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# The horizontal inclination angle is associated with the risk of inferior alveolar nerve injury during the extraction of mandibular third molars

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*Abstract.* The extraction of mandibular third molars can lead to injury to the inferior alveolar nerve. Hence, it is important to assess the proximity of the root to the inferior alveolar canal before extraction. The classification system of Pell and Gregory and the Winter classification are commonly used to evaluate the positional relationship of the third molar based on radiographs. This retrospective study involving 105 mandibular third molars was performed to assess whether these systems reflect the proximity of the root to the canal (based on computed tomography images), and to identify risk factors for nerve injury. Regarding the prediction of computed tomography-verified canal invasion, the sensitivity, specificity, and positive and negative predictive values were high for each Pell and Gregory category when there was radiographic evidence. The mean distance of invasion was significantly greater in class III than in class I. However, there were no significant differences between the Winter inclination categories. The mean distance differed significantly between a horizontal inclination angle to the buccal side of $>5^\circ$ and an angle of $\leq 5^\circ$. Thus, a horizontal inclination angle $>5^\circ$ represents a novel risk factor for nerve injury.

Key words: classification; computed tomography; high risk; inferior alveolar nerve; mandibular third molar; panoramic radiograph.

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The extraction of an impacted third molar (M3) is the most common type of oral surgery[1]. Mandibular M3 extraction often leads to postoperative complications, the most serious of which is paresthesia of the lower lip or tongue due to injury to the inferior alveolar nerve (IAN) or lingual nerve, respectively[1,2]. Previous reports have indicated that the incidence of IAN injury varies from 0.35% to 8.4% of cases, while <1% of cases involve permanent IAN injury[1–5].

There are many suggested risk factors for IAN injury during M3 extraction, including age, sex, tooth morphology,

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surgeon experience, institutional setting, surgical technique, method of anaesthesia, traumatic tissue damage, post-surgical oedema, and wound infection[1,5,6]. However, Ghaeminia et al. reported no significant association between IAN injury and age, sex, or surgeon experience[7]. It has been suggested that the proximity of the mandibular M3 to the IAN and their positional relationship are the most important risk factors[1,5–9]. Hence, in order to avoid damage to the IAN, it is necessary to accurately evaluate the positional relationship between the M3 and IAN, and to determine the most appropriate surgical technique before surgery[10].

Panoramic radiographs are currently the most common type of image used to assess the risk of IAN injury during mandibular M3 extraction[1,3,11]. Although the advantages of panoramic radiographs include coverage of the skeletal structures of the entire mouth, low radiation exposure, and low cost, the drawbacks include low image resolution, high distortion, and a lack of information on the buccolingual relationship[2]. Hence, the exact anatomical relationship (including the buccolingual relationship) between the mandibular M3 and inferior alveolar canal (IAC) cannot be detected using panoramic radiographs[5]. Nevertheless, panoramic radiographs are important for gauging the proximity of the M3 to the IAC[5,12]. Three-dimensional imaging using conventional computed tomography (CT) or cone beam CT (CBCT) is recommended when there is radiographic evidence of an overlap between the root and IAC in order to verify the exact anatomical relationship[5,12].

Rood and Shehab proposed the use of seven radiographic signs to predict the risk of IAN injury during M3 extraction: dark and bifid root apex, darkening, deflection, and narrowing of the root, division and narrowing of the IAC, and interruption of the white line of the IAC[13]. If these signs are present, it is recommended that a CT scan be performed to verify the positional relationship between the M3 and IAC[1,14].

In addition, several classification systems have been developed for the assessment of the difficulty of M3 extraction[2]. The classification system of Pell and Gregory and the Winter classification are the most popular such systems. The Pell and Gregory classification is used to categorize the amount of tooth covered by the anterior border of the ramus and the depth of the impaction, and the Winter classification is used to categorize the inclination of the M3[2,15,16]. These systems have been used in the clinical setting, but there have been few studies on the relationship between the M3 and IAC for each of the categories set out in these classification systems[17–19].

The aim of this study was to assess whether the Pell and Gregory and Winter classification systems (which rely on evidence from panoramic radiographs) reflect the proximity of the M3 to the IAC (verified using CT images), and to identify risk factors for IAN injury. These results may contribute to more accurate diagnosis, improved selection of surgical techniques, and prevention of IAN injury during M3 extraction. A retrospective study design was used, because a retrospective dataset was readily available; this included detailed information on potential risk factors for IAN injury.

## Materials and methods

### Study subjects

The institutional review board of Tokyo Metropolitan Hiroo Hospital approved the study design. This study involved the investigation of 105 teeth in 68 randomly selected patients who had undergone both panoramic radiography and CT scans at Tokyo Metropolitan Hiroo Hospital from April 2015 to March 2016. Patients who were undergoing mandibular M3 extractions and those who were not undergoing this procedure were included. Patients with cystic lesions, odontogenic tumours, and other lesions around the mandibular M3 and ramus were excluded.

### Pell and Gregory classification system

The panoramic radiographs were used to classify the mandibular M3 according to the Pell and Gregory system[15]. This system classifies the teeth based on the amount of tooth covered by the anterior border of the ramus (class I–III) and based on the depth of the impaction relative to the adjacent tooth (position A, B, or C) (Table 1).

### Winter classification system

The panoramic radiographs were used to assess the mesiodistal inclination of the mandibular M3 based on a modified version of the Winter system (Fig. 1A)[16,20]. The inclination of the M3 was classified with reference to the angle formed between the dental longitudinal axis (which is perpendicular to the occlusal plane) and the M3 axis (Fig. 1A), as measured using the high-resolution picture archiving and communication system SYNAPSE version 3.2.1 SR-356 (Fujifilm Medical Co., Ltd, Tokyo, Japan)[20]. The inclination was classified as distoangular ($\leq -6°$), vertical ($-5°$ to $4°$), mesioangular ($5°$ to $84°$), horizontal ($85°$ to $94°$), or inverted ($\geq 95°$)[20]. The measurements were taken three times, and the mean values were used for the analysis.

### Distance from the root to the IAC

Using continuous dental CT images, the proximity of the root to the IAC, or the invasion of the IAC, was measured. When the root did not overlap with the IAC, the distance from the tangential line to the white line of the IAC (on the CT image, with the smallest distance) was measured. When the root invaded the IAC, the distance of root invasion was calculated by measuring the distance between the tangential line and the perpendicular line (Fig. 1B). These measurements were taken using SYNAPSE.

*Table 1.* Patient characteristics.

| Variable | Value |
|---|---|
| Age, years, mean ± SD (range) | 36.1 ± 10.7 (18–65) |
| Sex, *n* | |
| Male | 25 |
| Female | 43 |
| Site of tooth, *n* | |
| Right | 55 |
| Left | 50 |
| Pell and Gregory class, *n* (%) | |
| I | 23 (21.9) |
| II | 58 (55.2) |
| III | 24 (22.9) |
| Pell and Gregory position, *n* (%) | |
| A | 20 (19.0) |
| B | 72 (68.6) |
| C | 13 (12.4) |

SD, standard deviation.