Self-assessed neurological disturbances after surgical removal of impacted lower third molar: a pragmatic prospective study on 423 surgical extractions in 247 consecutive patients

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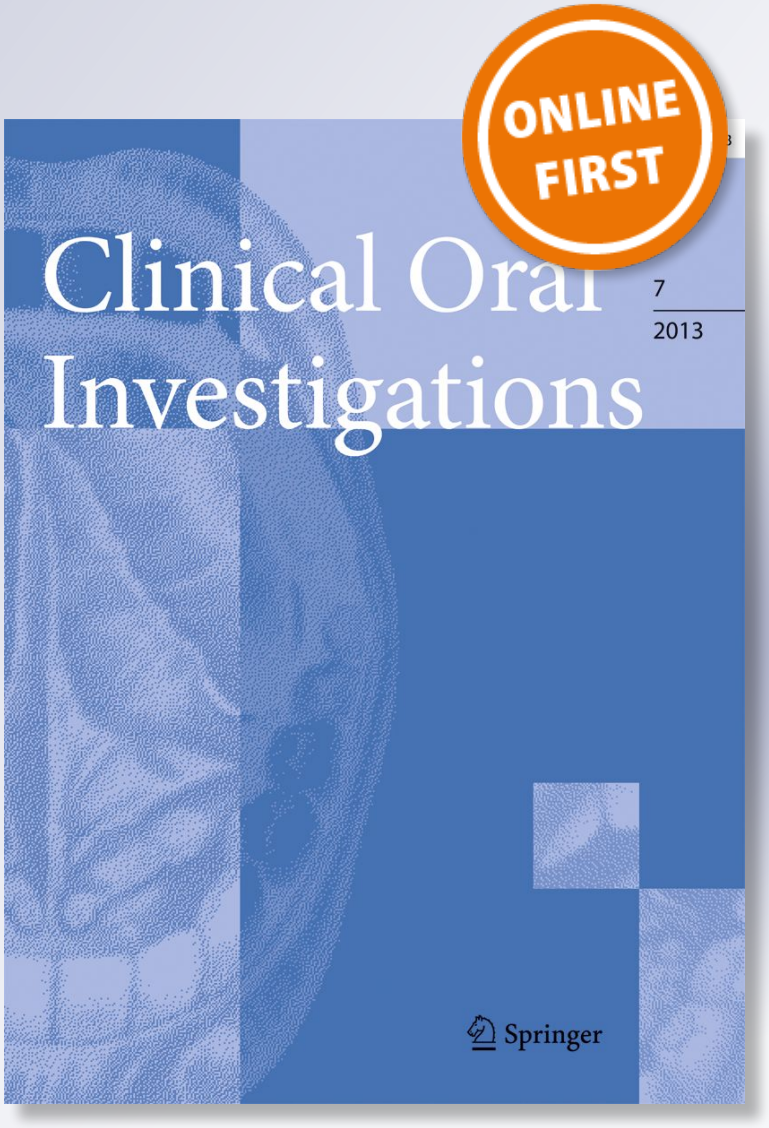

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ORIGINAL ARTICLE

Self-assessed neurological disturbances after surgical removal of impacted lower third molar: a pragmatic prospective study on 423 surgical extractions in 247 consecutive patients

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Abstract

Objectives The aim of this study was to assess the combined role of current radiographic risk indicators and patient age in predicting lower lip sensitivity disturbances after surgical removal of impacted lower third molars. The question was which combinations indicate low or high risk.

Materials and methods A prospective study was implemented involving 247 consecutive outpatients who underwent 423 surgical extractions. The predictor variables were patient age and risk indicators observed on panoramic radiographs. The outcome variable was the incidence of self-assessed lip sensitivity alterations. The extractions were subdivided into four groups according to the predictors.

