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ORIGINAL ARTICLE

Prediction of neurosensory disorders after impacted third molar extraction based on cone beam CT Maglione's classification: A pilot study

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KEYWORDS

Neurosensory deficit;
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Abstract *Background:* Surgical difficulty assessment in the extraction of impacted mandibular third molars is a constant challenge for oral surgeons.

Aim: The first aim was to apply Maglione's new classification on patients that needed surgical extraction of impacted mandibular third molars, and the second aim was to study the correlation of the classification classes with the occurrence of postoperative neurosensory disorders.

Materials & methods: The present prospective clinical trial pilot study was conducted on patients attending oral and maxillofacial surgery clinics from February 2017 until January 2018 for the surgical extraction of impacted lower third molars.

Results: Fifty-one out of sixty-nine patients made the surgical removal of one impacted mandibular third molar. The most common subclass was 1B (24.6%), followed by subclass 3B (23.2%). Subclass 3A and 4B showed an equal distribution of (11.6%) each, and then subclass 2B (10%). The most significant subclass was 4B with (5.9%) neurosensory disturbance. None of the patients had a permanent disturbance.

Conclusion: Maglione's classification offers unique detailed description of the buccolingual relationship of MTM with IAC that could be used as a future reliable radiographic guide to reduce the risk of post-operative neurosensory disturbances after MTM surgical removal.

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1. Introduction

The relationship between the lower third molars and the inferior alveolar nerve (IAN) presents a significant diagnostic concern. Iatrogenic injuries to the nerve can cause serious complications for the patient, such as pain and altered sensation. (Khalifa et al., 2012)

A multitude of dental procedures can cause nerve injury, including anesthetic injections, impaction, implants, endodontics, trauma, and orthognathic procedures. Injury related to impaction surgery is stated to be the second-most common iatrogenic cause (Ghaeminia et al., 2009; Kositbowornchai et al., 2010; Renton, 2010; Valmaseda-Castellon et al., 2001).

A number of studies have demonstrated the risk factors and complications associated with impacted lower third molar surgery. (Carvalho and do Egito Vasconcelos, 2011; Barbosa-Rebellato et al., 2011; Freudlsperger et al., 2012). Despite the fact that postoperative complications occur in a low percentage of cases, injury of the IAN is the main cause of patient suffering. Race and genetic background can result in anatomic variations between individuals, so it is vital to design the optimal plan for the surgical approach. In order to do this, a radiological preoperative examination of the inferior alveolar canal's (IAC) position in relation to the impacted third molar is the key stage required in evaluating the risk of a potential postoperative injury to the IAN.

Two radiographic classifications are the most commonly used for describing the angulation and position of third molars in both jaws through panoramic radiography. The first one was introduced by Winter, 1926, who explained that the inclination of the third molar in relation to the long axis of a normally positioned second molar can result in the tooth being mesioangular, vertical, distoangular, horizontal, or inverted. The second classification was made by Pell and Gregory, 1933. They defined three classes (classes I, II, and III) and three positions (positions A, B, and C) depending on the position of the mandibular third molar in relation to the mandibular bone and second molar occlusal plane. (Almendros-Marqués et al., 2008). However, while these classifications can predict surgical difficulty, they offer no information concerning the correlation between the tooth and the IAC, nor the risk of IAN injury. These previous classifications rely only on 2D imaging modalities, where the third dimension or bucco-lingual dimension was not included.

Recently, cone beam CT (CBCT) has become the most favored three-dimensional imaging modality in oral and maxillofacial surgery and implantology. This can be attributed to its spatial resolution, accuracy, high diagnostic quality of images, and the lower radiation dose equivalent to CT (Pohlenz et al., 2007; Dawood et al., 2012; Durack and Patel, 2012; Dalessandri et al., 2012).

The driving factor for utilizing CBCT is that 3D imaging can act as a guide for surgical intervention and reduces the risk of causing mechanical injury to the IAN. Still, no studies have described any guidelines for a change in mandibular third molar (MTM) surgical procedures based on pre-surgical CBCT imaging (Matzen, and Wenzel, 2015).

In an attempt to find a new classification, researchers looked at the relation of the impacted tooth with the IAC using 3D imaging modality. From this, Maglione et al., 2015 proposed a new classification showing the possible relationships between the IAC and third molars in the buccal/lingual direction using CBCT.

Eight classes were proposed (Classes 0–7) and six of them (Classes 1–6) were divided into two subtypes (Subtypes A-B). For example, in Class 1, the mandibular canal runs either apically or buccally in relation to the impacted tooth but without touching it. If the distance between the tooth and the IAC is more than 2 mm, this would be represented as Class 1A; if the distance is less than 2 mm, this would be represented as Class 1B (Shown in Table 1).

