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TOPIC HIGHLIGHT

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Clinical significance of computed tomography assessment for third molar surgery

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Abstract

Surgical extraction of the third molar is the most commonly performed surgical procedure in the clinical practice of oral surgery. Third molar surgery is warranted when there is inadequate space for eruption, malpositioning, or risk for cyst or odontogenic tumor formation. Preoperative assessment should include a detailed morphologic analysis of the third molar and its relationship to adjacent structures and surrounding tissues. Due to developments in medical engineering technology, computed tomography (CT) now plays a critical role in providing the clear images required for adequate assessment prior to third molar surgery. Removal of the maxillary third molar is associated with a risk for maxillary sinus perforation, whereas removal of the mandibular third molar can put patients at risk for a neurosensory deficit from damage to the lingual nerve or inferior alveolar nerve. Multiple factors, including demographic, anatomic, and treatment-related factors, influence the incidence of nerve injury during or following removal of the third molar. CT assessment of the third molar prior to surgery can identify some of these risk factors, such as the absence of cortication between the mandibular third molar and the inferior alveolar canal, prior to surgery to reduce the risk for nerve damage. This topic highlight presents an overview of the clinical significance of CT assessment in third molar surgery.

Key words: Computed tomography; Third molar; Extraction; Oral surgery; Assessment

Core tip: Surgical extraction of the third molar is the most commonly performed procedure in oral surgery. Careful preoperative examinations, including the use of computed tomography (CT) assessment, assist in the planning of in predicting the risks related to surgical interventions. The clinical significance of CT assessment in relation to third molar surgery is therefore reviewed and discussed.

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INTRODUCTION

Surgical extraction of the third molar is the most common procedure performed by oral surgeons. Appropriate surgical procedures should be determined based on findings from the preoperative examinations that critically assess the morphology of the third molar, and its relationships with adjacent structures [particularly the inferior alveolar canal (IAC)] and surrounding tissues.

Preoperative imaging assessments have typically included conventional intraoral radiography or orthopantomography (OPG). Following more recent developments in medical engineering technology, computed tomography (CT)

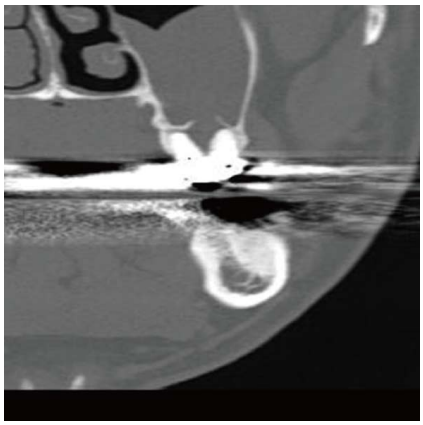

Figure 1 Coronal view of the maxillary molar with multi-detector computed tomography. The absence of cortication between the root apex and maxillary sinus can be observed.

now serves as an integral method to provide clear images for use in clinical practice. Multi-detector CT (MDCT) and cone-beam CT (CBCT) imaging of oral and maxillofacial regions serve as essential methods for diagnosis and treatment planning. Recently, the clinical importance of preoperative CT assessments in third molar surgery has been reported[1-3]. In this article, the general problems related to third molar surgery are reviewed. In addition, current topics associated with the clinical significance of CT assessment for third molar surgery are discussed.

WHY SHOULD THE THIRD MOLAR BE EXTRACTED?

Third molars should be extracted when there is inadequate space for eruption in the retromolar region, between the second molar and the mandibular ramus. This can lead to a disturbed eruption of the third molar, which may create a flap of gingival tissue around the partially erupted tooth, or a pericoronal pocket, which can potentially develop into pericoronitis. In addition, Rahman *et al*[4] recently reported that asymptomatic pericoronal tissue associated with impacted teeth showed a high rate of squamous metaplasia and proliferative activity. Although impacted teeth with pericoronal tissue can lead to cyst formation or odontogenic tumors, the prophylactic removal of disease-free third molars is still controversial[5,6]. Extraction is also warranted when there is mesioangular or "horizontal" malpositioning of the third molar. Such malpositioning can lead to difficulties in plaque control between the second and third molars and may occasionally lead to second molar dental caries. Furthermore, this form of malpositioning may also affect the dental arch shape and result in tooth crowding.