Results Two hundred forty-five teeth were extracted in patients younger than 25 years and 178 in patients 25 years old or older; radiographic risk indicators were associated with 226 out of 423 teeth (53.43%). No permanent neurological damage was observed. Transient lip sensitivity alterations were observed in five cases (1.18%; 95% confidence interval = 0.4 to 2.7%), all in the older group with radiographic risk indicators.

Conclusions The data indicate a low overall incidence of transient lip sensitivity impairment that occurred only in the presence of radiographic risk indicators in patients aged ≥ 25 years.

Clinical relevance Informed consent should include the possibility of inferior alveolar nerve injury in mature patients with radiographic risk indicators. Prophylactic removal of impacted teeth with radiographic signs of risk may be indicated when the patient is not yet aged 25 years.

Keywords Third molar surgery · Mandibular nerve · Paraesthesia · Risk indicator · Panoramic radiograph · Age

Introduction

Surgical removal of impacted lower third molars may cause damage to the inferior alveolar nerve (IAN). The reported incidence of IAN injury after the surgical removal of impacted lower third molars ranges from 0.17 to 1.8% on a tooth/extraction basis in the recent literature [1–7].

Persistent damage appears to be rare, ranging from 0.04 to 0.7% according to data published in the last decade [1, 2, 4, 6–9], but even a transient impairment of lip sensitivity could be a clinical problem.

The probability of neurological damage appears to be related to the anatomical relationship between the impacted tooth and the alveolar canal. Information given to the patient should address the issue of neurological damage in such a way that the risk estimate is realistic in any individual patient. Risk indicators appear to be helpful in evaluating the probability of damage. Rood and Shehab [10] have identified a series of risk indicators on panoramic radiographs. The association between these radiological features and nerve injury has been confirmed in recent studies [11, 12]. Moreover, a positive correlation between these indicators and a close anatomic relationship has

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been assessed by tridimensional imaging [13–17]. The sensitivity of these radiographic risk indicators has been questioned by Gomes et al. [18] on the basis of a study of 260 lower third molar extractions. Another significant risk indicator appears to be the age of the patients [3–5, 7, 19–23], with a cutoff at around 25 years [3, 5, 7, 19, 20, 24]. The combined effect of age and radiographic features on the occurrence of nerve injury has been investigated by Blondeau and Daniel [25], who reportedly employed the classifications of Pell and Gregory [26] and Winter [27] to evaluate the risk of postoperative complications, in particular neurosensory problems. These classifications describe the position of the impaction and the height of the alveolar canal relative to the third molar, but do not take into account more subtle spatial relationships between the third molar and the alveolar canal nor morphologic features of the roots and/or the canal that may play a role in determining nerve injury. Classifications of Pell and Gregory [26] and Winter [27] appear to be related to the operative difficulty rather than to neurological damage, even if a significant association had been found [28]. Instead, the risk indicators identified by Rood and Shehab [10] are peculiar radiographic features that came out to be statistically associated with higher frequency of alveolar nerve injury; they are still widely employed in neurological risk assessment and have received more attention in the recent literature [17, 29–33].

The aim of this prospective study was to investigate the possibility of improving preoperative risk assessment by considering various combinations of demographic and currently validated radiographic risk indicators [10–17, 29–33]; therefore, the risk related to any extraction was categorised by the presence of the indicators proposed by Rood and Shehab [10] and using 25 years as a cutoff for the age-linked risk.

Materials and methods

This study was approved by the Review Board of the Istituto Ortopedico Galeazzi (IRCCS) and all participants signed an informed consent agreement.

One of the authors (RB) carried out a total of 423 surgical extractions of impacted lower third molars in 247 consecutive outpatients in his private practice over 18 months. A panoramic radiograph was obtained preoperatively in all cases. A cone beam CT was requested to plan surgery when recommended by the evidence-based guidelines of the SEDENTEXCT project of the European Commission [34]: briefly, a CBCT was requested if radiological risk indicators [10] were detected and the alveolar canal image crossed the third molar root at its coronal or middle third and whenever the canal approached the furcation of the third molar. Bilateral extractions were carried out in the same session. Prior to surgery, each patient was informed of the risk of neurological damage and provided informed consent.

