared with the "intimate" group, was statistically significant ($P < .01$). The difference between the "close" and "intimate" groups was also statistically different ($P < .01$).

Bleeding and mental anesthesia

Bleeding remains a common and potential serious complication of lower third molar removal. The overall incidence of unexpected and excessive bleeding, requiring an additional surgical intervention, was 2.8% per tooth. Thirty-five (78%) of the 45 episodes of untoward/excessive bleeding were encountered during surgery. Excessive bleeding (Table V) was most prevalent when both bone removal and tooth division was needed (4.8%) and least likely after simple elevation

Table IV. Incidence of mental anaesthesia and relationship to inferior dental canal

Relationship	*Left*	*Right*	*Total*
Distant from canal	1/229 = 0.4%	3/237 = 1.2%	4/466 = 0.8%
Close to canal	4/440 = 0.9%	4/429 = 0.9%	8/869 = 0.9%
Intimate to canal	14/128 = 11%	14/126 = 11%	28/254 = 11%
All	19/797 = 2.4%	21/792 = 2.7%	40/1,589 = 2.5%

Table V. Relationship between surgical technique and excessive bleeding (bleed/total)

Surgical technique	*Left*	*Right*	*Total (%)*
Bone removal only	4/136	2/183	6/319 (1.9%)
Bone removal + lingual split	2/46	3/29	5/75 (6.7%)
Bone removal+ tooth division	17/310	12/292	29/602 (4.8%)
Bone removal + lingual split + tooth division	1/19	2/14	3/33 (9.1%)
Elevation only	1/286	1/274	2/560 (0.36%)
Total	25/797	20/792	45/1,589 (2.83%)

(0.36%). These differences were highly significant ($P \leq .001$). When bone removal alone is compared with bone removal plus additional techniques, e.g., tooth division, the reduction in excessive bleeding in the former group is statistically different ($P \leq .05$). Although the highest incidence of excessive bleeding (9%) occurred when bone removal, tooth division, and a lingual split technique was used, there was no significant difference between the 3 groups of bone removal with lingual split, bone removal with tooth division, and bone removal with tooth division and lingual split.

Management most commonly involved the use of Surgicel (36/45 cases) pack with additional suturing. Less common methods to achieve hemostasis include bipolar diathermy (3 cases) and tranexamic mouthwashes (3 cases). However, 9 (20%) of the 40 patients who bled excessively and required additional measures developed temporary mental anesthesia, of which 8 (89%) had root apices intimate or close to the ID nerve.

Contralateral lower third molar removal

Two hundred ninety-six asymptomatic contralateral impacted lower third molar teeth (18%) were surgically removed under general anesthesia. Seventy-six teeth (26%) were "distant" from the canal, one 181 teeth (62%) were "close" to the canal, and only 34 teeth (12%) were classed as "intimate" to the canal. Nearly one-half (46%) of the contralateral partially erupted teeth were either mesioangular (33%) or horizontally impacted (13%). Six procedures (2%) resulted in neurosensory deficit of the inferior dental nerve, of which 5 were mesioangular impactions. All neurosensory deficit in contralateral wisdom tooth removal occurred after bone removal and tooth division. Recovery of sensation occurred in 5 of the 6 patients within 6 months. One patient (0.3%) reported persisting mental anesthesia 12 months after surgery, for a mesioangular impaction intimate to the ID canal: The procedure was recorded as "difficult" owing to limited access, demanding bone removal, and tooth division and complicated by perioperative hemorrhage necessitating a Surgicel pack. Unfortunately, the patient was lost to follow-up 12 months after surgery, albeit with a resolving neurosensory deficit.

DISCUSSION

Injury to the ID nerve during lower third molar removal remains a significant clinical and medicolegal problem. Nevertheless, many patients still require the surgical removal of their impacted third molars to eradicate infection and pain and to permit restorative work on the adjacent molar tooth. The surgeon is currently obliged to inform all patients before surgery of the risk of neurologic injury. Conversely, a patient's anxiety may be alleviated when the risk of neurosensory injury is so remote that preoperative warnings can be tailored appropriately. With accurate information, patients are more likely to make a reasonable judgment whether to accept or decline surgery. Earlier data used multiple operators of variable experience, which is known to influence postoperative complication rates[11]; the present study is unique in using a single operator.[2] Moreover, confounding variables, such as radiographic interpretation and inconsistent data collection, were eliminated. Preoperative counseling, as well as clinical assessment, were all reproducible in a single-operator review.

