Update on coronectomy

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Abstract: Prevention of inferior alveolar nerve injury (IANI) related to surgery for high risk mandibular third molars (M3Ms) is possible. However, the justification for undertaking M3M coronectomy rather than removal is based upon risk assessment of the M3M, for which we have no clear parameters. This narrative review paper was undertaken by the author, aimed at highlighting the complexities around investigating, prescribing, patient consent and undertaking coronectomies. In order to assist the clinician in making surgical decisions faced with ever changing evidence base and lack of specific criteria for the coronectomy procedure. There is international acceptance of the coronectomy technique, however, there are many outstanding issues relating to the criteria for prescription, investigation and decision making for this procedure. A consensus is required to ensure that the terminology, assessment, operative and post-operative parameters are reported consistently for coronectomy, in order to develop appropriate and much needed evidence base for optimal patient care.

Keywords: Coronectomy inferior alveolar nerve injury (IANI); mandibular third molars (M3Ms); third molar surgery; neuropathy; risk assessment of mandibular third molars

Introduction

Mandibular third molars (M3M) are the most commonly impacted teeth (1). Removing M3Ms is a challenging surgical procedure due to close proximity to anatomical structures such as the inferior alveolar nerve (IAN) and lingual nerves. IAN injury (IANI) should be prevented where possible as trigeminal sensory neuropathies result in long term chronic pain and disability for 70% of patients affected (2).

Coronectomy (partial tooth removal, deliberate vital root retention and partial odontectomy) has become a routine oral surgical procedure with the aim to minimise risk of IANI in relation to the removal of high-risk M3Ms. Coronectomy, a coded surgical procedure both in US (OMFS Category service 2 D7251) and Japan, has been defined as a method of removing the crown of a tooth but leaving the roots untouched, which may be intimately related with the IAN, so that the possibility of nerve injury is reduced. At the inception of this technique questions were raised (3). and despite its increasing popularity and

acceptance, there are many concerns.

The main justification for considering a coronectomy is based upon the assessed risk of IANI related to M3M surgery. Neurosensory impairment is a common complication of extraction of impacted M3Ms, and the incidence ranges from 0.35% to 8.4% (4-6). The consequences of sensory nerve injury are unpleasant and result in a negative effect on patient's life, often with medicolegal repercussions.

The IANI, may occur a due to direct or indirect trauma during M3M removal (7). For example, it may result from direct compression of the nerve by instruments or the elevated roots. The IAN may also be damaged by rotating instruments used for the surgical procedure and in relation to IAN regional anaesthetic block injections (8,9). The IANI incidence varies depending upon the level of M3M anatomical risk, operative technique and following management (9-23).

Recognised factors associated with an increase the risk of IANI related to M3M surgery include; patients over the age of 25 years (24,25). This has led to recommendations

Figure 1 Panoral illustrating M3M roots of tooth crossing the IDC. M3M, mandibular third molar; IDC, inferior dental canal.

Figure 2 Sectional panoral illustrating diversion of the IDC (darkening of the M3M root) with CBCT confirming proximal relationship of M3M roots and IDC. IDC, inferior dental canal; M3M, mandibular third molar; CBCT, cone-beam computed tomography.
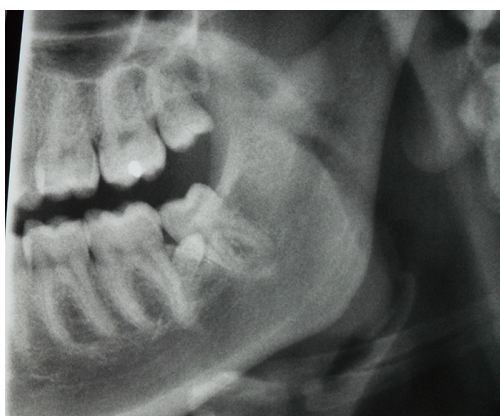

Figure 3 Sectional panoral illustrating interruption of the lamina dura associated with the M3M roots. M3M, mandibular third molar.

Figure 4 Clinical picture of a panoral illustrating juxta apical area associated with the M3M roots. M3M, mandibular third molar.

for M3M early interventional surgery (14). Females have been reported to be more at risk of persistent IANI (20). The prevalence of IANI is also dependent on the surgeon experience and the methods used (24-26). A literature review of 32 prospective articles (24) highlighted that unerupted M3M status was the strongest indicator for IANI and impaction of the M3M may be associated with IANI (20). Intra-operative nerve exposure during surgery increase the risk of postoperative paraesthesia (12). IAN bleed during surgery is also reported to be associated with increased IANI (19).