Antibiotics were administered only in cases of acute infection or risk of endocarditis and other systemic pathologies related to bacteraemia according to the guidelines of the American Heart Association [35]. Non-steroidal anti-inflammatory medication, usually ibuprofen 600 mg was administered preoperatively to control postoperative pain. All surgeries were performed after local anaesthesia by IAN block and buccal infiltration with articaine and epinephrine 1:100,000. A dexamethasone solution 8 mg was administered by submucosal injection immediately after anaesthesia. The technique was based on bone resection and/or tooth fragmentation as in a similar previous study [25].

No lingual flap was elevated. No lingual bone resection was ever made; the external oblique line was preserved whenever possible.

The wound was closed with 4–0 resorbable sutures. Plaque control in the postoperative period was obtained by 0.12% chlorhexidine digluconate rinses twice a day for 10 days. Ibuprofen 600 mg thrice a day was usually prescribed to control postoperative pain. A check-up was scheduled 2 weeks after surgery and up to resolution of possible neurological disturbances.

Data gathering

The following variables were recorded before surgery:

Age and sex

Tooth-related variables:

- Type of impaction categorised as
  - Unprobeable complete submucosal impaction (if the crown of the impacted tooth could not be detected by a periodontal probe)
  - Probeable complete submucosal impaction (if the crown of the impacted tooth could be detected by a periodontal probe)
  - Partial submucosal impaction (if the crown could be partially seen in the arch)
- History of symptoms associated with the individual tooth
- Tooth inclination was classified as vertical, horizontal, mesioangular, distoangular, lingual, and inverted, according to a modified Winter's classification [27] to which the last two categories were added; the inclination was not recorded in cases of germectomies
- Absence or presence of radiographic risk indicators for neurological damage assessed preoperatively and classified according to Rood and Shehab [10]: darkening of the root in correspondence with the alveolar canal, deflection of the roots, interruption of the white lines that define the alveolar canal, narrowing of the inferior alveolar canal,

dark and bifid root, narrowing of the root, and diversion of the inferior alveolar canal
- Level of the alveolar canal relative to the roots of the impacted tooth in case of superimposition of their images: the canal level was categorised as crossing the apical, middle, or cervical third of the roots
- Presence or absence of radiolucent lesions (compatible with the diagnosis of cysts) superimposed to the alveolar canal in the panoramic radiograph
- Mature vs immature roots according to the stage of formation of the apex

Patients were asked to call the office in the event of alteration of lip and tongue sensitivity in order to start corticosteroid therapy. Betamethasone was administered in decreasing doses for 8 days, starting with 4 mg in the morning and 4 mg in the afternoon.

All the patients were asked about chin, lip and tongue sensitivity 2 weeks after surgery in order to detect any subjective alteration of tongue and lip sensitivity. The reported alterations of sensitivity were categorised as anaesthesia, hypoaesthesia, paraesthesia or hyperalgesia. The patients with altered sensitivity were followed until recovery.

Statistical analysis

The outcome was the alteration of lip or tongue sensitivity. The analysis unit was the extraction.

The extractions were classified into four groups, according to the patient age and the presence or absence of radiographic risk indicators according to Rood and Shehab [10].

- Teeth without radiographic risk indicators in patients under 25 years of age (no estimated risk)
- Teeth without radiographic risk indicators in patients aged ≥ 25 (intermediate risk)
- Teeth with radiographic risk indicators in patients < 25 years (intermediate risk)
- Teeth with radiographic risk indicators in patients ≥ 25 years (high estimated risk)

The event rates and their 95% confidence intervals (95% CI) in different groups were determined. The absolute risk increase (ARI) was computed by subtracting the control event rate (number of complications/number of no-risk cases) from the experimental event rate (number of complications/number of cases at risk). The number needed to harm (NNH) is the reciprocal of ARI rounded to the nearest integer.