COMPLICATIONS OF THIRD MOLAR SURGERY

Careful preoperative evaluation of the relationship between the maxillary third molar (UM3) and the maxillary sinus is critical in order to prevent perforation of this sinus. For example, a patient is at risk for perforation in the absence of cortication between the UM3 and the maxillary sinus. It is important to note that excessive curettage at the base of the root apex region should be avoided (Figure 1). Removal of the mandibular third molar (LM3) can put patients at risk for serious neurosensory deficits, particularly due to injury of the lingual nerve (LN) and the inferior alveolar nerve (IAN). Lastly, if the third molar is fully or partially impacted in the alveolar bone, bone removal and tooth sectioning are required. Such surgically invasive procedures may cause postoperative pain, edema, and limited opening or mobility of the mouth due to muscle spasms.

RISK FACTORS ASSOCIATED WITH NERVE INJURIES

LN and IAN nerve injuries are thought to be due to mechanical irritations from surgical intervention and are influenced by several demographic, anatomic, and treatment-related factors[7,8]. Risk for injury is increased with the age of the patient because of technical difficulties during surgery, decreased bone elasticity, or increased incidence of tooth hypercementosis. In addition, age may contribute to a reduced capacity for damaged nerve fiber recovery. Furthermore, elderly patients with evidence of sclerotic change are at a considerably higher risk for pathologic osteomyelitis around the impacted tooth[9]. Nakagawa *et al*[10] reported that female patients are at a higher risk for IAN injuries due to decreased buccolingual thickness of the mandible. The risk for damage is increased with a thinner mandible as there is less space between the IAC and LM3. Additional anatomic risk factors for injury from surgery include tooth angulation, the presence of a distal overhang, and the degree of impaction, which are integrally related to the need for surgical intervention. Treatment-related risk factors include injection of local anesthesia, mucoperiosteal incision and elevation of the mucoperiosteal flap, bur usage during alveolar bone removal and tooth sectioning, stretching of the nerve during surgery, and accidental fractures of the lingual cortical bone of the mandible[11]. These treatment-related risk factors are associated with the surgeon's level of experience[12,13].

The lingual split technique for third molar extraction is highly associated with a risk for LN deficit, though the associated risk for LN morbidity remains controversial[11,12]. Therefore, the most widely used technique in clinical practice to decrease the risk of LN injury is the buccal approach. Preoperative imaging assessments can also be employed to limit nerve injury occurrence. Ultrasonography should be used to detect the LN, since the location of the nerve in the mandible prohibits detection by CT imaging[14]. As the IAN is located within the IAC, it can be indirectly evaluated through radiographic assessment of the IAC. Importantly, preoperative radiographic

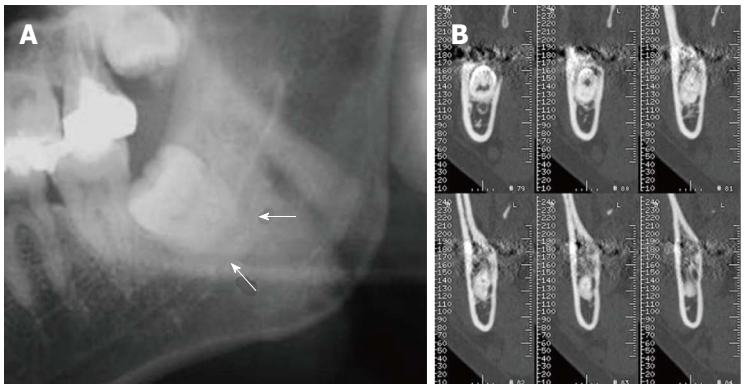

Figure 2 Root darkening and inferior alveolar canal shape. A: Darkening of the root is observed in this orthopantomography image. A black band is visible (white arrows) at the root apex site; B: A cross-sectional multi-detector computed tomography image indicates alterations (dumbbell shape) to the inferior alveolar canal shape and a loss of the lingual cortex of the mandibular bone.