The radiographic position of the M3M in relationship to the inferior dental canal (IDC) has been shown to be useful in assessing the risk of damage to the IAN following extraction. Plane film radiographic signs on panorals indicative of possible IAN risk include:

- ❖ Roots of tooth crossing the superior border of the IDC (17-19) (*Figure 1*);
- ❖ Diversion of the IDC (darkening of the root) (27) (*Figure 2*);
- ❖ Interruption of the lamina dura (LD) (28,29) (*Figure 3*);
- ❖ Juxta apical area (29) (*Figure 4*);
- ❖ The narrowing of the root was the most significant type of superimposition, followed by dark and bifid apexes of the root (27).

Most studies (4,28-47) report a combination of panoral risk factors predisposing to IANI. However, the presence or absence of these radiographic signs does not always determine the possibility of IANI, indicating that the
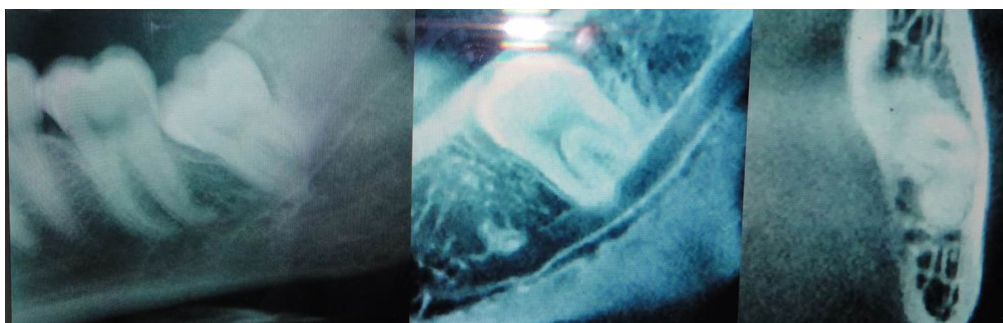
Figure 5 Sectional panoral and CBCT section illustrating the IDC lingual to the M3M roots. M3M, mandibular third molar; CBCT, cone-beam computed tomography; IDC, inferior dental canal.
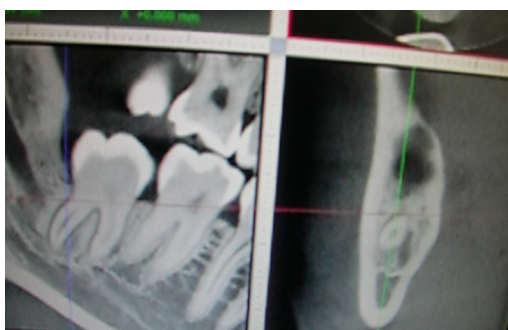

Figure 6 CBCT scan section illustrating a decorticated and deformed IDC buccal and proximal to M3M root. CBCT, cone-beam computed tomography; IDC, inferior dental canal.

panoral does not have high diagnostic accuracy in the assessment of risk in surgical extractions of lower M3Ms (48,49). When the radiological marker on the panoral indicates that there is a close relationship between the M3M and the IDC, additional investigation using computed tomography (CT) may be recommended to verify the relationship in a three-dimensional (3D) view (36-51). This 3D imaging allows the surgeon to further scrutinise the need for modified surgery or intentional coronectomy (10) potentially resulting in a change of practice in up to 90–95% of cases (removal rather than coronectomy). There is limited evidence base that use of cone-beam computed tomography (CBCT) leads to reduced nerve injury despite some reports state using CBCT will reduce the morbidity to the IAN (39,40). The software associated with CBCT provides better imaging quality of M3Ms and their surrounding structures compared with conventional hospital-grade CT scans (52-54). However, CBCT has higher radiation dose and added expense

compared with panoral.

Several CBCT radiographic signs have been reported to associated with higher risk to the IAN and assist the clinician in case selection for coronectomy (55).