Patients were treated under NICE guidelines,[14] and results confirmed that pericoronitis remains the most common indication for the surgical removal of the impacted lower third molar tooth, followed by unrestorable caries. The age range, mean, and median underpin these guidelines, because many patients seek treatment many years after their wisdom tooth has achieved its final position, either erupted, partially erupted, or completely buried in the mandible. More than 25% of the patients are >40 years old, with a wide age distribution (13-87 years), which reinforces the argument that a significant number of patients develop pathology, report symptoms, and seek treatment in middle or even old age.

Earlier studies have revealed a wide range in the incidence of ID nerve injury from 0.25%[15] to 8.4%[2,16]; the present study reports the lowest incidence of permanent ID neurosensory deficit (0.4%) in a single-operator series. This study does have limitations, because the preoperative radiologic assessment as well as the postoperative neurologic testing was performed by the same clinician, thereby potentially introducing bias to the results.

The flexibility in surgical technique, particularly regarding the concept of "lingual tissue release" rather than conventional lingual nerve protection with a narrow retractor, challenges the view that lingual retraction is to be avoided at all costs.[17] Certainly, lingual nerve injury appears not to be directly related to lingual flap elevation, particularly as the isolated permanent lingual neurosensory deficit arose in the absence of lingual nerve protection. The technique of "lingual tissue release" with the use of a broad lingual retractor has a role in lower third molar surgery, being safe and reliable when used by appropriately trained personnel.

Many authors have reported the accuracy of the OPT in assessment of the ID canal in relation to the root apices. The present paper argues that CT scan of the mandible is not indicated before lower third molar removal, because the risk of neurosensory injury is extremely low and exposure to radiation is minimized. Furthermore, patients whose teeth are "distant" from the ID canal and require simple elevation need only minimal counseling on the risks of ID nerve damage. Conversely, when the tooth is "intimate" to the canal and requires bone removal and tooth division with or without lingual split technique, then supplementary counseling about ID nerve damage is mandatory, not only because of the anatomic relationship but also because of the increased risk of "excessive" hemorrhage.

Although coronectomy (elective removal of the crown and retention of the roots) appears to eliminate the risk of neurologic injury,[18] it is complicated by inadvertent root dislodgement during surgery, which may unexpectedly increase the risk to the ID nerve. Pogrel et al. (2004)[19] reported root migration in which 30% of cases necessitated a second procedure, and as such a preoperative warning would still be required.

The present study does not encourage coronectomy, even in the presence of an intimate relationship between the tooth apices and the canal. Permanent neurosensory deficit in this large single-operator series was very low, and the aforementioned complications of coronectomy were avoided.

Temporary neurosensory deficit that ensues may often result from either direct injury from the tips of the third molar tooth or blood entering the enclosed bony canal and compressing the nerve. Whereas excessive bleeding is least likely with elevation alone, the incidence significantly increases when bone removal is used with additional techniques, i.e., tooth division and lingual split, but no one additional technique confers an increasing incidence of bleeding over another. The physical pressure of hemostatic agents, e.g., Surgicel into the socket, although often an inevitable sequelae for "excessive" hemorrhage, appears to be associated with the highest risk (20%) of ID neurosensory deficit, albeit temporary.

Although NICE guidance[14] has discouraged the removal of asymptomatic lower wisdom teeth, the Royal College of Surgeons of England[20] originally proposed that the simultaneous removal of the contralateral asymptomatic wisdom tooth should be considered when general anesthesia is planned. The present author supports but qualifies this approach by recommending simultaneous removal of the asymptomatic contralateral lower third molar when it likely to develop pathology, e.g., partially erupted and is either "distant or close" to the ID canal. The recommendation is reinforced by the significant number of patients who develop pathology, particularly caries, in the adjacent molar many years after the tooth has achieved its final position. Earlier studies[21,22] emphasize that distal caries in the adjacent second molar remains a significant complication, particularly where the third molar is partially erupted and mesioangularly impacted. However, if the asymptomatic contralateral tooth shows an "intimate" association with the ID canal, then its removal should be deferred until pathologic changes develop.

CONCLUSION

The risk of damage to the ID nerve during lower third molar removal is highly dependent on the radiologic relationship to the ID canal of the root apices. The incidence was highest (11%) when the root apices were "intimate" to the nerve and lowest (1%) when the apices were "close" or "distant." Permanent ID nerve injury was exceptionally low (0.4%), such that preoperative CT scanning and associated exposure to radiation appears to be unjustified. Troublesome or "excessive" hemorrhage, frequently the consequence of bone removal and tooth division with or without a lingual split technique, appears to be associated with a higher (20%), albeit transient, ID neurosensory deficit. Permanent lingual nerve injury was very rare (0.06%) and not related to lingual retraction/nerve protection. Greater consideration should be given to the removal of the asymptomatic partially erupted lower third molar tooth during general anesthesia, because many patients appear to develop pathology at a later date.

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