ARI and NNH were computed to compare the highest risk group (older age and presence of radiographic indicators) to the lowest risk group (younger patients without radiographic risk indicators) and to the pooled set of lowest and intermediate risk groups (including the two groups with only one type of risk factor).

Results

The composition of the sample and its main demographic features are detailed in Table 1.

The presence of radiographic risk indicators was observed in 226 teeth (53.43%): other radiographic and clinical features of this group of teeth are reported in Table 2. No risk indicator was found in 197 teeth (46.57%) (Table 3).

The distribution of the extractions into the four risk groups is reported in Table 4.

Ten radiolucent images superimposed on the alveolar canal were observed: seven of these were associated with radiographic risk indicators. None of these patients complained of postoperative disturbances of lip sensitivity.

No damage to the lingual nerve was observed in any group, neither permanent nor transient. This finding was expected since the buccal triangular flap without lingual flap elevation does not interfere with the lingual nerve.

Transient neurological disturbances to the IAN were observed after five extractions (1.18%) in five different patients (2.02%), all of whom in the group with radiographic risk indicators aged 25 years or more (group D). All these patients called the office on the first postoperative day and assumed betamethasone for 8 days at progressively decreasing dosage, starting with 8 mg on the first day and ending with 1 mg on the last day. No further treatment was prescribed thereafter.

Table 1 Composition of the sample. The age of the patients ranged from 12 to 74 years, with a median of 24 and a mean of 27.6 (standard deviation 11.53)

Variable	Categories	Number (%)
Extractions	Unilateral	71 patients
	Bilateral	176 patients
	Total	423 teeth
Patients		247
Sex	Male	115 (46.6%)
	Female	132 (53.4%)
Age	Less than 25 years	134 (54.3%)
	25 years or more	113 (45.7%)
Nerve position[a]	Coronal third of the root	1
	Middle third of the root	45
	Apical third of the root	99
Neurologic disturbances	Patients less than 25 years old	0
	Patients 25 years old or over	5

[a] Position of nerve was determined as the most coronal root third crossed by the alveolar canal, in the 151 teeth with superimposition of the images of alveolar canal and root(s) of the extracted tooth

Table 2 Features of the 226 teeth (53.43%) with risk indicators

Associated conditions	Categories	Number (%)
	Symptomatic teeth	144 (63.7%)
	Cysts associated with impaction	7 (3.1%)
Degree of inclusion	Partial submucosal impaction	117 (51.8%)
	Probeable submucosal impactions	97 (42.9%)
	Unprobeable submucosal impactions	12 (5.3%)
Inclination	Vertical	40
	Mesioangular	114
	Horizontal	32
	Distoangular	33
	Lingual	6
	Vertical inverted	1
Number of risk indicators	Only one risk indicator	185
	Two or three risk indicators	41
Nerve position[a]	Coronal third of the root	1
	Middle third of the root	45
	Apical third of the root	99
Neurologic disturbances	Patients less than 25 years old	0
	Patients 25 years old or over	5

[a] Position of nerve was determined as the most coronal root third crossed by the alveolar canal, in the 151 teeth with superimposition of the images of alveolar canal and root(s) of the extracted tooth

1. A 29-year-old female smoker who had undergone surgical removal of her partially impacted left lower third molar. The tooth was associated with a darkening of the root on the panoramic radiograph. The alveolar canal crossed the middle third of the roots (Fig. 1). The patient complained spontaneously of decreased lip sensitivity (hypoaesthesia) in the first postoperative day and reported that lip sensitivity had recovered fully in the first postoperative week. No neurological alteration was perceived at the scheduled follow-up visit 2 weeks postoperatively.
2. A 46-year-old male smoker had his totally impacted left lower third molar extracted. The tooth was probeable and was associated with a darkening of the root. It was mesially inclined and crossed by the image of the lower alveolar canal at the middle third of the roots (Fig. 2). When questioned at the 2-week follow-up visit, the patient confirmed the total loss of