❖ M3M root perforation by the IDC: If the tooth is perforated, though rare, a CBCT will confirm this thus avoiding unnecessary nerve injury during extraction and lead to recommendation of a coronectomy (56);

❖ IDC perforation or loss of LD: Shahidi *et al.* (2013) (57) reported that the loss or interruption of the cortical line (LD) on the panoral, having a close correlation with proximity of the IAN to the M3M confirmed on a CBCT scan. This is "highly suggestive of the risk of nerve injury". Also, an IDC's LD perforation, as seen on a CBCT scan the relationship can be closely correlated to darkening of the root seen on a panoral (*Figure 5*) (51);

❖ LD interruption by the root(s) or crown of the M3M (37-40). Monaco *et al.* (2004) stated that the risk of IAN injury increased from the average of 1–5% to 20–30% when the IDC LD interruption by roots was observed (51);

❖ The length of the IDC perforation or defect depends on: the impaction depth and angulation of a M3M (37): An IDC cortical defect length (distance) of at least 3 mm on CT scan has been associated with an increased risk for intraoperative IAN exposure;

❖ Deformation of the IDC at the point of contact with a M3M roots (*Figure 6*) may indicate proximity and risk of IANI. The intimate proximity of a M3M can modify the common oval configuration of the IDC toward a more "dumbbell" or "tear-drop" shape or a concave configuration (58). Invagination of the
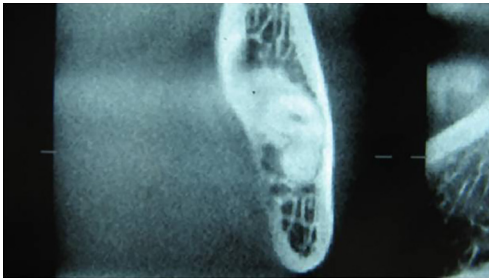
Figure 7 CBCT scan illustrating the buccal position of the M3M roots in contact with a lingually placed IDC as seen on a CBCT scan. M3M, mandibular third molar; CBCT, cone-beam computed tomography; IDC, inferior dental canal.

IDC—"compression" (concave deformation) of the IDC resulting from the proximity of root(s) of a M3M. In a second study, among 169 M3Ms (115 patients), IAN injury was observed in 13 of 169 M3Ms (7.7%) and in all 13 cases with IAN injury exhibited absence of cortication. A dumb-bell-shaped IDC was considered a useful predictor for IANI [sensitivity, 69.2%; specificity, 84.6% (P=0.005)] (25);

❖ CBCT prediction of nerve exposure: in a study comprised by Neves *et al.* (2012) (47), in all 14 cases where IAN was exposed during surgery, the preoperative assessment by multi-detector computed tomography (MDCT) images classified the relationship between the roots of the M3Ms and the IDC as at-risk (the tooth roots invade and restrict the IDC space). There was a statistically significant relationship between IAN exposure and the relationship between the roots of the M3Ms and the IDC (P=0.015);

❖ Bifid IDCs are common in the M3M region (40): Care must be taken to carefully scrutinize the presence of bifid IDCs as often a smaller branch may be passing close to the M3M roots and on extraction will cause partial permanent IANI (44);

❖ M3M roots "positioned between missing lingual cortex and IDC. Thirty percent of high risk M3M cases are reported to have a defect of the lingual cortex (40), if the M3M root is sandwiched between the IDC and lost lingual cortex this may be a secondary decision factor to undertake a coronectomy (10);

❖ Buccal position of roots in contact with a lingually placed IDC may be associated with increased IANI

rate (*Figure 7*) (41,59).

As yet there are no evidence-based criteria to indicate the need of a CBCT based upon panoral findings. The M3M roots should be proximal to (touching/passing roof or and floor) IDC with following features which correlate with CBCT identification of IDC proximity and M3M roots (60).

❖ Darkening of M3M root only or with;
❖ Diversion of IDC by M3M root;
❖ Deflected M3M root by IDC.

Consideration of how CBCT may impact on patient selection for coronectomy assumes that if 100 patients display afore mentioned risk indices on a panoral, then 98 of the 100 patients will experience no permanent IANI on M3M removal, based upon the evidence presented. Thus, if all the patients undergo coronectomy, based upon panoral films, 98% of patients will have undergone inappropriate surgery as it is ideally indicated only the 2% patients likely to get the permanent nerve injury.

Therefore, I suggest that further risk assessment using CBCT must optimise treatment planning and restricting prescription of coronectomy only to the cohort of patients at risk of permanent IANI (2%). Based upon the argument above then in my opinion all patients, identified at high risk on panoral, should undergo CBCT (as lower radiation dose as possible). However, it may not always be possible to have physical or financial access to CBCT for risk assessment prior to M3M surgery. If a patient is at obvious risk based upon the panoral findings, a decision should be agreed between patient and clinician as to whether a coronectomy should be undertaken, based upon the full understanding the related risks of coronectomy as against the preferred removal of the M3M.