Even with the development of some lower third molar classifications, no studies that we know of have explored the correlation between these recent three-dimensional classifications and the occurrence of postoperative neural injuries. Such findings are essential in allowing the use of these classifications as radiographic guidance for detecting or reducing the possibility of postoperative complications due to surgical intervention.

Therefore, the first aim of this study was to apply Maglione's new classification on patients who required surgical extraction of impacted mandibular third molars. The second aim was to study the correlation between the classification classes and the occurrence of postoperative neurosensory disorders.

2. Patients & methods

A prospective, parallel, clinical trial pilot study was used for the current research. Patients attending oral and maxillofacial surgery clinics for extraction of impacted lower third molars were targeted. The study included the selected patients from February 2017 until January 2018. Approval was given by Ethical Committee, College of Dentistry (TUCD-/). A consent form was signed by all patients. Privacy of data was assured by the main investigator. The sample size was convenient enough for this study due to the time restrictions imposed by the selected period.

Inclusion criteria for the study participants were as follows: patients with nearby connection between the IAC and impacted lower third molar roots, as detected on the digital panorama; the presence of one or more of Rood's radiographic signs of risk (Rood, and Shehab, 1990); systemically healthy individuals; age range of 18–40 years; no infection or lesion in the area of the impacted tooth, and no former neurosensory deficit related to the IAN.

Using CBCT scans, 69 female patients were divided into 7 classes (Class 0 to 7) based on Maglione's classification (Maglione et al., 2015), as shown in Table 1. After CBCT was performed, 18 patients refused to proceed with the surgical extraction and so these results were not included in the study. The 51 patients assigned for the surgery were further classified into two groups according to postoperative neurosensory disorders; Group I included patients who were undergoing surgery and had *no* postoperative neurosensory disorders, and Group II included patients who were undergoing surgery and had postoperative neurosensory disorders.

A CS 9300 PREMIUM 3D CBCT device (Care-stream SM 749, Rochester, NY, USA) was used to develop the images. The technical factors were: 90 kV, 4 mA, 6.3 sec scan time, FOV 17 × 6 cm. Both voxel size and image slice thickness were 0.2 mm. The radiation dose was 528 mGy.cm^2. An oral and maxillofacial surgeon and an oral and maxillofacial radiologist with an extended practice independently evaluated the CBCT

Table 1 Maglione's CBCT radiological classification for impacted mandibular third molars.

Classes	Class 0	Class 1		Class 2		Class 3	
	The canal is not visible on the images	The canal runs either apical or buccal to the tooth but without touching it (the canal white line is not interrupted)		The canal runs lingual to the tooth but without touching it (the canal white line is not interrupted)		The canal buccal or apical touching tooth	
Sub-classes	–	**Subtype 1A** The distance between IAN/tooth is > 2 mm	**Subtype 1B** The distance between IAN/tooth is < 2 mm	**Subtype 2A** The distance between IAN/tooth is > 2 mm	**Subtype 2B** The distance between IAN/tooth is < 2 mm	**Subtype 3A** canal shows a preserved diameter in point of contact	**subtype 3B** the mandibular canal shows a smaller caliber and/or an interruption of the corticalization
Classes	**Class 4**	**Class 5**		**Class 6**		**Class 7**	
	The canal runs lingually touching the tooth.	The canal runs between the roots but without touching.		The mandibular canal runs between the roots touching them.		The canal runs between fused&& roots	
Sub-classes	**Subtype 4A** As 3A	**Subtype 4B** As 3B	**Subtype 5A** distance > 2 mm	**Subtype 5B** distance < 2 mm &	**Subtype 6A** As 3A	**Subtype 6B** As 3B	–

scans of all included patients in identical and standardized working environments. Repeated discussions and training meetings were held with the two evaluators to standardize the evaluation criteria. When the evaluators had differing opinions about something, an agreement was reached through discussion.

The CBCT scans were manipulated and assessed preoperatively by Care Stream Software. The slices were done in the axial, cross-sectional, and sagittal planes, as well as along the long axis of the impacted mandibular third molars. Mandibular canal tracing was performed using a slice thickness of 0.2 mm and a distance of 2 mm between different slices. The location of the impacted mandibular third molars (MTM) could then be analyzed in relation to the IAC bucco-lingually.

2.1. Procedure

The surgical extractions were carried out by the same oral surgeon. Local anesthetic 2% Octocaine (Lidocaine, Canada) with 1:100,000 adrenaline was used. All procedures were standardized; a buccal flap with a vertical release incision was made with a No. 15 blade and a periosteal elevator was used for reflection. Bone was removed using a fissure bur No.702 and a fast handpiece under constant cooling. In-depth curettage of the socket was performed before closure of the tissue using 3–0 black silk.