Table 3 Features of the 197 (46.57%) teeth without risk indicators

Associated conditions	Categories	Number (%)
	Symptomatic teeth	80 (40.6%)
	Cysts associated with impaction	3 (1.5%)
Degree of inclusion	Partial submucosal impaction	123 (62.4%)
	Probeable submucosal impactions	24 (12.2%)
	Unprobeable submucosal impactions	50 (25.4%)
Inclination	Vertical	49
	Mesioangular	78
	Horizontal	29
	Distoangular	33
	Lingual	5
	Anomalous	1
	Germectomies	12
Neurologic disturbances	Patients less than 25 years old	0
	Patients 25 years old or over	0

Table 4 Neurological damage in the different risk groups

Group	Number	Percentage	IAN damage	ARI	95% CI	NNH
A	128	30.3	0	0	0 ÷ 0.023	
B	69	16.3	0	0	0 ÷ 0.042	
C	117	27.6	0	0	0 ÷ 0.025	
A + B + C	314	74.2	0	0	0 ÷ 0.0095[a]	
D	109	25.8	5	0.046	0.015 ÷ 0.104[a]	22
Total	423		5	0.012	0.004 ÷ 0.27	

Group A: no radiographic indicator, age < 25; group B: no radiographic indicator, age ≥ 25; group C: presence of radiographic risk indicators, age < 25; group (A + B + C): pooled low/intermediate risk patients group; group D: radiographic risk indicators and age ≥ 25 (high-risk group)

N number of extracted teeth, *IAN* damage number of transient impairments of the inferior alveolar nerve, *ARI* absolute risk increase, *95% CI* 95% confidence interval of ARI, *NNH* numbers needed to harm

[a] The 95% confidence interval of ARI of these groups do not overlap, thereby indicating statistical significance of the difference at the 0.05 level between the high-risk group (D) and the rest of the sample, consisting of low and intermediate risk groups (A + B + C)

sensitivity (anaesthesia) of the left half of the lower lip. The sensitivity returned in 10 weeks.

3. A 31-year-old non-smoking female had her left lower third molar extracted. The tooth was mesially inclined and partially impacted; it was associated with a risk indicator on the panoramic radiograph (darkening of the root) and crossed the alveolar canal at the middle third of the roots (Fig. 3). When questioned at the 2-week follow-up visit, the patient confirmed the total loss of sensitivity (anaesthesia) of the left half of the lower lip. The patient declared full recovery of her lip sensitivity 6 weeks after surgery.
4. A 56-year-old non-smoking male whose right lower third molar was totally impacted, but probeable. The tooth was vertical and crossed the alveolar canal at the middle third of the roots. Diversion of the inferior alveolar canal could be detected on the panoramic radiograph (Fig. 4). When questioned at the 2-week follow-up visit, the patient confirmed the total loss of sensitivity (anaesthesia) of the right half of the lower lip. This patient had the longest duration of postoperative anaesthesia (12 weeks).
5. A 25-year-old smoking female whose left lower third molar was partially impacted. The tooth was mesially angulated. Two risk indicators (interruption of the upper white line and diversion of the inferior alveolar canal) could be detected on the panoramic radiograph. The image of the alveolar canal did not cross the root of the extracted tooth (Fig. 5). When questioned at the 2-week follow-up visit, the patient confirmed the partial loss of sensitivity (hypoaesthesia) of the left half of the lower lip. Recovery took 6 weeks.

None of these five extractions was a prophylactic one: all these teeth had been associated with symptoms of pericoronitis before surgery.

All of the patients with transient alteration of lip sensitivity were followed until they recovered full sensitivity.

Statistical analysis

The overall incidence of neurological complications was 1.2% on a tooth basis and 2.02% on a patient basis in this sample: the 95% CI for the cumulated data were 0.4 to 2.7% and $0.66 \leq p \leq 4.66\%$ respectively.