Indications for coronectomy are based upon several criteria including;

❖ When there is an indication for extraction;
❖ The tooth in question has been identified as "High risk" of IANI (M3M or other teeth) (CBCT risk factors listed in *Table 1* and Plain film risk factors listed in *Table 2*);
❖ The patient is healthy (medical history and social follow-up accessibility);
❖ Dental (vital tooth).

Contraindications for coronectomy include;

❖ Dental factors;
  ◆ Non-vital tooth;
  ◆ Active caries into the pulp or demonstrating periapical abnormality;
  ◆ M3Ms that are mobile should be excluded as

Table 1 CBCT features that may lead to increased risk of nerve injury on removal of the M3M and lead to consideration of coronectomy

Tooth root perforation by IDC: the "polo minted" tooth is the single unambiguous indicator for coronectomy. This is a rare phenomenon but increased in the Asian population (27-47)

Lingual Position of the IDC in relation to the M3M root

Direct contact is reported to be significantly associated with IANI but usually in relation to additional CBCT findings. Multivariate analysis showed narrowing of the IAN IDC to be the strongest independent predictors of IANI (39)

Decortication: a cortical defect size ≥3 mm was associated with an increased risk for intraoperative IAN visualization with a high sensitivity and specificity (≥0.82) (37)

Altered shape of IDC: CBCT influenced the treatment plan for 12%. Direct contact in combination with narrowing of the IDC lumen and IDC positioned in a bending or a groove in the root complex observed in CBCT images were significant factors for deciding on coronectomy (39,46)

Loss of lingual cortex occurs frequently (30%) and may be a second indication for undertaking coronectomy if a root is positioned between the missing lingual cortex and the IDC (40)

M3M, mandibular third molar; IDC, inferior dental canal; IANI, inferior alveolar nerve injury; CBCT, cone-beam computed tomography.

Table 2 Radiographic signs that may indicate higher risk of IANI where roots of the M3M are in close proximity with the IDC on panoral

Plain radiographic signs indicative of possible IAN risk include:

Diversion of the IDC

Darkening of the root

Narrowing of the root/IDC

Interruption of the IDC lamina dura.

Interruption of the juxta‑apical area

CBCT radiographic signs if increased risk to IAN

Loss of IDC cortex (>3 mm)

Dumb bell distortion of IDC

Lingual position of IDC to roots

Perforation of tooth roots by IDC

Inter radicular IDC with multiple roots

M3M, mandibular third molar; IDC, inferior dental canal; IANI, inferior alveolar nerve injury; CBCT, cone-beam computed tomography.

they act as a mobile foreign body and become a nidus for infection or migration;
- M3Ms associated with tumours;
- Horizontally impacted M3Ms more difficult to obtain a successful coronectomy due to high placement of the retained root surface in relation to the alveolus.
❖ Medical history immune compromised with likely poor healing is a contraindication for coronectomy and removal is advised where bye the patient may be more at risk of infection with retention of roots;
❖ Social and psychological factors.
- The patient's understanding is compromised;
- Travelling/difficult access to healthcare;
- Specific indications to remove the tooth: avoidance of third molar surgery will avoid nerve injury, which is possible for non-diseased unerupted M3Ms in accordance with AAOMS 2016 guidelines recommending active surveillance for 23% of M3Ms (http://www.aaoms.org/docs/govt_affairs/advocacy_white_papers/management_third_molar_white_paper.pdf);
- Patients scheduled for future surgery involving the site.

When should the surgeon consider undertaking a coronectomy? Some possible indications are listed in *Tables 1,2*. There are complications related to coronectomy which leads to complex consent processes and requires detailed explanation for informed patient consent. Recent systematic reviews (61,62) have evaluated the clinical effectiveness of the surgical technique of coronectomy for M3M extraction in close proximity with the IAN. The authors assessed the following variables: IANI, lingual nerve injury, postoperative adverse effects, pulp disease, root migration and rate of reoperation. Ten articles qualified for the final analysis. The successful coronectomies varied from a minimum of 61.7% to a maximum of 100%. Coronectomy was associated with a low incidence of complications in terms of IANIs (0–9.5%), lingual nerve injury (0–2%), postoperative pain (1.1–41.9%) and swelling (4.6%), dry socket symptoms (2–12%), infection rate (1–9.5%) and pulp

disease (0.9%). Migration of the M3M retained roots seems to be a frequent occurrence (2–85.3%). Their conclusion was that coronectomy appears to be a safe procedure at least in the short term, with a reduced incidence of postoperative complications.

A further systematic review (63) of four studies indicated that the pooled risk ratio (coronectomy *vs.* total removal). The authors therefore concluded that, coronectomy appears superior to total removal for reducing IAN damage and could be used in clinical practice for third molar extractions with high risk of nerve injury.