Table 1 Specificity and sensitivity for predicting inferior alveolar nerve injury with third molar surgery

Imaging procedure	Sensitivity	Specificity
Orthopantomography[22-26]		
Darkening of the root	32%-71%	73%-96%
Interruption of the canal	22%-80%	47%-97%
Diversion of the canal	3%-50%	82%-100%
CT/Cone-beam CT[1,38,41,42]		
Cortication	66%-100%	46%-86%

CT: Electronic computer X-ray tomography technique.

assessment provides increased information on the relationship between the LM3 and the IAC and can be used to identify whether risk factors for IAN injury are present prior to LM3 extraction. In cases where preoperative examination has identified a high-risk factor, surgeons may consider the use of special surgical approaches, including coronectomy[15,16], multistep extraction[17,18], or orthodontic extraction techniques[19-21] to decrease the risk for IAN injuries.

RADIOLOGICAL IMAGING

There are several different radiology procedures that can be used prior to third molar surgery. Conventional intraoral radiography provides surgeons with detailed information regarding structures at the exposed site. If two structures are superimposed, a parallax technique can be applied to determine the buccolingual relationship. However, it is sometimes difficult to position films or an imaging plate at an ideal position, as the LM3 is predominantly located posterior to the mandible.

OPG

OPG is widely used during treatment planning for third molar surgery because it enables assessment of the two-dimensional relationship between the tooth and the IAC. Rood and Shebab have outlined seven important findings that can be obtained from OPG images: darkening of the root, deflected roots, narrowing of the root, dark and bifid roots, interruption of the white line(s), and diversion and narrowing of the IAC[22]. These authors concluded that the diversion of IAC, darkening of the root and interruption of the white line were significantly related to IAN injuries. There have been several OPG assessment studies which support the usefulness of these seven findings[3,23-25]. According to a meta-analysis study, three signs-darkening of the root or increased radiolucency, interruption of radiopaque borders of the mandibular canal, and diversion of the mandibular canal-have been implicated as the most significant predictive factors of a close relationship between the IAN and the LM3[26]. It should be noted, though, that the statistical results from these analyses had various levels of specificity and sensitivity (Table 1).

Recent research indicated that high-risk signs identified by OPG are significantly associated with absence of the cortication between LM3 and IAC[27,28]. In particular, darkening of the root is closely related to cortical bone loss and/or grooving of the root[27,29-31] (Figure 2). Furthermore, interruption of radiopaque borders has been attributed to loss of cortical structure of the canal. A sign for diversion of the mandibular canal is classified by a nerve running between the roots or the interposition between the root and the mandibular cortical bone.

CT

CT and/or CBCT examinations enable easy assessment of three-dimensional anatomic relationships between the third molar and adjacent structures and surrounding tissues, as well as for detection of the mental foramen and bifid mandibular canal[32-34]. Furthermore, if the third molar becomes dislocated during surgery, the CT image is a useful tool for detecting the dislocated tooth (Figure 3).

