Royal College of Surgeons
FACULTY OF DENTAL SURGERY

Parameters of care for patients undergoing mandibular third molar surgery

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Dr Obi Egbuniwe, Keith Horner and Selina Master.

Intended audience

All clinicians managing (and patients involved in) mandibular third molar (M3M) surgery

Statement of conflict of interest

The Faculty of Dental Surgery (FDS) is funded by its fellows and members, and no contributors are paid for their work on a guideline.

Background

A review of the guidelines was necessary because evidence suggests increasing patient harm due to retention of M3Ms. Based on the available evidence, consideration of clinical review is recommended, together with therapeutic, prophylactic and interventional surgery for patients, when appropriate.

Aims and objectives

- To describe appropriate care based on the best available scientific evidence and broad consensus
- To reduce inappropriate variation in practice
- To provide a more rational basis for referral
- To provide a focus for continuing education
- To promote efficient use of resources
- To enable setting and monitoring of standards, including audit
- To act as a quality control with the aim of promoting clinical excellence
- To highlight shortcomings within existing literature and suggest appropriate future research

Methodology

The FDS Clinical Standards Committee invited representatives from all stakeholder groups to join a working group to review the clinical standards of care for patients with M3Ms. Each member of the working group was invited to undertake a rapid review of literature relevant to the management of patients undergoing third molar surgery and their specialty. A time restriction of six months between the initial and final (third) meeting for the literature searching and retrieval stages was set. It is acknowledged that the literature review and search term selection were not iterative processes, it is therefore possible that some relevant references may have been missed. The criteria for evidence level type are summarised below. Each member provided a synopsis of the evidence base relating to their specialty and participated in text reviews over the ensuing year, and a consensus was achieved regarding the main documentation.

Classification of evidence levels (modified from Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften, 2001)	
A	Evidence based on meta-analyses of randomised controlled studies
A2	Evidence based on one randomised controlled study
B1	Evidence based on at least one well designed controlled study without randomisation or at least one well designed quasi-experimental study
B2	Evidence based on well designed non-experimental descriptive studies (eg cross-sectional studies)
C	Evidence based on reports or opinions of groups of experts, consensus conferences and/or clinical experience of recognised authorities; case studies

A classification by recommendation levels is arrived at based on the above criteria by consensus; account must also be taken of factors that will influence

treatment, such as patient preference, clinical relevance and feasibility of application in the routine medical situation.

Recommendations levels	
A	Strong recommendation
B	Recommendation
O	Open recommendation

It was agreed that the evidence level would be provided by the stakeholder with the specialist interest. Areas lacking in consensus have been discussed and the evidence level agreed by the taskforce.

Plain language statement

The working group has intended to follow the official guidelines of the Plain Writing Act of 2010 and the Plain English Campaign.

Evaluation and updating

The FDS parameters of care for patients undergoing M3M surgery will be revisited on a three-yearly basis by the FDS Clinical Standards Committee and sooner should significant evidence arise that requires guideline update. The various components of the evaluation of clinical practice guidelines would include:

- an assessment of awareness of the guideline
- an assessment of whether clinical practice has changed in line with the guideline's recommendations
- an assessment of whether health outcomes have changed
- an assessment of the guideline's impact on patients' and clinicians' knowledge and understanding

Publication

When final approval is given by the FDS Clinical Standards Committee, the guideline will be formatted to produce a PDF document. A printed version will only be available if specific funding has been provided for the purpose by a specialty association or other interested body.

Dissemination

In order to disseminate the guideline, the FDS will:

- publish the guideline on its Clinical Guidelines webpage
- copy the guideline and web link to the relevant specialty associations
- copy the guideline and web link to its regional and specialty advisors across the UK
- publicise the document in the *Bulletin* of the Royal College of Surgeons of England
- send a copy to the National Institute for Health and Care Excellence for publication on its website and inclusion in its search database
- send a copy to the *British Dental Journal*
- publicise the guideline via the FDS Twitter feed

Executive summary

Parameters of care for patients with M3Ms

The National Institute for Health and Care Excellence introduced guidance relating to third molar surgery in 2000, discouraging the prophylactic removal of mandibular third molars (M3Ms). However, there is growing evidence that this may not be in the best interests of the patient, resulting in delay of inevitable surgery with additional damage to the adjacent second molar. This prompted the stakeholder group to review the Faculty of Dental Surgery's guidelines based on the best available research evidence.

- The main reason for third molar disease and the subsequent removal of third molars is infection, whether it be pericoronitis, caries in the M3M or adjacent teeth, periapical disease or local bone infections.

Assessment of patients with M3Ms

Third molar management begins with a thorough medical and dental history, which focuses on symptoms that may be associated with the patient's third molar. The overall dental health of the patient is assessed. The assessment of the third molar should include the eruption status, the position in relation to the adjacent second molar, the function and occlusion, and the periodontal and caries status. The opposing contralateral and maxillary third molar should also be assessed.

After taking a history and performing a clinical examination, panoramic radiography is indicated for third molar assessment when surgical intervention is being considered. The following need to be determined: the presence or absence of disease within the tooth or in the surrounding area, the anatomy of the tooth and its root formation, and the relationship to the relevant structures such as the inferior alveolar nerve and adjacent second molar. Routine 'radiographic screening' of unerupted third molars that have no disease or symptoms is not recommended.

Where conventional imaging has shown a close relationship between the third molar and the inferior dental canal, cone beam computed tomography (CBCT) may be of benefit. On plain film the three most significant radiological signs are diversion of the IAN canal, darkening of the root and interruption of the cortical white line. If CBCT is unavailable, then computed tomography (CT) can be used instead, but the limited field of view of CBCT is advantageous in terms of image reconstruction and radiation dose. The key information to be ascertained, is whether there is direct contact between the inferior dental canal contents and the third molar, or whether a bony wall exists between them. There is evidence that preoperative CBCT does not offer any benefit to patients in terms of reducing the incidence of inferior alveolar neurosensory disturbance. As the radiation dose and financial costs are higher than for conventional imaging, CBCT should not be used routinely when assessing M3Ms.

Where conventional imaging has shown a close relationship between the M3M and the IAN canal, CBCT may be considered in carefully selected cases where the findings are expected to alter management decisions.

Types of actions or interventions for M3Ms

The following types of actions or interventions have been described:

Common	Less common
■ Referral ■ Clinical review ■ Removal of M3M ■ Extraction of maxillary third molar ■ Coronectomy	■ Operculectomy ■ Surgical exposure ■ Pre-surgical orthodontics ■ Surgical reimplantation/ autotransplantation

Clinical review vs Active Surveillance

Clinical review is simply reviewing the patient's signs and symptoms. Radiography is only indicated if there were clinical signs or symptoms of disease from the partially erupted M3M. Routine bitewings for caries should include the distal aspect of the erupted adjacent second molars to avoid neglecting second molar caries arising adjacent to partially erupted M3Ms. Partially erupted and functional third molars can be considered the same as any other fully erupted functional molar tooth. Normal radiographic selection criteria would apply with regard to caries, periodontal disease and periapical disease. Unerupted third molars would require clinical review even though the likelihood of significant disease is low. Supplementary radiography is only indicated if clinical signs or symptoms arise.

Active surveillance is different; it is a non-operative management strategy for retained mandibular third molars (M3Ms), characterised as a prescribed, regularly scheduled set of follow-up visits that include both clinical and radiographic examinations

Factors to consider for removal

Therapeutic indications

Therapeutic indications for removal of M3Ms are infection (pericoronitis, osteomyelitis, osteonecrosis, osteoradionecrosis), caries in M3Ms or in adjacent teeth, periapical abscess, periodontal disease, other disease such as cysts or tumours and external resorption of the third molar or of the second molar (although this is relatively rare).

Surgical indications

If the M3M is present within the perimeter of a surgical field (orthognathic surgery, mandibular fracture management or resection of diseased tissue), then consideration should be given for its removal.

'High risk' of dental disease

There is a significant increased risk of distal caries developing in the adjacent mandibular second molar from partially erupted impacted third molars that are horizontally or mesially angulated between 30 and 90 degrees. M3Ms in this position may also produce periodontal detriment to the second molar. Intervention may be required 'sooner' rather than 'later'.

Medical indications

Necrosis of the jaws is debilitating and may compound the patient's pre-existing co-morbidity. The priority is to prevent medication related osteonecrosis and/or osteoradionecrosis of the jaw. If the decision is made to start medical treatment, a full dental assessment (taking into account the third molars) needs to be undertaken, ideally before treatment starts. The threshold for removing third molars may be lowered. This should also apply to patients who will be subjected to immunosuppressant therapy.

Accessibility

Situations where patient access to dental services may be restricted or limited should also be considered. Examples include army or service personnel on long deployment or when an individual is planning a long overseas trip.

Patient age

The evidence indicates clearly that complications and recovery time is increased with increasing age of the patient.

Patient involvement

It is difficult to predict the long-term outcome for the asymptomatic third molar that is currently disease free. It is a dynamic process. Reliance is based on the clinician's experience in weighing up the probability that disease may develop.

Patient involvement is paramount when making the decision about third molar management. The findings of the assessment, the risk status, and the treatment options along with their risks and benefits all need to be communicated clearly and effectively at a level the patient can comprehend. This will allow them to make a decision about the treatment option they wish to have. Clear documentation is essential. Clinicians must now ensure that patients are aware of any 'material risks' involved in a proposed treatment and the potential for pain and discomfort. Finally, the patient should be fully cognisant of the potential risks of deferring or declining surgical intervention.

Coronectomy

Coronectomy is an alternative method for management of M3Ms that are in close approximation to the inferior dental canal and is effective in minimising inferior alveolar nerve injury. However, there are strict criteria on patient selection. The risks of coronectomy include the possibility of infection and pain, and the potential future need for removal of the roots. Contraindications related to the tooth are: non-vital third molars, caries with risk of pulpal involvement, tooth mobility, apical disease, association with cystic tissue that is unlikely to resolve if the root is left in situ and

tumours. Contraindications related to the patients are: immunocompromised patients, previous radiotherapy to the head and neck or treatment before radiotherapy, neuromuscular disorders and diabetes mellitus. Patients who are unable to return for treatment easily should complications occur. Patients should be advised that if they have pain or recurrent infection they can be followed up after this procedure.

Surgical intervention

- When surgery is indicated, consideration should be given to methods of local anaesthesia, local anaesthesia with conscious sedation and general anaesthesia. There is evidence that 7% of the English population are likely to need conscious sedation for dental treatment. There is likely to be a higher need for sedation for invasive treatments such as M3M surgery but currently, this is not described by any specific studies.

- When surgery is indicated, consideration should be given to methods of analgesia. Severity of postoperative pain is associated with duration of surgery, patient age, depth of impaction, patient ethnicity, patient weight and surgeon experience. There is limited evidence for the benefits of pre-emptive analgesia, with conflicting reports. Optimal postoperative analgesia has been described with the combined effect of ibuprofen and paracetamol.

- When surgery is indicated, steroid medication given parentally pre-operatively has been shown to reduce pain, trismus and swelling.

- When surgery is indicated, it should be noted that there is limited evidence supporting the efficacy of commonly used antibiotics in preventing complications after M3M removal. Clinicians should consider carefully whether treating 12 healthy patients with antibiotics to prevent one infection is likely to do more harm than good.

- There have been further studies since the initial Cochrane review in 2012 investigating the use of chlorhexidine. The most recent systematic review and meta-analysis in 2017, found that in any formulation, concentration or regimen, chlorhexidine is efficacious and effective in preventing alveolar osteitis in patients who have undergone third molar extraction. Chlorhexidine gel was found to be moderately more efficacious than the rinse formulation. There are still limited data collected on adverse events. Staining, altered taste sensation, burning sensations, hypersensitivity and mucosal lesions have been reported as adverse effects of chlorhexidine use. There have been two cases of serious adverse events associated with irrigation with chlorhexidine mouth rinse. Clinicians prescribing chlorhexidine products should be aware of the potential for both minor and serious adverse side effects.

- Systematic reviews suggest that longer periods of smoking cessation decrease surgical complications but few studies have addressed M3M surgery in particular.