No sensitivity alteration was observed in the three groups with only one or no risk indicator. Instead, five occurrences (4.6%) of transient alterations were associated with the presence of both demographic and radiographic risk indicators (high-risk group).

The absolute risk increase (ARI) associated with the simultaneous occurrence of both demographic and radiographic risk indicators was therefore 0.046 and the corresponding NNH is 22 (95% CI = 10 to 67). These figures mean that one transient lip sensitivity alteration has to be expected every 22 extractions of impacted third molar exhibiting radiographic risk markers in patients aged 25 years or older: a safe estimate (95% CI) indicates that the transient damage might occur once every 10 cases at worst in this risk group and once every 67 at best.

Fig. 1 Preoperative panoramic radiograph of the first patient with a postoperative lip sensitivity disturbance. The partially impacted left lower third molar was associated with a darkening of the root. The alveolar canal crossed the middle third of the roots

Fig. 2 Panoramic radiograph of the second patient with a postoperative lip sensitivity disturbance. The totally impacted left lower third molar was associated with a darkening of the root. It was mesially inclined and crossed by the image of the lower alveolar canal at the middle third of the roots

No damage was observed in the other three groups; therefore, the maximum expected frequency of transient disturbances is less than 1% at worst when demographic and radiographic risk markers are not noticed together (Table 4).

The inclination of teeth associated with transient neurological damage was vertical in one case, distoangular in another case, and mesioangular in the remaining three cases.

In four cases, the image of the lower canal crossed the image of the roots of the removed tooth (associated with complication) at their middle third (Figs. 1, 2, 3, and 4); only one radiographic risk indicator was detected in each of these cases: darkening of the root in three cases and diversion of the inferior alveolar canal in the other. No superimposition was observed in the fifth case, which was associated with both interruption of the white line and diversion of the inferior alveolar canal (Fig. 5).

The subgroup analysis on different cohorts did not reveal any significant correlation between age and the occurrence of injuries in the high-risk group (age ≥ 25 and radiographic risk indicators).

Fig. 3 Panoramic radiograph of the first patient with a postoperative lip sensitivity disturbance. The left lower third molar was associated with darkening of the root and crossed the alveolar canal at the middle third of the roots

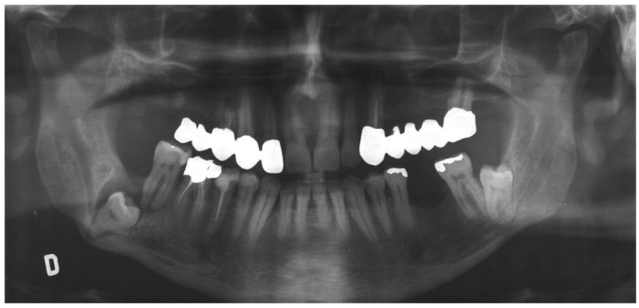

Fig. 4 Panoramic radiograph of the first patient with a postoperative lip sensitivity disturbance. The right lower third molar was associated with diversion of the inferior alveolar canal and crossed the alveolar canal at the middle third of the roots

Discussion

This study was designed to assess the frequency of neurological damages after surgical removal of impacted lower third molars in different risk groups. The hypothesis to be tested was the combined role of radiographic images and patient age in predicting the occurrence of subjectively perceivable sensitivity alterations.

The focus of this investigation was on the safety of the surgical removal of impacted third molars in terms of neurological damages, as perceived by the patients: in particular, the areas innervated by lingual and inferior alveolar nerves were considered.

Surgical removal of impacted lower third molars was associated with low incidence of lip sensitivity alterations. No permanent neurological damage was observed after 423 surgical extractions in 247 consecutive outpatients, despite the high prevalence (53.43%) of recognised radiographic risk indicators.