2.2. Follow up

Assessment of IAN injury was conducted on day 7, after suture removal. The aim was to look for any neurosensory deficits using both subjective and objective evaluations. The subjective evaluation was based on a Visual Analogue Scale (VAS), which is an unmarked 100 mm horizontal line affixed by a descriptive word at each end. The patients put a mark on the line at the point at which they felt represented their perception of pain. The score was recorded by measuring, in millimeters, from the left-hand end of the line to the marked point (Flaherty, 1996).

The objective evaluation took the form of a pinprick test. A sharp dental probe was used to test pain perception by pricking the tissues innervated by the IAN (tongue, mucosa, lip, and skin over chin region). The patients who complained of neurosensory disturbance were examined postoperatively to assess the recovery after 1, 3, and 6 months (Meshram et al., 2013).

2.3. Statistical analysis

Descriptive statistics of age were presented as a mean and standard deviation (SD). Descriptive statistics of Maglione's classification frequency distribution were calculated as a percentage.

A chi-square test was used to determine the correlation between the classification (independent variable) and the occurrence of postoperative nerve injury (dependent variable). The data was analyzed using SPSS® software version 20 (SPSS Inc., Chicago, IL, USA) (Significance level ≤ 0.05).

3. Results

From February 2017 to January 2018, 69 female patients (mean age 23.7 ± 5.7 years) were enrolled in the study for the surgical removal of impacted lower third molars. Fifty-one patients underwent the surgery for the following reasons: orthodontic, prophylactic, and caries.

3.1. Classification results:

All patients were categorized according to Maglione's classification. The most common subclass was **1B,** which represented 24.6% of the patients, followed by Subclass **3B** (23.2%). Subclasses **3A** and **4B** showed an equal distribution of 11.6% each. Subclass **2B** had the smallest number of patients at 10%, while Classes 0, 7 and Subclass 5A had no patients in our study sample (0%). This is shown in Fig. 1.

3.2. Neurosensory results:

Among the 51 patients who underwent the surgery, Group I (45 patients) displayed no postoperative neurosensory disorders. Group II included six patients, with one patient in Subclass 3A (13.7%), and one in 3B (19.6%). Both patients had paresthesia lasting for 2–3 weeks after surgery. In Subclass 6A (2%), one patient had paresthesia which was resolved within 1 month. In Subclass 4B, three patients (5.9%) showed neurosensory disturbance; the first patient presented paresthesia for 2 months postoperatively, the second for 6 weeks, and the third for 3 weeks. CBCT of the third patient can be seen in Fig. 2. None of the patients had permanent disturbances. In Subclasses 1A, 2A, 4A, 1B, 2B, and 5B, none of the patients had disturbances.

Although the highest percentage of cases were in Classes 1B and 3B (IAC located apical or buccal to MTM), we found that the majority of the sensory injuries occurred when the mandibular canal was located at the lingual side (Subclass 4B) or inter-radicular (Subclass 6A) to the roots of the third molar ($p = 0.001$). See Table 2.

4. Discussion

MTM extraction is a common oral and maxillofacial outpatient surgery, yet it can present challenges to the dentist due to post-operative complications. This includes nerve damage in particular, which is the most severe complication after MTM surgical extraction and can negatively influence the quality of life for the patient. Moreover, it is considered to be the most common reason for controversy and legal issues (Sharma et al., 2012).

A number of factors should be considered regarding injury to the IAN during MTM surgery, such as angulation of the third molars, patient age, impaction depth, proximity of the tooth root to the IAN, the oral surgeon's skills, as well as the proposed surgical procedure itself (Bataineh, 2001; Benediktsdottir et al., 2004; Black, 1997; Brann et al., 1999; Gulicher and Gerlach, 2001; Miura et al., 1998; Queral-Godoy et al., 2005; Valmaseda-Castellon et al., 2001).

Performing a precise, preoperative, radiographic investigation before MTM extraction can assess the depth and location of the tooth and the complexity grade of the operating method. Recognizing these features will minimize the probability of complication (Guerrero et al., 2014 Jan 1Elkhateeb and Awad, 2018 Jun 1De Andrade et al., 2017 Sep 1,Nakamori et al., 2014).

To acknowledge the diverse categories of probable relations between the MTM and the IAC, the present study applied Maglione's classification based on the IAC's bucco-lingual position with the impacted tooth. CBCT was used and any neurosensory disturbances that occurred after the surgical extraction of the tooth were assessed.