- The updated 2020 Cochrane systematic review addresses the evidence relating to different surgical techniques:

  - There was insufficient evidence to determine whether envelope or triangular flap designs led to more alveolar osteitis, wound infection, or permanent altered tongue sensation

  - There was insufficient evidence to determine whether the use of a lingual retractor affected the risk of permanent altered sensation compared to not using one.

  - There was insufficient evidence to determine whether lingual split with chisel is better than a surgical hand-piece for bone removal in terms of wound infection. Alveolar osteitis, permanent altered sensation, and other adverse eIects were not reported.

  - There was insufficient evidence to determine whether there is any difference in alveolar osteitis according to irrigation method or irrigation volume or whether there is any difference in postoperative infection according to irrigation method or irrigation volume.

  - There was insufficient evidence to determine whether primary or secondary wound closure led to more alveolar osteitis wound infection, or adverse effects (bleeding).

  - It was not possible to draw any conclusions about the use of a surgical drain versus no drain, as the included studies did not report on any of the primary outcomes.

  - Placing platelet rich plasma or platelet rich fibrin in sockets may reduce the incidence of dry socket, but the evidence is of low certainty. Other primary outcomes were not reported.

  - There were no trials of partial root retention versus whole root retention (coronectomy). There were two trials that assessed the comparison of coronectomy versus complete tooth removal, but the data from these studies was not considered to be sufficiently reliable for inclusion in the analysis.

The varied position of M3Ms in relation to the surrounding structures requires a tailormade treatment plan with patient involvement at the centre of the decision making process. The aim of this guidance is to provide the clinician with the up-to-date knowledge to communicate to the patient, the treatment options along with the risks and benefits of each. This should be at a level they can understand for them to make a decision about which treatment option they want to have.

Professor Paul Coulthard
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Summary of the management of patients with Mandibular Third molars (M3Ms)

The principles are about assessing the current status of the patient and their third molar along with the chances of change for both. The clinician must remind the patient that the current symptom and disease status may change over time, and that treatment options and risks may also change accordingly. Using Montgomery principles, patients need to be made aware of the benefits and risks of each of the treatment options for them to decide which option they wish to take. This includes non-surgical treatment.

What is the current status of the patient and the M3M?	**Factors to be taken into account regarding M3M status**
• History (medical, social and dental) • Clinical examination • Appropriate radiological investigations	• Patient age and medical status • Risk of complications (e.g. risk of Inferior alveolar nerve injury, risk of leaving M3M in situ) • Patient access to appropriate treatment (e.g. Army personnel on long deployment, Long-term travel) • Opposing third molar/contralateral third molar status, if patient is undergoing a general anaesthetic

	Diseased/ High risk of disease development	**Non-Diseased/ Low risk of disease development**
Asymptomatic	The likelihood that disease will develop is assessed by the clinican into high or low risk. If the risk is high, surgical intervention should be considered. If there is any doubt and the tooth has a higher risk of surgical complications (close approximation to the inferior alveolar nerve) then active surveillance is recommended until symptoms develop or early disease progression has been proven. Quiescent pathology may include undiagnosed second or third molar • Caries • Periodontal disease • Resorption (internal or external) • Cysts or tumours	In the absence of disease or if there is a low significant risk of disease, then clinical review is required, supplemented with radiographic assessment if indicated. An assessment of risk of disease needs to be made and review interval made accordingly **Factors for consideration for prophylactic removal** *Medical factors:* Patients undergoing planned medical treatment/therapy that may complicate the likely surgery of M3Ms including • Pharmaceutical therapy (bisphosphonates, antiangiogenics, chemotherapy) • Radiotherapy of head and neck • Immunosuppressant therapy *Surgical factors:* The third molar lies within the perimeter of a surgical field. • Mandibular fractures • Orthognathic surgery • Resection of disease (benign and malignant lesions)
Symptomatic	**Consideration for therapeutic extractions is indicated for:** • Single severe acute or recurrent subacute pericoronitis • Unrestorable caries of the M3M or to assist restoration of the adjacent tooth • Periodontal disease compromising the M3M and/or adjacent tooth • Resorption of the M3M and/or adjacent tooth • Fractured M3M • M3M Periapical abscess, irreversible pulpitis or acute spreading infection • Surrounding pathology (Cysts or tumours) associated with the M3M Treatment to be considered • Therapeutic Removal of M3M (or coronectomy) • Removal of upper third molar	Leave deeply Impacted M3Ms with no associated disease Manage other diagnoses causing pain in the region: • Temporomandibular disorders • Parotid disease • Skin lesions • Migraines or other primary headaches • Referred pain from angina, cervical spine • Oropharyngeal Oncology

Background

Third molar surgery is one of the most common surgical procedures performed in secondary care in the National Health Service (NHS).[1]
When combined with outpatient procedures undertaken in both secondary care and primary dental care, it rates as the most common surgical procedure in the whole of the NHS. The presence of an impacted third molar is a developmental condition and is recognised as such by the World Health Organization within the definitions of the International Classification of Diseases (ICD-10).[2] It is accepted that the removal of a diseased or symptomatic third molar will alleviate pain and other symptoms, and improve the oral health and function of patients.[3,4]

Guidelines are a useful support for clinicians and patients in making evidence-based decisions about the specific choices to optimise treatment and outcome, provided evidence exists.[5] Nevertheless, clinical guidelines should be based on the best available evidence, which is often scant, even for such a high volume surgical practice. The National Institute for Health and Care Excellence (NICE) introduced guidance in 2000, discouraging the prophylactic removal of mandibular third molars (M3Ms).[6,7] However, there is growing evidence that this may not be in the best interest of the patient, resulting in the delay of inevitable surgery and in addition, causing caries in the adjacent mandibular second molars (M2Ms).[2,8–11]

The NICE guidance followed the introduction of other notable clinical guidelines for third molar management. In 1979, the US National Institutes of Health issued their guidelines on the management of third molars, partly as a result of critique by medical insurance companies that third molars were being removed unnecessarily without any evidence-based clinical indication,[12] while in 2014, The American Association of Oral and Maxillofacial Surgeons (AAOMS) introduced its parameters of care document.[13]

The first UK evidence-based guide to third molar management was issued by the Faculty of Dental Surgery (FDS) in 1997,[14] with the most recent guidance published by NICE in 2000,[6] complemented by the Scottish Intercollegiate Guidelines Network (SIGN) guidance, issued in the same year.[15] Both the FDS Parameters of care and the SIGN guidance have been periodically reviewed since initial publication. There has been no such review for the NICE guidance despite the comment that current research would be reviewed (item 5.1, NICE, 2000) and that an intention date of 2003 was set in the original document.

In 2016, the AAOMS revisited its M3M guidelines[16] in the light of significant criticism in the *American Journal of Public Health*,[17] resulting in the introduction of active surveillance for patients presenting without overt indications for surgery or presence of disease. This has significantly reduced surgical intervention. These updated guidelines[16] are endorsed by both BAOS and BAOMS. In contrast, the Finnish guidelines have recommended earlier intervention for patients with M3Ms likely to cause future morbidity.[18] It

appears that internationally, M3M surgical intervention guidelines appear to be in concordance as a result of contemporaneous evidence.

Variation between guidelines may reflect aspects of both the national culture and their healthcare system(s).[5] A number of national guidelines specifically address the indications for removal of third molars with no reference to adjunctive care, timing of care or prevention of complications. There is considerable variation between national guidelines, with most of them focused solely on indications for surgery, and very few applying a holistic approach to patient care. In addition, there is variation in how the evidence base was assessed and recorded, what search methodology was used (if described as a systematic review) and how the working panel was composed.

In the light of emerging evidence, the FDS Clinical Standards Committee recommended the establishment of a dedicated panel with representation from all dental specialties, to revisit the FDS parameters of care for patients undergoing M3M surgery. This updated document is not a formal systematic review but a consensus document based on the best available evidence by the multidisciplinary group. It takes account of the range of current best practice and parameters of care for the guidance of patients, healthcare providers and commissioners.

The final document has been endorsed by FDS.

Natural history of third molars

Impacted third molars are one of the most common developmental conditions that affect humans and require surgical intervention.[19]

M3M development

Agenesis (lack of development) of third molars in human populations affects 100% of indigenous Mexicans but occurs rarely in Tasmanians, the difference reported to be related to the *PAX9* gene (and perhaps other genes).[20]

Crown calcification starts at 7–9 years for maxillary third molars and at 8–10 years for M3Ms. Crowns are completely formed at 12–16 years and roots are complete at 18–25 years. M3Ms usually erupt at around 19–20 years of age.[19,21] Third molars that appear missing radiographically at the age of 14 years almost always fail to develop. In order to erupt into the mouth, teeth must develop or migrate into a favourable upright position, which commonly continues up to age 25 years. Those in a vertical position commonly proceed to full eruption while those remaining unerupted may change position favourably or unfavourably until the middle of the third decade or later.[21] Third molars normally erupt at between 18 and 24 years.[21,22] However, one or more third molars fail to develop in approximately 1:4 adults. Two per cent of the population lack all four molars in Swedish, Finnish, Turkish and Indian populations.[23–27]

M3M impaction

The failed eruption of M3Ms may be either due to ectopic development (abnormal position of developing tooth) or impaction (eruption path blocked by healthy hard or soft tissue, or disease).[14] Impaction is a descriptive term and not an indication for surgery. When M3Ms fail to erupt properly, this is usually due to impaction of the tooth against an adjacent tooth, alveolar bone, the surrounding mucosal soft tissue or a combination of these factors.

M3Ms may be unerupted, partially erupted or fully erupted. Partial impaction is defined as when some of the tooth has erupted into the oral cavity, and complete impaction is when the tooth is completely buried. In 90% of Swedish 20-year-olds, at least one third molar will be partially erupted.[23] If the M3M is partially erupted (visible) or soft tissue impacted and non-visible, communication with the oral cavity may develop, allowing bacterial ingress and infection to occur.

The incidence of M3M impaction ranges from 36% to 59%, and full or partial M3M retention has been shown to be associated with diseases such as dental caries, pericoronitis, cyst formation and tumours in a Turkish population.[26] A non-age stratified longitudinal Finnish study reported M3M impaction prevalence of 16% (at 20 years) and 11.7% (at 30 years), illustrating a sharp decline in the numbers of third molars between these ages, principally due to operative removal.

The M3M orientation is important when planning the surgical approach. Orientation is defined in relation to the geometric angle to the occlusal plane (eg mesioangular, distoangular, vertical or horizontal) and is a clinical description, not in itself a diagnosis. In a study of 1,200 Indian patients, mesioangular impaction was most prevalent followed by distoangular impaction. Fifty per cent of cases showed proximity of the unerupted tooth to the inferior alveolar nerve, which was more frequent in males (58.3%).[27]

Predicting the eruption of M3Ms

The most significant variable associated with third molar impaction is inadequate hard tissue space (between the distal aspect of the second molar and the ascending ramus of the mandible) with the vast majority of impacted third molars having insufficient space to erupt.[28]

Scant longitudinal data exist on the changes over time of impacted third molars. Impacted teeth that remain without changes in position or angulation, are rare.[29] Unerupted teeth can change position even beyond the middle of the third decade of life.[21] As there is no reliable way to predict pathological changes associated with impacted teeth, it has been suggested that the lifecycle of impacted teeth be monitored periodically with radiography.[30]

The space for eruption to the occlusal plane can be measured using a variety of radiographic techniques.[31,32] This will enable determination of whether an impacted M3M may be able to erupt in the future. One study has validated a method to predict eruption of M3Ms in a dental student population (*n*=28) in Finland, with long-term follow-up.[33] Baseline clinical status and radiographs

were taken at a mean age of 20.6 years (standard deviation: 1.4 years) and compared after 4 years of follow-up for a total of 43 third molars. The predictor model is a matrix superimposed on to a panoral radiograph taken of a patient at age 20 years, to make predictions of future eruption or impaction of M3Ms. One half of the M3Ms remained impacted and the other half erupted by age 26 years. A 97% correct full eruption prediction of M3Ms was possible by using the supplied overlay assessing the intersection of a horizontal reference line and the anterior border of the ascending ramus, measured from the anterior ramus point to the distal aspect of the M2M. It was concluded that the method was simple to use and may prove a good addition for predicting M3M eruption.[32,33]

A separate study followed 19 patients (13 male, 6 female) from age 20 to 32 years, with 34 impacted third molars, 21 in the mandible,13 in the maxilla. [34] Radiographic analysis included resorption, enlargement of the follicle, development of the root, change in inclination, state of impaction, relative depth of the third molar in bone, and relation to the ramus of the mandible and to the M2M. In the mandible, the mean change in inclination was 19 degrees and the percentage of teeth with changed angulation was 76%. In the maxilla, only 23% of the teeth changed their inclination. The state of impaction (soft tissue, partially in bone, completely in bone) had changed for 44% of the teeth. According to the questionnaire, which was completed at aged 20 and 32 years, no pain or symptoms in the region of the third molars were reported by 74% of the students during the 12-year study period. It was concluded that considerable radiographic changes (without notable symptoms) may occur, involving inclination of the tooth and state of impaction of third molars, after the usual age of eruption.[34,35]

The fate of M3Ms

Very few studies have reported long-term follow-up of M3Ms. However, the Finnish group led by Professor Irja Ventä has reported robust follow-up data on students,[34] confirming that by 38 years of age, most M3Ms require removal.[36] In 2002, the Finnish M3M working group reported that at least one third molar extraction is needed in 68% of those aged 20 years.[37] Furthermore, at least one third molar had been removed before 32 years of age in 67% of patients,[36] the majority being extracted at around the age of 27 years.