❖ "Dry socket" symptoms and infection: Rates for socket infection (2–12%), infection rate (1–9.5%) and pulp disease (0.9%) were reported in a systematic review of four studies (63). Two randomized controlled trial involving coronectomies and controls reported a significantly lower pain and "dry socket" incidence in the coronectomy group (64,65);

❖ IANI deficit: Lower incidence of IANIs is reported for coronectomy compared to complete extraction of M3M (65-70). Leung and Cheung (2010) (64) reported a 0.65% IANI rate for coronectomy versus 5.10% removal;

❖ Failed coronectomy: Renton *et al.* (2005) (65) reported a high failed coronectomy rate with intraoperative mobilization of the tooth roots on separating the M3M crown from the roots intra-operatively. As a result, the technique has been modified. This study preceded CBCT and when a M3M is identified as high risk based upon CBCT the crown section is less minimal than for an extraction procedure but sufficient to ensure separation of the crown from the roots without mobilizing the roots;

❖ Enamel retention: a repeat coronectomy is recommended for cases in which enamel retention is diagnosed in order to prevent residual roots from becoming infected (71);

❖ Root migration with eruption: migration of the roots was identified in 80% of 116 patients and was increased in younger patients (64). Three percent at 3 years eruption and necessary removal has been reported (64). A study of coronectomies undertaken in 64 patients (72), reported that the most common complication was tooth migration away from the mandibular IDC (n=14), followed by root exposure (n=5). Re-operation to remove the root was performed in cases with periapical infection and root exposure. Migration of the roots was found more

commonly in younger patients and within the first 6 months post-surgery (73);

❖ Reoperation rates.
◆ Late extraction due to root migration is reported in many studies. Extraction in 3.6% cases was necessary due to late eruption (74) and 6% (75). On removal of these roots one study reported that there was no pathology associated with retained roots when removed (76);
◆ Repeat coronectomy is reported and successful if enamel remnants require removal (71);
◆ Reoperation in 20 cases (3.26%) were reoperated on to.
• Remove residual enamel [2];
• Chronic infection [2];
• Root exposure [13] and roots removed (2.12%);
• Vague pain [2] resulting in roots being removed;
• One case required orthognathic surgery and root was removed (73).

Legal issues

Coronectomy is an accepted and emerging technique. Currently, 3 National M3M Guidance include coronectomy as a treatment option, however, there was a National Health Service Litigation Authority (NHSLA) case (2009) that concluded that it was a breach of duty not to offer a patient with high risk M3M further risk assessment and or a coronectomy (77).

Patient consent is complex for coronectomy and time should be taken to explain the risks and benefits of the procedure. The surgeon must be primarily responsible for the presurgical assessment and as a result must be competent in reading the CBCT and reporting the risk assessment. There are additional issues regarding CBCT including radiographic reporting of a large anatomical area and the legal responsibilities of both clinician and radiologist (78). The surgeon must be appropriately trained in the technique, incidence of IANI and LNI would not occur if the procedure is appropriately undertaken. In addition, the internet is peppered with poor surgical practice videos of coronectomy using high-speed drills, half sectioning the enamel crown and complete sectioning of the crown which is more likely to lead to lingual nerve injury.

Lastly there is insufficient evidence to state that CBCT reduces IANIs. However, reports claim that due to the high

variability of the anatomical relationship in case of high-risk M3Ms, a CBCT scan should be performed for thorough case planning (60). Furthermore, using CBCT will avoid unnecessary coronectomies thus increasing removal without nerve injury, which is the optimum possible treatment. Over 30% of high-risk M3Ms as seen on panoral radiography are found to be distant from the IDC on CBCT and therefore should be extracted (60). Further research is required to ascertain the benefit of CBCT in these cases. Renton *et al.* (2005) (65) described a change in practice of over 95% of cases based upon CBCT findings resulting in only 5% of M3Ms undergoing coronectomy. If patient is unsuitable or the M3M is carious, thus extraction is indicated, (CBCT can offer an excellent planning tool to minimize risk to IAN when planning surgery, the evidences, to support this practice is emerging.

Recommendations

Coronectomy is an effective and accepted method for minimising IANIs related to the management of high-risk M3Ms (79). However, explicit criteria for requesting a CBCT based on risk assessment of the panoral are not yet absolutely clear. Nor are there explicit criteria for recommending a coronectomy based on CBCT findings as yet. This leaves a degree of ambiguity and uncertainty in prescribing coronectomy rather than extraction for M3Ms

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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