With regard to the distribution of the subclasses in this study, Subclass 1B was the most common, followed by Subclass 3B. This supports Tantanapornkul et al.'s 2014 study, which found that the IAC was inferior in almost half of the cases, while it was buccal in only a quarter of the cases and lingual in another quarter.

Our results were in agreement with those found in Guerrero ME et al.'s 2014 Guerrero et al., 2014 Jan 1study. The authors reported that the most common position of the IAC was inferior, reflecting the findings of some previous studies (Mahasantipiya et al., 2005, Monaco et al., 2004). Our results also aligned with those of Kaeppler, 2000 and Maglione et al., 2015, in that the buccal position of the IAC was the predominant position, represented by Subclass 3B in Maglione's classification. The frequency of Classes 0, 7, and Subclass 5A were 0%. This mirrors Maglione et al.'s 2015 study, which classified

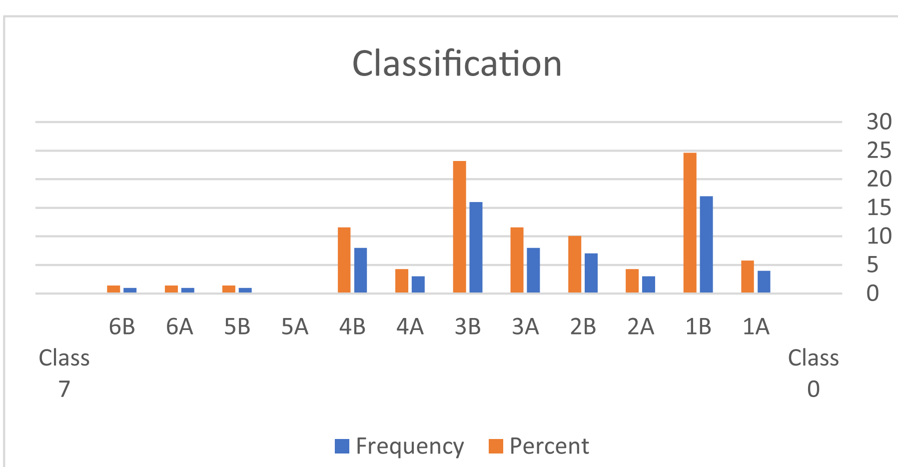

Fig. 1 The frequency and percentage of Maglione's classification.