In 2004, a study followed the clinical changes in third molar status over an 18-year period in patients aged 20–38 years. [21] The patient cohort consisted of 118 subjects (37 men and 81 women). More than half of the third molars which were initially partially erupted, were removed during the follow-up period (64%, maxilla and mandible together). The percentage of erupted third molars found in the mouth at age 38 years increased significantly depending on the initial status. Of the initially unerupted, partially erupted and erupted third molars, 10%, 33% and 50% respectively were erupted at age 38 years (maxilla and mandible together). At 38 years of age, only 31% of M3Ms remained.[21]

In dentate Finns, the prevalence of partially erupted or erupted third molars decreases from 30% to less than 5% between the ages of 30 and 65 years.[38] By 38 years of age therefore, 80% of M3Ms are missing and by the age of 65 years, 95% are missing. On this basis, the Finnish M3M guidelines recommend an interventional approach to M3M extraction to minimise the risks of retention and the associated risks of surgery in older patients. The English version emphasises preventive removal in selected cases and is summarised very well in this specific article.[39] Based on this evidence, it is apparent that over 80% of third molars are removed anyway,[39–41] so why not extract the M3M when the risks are minimal?

However, it must be mentioned that at the time of the study, there was no Finnish equivalent of the NICE guidance for M3Ms. Only 28% of the study cohort had any symptoms. The remainder had their M3Ms removed on the recommendation of the dentist and/or on the student's own initiative. The study noted that a significant proportion of the M3Ms were removed at the age of 27 years. They recognised that the study cohort comprised of students, they would have had access to Finnish dental care at a very low fee until the age of 27 years.

Conversely, an alternative 'experiment' was unintentionally initiated by NICE when it introduced its guidance relating to third molar surgery in 2000,[6,7] discouraging prophylactic removal of M3Ms. NICE[6] recommended:

- Impacted third molars that are free from disease (healthy) should not be operated on. There are two reasons for this:
    - There is no reliable research to suggest that this practice benefits patients.
    - Patients who do have healthy third molars removed are being exposed to the risks of surgery. These can include nerve damage, damage to other teeth, infection, bleeding and (rarely) death. Also, after surgery to remove third molars, patients may have swelling, pain and be unable to fully open their mouth.
- Patients who have impacted third molars that are not causing problems should visit their dentist for their usual check-ups.
- Only patients who have diseased third molars (or other problems with their mouth) should have their third molars removed. Your dentist or oral surgeon will be aware of the sort of disease or condition that would require you to have surgery. Examples include untreatable tooth decay, abscesses, cysts or tumours, disease of the tissues around the tooth or where the M3M prevents adequate access for restoration of the adjacent tooth.

However, there is increasing evidence that this may not be in the best interests of the patient, resulting in delay of inevitable surgery with additional damage to the adjacent M2Ms.[8–10,42]

The implications of M3M retention are less well detailed. Recent studies involving patient cohorts who elected to retain their M3Ms have demonstrated that these frequently and unpredictably change position, eruption status and periodontal status. Depending on the duration of follow-up, up to 63–78% of retained M3Ms will be extracted at some time in the future owing to:

- periodontal deterioration, which has been reported in relation to M2Ms and retained M3Ms[43,44]
- caries in the M3M and in the distal aspect of the adjacent M2M[1,9,45–47]
- disease related to M3Ms

Several studies have reported the prevalence of disease associated with retained third molar teeth. Although most oral surgeons have encountered many patients with infection and osteolytic lesions associated with retained third molars, assessment of the frequency of abnormality around these teeth has previously been hampered by the lack of well designed studies.

Disease related to M3M eruption

Eruption of the M3M to the occlusal plane and into a functional position, does not always ensure adequate periodontal support. This is due to a lack of physiological space for the maintenance of a tooth in good health.[10,48] Impaction is an abnormality of development that predisposes to pathological changes such as pericoronitis, caries, resorption and periodontal problems. The US National Institutes of Health considered that impaction or malposition of a third molar is an abnormal state,[12] which may justify its removal, such treatment not being considered 'prophylactic'. It is nevertheless important to draw a distinction between an abnormal state and disease. Under these circumstances, the decision to recommend removal must be based on a balance between the risk of observing a tooth until it becomes associated with disease against that of removal before overt disease develops.[49] Relative risks have been estimated in two decision analyses, both of which have suggested that surgical intervention in the absence of disease is generally not justified and removal of impacted M3Ms is *not* indicated to alleviate or prevent dental crowding.[49]

Infection

This includes pericoronitis, caries, periapical disease and local bone infection and is the main cause of third molar disease and the reason for their subsequent removal.[50,51]

- **Pericoronitis**

  Inflammation around the crown of a partially erupted tooth may become symptomatic. It is usually a transient/self-limiting single event associated with normal eruption of any tooth. Prevalence of pericoronitis was

estimated from a sample of 245 patients; the highest incidence of pericoronitis was found in the 20–29-year age group (81%).[49] The condition was rarely seen before the age of 20 or after 40 years. The general health of the patient was not found to be a predisposing factor, apart from upper respiratory tract infection, which preceded the occurrence of the disease in 43% of cases. Von Wowern and Nielsen found that 10% of a sample of 130 students with partially erupted M3Ms followed over 4 years, developed pericoronitis.[44] Many reports state pericoronitis as the predominant indication for M3M extraction.[7] More recently however, pericoronitis has become a less common indication than caries (in the M3M or M2M). Recurrent pericoronitis (26.3%) was the indication for surgery in a retrospective cohort study of 1,763 patients and caries was the indication in most patients (63.2%).[51] Predisposing factors for pericoronitis include:

- partial eruption (usually at 20–25 years of age) and vertical or distoangular impaction[51–58]
- opposing maxillary M3M or M2M causing mechanical trauma contributing to recurrent infection[55]
- upper respiratory tract infections as well as stress and fatigue pericoronitis[59]
- poor oral hygiene[56]
- insufficient space between the ascending ramus of the lower jaw and the distal aspect of the M2M[31,32,58]
- white race[60]
- a full dentition[34]

Microbiology of pericoronitis

Several studies have shown that the microbiota of pericoronitis is predominantly anaerobic.[61] The most common bacterial species identified are: *Streptococci* , *Actinomyces*, *Propionibacterium*, a beta-lactamase producing *Prevotella*, *Bacteroides*, *Fusobacterium*, *Capnocytophaga* and *Staphylococci*.,[62] *Prevotella intermedia* and *Campylobacter rectus* have been related to the increased incidence of second and the third molar periodontal pockets deepening (≥4–5 mm) over two years.[63,64] *Treponema denticola* has also been recently implicated in pericoronitis.[65] Persistence into an acute spreading infection or repeated infection impacting on quality of life or requiring antibiotic prescription, are indications to remove the causative molar and in such situations, surgical removal is preferred to the prescription of antibiotics.[50] Antibiotics should only be prescribed when surgical removal of the cause or drainage of the infection under local anaesthesia is impossible (e.g. trismus, patient compliance). Antibiotics are required if there is evidence of a systemic spreading infection necessitating urgent referral for hospitalisation.

Antibiotic regime

Antibiotic prescriptions by dentists continue to increase the risk of bacterial antibiotic resistance.[66] Antimicrobial regimes and guidelines for prescription in relation to third molar management, are covered in **Appendix 1.**

Periapical infection

This is a consequence of advanced caries causing pulp necrosis, periapical abscess or chronic periapical granuloma. Unlike periapical infection of other teeth, this cannot be managed by root canal therapy due to limitations in access.

Spreading chronic local infection or inflammation includes:

- osteomyelitis
- osteoradionecrosis and osteonecrosis

Dental caries

Caries (tooth decay) is a bacterial infection that causes demineralisation, destruction and cavities in teeth. Caries (77%) and gum disease (89%) were the main causes indicating removal of M3Ms in patients aged 52–74 years.[67–68] Dental caries may require the extraction of M3Ms if it affects either the M3M itself or the M2M.

M3M caries

If the M3M is unrestorable, surgical removal of the M3M may be indicated. If restoration is possible, this is the preferred treatment option for M3Ms. In van der Linden *et al*'s review of 1,001 patients whose third molars were removed at age 13–75 years, caries was present in 7.1% of impacted third molars and in 42.7% of adjacent molars (204 and 1,227 of 2,872 teeth respectively).[68] Another 4-year follow-up patient cohort study revealed that for 179 subjects (mean age 29 years), 85% had caries experience detected on the first or second molars and 50% had a third molar affected.[69]

M2M caries

There is an increasing body of evidence highlighting the association of retained M3Ms with the development of distocervical caries in the adjacent M2M in patients with horizontal or mesioangular partially erupted M3Ms that have been present in the mouth long enough to cause caries in the adjacent M2M.[70-74]

Diagnosis of M2M distocervical caries is often late, leading to poor prognosis of the M2M and extraction of the M2M may be indicated. There is limited evidence for the removal of the M3M in order to facilitate restoration of the M2M. Mansoor *et al* reported that 38% of M3Ms in a prospective patient cohort at the University of Manchester School of Dentistry required removal because of M2M caries.[9] McArdle and Renton reported an increase in NHS OPCS codes for M2M caries as an indication for M3M surgery.[73] They concluded that this was likely to be as a result of the increased age of patients having delayed M3M surgery, following the NICE guidance.[9,11,73] M2M distocervical caries is significantly more common adjacent to a partially erupted and mesially angulated M3M. This is evidenced from data collected over 25 years from 416 adult men enrolled in the Veterans Health System in

the US).[72] Furthermore, the presence of a soft tissue over impacted third molar increased the risk of incidence of second molar disease 4.88-fold (95% confidence interval [CI]: 2.62 to 9.08). Having an erupted or bony impacted third molar, increased the risk of incidence of second molar disease by 1.74 (95% CI: 1.34 to 2.25) and 2.16 (95% CI: 1.56 to 2.99) respectively. Therefore, the retention of third molars is associated with increased risk of second molar disease in middle-aged and older adult men.[72]

Periodontal disease

Periodontitis is a bacterial infection causing inflammation and bone destruction at sites where the gingivae are not cleaned effectively. Periodontal disease may be painless, so diagnosis is often delayed. [75] In a study by Marciani, where young, healthy patients were studied for the presence of periodontal disease in their molars; at follow-up, the presence of at least one periodontal probing depth of a minimum of 4 mm, was marginally more prevalent on the third molars than on the first or second molars (56% and 50% respectively). [76] Fewer subjects had third molars free of caries experience and periodontal disease at follow-up than those at enrolment (28% vs 38% respectively). Therefore, there was an increase in periodontal disease of 10% over four years related to M3Ms in this otherwise young and healthy patient cohort.[76]

The reported prevalence of periodontal disease due to partially erupted M3M varies with the diagnostic criteria and patient cohort. In a recent study, periodontal disease was associated with asymptomatic M3Ms at baseline in 25% of 329 asymptomatic subjects.[76] Impacted third molars associated with periodontal disease of adjacent (usually second molar) teeth should be removed early as the disease may be irreversible by 30 years of age. This is particularly important in smokers, in whom periodontal disease may progress rapidly. There is increasing evidence that presence of a partially erupted M3M may increase the risk of periodontal disease around other molar teeth in adolescent patients (**Appendix 2**).