No lingual flap was elevated nor retracted and no damage to the lingual nerve was observed. The results clearly indicate that the combined presence of radiographic risk indicators and age over 25 is associated with higher levels of risk of altered lip sensitivity, even if transient impairment was not frequent and permanent damage was not observed.

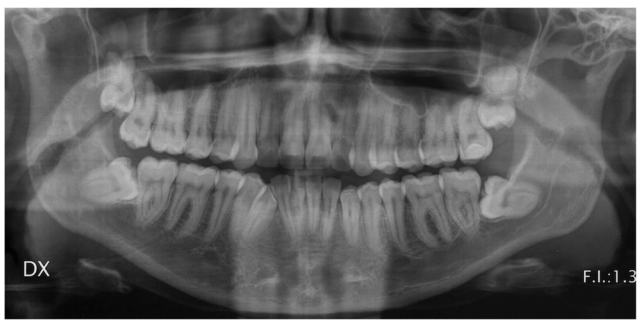

Fig. 5 Panoramic radiograph of the first patient with a postoperative lip sensitivity disturbance. The left lower third molar was associated with interruption of the upper white line and diversion of the inferior alveolar canal. The image of the alveolar canal did not cross the root of the extracted tooth

It is interesting to note that all of the neurological complications occurred after removal of symptomatic teeth. This fact is at least partly due to the choice of avoiding prophylactic extractions of asymptomatic teeth in patients older than 25 years.

The simultaneous occurrence of two or more different radiographic signs of risk was observed in 44 teeth: therefore, transient damage associated with two indicators appears to be associated with the same level of risk (1/42) as in cases with only one indicator (1/45).

The distribution of damages among the different categories of tooth inclination substantially reflects the frequency of each category: 3 out of 114 cases were associated with mesioangular inclination, 1/40 with vertical inclination, and 1/33 with distoangular inclination. No paraesthesia was associated with horizontal teeth (32 cases) or lingual inclination (6 cases).

The height of the alveolar canal relative to the tooth to be removed is an obvious factor of operative risk: in fact, a complication occurred in four out of 45 cases of crossing at the middle third of the roots, while only one case was not associated with image superimposition (although it was associated with two risk indicators).

No complication ensued in the unique case of crossing at the coronal third, nor in the 99 cases of crossing at the apical third. These figures have no statistical impact, but are suggestive and consistent with common sense considerations and are in agreement with the results of Blondeau and Daniel [25], who found a correlation between neurological disturbances and depth of impaction relative to the alveolar canal, categorised according to Pell and Gregory [26]. Concern about a high level of the alveolar canal appears to be sensible, while the role of risk indicators appears to be confirmed.

The main outcome of this pragmatic prospective study was the frequency of patient-reported postoperative alterations of the lip sensitivity. The expected frequency of permanent damage is so low that a huge sample (thousands of extractions) would be needed to ascertain its incidence, but transient disturbances are rather common in both retrospective [1–5] and prospective studies [6, 7]. The incidence of transient neurological impairment was 1.18% in the whole sample. These data are quite consistent with studies on large samples [1–7, 19–21].

The patient age (under or over 25 years) and the presence of widely used risk indicators on the panoramic radiograph [10] were used as the assignment criterion to different risk groups: the choice of these radiographic signs was based on the repeated confirmation of their suitability in assessing neurological risk [11–17, 29–33] while the rationale for using Winter or Pell and Gregory classifications has limited support [28].

The subdivision of the sample into groups was intended to facilitate the interpretation of the data about frequency of neurological complications as related to different predictors. In fact, the results of this study confirm the reliability of the age [3–5, 7, 19–24] and radiographic risk indicators [10] in identifying cases associated with higher risk, but only when both markers occur together. This finding partly support the results observed by Blondeau and Daniel, who recorded three temporary and three permanent neurosensory disturbances in a sample of 550 extractions: only one temporary deficit occurred in a patient aged less than 24 years [25]. This result was not statistically significant according to the authors. We did not observe any permanent neurosensory deficit and all the disturbances occurred in patients aged 25 years or more after extraction of teeth associated with radiological risk indicators: the difference between this group and the rest of the extractions was statistically significant. We did not observe a clear pattern of gender preference.