The accuracy of measurement by CT was evaluated by a comparative study of the skull, showing that medical CT (single-detector CT or MDCT) or CBCT is sufficient if preoperative CTs have been taken[35,36]. Accurate assessment of the IAC position is important in the field of oral surgery, and several studies have reported the clinical significance of the position of the IAC with respect to LM3[10,32,37]. When the IAN is positioned at the lingual site of the LM3, and sandwiched between the LM3 and the lingual cortex, it may become compressed during LM3 extraction. Several studies have reported that the predictive value of CT assessment for IAN injuries was

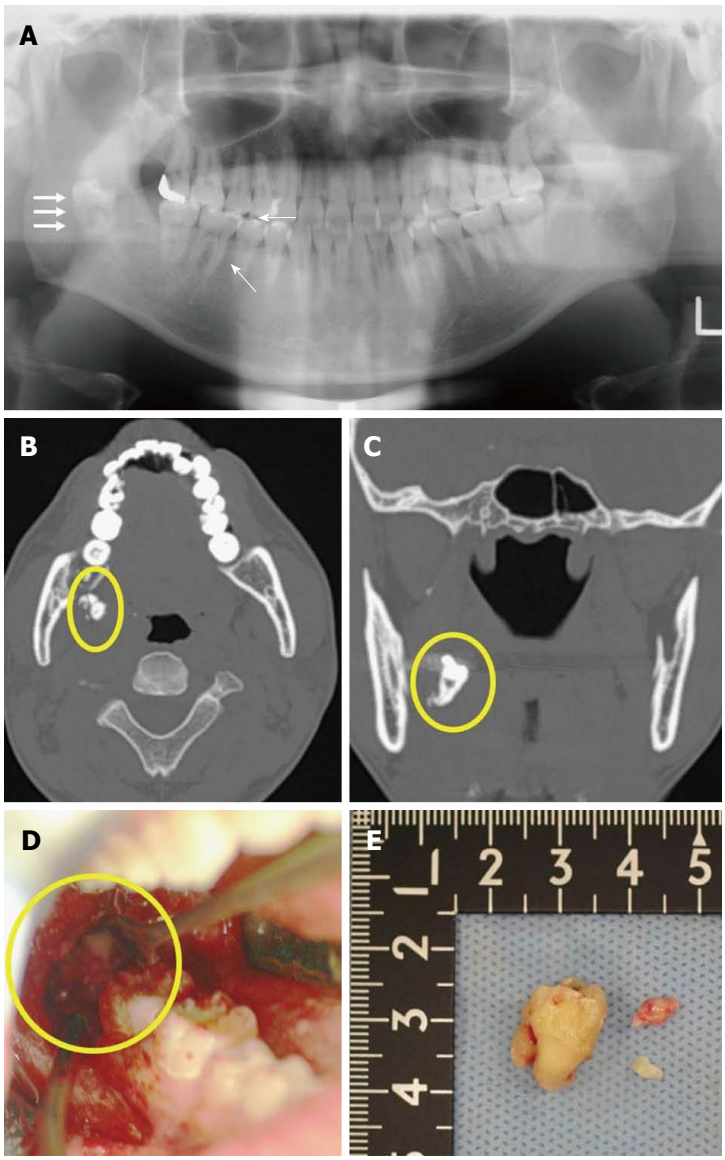

Figure 3 Imaging and surgical removal of a dislocated third mandibular molar (LM3). A: Orthopantomography showing a dislocated LM3 during surgical removal. The dislocated LM3 is superimposed over the middle part of the mandibular ramus (white arrows); B: Axial multi-detector computed tomography (MDCT) image and C: coronal MDCT image of the dislocated LM3 deviating into the pterygomandibular space (yellow circle); D: Surgical extraction; E: Extracted LM3.

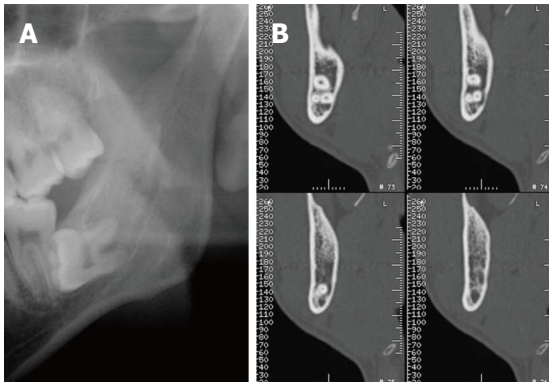

Figure 4 Radiolucency is not observed with orthopantomography. A: No significant radiolucency is observed in the roots of the third mandibular molar with orthopantomography; B: A cross-sectional multi-detector computed tomography image shows the dumbbell shape of the inferior alveolar canal and loss of the lingual cortex of the mandibular bone.

approximately 20%-30%[1,37-39], and 30% when the nerve-vascular bundle was observed[40].