Cysts and tumours

Cysts and tumours may also arise, and can reach an advanced stage before presentation with symptoms.[68,75] Benign disease that causes local damage to teeth or bone requires removal or coronectomy of M3M, whether symptomatic or asymptomatic. The presence of a malignant lesion may dictate the loss of M3Ms and adjacent dentition. Preoperative radiotherapy for malignancy or administration of bisphosphonates may also be facilitated by carefully pre-planning and strategic extraction of teeth, if they are of poor prognosis (**Appendix 3**).

Internal/external resorption of a tooth or adjacent teeth

Resorption is the destruction, disappearance or dissolution of tissue including bone or tooth dentine. The cause of the localised inflammation is unclear but if

untreated, the condition is usually progressive. A study evaluated 3,883 dental pantomograms to assess the prevalence of dental resorption related to M3Ms and reported a range of 2–5%.[77] The clinical significance of resorption is not clear, and the sensitivity and specificity of using different radiographic techniques to diagnose dental root resorption is problematic.

Fracture of the mandible or tooth/teeth

Fractures of the mandibular angle may necessitate M3M removal to facilitate reduction and fixation of the fracture. However, if the fracture is non-displaced or if the M3M is in a favourable position, retention may be possible. [78]

Trauma to teeth and jaws may result in localised dental fractures or fracture of the jaws themselves. M3Ms may require extraction for unrestorable dental fractures and to facilitate reduction of fractures prior to immobilisation.

The incidence of M3M surgery related to intraoperative mandibular fracture is 1:22,000 surgical operations. It may be as a result of the use of excessive force during the dental extraction. Predisposing factors include male gender, age (fracture patients average 45 years), a full set of teeth and a deeply impacted M3M.[78-9]

In patients at risk of fracture due to inadequate bone surrounding the M3M, the patient must be informed of the increased risk.

Orthognathic surgery

The presence of M3M in the line of surgery is the most frequently reported risk factor for bad splits although some authors found no significant association between third molars and bad splits.[80] Age as risk factor can increase the risk of a bad split when M3M's are present in the older patient. Some surgeons remove M3M prior to surgery when the tooth is erupted to allow primary closure of the surgical incision but there is no evidence of the benefits of this approach. Until firm evidence is generated, surgeons should time M3M removal before or during orthognathic surgery to balance potential patient/social benefits and risks/costs.

Age of patient and related disease indications for surgery

One study noted that between 1997 and 2002, there was an increase in patients over the age of 40 years requiring third molar removal.[81] The proportion increased from 10.5% to 17.3% of all M3Ms removed. This was thought to be attributable to changing demographics within the geographical areas reviewed as part of this study. It does appear that the eruption of third molars in older patients is more frequent than may have been expected. Many of these late erupting teeth have disease, including caries and periodontal disease.[47] A 2 year follow up of a study of 14–45-year-olds, found that 51% of 312 late erupting third molars had periodontal disease.[76]

Definitions in oral surgery

Active surveillance
A non-operative management strategy for retained mandibular third molars (M3Ms), characterised as a prescribed, regularly scheduled set of follow-up visits that include both clinical and radiographic examinations

Anaesthesia
Lack of sensation/numbness

Analgesia
Pain relief

Caries
Also known as tooth decay or a cavity, caries is a bacterial infection that causes demineralisation and destruction of the hard tissues of the teeth (enamel, dentine and cementum). It is a result of the production of acid by bacterial fermentation of food debris accumulated on the tooth surface.

Clinical review
A review of the patient's signs and symptoms. Radiography would only be indicated if there were clinical signs or symptoms of disease.

Cone beam computed tomography
An imaging modality that uses a cone shaped x-ray beam to provide high resolution 3D images of the teeth and jaws. The effective dose is generally lower than for medical computed tomography but higher than for conventional dental imaging.

Coronectomy
This is a procedure that involves partial tooth section of a vital tooth, when the crown and all the enamel is removed. The roots are left in situ, minimising injury to the inferior alveolar nerve.

Ectopic teeth
A tooth is ectopic if it fails to erupt owing to malposition of the developing tooth.

Eruption
This defines the state/position of the M3M dental crown in relation to the oral cavity. The M3M may be unerupted, partially erupted or fully erupted. If the molar is partially visible and is still in the process of erupting or if it has failed to fully erupt into a normal functional position, this is defined as partially erupted. There is a risk that the communication with the oral cavity may allow infection to occur. The molar is unerupted if it has not yet commenced the process of eruption or if it is completely buried. (See *Impaction* section below)

Hyperaesthesia
Exaggerated sensation to touch, or cold or warm stimuli.

Hypoaesthesia
Reduction of sensation.

ICD-10
ICD-10 is the 10th revision of the International Classification of Diseases, a list of diagnostic codes compiled by the World Health Organization.

Inferior dental canal
The inferior dental canal is situated in the mandible and contains the inferior alveolar nerve, it starts on the lingual side behind the lingula and exits on the buccal side at the mental foramen

Impaction
The M3M is impacted if there is failure to erupt into a full or partial functional position or if the tooth fails to erupt at all. This may be due to lack of space within the dental arch, obstruction by another tooth or pathology, or an abnormal position of the molar. It may be partially or completely covered by soft tissue and/or alveolar bone.

Inferior alveolar nerve
Also known as the inferior dental nerve, this is a peripheral sensory nerve formed from the mandibular division of the trigeminal nerve (the fifth cranial nerve). This nerve supplies all the mandibular teeth on one side, the buccal gums associated with these teeth, and the mucosa and skin of the lower lip and chin on each side.

Lingual nerve
This is a branch of the mandibular division of the trigeminal nerve. It supplies the anterior two-thirds of the dorsal and ventral mucosa of the tongue. It also gives off a gingival branch, which supplies the lingual gingivae and floor of the mouth. The submandibular ganglion is suspended from the lingual nerve by two short branches. It is a relay station for the parasympathetic secretomotor fibres in the chorda tympani (a branch of the facial nerve). It contains taste fibres from the tongue and secretomotor fibres for the salivary glands within the floor of the mouth.

OPCS
The OPCS (Office of Population Censuses and Surveys) is an operations, procedures and interventions coding system used by clinical coders in the National Health Service.

Panoramic radiograph
An extraoral tomographic view demonstrating the teeth and supporting structures. This view is also known as a dental panoramic tomograph (DPT).

Paraesthesia
Altered sensation with a feeling of pins and needles. This sensation may be constant or elicited, usually by touch.

Pericoronitis
Inflammation associated with pericoronal tissues of an erupting tooth. Communication between the oral cavity and erupting tooth must be present to allow microflora invasion and subsequent disease including pericoronitis, periodontal disease and acute infections.

Periodontal disease
This is an inflammatory disease affecting the soft and hard structures which support the teeth. In its early stage (called gingivitis), the gums become swollen and red due to inflammation, which is the body's natural response to the presence of harmful bacteria.

Preoperative risk assessment

Mandibular third molar (M3M) surgery is related to several surgical risks (infection, haemorrhage, pain and swelling) as well as specific risks related to adjacent structures, particularly inferior alveolar and lingual nerve injury.

Risk assessment requires a comprehensive understanding of patient and dental factors that may impact on care of the patient.[82] Clinical assessment must include taking a full medical, social and clinical history, and importantly, an evaluation of the patient's ability to understand the risks and benefits of alternative proposed care plans (**See Appendix 4**).

Medical factors

Medical modifiers for patient care are essentially contraindications/indications that influence removal or retention of M3Ms, according to the medical condition of the patient (ICD-10) (**See Appendix 8**). One article comprehensively covers medical modifying factors for oral surgery.[83]

Social factors

If a patient has limited access to routine medical care (travelling long distances within the UK or travelling abroad) or their occupation will necessitate long periods away from civilisation (eg astronauts, nuclear submariners, explorers), a decision may favour a more interventional prophylactic approach. Furthermore, there may be modifying factors for patients requiring special care (**See Appendix 4**).

Several military M3M surgical guidelines advocate aggressive prophylactic M3M removal, as dental disease often requires return of troops, supporting the military sentiment 'If you can't bite, you can't fight!'[84]

Clinical factors

- Anxiety in adults can be assessed for sedation need.[85–86]
- Age carries the highest risk for complications after surgery.[87]

The American Association of Oral and Maxillofacial Surgeons white paper on third molars in 2014[13] stated:

- Periodontal defects (as assessed by pocket depths) deteriorate with increasing age in the presence of retained third molars.
- Caries in erupted third molars increases in prevalence with increasing age.

- The incidence of postoperative morbidity following third molar removal is higher in patients aged >25 years.
- Interventional surgery is associated with a lower incidence of postoperative morbidity.

Clinical assessment:

Examination is based on a social and medical history, including:

Extraoral assessment:

Temporomandibular joints to exclude temporomandibular disorders, which may present with preauricular pain similar to that caused by pericoronitis. This could result in an incorrect diagnosis and unnecessary and inappropriate M3M surgery.[88]
Consideration of limited mouth opening, which may complicate surgery. This has been reported to increase surgical difficulty of M3Ms
Lymph node enlargement as tender, enlarged lymph nodes may confirm spreading infection (**Appendix 1**)
Facial asymmetry
Exclusion of any pre-existing trigeminal neuropathy

Intraoral assessment:

Soft Tissues: Mucosal health
Hard Tissues: Dentition
Condition of and prognosis of M2M (restoration, apex closure, suitability for endodontic therapy, periodontal condition, vitality and mobility)
Eruption status of the M3Ms and potential eruption potential
Condition of the remaining dentition; caries risk and history of previous extractions
Hypodontia
Occlusion
Oral hygiene

Investigations:

Haematological investigations may be required for patients with specific medical conditions.[89]

Radiographic assessment:

(See **Appendix 5** for recommended practice for M3M surgery).

After taking a history and performing a clinical examination, panoramic radiography is indicated for third molar assessment when surgical intervention is being considered. Routine 'screening' of unerupted third molars is not recommended.

Evidence grade: **B2**
Recommendation: **A (strong recommendation)**

Cone Beam Computed Tomography (CBCT)

The current evidence suggests that CBCT has no effect on outcome. As the radiation dose and financial costs are higher than for conventional imaging, CBCT should not be used routinely in the radiographic assessment of third molars.

Evidence grade: **A (evidence based on meta-analysis)**
Recommendation: **A (strong recommendation)**

Where conventional imaging has shown a close relationship between the third molar and the inferior dental nerve canal, CBCT may be useful in those cases where the radiographic findings will alter management decisions.

Evidence grade: **B2**
Recommendation: **O (open recommendation)**

Valid Consent

It is difficult to predict the long-term outcome for asymptomatic third molars that are disease free. It is reliant upon the clinician's experience and expertise in collating the information gathered from the assessment process and then, weighing up the probability and severity of the risks. The clinician is required to communicate and explain the risks and benefits accurately and effectively to the patient, in order to obtain valid and informed consent.

Patient involvement is paramount when making the decision about third molar management. The findings of the assessment, the risk status, and the options along with their risks and benefits all need to be communicated at a level the patient can understand to assist in their decision making. Clear and comprehensive documentation is essential. Clinicians must now ensure that patients are aware of any 'material risks' involved in a proposed treatment and of reasonable alternatives, including conservative management, following the *Montgomery v Lanarkshire Health Board* judgement. The Bolam test no longer applies to the issue of consent.

Any difficulty in comprehension of the risks and benefits of the proposed care, must be addressed. The patient must be appraised of potential complications and sequelae, for example; a dry socket or nerve injury. There are several patient leaflets available[90,91] including those on the websites of the Royal College of Surgeons of England, British Association of Oral Surgeons and British Association of Oral and Maxillofacial Surgeons.

Risks versus benefits

This section focuses on the associated surgical risks and modifying factors which may affect treatment planning, decision-making and thereby, modify surgical management.