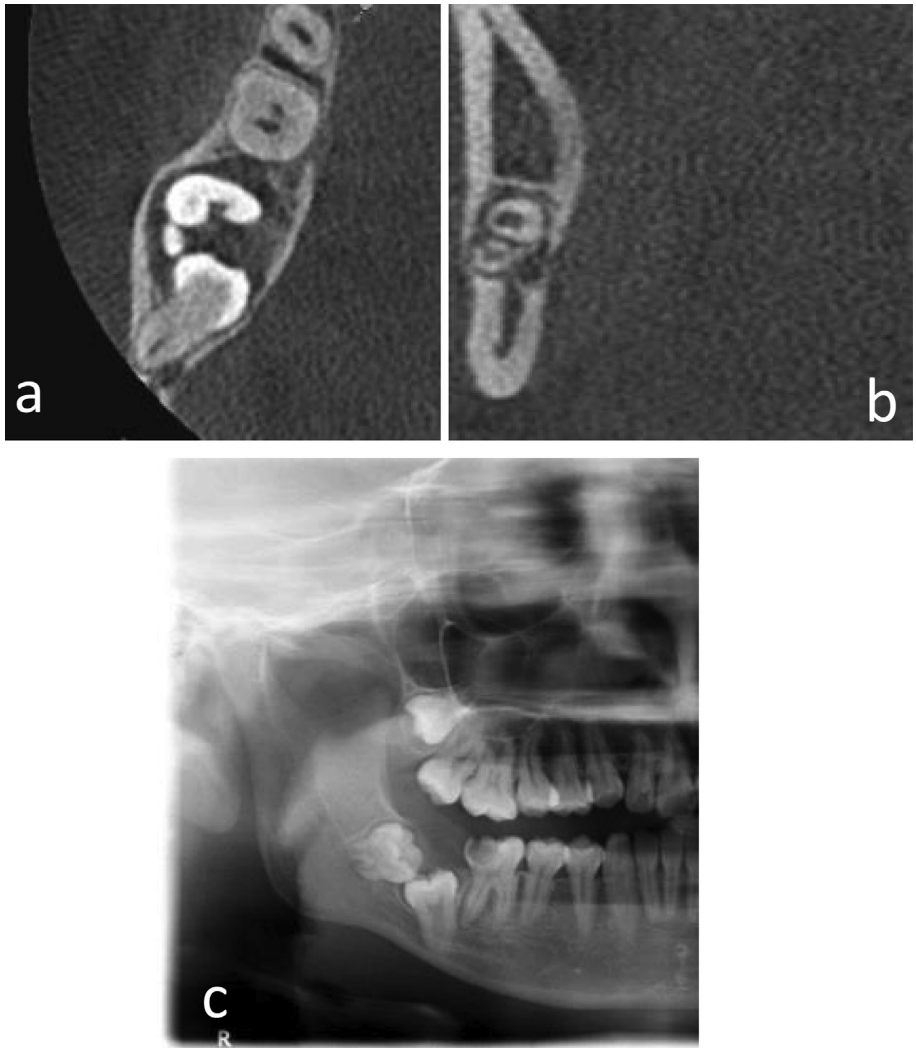

Fig. 2 (a): Axial CBCT slice, (b): Cross-sectional CBCT slice showing mesioangular impacted tooth #48 with classification 4, subtype 4B. (c): Cropped panoramic radiograph showing interruption of bony wall of inferior alveolar canal with narrowing which is a radiographic risky sign of close contact to the canal.

133 patients into eight classes and showed no cases for these specific groups.

In the present study, the subclass associated with the most neurosensory disturbance was Subclass 4B, where the IAC was located lingually contacting the tooth - at the area of connection, the IAC displayed a smaller caliber and/or an interruption of the white canal line. This is supported by Guerrero et al., 2014 Jan 1, who described that the lingual position of the IAC with loss of its corticated border was associated with post-operational neural disorders. This was also demonstrated by earlier studies (Ghaeminia et al., 2009; Maegawa et al., 2003). Maegawa et al., 2003 reported that the lingual and interradicular locations of the IAC were majorly linked to loss of the canal cortical lining, most likely a result of neural exposure during surgical extraction.

The risk of neurosensory disturbances was 11.8% in the present study, with none of these being permanent. This reflects the findings of Smith 2013, who found that the occurrence of neural injury was 11% when there was 'intimate' contact between the IAC and the root apices of the third molar. Smith reported a 0.4% occurrence of permanent nerve damage, while former studies have given diverse percentages of neural injury frequency rate, starting as low as 0.25% (Sisk et al., 1986) and rising up to 8.4% (Leung and Cheung, 2011), (Lopes et al., 1995).

Many studies have reported that patients with neurosensory disturbances occurring after third molar surgery recover during the first 6 months postoperatively (Alling, 1986; Blackburn and Bramley, 1989; Wofford and Miller, 1987; Jerjes et al., 2006). Likewise, all of the affected patients in our study had fully recovered by the 6-month follow-up period.

Regarding sex, the current study only included female patients. This was not considered to be a limitation, as Maglione et al.'s 2015 study found no differences in anatomic relationships between male and female groups in the distribution of the classes. The single exception to this was Subclass 4B, where the main risk of real contact without corticalization of the canal was found to occur in female patients.

To our knowledge, the current study is the first to explore the correlation between the occurrence of postoperative neural disorders and Maglione's classification. However, the study did have the limitation of having a small sample size.

Table 2 Incidence of neurosensory disorders in relation to MTM Maglione's classification.

Maglione's classification.	Neurosensory deficit		Total
	Group I (No disorders)	Group II (with disorders)	
1A	4_a	0_a	4
1B	14_a	0_a	14
2A	1_a	0_a	1
2B	4_a	0_a	4
3A	6_a	1_a	7
3B	9_a	1_a	10
4A	3_a	0_a	3
4B	3_a	3_a	6
5B	1_a	0_a	1
6A	0_a	1_b	1
Total	45	6	51
	88.2%	11.8%	100.0%

a, b: Groups with the same letter indicates no statistically significant difference ($p = 0.5$).

5. Conclusion

Maglione's classification offers a unique and detailed description of the bucco-lingual relationship of the MTM with the IAC. This could be used as a future reliable radiographic guide to reduce the risk of post-operative neurosensory disturbances after MTM surgical removal. However, further investigations should be conducted with a larger sample size to test the validity of these results.

6. Ethics statement**a

The current study approved by the Ethical Committee of Taibah University, College of Dentistry TUCD-REC/20160301. An informed consent was signed from all patients. Privacy of data was assured by the obligation of the main investigator.

CRediT authorship contribution statement

Sally Awad: Conceptualization, Methodology, Validation, Writing - original draft, Investigation, Resources, Writing - review & editing, Formal analysis. **Sara M. ElKhateeb:** Methodology, Resources, Writing - original draft, Investigation, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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