Either age under 25 years and absence of risk indicators on the panoramic radiographs showed high negative predictive value. In fact, the subdivision of the sample according to the risk indicators allowed to observe that all the five IAN transient damages out of the 423 extractions occurred in the group associated with both types of risk indicators (age ≥ 25 years and radiographic signs of risk) while no cases of damage were observed in the other groups: the difference was statistically significant. It should be stressed that no case of permanent damage was observed even in older patients with radiographic risk markers.

The incidence of transient lip sensitivity alterations was low even in the highest risk group (4.6%). This figure seems similar to the findings of Jerjes et al. [7], who observed a prevalence of 4.5% of IAN damage at 1 month and 2.5% at 18–24 months in the age group 26 to 30 years. Even cases of permanent damage were observed in that study [7].

Our data appear to confirm the results of Blondeau and Daniel [25], at least partly, even using different radiographic risk indicators. It should be kept in mind that the low prevalence of nerve injury, even in the "high"-risk patients, explains the high negative and low positive predictive value of risk indicators. This is the reason why the absence of risk indicators strongly suggests a safe condition, while the presence of risk indicators adds little value to the a priori information about the overall low frequency of damage [32, 33].

Alterations of lip sensitivity occurred only in patients aged 25 years or more, but were not significantly more frequent in older ages in this sample. The perception of injuries appeared to last longer in older patients (over 45 years).

The new information provided by the present study consists of

- The significance of the difference in lip sensitivity alterations between a "high"-risk group of extractions of impacted teeth associated with currently validated radiographic risk indicators [10–17, 29–33] in mature patients and the rest of the sample
- Summarising the combined treatment effect of radiographic and demographic as a number needed to harm that is easily understood and explained and is thus employed in various fields of health science [36].

Conclusions

The radiographic features identified by Rood and Shehab are associated with greater incidence of lip sensitivity alterations: the correlation has been repeatedly confirmed in the literature up to the current year, but the positive predictive value is low [18, 32, 33]. In fact, the presence of these radiographic risk indicators is not a good predictor of damage, given the low incidence of nerve injury even in aged patients with radiographic signs of risk. On the other hand, the absence of the indicators, as well as the young age of the patients, are reliable predictors of the most desirable outcome, without nerve injuries; the negative predictive value is high.

While only the simultaneous presence of both radiographic and demographic risk indicators suggests a mild risk, the absence of either one is sufficient to classify the extraction as a safe one.

Few cases of transient lip sensitivity alterations were observed only in mature patients with radiological risk indicators on panoramic radiograph: a very low incidence of damages, even transient, may be expected in young patients (less than 25 years of age) irrespective of the radiographic appearance and even in older patients after extraction of teeth not associated with risk indicators in the panoramic radiographs. The upper limit of the 95% confidence intervals of the expected frequency of (transient) injury in patients aged 25 years or more without radiographic risk indicators is 0.042. The corresponding figures for young patients with or without radiographic risk indicators are 0.023 and 0.025, respectively. We did not record any lip sensitivity impairment in young people despite the presence of radiographic risk indicators, but it can be inferred safely (at the 0.05 level) that the worst scenario consists in one transient impairment of lip sensitivity every 40 surgical extraction in young patients exhibiting radiographic risk signs. Therefore, it appears that prophylactic removal of asymptomatic third molars before 25 years of age is associated with negligible risk of permanent neurological damage.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval All procedures performed in human participants were in accordance with the ethical standards of the institutional research committee, with the national guidelines and with the 1964 Helsinki declaration and its later amendments.

Informed consent For this type of study, formal consent is not required. Informed consent was obtained from all individual participants included in the study.

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