Modifying medical factors [83]

There are a number of medical factors which may compromise healing.
These include the presence/absence of underlying systemic disease that may interfere with the normal healing process eg diabetes mellitus, chronic renal disease, hepatic disease, haematological disorders, malnutrition including eating disorders, immunosuppression, radiotherapy or chemotherapy, and local bone disease.
The patient's medication also needs to be considered as part of the decision making process. This includes specific medication such as contraceptives, steroid therapy, previous history of taking steroids, bisphosphonates.
There is insufficient evidence to support prescription of antibiotics for patients with compromised healing but individual assessment must be made (**see Appendix 1).**
In some cases, prophylactic removal of compromised teeth may be recommended prior to radiotherapy, chemotherapy or other drug therapy that may cause osteonecrosis, osteomyelitis or osteoradionecrosis.

Guidelines for patients at risk of medication related osteonecrosis are provided by SDCEP (2017) (https://www.sdcep.org.uk/published-guidance/medication-related-osteonecrosis-of-the-jaw/) and for patients at risk of radio osteonecrosis (https://oralcancerfoundation.org/complications/osteoradionecrosis/).
Bleeding propensity will modify treatment decisions and surgery. Anticoagulant therapy recommendations are provided by SDCEP (2015) (https://www.sdcep.org.uk/published-guidance/anticoagulants-and-antiplatelets/).

Age alone is not regarded as a significant risk factor in patients judged healthy by classification of the American Society of Anesthesiologists (ASA https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system) but it is generally agreed that with increased age, local complications of removal become more common and severe.

Compliance and anxiety[85,86]

Anxiety related to dental procedures is best managed following the Scottish Dental Clinical Effectiveness Programme (SDCEP) guidance on conscious sedation (2017).

Providing patient information is likely to improve the consent process and alleviate patient anxiety and fear.[91,92] Travel distance from surgery may limit access to day surgery.

Modifying factors for patients requiring special care

(**See Appendix 4**)

Availability of escort or carer may limit access for sedation and surgery under general anaesthesia.

Modifying local factors

Difficulty of surgery

Predicting the difficulty of M3M surgery preoperatively is challenging.[93-4]

Risk of nerve injury

Age is the main predictor of lingual and inferior alveolar nerve injury[82,87]

Lingual Nerve Injury

There are no identifiable preoperative factors related to lingual nerve injury as this is predominantly related to surgical technique. Placing a barrier instrument is designed to prevent permanent nerve injury although gaining access and subsequent instrumentation to retract the lingual tissues may poses as a risk of to temporary nerve injury in avoiding permanent injury.[95] Other risk factors include duration of surgery, operator experience, depth of impaction, distal bone removal and anatomical differences. 11-18% of lingual nerves are above the distal aspect of M3M alveolar ridge

Inferior alveolar nerve injury (IANI).

Only radiographic signs on plain films are predictive of IANI (see **Appendix 5**). The following signs have been associated with a significantly increased risk of nerve injury during third molar surgery:[96]

- diversion of the inferior dental canal
- darkening of the root where crossed by the canal
- interruption of the white lines of the canal

Risk of damage to adjacent tooth

Intraoperative damage to the adjacent dentition requires informing the patient immediately (or on recovery from anaesthesia) and organisation of appropriate reparative restoration, endodontics or extraction of the M2M.

Adjacent heavily restored or compromised M2M or another adjacent tooth to surgical site, may complicate the extraction

Risk of post operative infection

Risk of dry socket

Dry socket (alveolar osteitis) is the most common complication after third molar surgery.[97] Recognised risk factors include; age of the patient, previous dry socket experience, mandibular and surgical procedures.

The prevalence of dry socket (alveolar osteitis) varies from 5% in routine extractions up to almost 30% in surgically extracted third molars. A recent Cochrane review assessed the management of dry socket.[97] It concludes that there is some evidence that rinsing with Chlorhexidine (0.12% and 0.2%) or placing chlorhexidine gel (0.2%) in the sockets of extracted teeth, provides a benefit in preventing dry socket in comparison to placebo. The number needed to be treated with chlorhexidine rinse to prevent one case of dry socket for a control prevalence of 30%, was 8. There was insufficient evidence to determine the effects of the other 10 preventative interventions each evaluated in single studies. The present review found some evidence for the association of adverse reactions with use of 0.12%, 0.2% and 2% chlorhexidine mouth rinses, though most studies were not designed to detect the presence of hypersensitivity reactions to mouthwash as part of the study protocol. No adverse events were reported in relation to the use of 0.2% chlorhexidine gel placed directly into a socket (though previous allergy to chlorhexidine was an exclusion criterion in these trials).

The most recent systematic review and meta-analysis in 2017,[98] found that in any formulation, concentration or regimen, chlorhexidine is efficacious and effective in preventing alveolar osteitis in patients who have undergone third molar extraction. Chlorhexidine gel was found to be moderately more efficacious than the rinse formulation. There are still limited data collected on adverse events. Staining, altered taste sensation, burning sensations, hypersensitivity and mucosal lesions have been reported as adverse effects of chlorhexidine use. There have been two cases of serious adverse events associated with irrigation with chlorhexidine mouth rinse. Clinicians prescribing chlorhexidine products should be aware of the potential for both minor and serious adverse side effects.

Therapeutic indications

This section includes diagnostic and therapeutic codes where possible: OPCS ICD-10 coding systems.

Infection

Where there is history of pericoronitis (acute spreading single episode, recurrent, chronic K053) cellulitis (K122), or where there have been one or more episodes of infection such as abscess formation; or untreatable pulpal/periapical disease, then removal of any symptomatic third molar should be considered. [13-16]

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Evidence grade: **B1**
Recommendation: **A (strong recommendation)**

Removal is recommended if the M3M has a periapical abscess (K047), is non-functional or in a compromised position, or when root canal therapy is not indicated.

Evidence grade: **B2**
Recommendation: **B (recommendation)**

Removal is recommended where there is M3M involvement in osteonecrosis, osteoradionecrosis or osteomyelitis (M8698).

Evidence grade: **B2**
Recommendation: **B (recommendation)**

Caries

See Appendix 9
Caries and 'induced' caries in adjacent teeth are coded as K029.
It is important to note that there is no surgical coding to distinguish between caries in M3M or M2M as an indicator for surgery. Removal should be considered when there is caries in the M3M and the tooth is unlikely to be usefully restored. Consideration should also be given to extracting it when the impaction makes it difficult to restore, unless there is a high risk of complications associated with the removal. If there is caries in the adjacent M2M which cannot be treated satisfactorily without the removal of the M3M, this would be another recommendation for its removal.

Evidence grade: **B2**
Recommendation: **B (recommendation)**

If the M3M is unerupted and the M2M requires extraction, it is advisable to remove the unerupted M3M, unless it could erupt into a functional position.

Evidence grade: **B2**
Recommendation: **B (recommendation)**

Periodontal disease (K056)

See Appendix 2
Removal should be considered in cases of periodontal disease because of the relative positions of the M3M and M2M. Untreated horizontal and mesioangular impaction is particularly prone to causing bone loss distal to the M2M. Late removal of such impacted teeth (especially after the age of 30 years) has not been shown to improve the periodontal status of the adjacent M2M but early extraction of the impacted M3M reduces periodontal damage.[43-7]

Evidence grade: **B2**
Recommendation: **B (recommendation)**

Associated disease

See Appendix 3
Radicular cyst K048, Odontogenic cyst K090
Dentigerous cyst formation and other odontogenic diseases are rare but often associated with third molars.[68] In most cases, there is a strong indication for removal of the third molar in order to prevent expansion or recurrence of a keratocyst.[99]

Evidence grade: **B2**
Recommendation: **B (recommendation)**

Third molar removal should be considered in cases of dentigerous or other cyst formation. However, there are many reports of successful coronectomy of M3Ms and M2Ms with benign cyst enucleation, in order to preserve the inferior alveolar nerve.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Prophylactic removal of teeth (including M3Ms) may be indicated for medical procedures such as organ transplantation, chemotherapy or the insertion of alloplastic implants. A similar situation arises with tumour resection and irradiation of the tissues, which lead to a reduction in the blood supply, with risk of infection or osteoradionecrosis. Early removal of teeth at the site of the resection may reduce the risk of infection. Removal may be considered in cases of fracture of the mandible in the third molar region or when a tooth is involved in tumour resection.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Tooth resorption (K033)

See Appendix 9
External resorption of the third molar or of the second molar is relatively rare and occurs principally in patients aged 21–30 years. The risk of developing resorption after the age of 30 years is remote.[100] Third molar removal should be considered in cases of external resorption of the third molar or of the second molar, where this appears to be caused by the third molar.

Evidence grade: **B2**
Recommendation: **B (recommendation)**

Fracture to teeth or jaws (S024/S26 upper/lower jaw, S025 teeth)

Incomplete extraction and retention of roots is possible with vital M3Ms. The presence of a tooth in a fracture line increases the risk of infection in some cases, particularly when that tooth has been displaced or rendered non-vital.[101]

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Adjunctive surgery (orthognathic, ablative)

There is no reliable evidence that third molar removal affects the growth of the mandible. Removal of the third molar may be indicated prior to orthognathic surgery.

Evidence grade: **B2**
Recommendation: **B (recommendation)**

Autotransplantation

The third molar tooth (when it is sound) is occasionally used for autogenous transplantation, usually to a first molar socket site.[102] The low incidence of success with the procedure means it is not widely used, except in specific circumstances.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Socket or bone ridge augmentation

The topic is not covered in this review.

Timing of surgery

Age of the patient

There is no evidence to suggest that leaving the teeth in situ makes surgery easier and there is strong evidence that morbidity increases with age.[103-4]

Evidence grade: **A2**
Recommendation: **A (strong recommendation)**

Removal of an unerupted third molar in an atrophic mandible may be appropriate if causing discomfort whilst wearing a denture.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

The options for surgical intervention include:

- no surgery but clinical review
- prophylactic surgery (removal of a non-diseased M3M)
- interventional surgery (required for non-symptomatic diseased M3Ms or those at high risk of developing disease)
- therapeutic surgery (removal of a diseased M3M)

Clinical review

If the M3M is erupted and functional or there is no explicit therapeutic, interventional or prophylactic indication for M3M surgery, then active surveillance or clinical review will be necessary to confirm continuing absence of developing disease. Active surveillance involves routine radiography at review even without clinical symptoms, as recommended by some guidelines. The argument is that routine bitewings for caries should include the distal aspect of the erupted adjacent M2Ms in order to avoid missing the presence of caries in the M2M when adjacent to a partially erupted M3M. There are explicit recommendations for interventional surgery by the American Association of Oral and Maxillofacial Surgeons (AAOMS) in 2016[16] where patients with asymptomatic and disease free M3Ms, were recommended to undergo active surveillance. See Group D below. Active surveillance would include clinical review supplemented with radiographic assessment, if indicated.

Prophylactic surgery

The AAOMS previously recommended prophylactic removal of M3Ms but a surveillance strategy has been introduced, applicable to approximately 23% of M3Ms, following a recent re-evaluation of risks versus benefits and pressure

from the American Public Health Association. The AAOMS guidelines suggest that M3Ms can be categorised into four groups to dictate treatment:

Group	Description	Treatment
Group A	Symptomatic and disease present (S+/D+)	Extract
Group B (Confirm diagnosis)	Symptomatic and disease absent (S+/D-)	Confirm diagnosis
Group C	Asymptomatic and disease present (S-/D+)	Extract
Group D	Asymptomatic and disease absent (S-/D-)	Surveillance

Group B should be determined by the working diagnosis (eg temporomandibular disorders).

Many military guidelines advocate pre-deployment prophylactic surgery to minimise renationalisation of military staff mid-deployment because of dental disease. Recent reports highlight disease related to third molars causing significant problems in deployed staff, for example; during deployment of personnel to Iraq, 303 individuals required transport back from active duty (70% were moved by helicopter) owing to pericoronitis. The study recommended active management of M3Ms prior to deployment.[105] Many national military M3M guidelines (US, Australian and UK) recommend a prophylactic approach because of the risks entailed in loss of ability to perform owing to dental disease.
There is weak evidence for the prophylactic removal of teeth (including M3Ms) for medical procedures such as organ transplantation, chemotherapy and the insertion of alloplastic implants.[104] In a healthy patient cohort with non-diseased, bone impacted M3Ms, the strongest evidence does not support prophylactic surgery.[104]

Interventional extractions

In many studies, patients undergoing M3M surgery aged over 25 years suffer a significant increase in intraoperative and postoperative complications. On this basis, many national guidelines recommend a prophylactic approach to M3M surgery.[38-41] Several national guidelines include recommendations for interventional extraction of M3Ms. There may be differences in costs and sick leave requirements between retention and early removal of M3Ms at risk of disease.[41] This could be important for patients when choosing between operative and non-operative management of their M3Ms, and this information should be provided during the consent process.