CT images of reconstructed cross-sectional (or coronal) views have been used for assessment of the cortical status around the IAC. Two studies have suggested a predictive value for cortication status in IAN injuries[2,41], which currently appears to be the gold standard finding for predicting signs of IAN injuries. In our own retrospective and prospective studies, the absence of cortication between LM3 and the IAC was a requirement for IAN injuries[38,42,43]. In addition, Susarla *et al*[39] reported that the estimated cortical defect size, computed by counting the number of consecutive slice images with interruptions in the white line around the IAC, was closely related to IAN injury. If reconstruction software is unavailable, a reformatted coronal view can be obtained through reconstruction of the perpendicular image of the IAC, which is based on the axial and sagittal vertical planes[38].

The shape of the IAC has become a significant new finding for estimating the proximity between the IAC and LM3[38,42,44]. Although high-risk signs from OPG findings

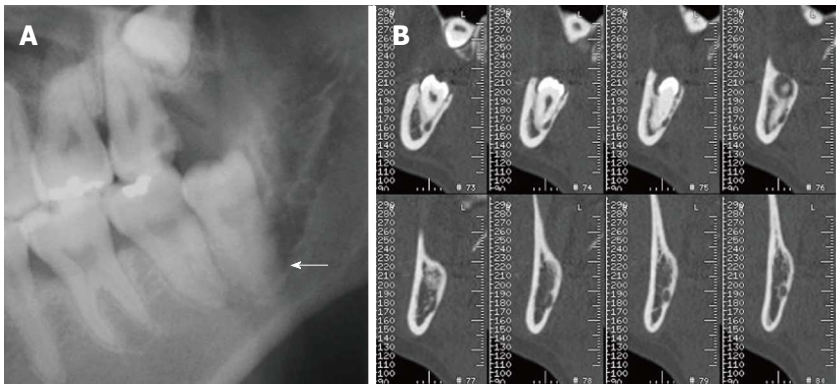

Figure 5 Root darkening and altered third mandibular molar (LM3) root. A: Darkening of the root observed by orthopantomography. A black band is visible (white arrow) at the root apex site; B: Alteration of the LM3 root (grooved) and loss of the lingual cortex of mandibular bone can be observed on cross-sectional multi-detector computed tomography images.

indicated a relationship with lost cortication, some alterations have been recognized in the IAC without the OPG finding (Figure 4). All IAC shapes are initially round/oval near the mandibular foramen, although some canals change shape toward the anterior aspect of the mandible[42]. Alteration of canals is observed most often at the section closest to LM3 (Figure 4B). The altered canal shapes are described as "teardrop-shaped", "dumbbell-shaped"[42], or as an invagination[44]. Collectively, the alteration indicates the degree of proximity between the IAC and LM3.

The number and shape of the LM3 roots can also be assessed by CT examination and should be recommended to surgeons seeking important clinical information. For instance, if the LM3 has three roots, a root-sectioning technique may be needed. However, the number of LM3 roots does not correlate with the incidence of IAN injury. A grooved root shape is intimated due to the close relationship between the root and IAC (Figure 5).

CONCLUSION

Preoperative CT examination is now considered an important assessment tool for third molar surgery. Despite this, standard eligibility criteria have not yet been established to necessitate the use of CT examination[45,46]. Furthermore, standardized significant findings have not been put in place for third molar surgery. This may be due to the low incidence of complications during third molar surgery. To resolve these issues, multi-institutional studies and development of a uniform protocol are needed.

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