Several international guidelines include interventional extractions for M3Ms (Finnish, German and Scandinavian). The Finnish guidelines emphasise therapeutic or preventive removals in selected cases.

Therapeutic surgery

Therapeuic indications are the most commonly applied in M3M surgery.[106] Introduced in 2000, the National Institute for Health and Care Excellence guidance on the management of patients with third molars[6] has resulted in delay of surgery until patients are older. The frequency of surgery has not diminished; it is just performed in older patients.[11] The recurrent observation in this older cohort of patients was the apparent increase in the incidence of caries arising in the distal aspect of a second molar, as a consequence of the presence of the third molar.[70-76] A rationale for considering changing from a solely therapeutic strategy to a mixed therapeutic and interventional policy for patients with M3M surgery is provided in **Appendix 6.**

Adjunctive medical care for M3M surgery

Preoperative assessment of the patient is essential for optimising patient care.[107-8] Methods of anaesthesia are listed below. It is common practice to use local anaesthesia within general anaesthesia cases. The vasoconstrictive content helps to improve field of vision and cardioprotection. Local anaesthesia should be considered first with or without sedation and general anaesthesis should be reserved for those patients who are unable to have their surgery with local anaesthesia.

Local anaesthesia

Combinations of different local anaesthetic agents are proving to be more efficacious than using single agents. An inferior dental block with 2% lignocaine with adrenaline combined with buccal infiltration of 4% articaine with epinephrine has been shown to be more efficacious than using lignocaine alone. A likely hypothesis is that articaine has a high liposolubility due to its thiophene ring and an additional ester ring in the structure allows articaine to diffuse through bone tissue and strengthens the anaesthetic effect. Interosseous injection of 4% articaine has been shown to be the most efficacious, however this is a painful technique and there is a risk of needle fracture when trying to enter the dense buccal bone in the third molar region. [109]

Palatal blocks could be avoided by using 4% articaine buccal infiltration for maxillary third molars.

Evidence grade: **B2**
Recommendation: **O (open recommendation)**

Conscious sedation

A patient's need for conscious sedation is based on their anxiety about treatment, medical and behavioural indicators, and treatment complexity/invasiveness. Some patients are very anxious about routine dental treatment while others who are able to cope with routine care, may be distressed by more unpleasant procedures such as M3M surgery under local anaesthesia alone. The 2017 SDCEP guidelines on conscious sedation provide guidance on how to manage anxiety related to dental procedures.

Oral sedation

There is some weak evidence that oral midazolam is an effective sedative agent for children up to 16 years of age who are undergoing dental treatment[110] but there are no high-quality studies of effectiveness specifically for oral surgery. Furthermore, there are no high quality oral sedation studies for M3M surgery in adults. Consensus opinion has shown that there is significant individual patient variability in the effectiveness of oral sedation for oral surgery and that determining optimal timing for dosing is not straightforward, owing to the variability of gastric absorption. [87]

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Inhalational sedation

There is very weak evidence that nitrous oxide inhalation sedation may be effective for children up to 16 years of age undergoing dental treatment[110] and some evidence for oral surgery[111].(There is a limited evidence base for inhalation sedation for M3M surgery in adults. Consensus opinion has shown that inhalation sedation is effective for oral surgery and that individual dose titration against patient response, is possible. Nitrous oxide and oxygen for conscious sedation is recommended for young people up to 19 years of age in the 2017 SDCEP guidance on conscious sedation. There are few medical contraindications and so it is ideally used for reducing anxiety for patients with medical co-morbidities.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Intravenous sedation

There is evidence that 7% of the English population are likely to need conscious sedation for dental treatment.[87] There is consensus opinion that intravenous sedation is effective for oral surgery and individual dose titration against response, is possible. The benzodiazepine midazolam is most commonly used and is titrated against patient response. Midazolam for conscious sedation is recommended for young people up to 19 years of age. Anxiety related to dental procedures is best managed following the 2017 SDCEP guidance on conscious sedation.

Evidence grade: **B1**
Recommendation: **B (recommendation to use intravenous sedation for IfSN indexed anxious patients)**

General anaesthesia

General anaesthesia may be needed for complex and lengthy procedures but it must be recognised that local anaesthesia carries less risk.[112]
General Dental Council guidance emphasises that general anaesthesia is a procedure that is never without risk and that in 'assessing the needs of an individual patient, due regard should be given to all aspects of behavioural management and anxiety control before deciding to prescribe or to proceed with treatment under general anaesthesia'.[113]

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Analgesia

The only method to predict a patient at higher risk of increased postoperative pain is quantitative sensory testing.[114] The severity of postoperative pain is associated with: duration of surgery, patient age, depth of impaction, patient ethnicity, patient weight and surgeon experience. [115-118]

Pre-emptive analgesia

There is evidence suggesting that pre-emptive analgesia may have some benefit[118] and also, that it has no benefit.[115]

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Optimal postoperative synergistic analgesia

Combined ibuprofen (optimal dose 400 mg) with paracetamol (1,000 mg) is the optimal postoperative pain management for dental extractions in adults.[116-117]

Evidence grade: **A**
Recommendation: **A (strong recommendation)**

Steroid medication

Steroid medication provided parenterally during surgery reduces trismus, pain and inflammation.[120 -122] There have been two systematic reviews[121,122] published in 2013 and 2019, looking at efficacy of steroids on the control of swelling and trismus after extraction of impacted M3Ms. A total of 45 randomised clinical trials were reviewed. The meta-analysis121 of 10 of the trials demonstrated that corticosteroids were effective in controlling pain ($P = 0.002$; mean difference −17.38, 95% confidence interval −24.81 to −9.95) and trismus ($P< 0.00001$; mean difference 6.10, 95% confidence interval 3.42 to 8.77). The administration of a corticosteroid in the preoperative phase, given parenterally, was superior to its use in the postoperative phase for the control of trismus. The studies that continued the use of corticosteroids in the postoperative period did not present better results than those in which a single dose was employed. The majority of studies that made use of dexamethasone employed a dose of 8 mg. However, positive results were also achieved with a dose of 4 mg. Other steroids used were: methylprednisolone, prednisolone and betamethasone, but there was no standardisation in the dosage used. Where an opportunity is available, there is evidence to justify parental steroids given peri-operatively.

Evidence grade: **A**
Recommendation: **A (Strong recommendation)**

Haemostatic agents

Life threatening haemorrhage after third molar extraction is rare.[123] Haemostatic agents may be used to assist with haemostasis on removal of M3Ms but the evidence to support their routine use is limited and not of high quality. While such agents may be helpful with achieving haemostasis, there is a suggestion that they may be associated with an increase in the incidence of dry socket.[124]

Haemostatic agents such as absorbable haemostatic gelatin sponge or collagen fleece may have a place when patients are at high risk of

haemorrhage. They may be used alone or in combination with tranexamic acid mouth wash (patients on warfarin), or with a platelet rich growth factor preparation (patients on oral anticoagulants), or with replacement therapy (patients with haemophilia A and B). SDCEP guidance from 2015 provides an excellent evidence base for managing patients with acquired thrombolytic disorders.

It is recommended that Surgicel® or similar agents are used when the patient is haemostatically compromised.

Evidence grade: **B2**
Recommendation: **B (recommendation)**

It is recommended that tranexamic acid is used in haemostatically compromised patients.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Antibiotics (Appendix 1)

A Cochrane review reported on 18 double blind, placebo controlled trials with a total of 2,456 participants.[124] Five trials were assessed as unclear risk of bias, thirteen at high risk and none at low risk. Compared with placebo, antibiotics probably reduce the risk of infection in patients undergoing third molar extraction(s) by approximately 70% (risk ratio: 0.29, 95% confidence interval: 0.16 to 0.50, p<0.0001, 1,523 participants, moderate quality evidence), which means that 12 people (range: 10–17) need to be treated with antibiotics to prevent one infection following extraction of impacted third molars.

Owing to the increasing prevalence of bacteria that are resistant to treatment by currently available antibiotics, clinicians should consider carefully the benefits and risk whether treating 12 healthy patients with antibiotics to prevent one infection. Twenty-three studies (15 low quality, 8 high quality) indicate that there is limited evidence supporting the efficacy of commonly used antibiotics in preventing complications after M3M removal.[125]
However, there are two systematic reviews that support antibiotic prescribing preoperatively for M3M surgery to reduce dry socket and infection.[126-7]

Evidence grade: **A**
Recommendation: **O (weak recommendation to routinely prescribe antibiotics for M3M surgery)**

Chlorhexidine

There is evidence that preoperative rinsing with chlorhexidine mouth may reduce development of a dry socket.[98,128]

Evidence grade: **B1**

Recommendation: **B (recommendation for preoperative rinse and dry socket irrigation *only*)**

Interventions for M3Ms

Evidence is summarised below for the following different actions and interventions: (See Figure in the Exceutive summary)

- Referral
- Clinical review
- Extraction of the maxillary third molar
- Operculectomy
- Surgical exposure
- Partial excision – coronectomy (**See Appendix 7**)
- Extraction
- Orthodontic treatment
    - Surgical reimplantation/autotransplantion
    - Pre-surgical orthodontics
    - Extrusion
- Restorative treatment (**See Appendix 9**)
- Periodontal treatment (**See Appendix 2**)

Referral

Once it has been decided that a third molar should be removed, consideration should be given to the appropriate treatment setting. General medical practitioners are encouraged to refer to a general dental practitioner although this does not preclude direct referral to a specialist practitioner. The decision with regards to choosing a treatment setting should take account of: the general suitability of the facilities for operative procedures and recovery, the competence of support staff and the training of the practitioner. In addition, each case should be assessed with regard to the patient's medical history and the expected degree of difficulty of surgical treatment.

Clinical review

The American Association of Oral and Maxillofacial Surgeons (AAOMS) have introduced active surveillance for unerupted M3Ms with no disease (Group D, which is approximately 23% of M3Ms in patients aged under 25 years).[16] This practice has yet to be proved effective but is endorsed by several national guidelines.
Current data are not sufficient to refute or support prophylactic extraction versus active surveillance for the routine management of M3Ms that are asymptomatic and free of disease. Although decisions regarding third molar management are usually straightforward, the evidence supporting extraction versus retention of asymptomatic disease free M3Ms is lacking. Active surveillance, a prescribed programme of follow-up and reassessment at regular intervals, is recommended for retained third molars rather than waiting for the onset of symptoms.[16]

Given that the risk of complications from third molar removal is age related, the rationale for recommending active surveillance instead of 'as required follow-up' is that the frequency of future disease among retained third molars is sufficiently high to warrant routine scheduled follow-up visits to detect and treat disease before it becomes symptomatic. Symptomatic disease is a late finding. Patients electing for active surveillance as their preferred management strategy might not avoid operative treatment in the future. However, it should increase their chances of being diagnosed at the youngest age possible, thereby minimising age-related operative complications. The AAOMS recommends that the frequency of follow-up visits be approximately every 24 months and the examination be completed by a specialist or general dentist. Active surveillance as a management strategy is based on level 5 evidence (ie expert opinion).

Evidence grade: **C**
Recommendation: **O (open recommendation)**

However, as radiography should only be performed when clinically indicated, clinical review is recommended rather than active surveillance.

Surgery

Extraction of the maxillary third molar

Extraction of a non-functional maxillary third molar may be beneficial in alleviating acute pain for patients.
However, there is limited evidence for consideration of removing a maxillary third molar that may be contributing to pericoronitis related pain in the opposing M3M.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Operculectomy

There is limited evidence for consideration of an operculectomy of a partially erupted M3M.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Surgical exposure

There is limited evidence for surgical exposure of the M3M.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Orthodontic Considerations Summary (by Nikki Atack)

The aetiology of dental crowding is complex and multifactorial.[129,130]

Having reviewed recent literature, there is no evidence to disagree with the findings of the AAOMS white paper,[13,16] from which the following points are supported:

Studies can be found that lend support both for and against third molars as contributing to crowding. While most suggest that third molars play at least some role in crowding, their role may not be clinically significant.[132,133]

No studies have been designed in a manner that isolates the effect of third molars from all other factors that may be associated with crowding. As a result, a cause and effect relationship between third molars and dental crowding is difficult to establish.[129]

It is not possible to explain, predict or prevent dental crowding, no matter what the cause. While it is possible that third molars play a role in the aetiology of crowding, they are only one factor to consider in making a clinical decision on third molar management. It is therefore prudent for clinicians to educate patients that the cause of dental crowding is multifactorial and while third molars may play a significant role in some patients, the current state of knowledge does not allow us to identify with accuracy who is at risk.

Evidence grade: **A2/B1/C**
Recommendation: **O (open recommendation)**

Orthodontic stability

Historically, third molars have been implicated in late mandibular arch crowding and relapse, following orthodontic treatment. The extraction of third molars for orthodontic purposes is rare. However, these teeth should be considered during treatment planning.

Third molars and treatment planning

Posterior crowding (particularly in the mandibular arch), may increase the risk of developing impaction.[129] Extraction of teeth towards the front of the mouth has little effect on posterior crowding while extractions towards the back improve the chances of acceptable third molar eruption. Studies are available that demonstrate the uprighting of third molars when premolars are removed as part of an orthodontic treatment plan.[22,131]

Factors influencing the stability of orthodontic treatment

These are multifactorial[132] and include:

Growth
Mesial drift
Type of treatment undertaken
Age of patient
Type of retention
Standard of post-treatment occlusion

Conclusion

Reviewing the literature, there appears to be no new evidence supporting the routine removal of third molars on the grounds of increasing orthodontic stability. Consequently, the recommendation remains that the routine removal of third molars to encourage orthodontic stability cannot be justified.[22,130–132]

Evidence grade: **A2/B1/C**
Recommendation: **O (open recommendation)**

Autotransplanting third molars

The autotransplantation of third molars is reported in the literature[102,143] although much of this information takes the form of case reports.

Sites of transplantation

The most common recipient site is the mandibular first molar site.[140,144]

Factors that influence the success of transplant:[102,134–135]

Careful selection of site
Stage of root development – immature roots have a greater chance of pulpal healing
Atraumatic removal of third molar
Immobilisation of transplanted tooth

Success rates

95% survival rates greater than two years have been reported[135-6] but survival rates reduce in the long-term.[137]

Conclusion

Having reviewed the literature, this supports the parameters of care document (Section 4.16), recommending that M3M is a ‘satisfactory tooth for use as donor for transplantation’.[115]

Evidence grade: **B2/C**
Recommendation: **O (open recommendation)**

Surgical techniques to minimise complications

See Appendix 6 for the rationale for interventional removal of M3Ms.
Incidence and prevalence of complications related to M3M extraction is summarised in this review. It also includes the information which supports extraction of M3Ms in younger patients, in order to avoid higher rates of peri-surgical complications. A Cochrane review addresses the evidence relating to interventions for M3Ms.[115]

A total of 62 trials (4,643 patients) were included. Several of the trials excluded individuals who were not in excellent health. Thirty-three studies (53%) were assessed as being at high risk of bias and 29 as unclear. Comparison of different suturing techniques and of drain versus no drain did not report any of the relevant primary outcomes. No studies provided useable data for any of the primary outcomes in relation to coronectomy. The evidence for making changes to surgical practice is therefore limited but can be sought from other types of sources that were excluded by the Cochrane methodology. The interventions under Cochrane consideration fell into six broad categories, with many comparisons, including only a small number of trials.

Triangular Flaps

There was insufficient evidence to determine whether envelope or triangular flap designs led to more alveolar osteitis (OR 0.33, 95% confidence interval (CI) 0.09 to 1.23; 5 studies; low-certainty evidence), wound infection (OR 0.29, 95% CI 0.04 to 2.06; 2 studies; low certainty evidence), or permanent altered tongue sensation (Peto OR 4.48, 95% CI 0.07 to 286.49; 1 study; very low-certainty evidence). In terms of other adverse effects, two studies [138, 139] reported wound dehiscence at up to 30 days after surgery, but found no difference in risk between interventions.

Evidence grade: **A**
Recommendation: **O (open recommendation)**

Use of Lingual retractors

There was insufficient evidence to determine whether the use of a lingual retractor affected the risk of permanent altered sensation compared to not using one (Peto OR 0.14, 95% CI 0.00 to 6.82; 1 study; very low-certainty evidence). None of our other primary outcomes were reported by studies included in this comparison.

Evidence grade: **A2**
Recommendation: **O (open recommendation)**

Bone removal technique

There is insufficient evidence to determine whether lingual split with chisel is better than a surgical hand-piece for bone removal in terms of wound infection (OR 1.00, 95% CI 0.31 to 3.21; 1 study; very low-certainty evidence). Alveolar osteitis, permanent altered sensation, and other adverse events were not reported.

Evidence grade: **A2**
Recommendation: **O (open recommendation)**

Irrigation method

There was insufficient evidence to determine whether there is any difference in alveolar osteitis according to irrigation method (mechanical versus manual: RR 0.33, 95% CI 0.01 to 8.09; 1 study) or irrigation volume (high versus low; RR 0.52, 95% CI 0.27 to 1.02; 1 study), or whether there is any difference in postoperative infection according to irrigation method (mechanical versus manual: RR 0.50, 95% CI 0.05 to 5.43;1 study) or irrigation volume (low versus high; RR 0.17, 95% CI 0.02 to 1.37; 1 study) (all very low-certainty evidence). These studies did not report permanent altered sensation and adverse effects.

Evidence grade: **A2**
Recommendation: **O (open recommendation)**

Closure technique

There is insufficient evidence to determine whether primary or secondary wound closure led to more alveolar osteitis (RR 0.99, 95% CI 0.41 to 2.40; 3 studies; low-certainty evidence), wound infection (RR 4.77, 95% CI 0.24 to 96.34; 1 study; very low-certainty evidence), or adverse effects (bleeding) (RR 0.41, 95% CI 0.11 to 1.47; 1 study; very low-certainty evidence). These studies did not report permanent sensation changes.

Evidence grade: **A2**
Recommendation: **O (Open recommendation)**

Surgical drains

It was not possible to draw any conclusions about the use of a surgical drain versus no drain, as the included studies did not report on any of the primary outcomes.

Platelet rich plasma and Platelet rich fibrin

• Placing platelet rich plasma (PRP) or platelet rich fibrin (PRF) in sockets may reduce the incidence of alveolar osteitis (OR 0.39, 95% CI 0.22 to 0.67; 2 studies), but the evidence is of low certainty. Other primary outcomes were not reported.

Evidence grade: **A**
Recommendation: **O (Open recommendation)**

Root retention techniques

• There were no trials of partial root retention versus whole root retention (coronectomy). There were two trials that assessed the comparison of coronectomy versus complete tooth removal, but the data from these studies was not considered to be sufficiently reliable for inclusion in the analysis.

The review provides a description and analysis of the relevant randomised controlled trial evidence, so that surgeons can make informed choices when adopting new techniques, or continuing with established techniques. It is not possible to recommend changes to surgical practice.

Coronectomy **(See Appendix 7)**

Although two RCTs compared coronectomy with complete extraction, flaws in the design and the unit of analysis of these studies meant that there were no reliable data available for inclusion.[114] There have been several studies, including four RCTs since the Cochrane review and this additional evidence is summarised in Appendix 7, reinforcing that coronectomy is an efficient method to minimise inferior alveolar morbidity.[97,140-143]

Evidence grade: **A1/B2**
Recommendation: **B (recommendation)**

Oroantral communication and or displaced roots related to extraction of maxillary 3Ms

Risk factors for displacement of molar roots into the maxillary antrum include; age over 40 years, lone standing molar with ridge resorption and protrusion of molar roots into the antrum. Careful root elevation rather than conventional forceps extraction methods, may minimise oroantral communication development and root displacement.

Evidence grade: **C**
Recommendation: **O (open recommendation)**

Other operative issues have limited evidence base;

Fractured tuberosity
Loss of tooth into soft tissues
Orthodontic extrusion of M3Ms

Main research questions arising

- What does high quality mandibular third molar (M3M) surgery look like?
    - What is the patient experience of M3M surgery?
    - When is the optimal timing for surgical M3M intervention?
    - What is the optimal intervention technique to minimise complications related to M3M surgery?
    - What is the optimal training for quality M3M surgery?
    - What is the best assessment of difficulty of surgery?
    - What is the effectiveness and health benefit of M3M surgery?
- How can we address the deficiencies of data collection and diagnostic and surgical coding for M3M surgery?

Summary and conclusion

The multidisciplinary working group has aimed to provide a comprehensive guideline for the clinical management of patients undergoing third molar surgery. Specific evidence-based guidelines exist in relation to antimicrobial prescription, cross-infection control, radiological assessment, orthodontic intervention, sedation and reporting complications (Care Quality Commission). Nevertheless, there remain significant unanswered questions relating to this high volume surgery. Large national prospective randomised studies would address the deficiency in evidence and answer some of the proposed main research questions above.

Given the current available evidence, we recommend changing from a solely therapeutic approach to a mixed range of interventions for patients with mandibular third molars based on a holistic and informed approach agreed with the patient.

The executive summary provides a summary of the working group's recommendations.

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Appendix 1: Microbiology considerations

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(Association of Clinical Oral Microbiologists)

Key actions/considerations

- This guidance is for the use of antibiotics in outpatient clinics in secondary dental care and general dental practices. It is not designed as a definitive guide to all oral infections. Please consult an oral microbiologist or medical microbiologist for the treatment of oral infections outside this guidance, and for the treatment of severe infections that justify deviation from this guidance.

- The relevant microbiological sample should be sent to the laboratory before starting empirical antimicrobial treatment.[1]

- This is empirical treatment guidance; all **antibiotic treatment should be reviewed after 48–72 hours** (or earlier according to severity of infection), and adjusted according to the laboratory results and the clinical picture of the patient.[1]

- A full medical history, medication list and allergy history should be obtained or checked before prescribing any antibiotics. Clinicians should apply their knowledge of drug interactions, cross-allergic reactions and side effects of antimicrobial agents to select the right option from the list below. If in doubt, please contact an oral microbiologist, medical microbiologist or pharmacist.

- Refer urgently for hospital admission to protect the airway, achieve surgical drainage and/or for intravenous antibiotics in severe odontogenic infections including: cellulitis plus signs of sepsis, difficulty in swallowing, signs of airway obstruction, and spread of infection bilaterally to the submandibular and sublingual spaces.

- **Immunocompromised patients*** are at higher risk of complications from infection. Consequently, antibiotic prophylaxis prior to oral surgery and/or prolonged courses of therapeutic treatment when there is oral infection should be considered and based on an individual clinical assessment. (Contact an oral microbiologist or medical microbiologist.)

- All antimicrobial doses in this guidance are adult doses. Please refer to the *British National Formulary for Children* for all child doses. Doses should be altered according to the body mass index, renal and liver function, where appropriate.

- Please refer to the *British National Formulary* in cases of **pregnancy and breastfeeding** before prescribing any medications.

- Abbreviations used in table for *Therapeutic use of antibiotics* (below): BD = twice per day; MC&S = microscopy, culture and sensitivity; OD = once per day; QDS = four times per day; TDS three times per day. Please note that when writing a prescription, it is recommended to not use abbreviations (ie write in full 'twice per day' instead of 'BD').

- Adherence to standard precautions and good infection prevention and control is mandatory when treating any patient in the clinical setting. Instruments used for minor surgical procedures should be sterile at point of use (evidence grade C). Please follow the national guidelines for infection prevention and control:

  - England: HTM 01-05
  - Scotland: HPS LDU guidance
  - Wales: WHTM 01-05
  - Northern Ireland: HTM 01-05

Prophylactic use of antibiotics in M3M

Prophylaxis (evidence grade A)

There is some evidence that routine prophylactic use of antibiotics has no effect on postoperative pain, swelling or wound healing.[2–4] A recent Cochrane review reported that in comparison with placebo, antibiotics for patients undergoing third molar extractions probably reduce the risk of infection by 70%. The number of patients needed to be treated to prevent one case of infection was 12 and clinicians should carefully consider the risk/benefit ratio for each individual patient .[5] Antibiotic prophylaxis should be considered when there is an increased risk of complications due to infection (ie immunocompromised patients)* and a history of previous alveolar osteitis (one preoperative dose).[6] Prophylactic use of antibiotics for any other reason is outside the scope of this guidance. Clinicians must therefore consider a patient's medical history and risk assess any related factors that might indicate antibiotic prophylaxis.

When choosing the timing of the dose, consideration should be given to achieving an effective serum dose at the time of surgery. Studies show this is between 1 and 2 hours following administration.

Therapeutic use of antibiotics

	Management of infection	Antibiotic indications	Diagnostic microbiology for MC&S	First line (no penicillin allergy)	First line (penicillin allergy)	Second line (no penicillin allergy)	Second line (penicillin allergy)
Pericoronitis (acute / chronic) Evidence grade: C	Local measures are sufficient in most cases and should be decided according to clinical assessment, including:[7] ■ debridement and irrigation ■ abscess drainage ■ operculectomy ■ occlusal adjustment or extraction of the opposing tooth ■ extraction of the impacted tooth if more than one episode of pericoronitis, when infection is under control[8]	Antibiotic therapy is only indicated if there is:[7] ■ fever ■ spreading infection ■ severe localised infection ■ persistent swelling despite local measures ■ trismus	Indicated in cases of severe infection and presence of purulent discharge. Samples include: ■ aspirate of pus (best quality specimen) ■ pus swab (Amies charcoal transport medium)	Amoxicillin 500 mg TDS +/- metronidazole 400 mg TDS for 3 days (depending on severity of infection) Chlorhexidine† or hydrogen peroxide mouthwash	Clarithromycin 500 mg BD for 3 days or clindamycin 300 mg QDS for 3 days (depending on severity of infection) Chlorhexidine† or hydrogen peroxide mouthwash	If severe spreading infection, refer for inpatient surgical management and intravenous antimicrobial therapy.	If severe spreading infection, refer for inpatient surgical management and intravenous antimicrobial therapy.

	Management of infection	Antibiotic indications	Diagnostic microbiology for MC&S	First line (no penicillin allergy)	First line (penicillin allergy)	Second line (no penicillin allergy)	Second line (penicillin allergy)
Management of postoperative infection Evidence grade: B2	Use local measures such as surgical debridement/drainage (as appropriate) in localised infections.	Antibacterial therapy is indicated in severe infections with systemic signs and symptoms of sepsis and/or evidence of local spread of infection.	Indicated in severe infections and presence of purulent discharge. (See above.)	Amoxicillin 500 mg TDS for 3 days	Clarithromycin 500 mg BD for 3 days	If severe spreading infection, refer for inpatient surgical management and intravenous antimicrobial therapy.	If severe spreading infection, refer for inpatient surgical management and intravenous antimicrobial therapy.
Osteomyelitis, osteonecrosis and osteoradionecrosis Evidence grade: C	A combined surgical and antimicrobial approach guided by culture and susceptibility testing is mandatory.	Close liaison between the clinical team and oral or medical microbiologist is critical for long-term success.	Obtaining high quality diagnostic specimens (eg multiple bone biopsies) uncontaminated by saliva is important for directing antimicrobial therapy and subsequent case management.	Good quality specimens submitted for culture and susceptibility testing must guide antimicrobial therapy. In the absence of specimens, treatment will be empiric; in the first instance, antimicrobial treatment should cover the *Streptococcus anginosus* group and oral anaerobes. For patients with complicated histories, consideration should also be given to coverage of *Staphylococcus aureus*. Treatment should last for at least 4–6 weeks. Prolonged treatment is indicated if actinomycetes are isolated. (Contact microbiologist.) Consideration should be given to prolonged intravenous therapy and outpatient antimicrobial therapy for successful outcomes. (Contact microbiologist.)[9]				
Management of alveolar osteitis Evidence grade: A	Dry socket or localised osteitis is a recognised complication following tooth extraction with a prevalence of approximately 4% for routine extractions and up to 30% for surgical extraction of third molars. Usually, it occurs 3–4 days after extraction and lasts up to 10 days.[9] The aetiology is thought to be associated with surgical trauma, localised infection and systemic factors. In the absence of spreading infection, antibiotic therapy is contraindicated. Management centres around local measures:[10–12] ■ If necessary, take radiograph(s) to exclude a foreign body or root. ■ Irrigate with chlorhexidine† to remove debris. The use of Chlorhexidine to flush open sockets should be considered with caution following two deaths resulting from type 1 allergy reactions. Use of a non-allergenic irrigant such as sterile saline, is recommended. ■ Pack the socket with a suitable dressing (eg Alveogyl). ■ Prescribe analgesics (non-steroidal anti-inflammatory drugs). ■ Review the patient after 24–48 hours.						

This guidance sheet is based on the two national guidelines below (unless indicated otherwise):

- Faculty of General Dental Practice (UK). *Antimicrobial Prescribing for General Dental Practitioners*. London: RCS; 2012

- Plus the supporting references:

- Summary of antimicrobial prescribing guidance: managing common infections – PHE context, references and rationales
  Ref: PHE publications gateway number 2018511
  PDF, 1.27MB, 107 pages
  Published October 2018
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/752613/Antimicrobial_prescribing_guidance_-_PHE_context_references_and_rationale.pdf

- The Management and treatment of common infections – guidance for consultation and local adaptation. 2017
  https://www.gov.uk/government/publications/managing-common-infections-guidance-for-primary-care

*Examples include uncontrolled diabetes mellitus, HIV patients with CD4+ count <500 cells/mm^3, neutrophil count ≤0.5x10^9/l, primary immunodeficiency, immunodeficiency secondary to immunosuppressive medications such as in transplant patients and immune related diseases etc.

†Please note that chlorhexidine can cause allergy.

Evidence levels (modified from the Scottish Intercollegiate Guidelines Network, 2001	
A+	Good recent systematic review of studies
A-	One or more rigorous studies, not combined
B+	One or more prospective studies
B-	One or more retrospective studies
C	Formal combination of expert opinion
D	Informal opinion, other information

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Appendix 2: Periodontal considerations

Paul Weston and Iain Chapple

Executive summary

A body of evidence derived from systematic reviews does not currently exist relating to mandibular third molar M3M removal due to periodontal considerations. There are, however, consistent findings from the evidence that is available.

- Impacted third molars increase the likelihood of loss of attachment and increased probing depths around the distal aspect of second molars. This is more likely to occur in the mandible (evidence level B2).

- Mesioangular impaction, pre-existing crestal bone loss and close approximation of the M3M crown to the distal aspect of the second molar together with suboptimal oral hygiene, increase the likelihood of attachment loss on the distal aspect of the second molar. These factors are also associated with residual periodontal pockets following extraction (evidence level B2).

- Removal of M3Ms when the distal aspect of the M2M is periodontally healthy, can lead to a loss of attachment and increased probing depths in this area (evidence level B2).

- The removal of impacted M3Ms that are associated with periodontal disease on the distal aspect of the adjacent M2M, may be beneficial in some cases and not in others. The decision to remove the M3M must therefore be made on a case-by-case basis and the opinion of a practitioner with additional competencies in periodontology or a specialist may be required.

Background

The National Institute for Health and Care Excellence (NICE) guidance on the extraction of third molars published in 2000[1] did not consider the presence or long-term challenges of managing periodontal disease as a factor in removal of M3Ms. This controversial omission has resulted in confusion on how to treat periodontal disease in the presence of impacted M3Ms. Moreover, periodontal specialists frequently request removal of M3Ms in successfully managed patients with periodontitis, in order to facilitate long-term maintenance of periodontal stability and retention of periodontally compromised M2Ms.

A number of guidelines subsequent to the NICE guidance in 2000 have considered this issue. The American Association of Oral and Maxillofacial Surgeons white paper published in 2007 concluded that the presence of

impacted M3Ms adversely affects the periodontium of adjacent M2Ms as reflected in disruption of the periodontal ligament, root resorption and increased pocket depths associated with loss of attachment.[2] It is therefore timely to review the evidence base for M3M removal for periodontal reasons and to provide guidance through NICE in this area. The clinical question is: 'Should impacted M3Ms be extracted to facilitate management of periodontal disease?'

Factors to consider in answering this question include:

- Can M3M impaction lead to periodontal disease, or exacerbate existing or treated periodontitis on the distal aspect of M2Ms?
- What is the effect of M3M removal on the periodontium distal to the M2M?

Can M3M impaction lead to periodontitis, or exacerbate existing or treated periodontitis on the distal aspect of second molars?

Using data from the Third National Health and Nutrition Examination Survey, Elter *et al* showed an elevated odds ratio for probing depths of >5 mm on the distal aspect of second molars of 2.1 (95% confidence interval: 1.6 to 2.8) in patients aged 25–34 years in the presence of an impacted M3M.[3,4]

In a longitudinal clinical trial designed to detect periodontal status in the M3M region, Blakey *et al* enrolled 329 patients with asymptomatic M3Ms.[5] The results demonstrated that 25% of patients had at least one probing depth of >5 mm on the distal aspect of a M2M or around a M3M after a 30-month period. Probing depths of >5 mm were associated with periodontal attachment loss of at least 1 mm in every patient. M2Ms and M3Ms were more often affected than the corresponding maxillary teeth.

In a similar trial, Blakey *et al* followed 106 patients with no periodontal disease in the M3M region at enrolment.[6] Of these, 38% had a detrimental change in M3M region periodontal status over a median follow-up of 4.1 years. Probing depths of >4 mm were detected significantly more often in the M3M region than in the maxillary third molar region.

What is the effect of M3M removal on the periodontium distal to the second molars?

In patients with a healthy periodontium at the time of M3M removal, there is an increased risk of loss of attachment or increased pocket depth after M3M removal.[2]

Montero and Mazzaglia evaluated the change in periodontal status of periodontally affected mandibular second molars after surgical extraction of the adjacent impacted M3M.[7] One year after extraction, the residual

probing depth at the distal aspect of the second molars had significantly improved. The mean baseline mid-distal probing depth was 5.5 + 2.1 mm. One year after extraction, this measurement had reduced to 2.6 + 0.8 mm and the periodontal health of the four posterior sextants improved with time following M3M removal. Indeed, the relative risk of having plaque and gingival indices classed as healthy or almost healthy was 10-fold higher at the end of the study than at baseline. The authors concluded that oral health education following removal of an impacted M3M and the depth of the M3M at baseline were correlated with the periodontal probing depth change at one-year follow-up.

Kan *et al* conducted a retrospective study on residual probing depths on the distal surface of mandibular molars up to 36 months after extraction of the impacted M3M in patients with established periodontal disease.[8] A relatively high prevalence of deep residual periodontal defects at the distal surface of the M2M was observed following M3M extraction. Risk factors for persistent localised periodontal pockets were mesioangular impaction, radiographic pre-extraction crestal radiolucency and inadequate post-extraction plaque control.

The age of the patient at the time of M3M removal was considered by Kugelberg *et al* in a prospective study.[9] Patients over the age of 30 years showed a higher incidence of residual intrabony defects following M3M removal than patients aged under 20 years. The authors concluded that early removal of impacted M3Ms with large angulation and a close positional relationship to the adjacent M2M, has a beneficial effect on periodontal health.

Conclusions

There is currently a limited evidence base to support decision making on M3M removal based on periodontal considerations associated with the distal aspect of M2Ms.

The available evidence supports removal of mesially impacted M3Ms when associated with periodontitis distal to the M2Ms and generally when access to the distal aspect of the M2M in order to perform oral hygiene is compromised by the presence of the adjacent M3M.

There is, however, a need for randomised controlled trials designed specifically to address this important oral health question. At present, decisions should be made on a case-by-case basis, balancing risks and benefits, and may require expert advice and/or guidance.

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Appendix 3: Long-term development of M3M associated disease

Edward Odell

All current guidelines indicate that any disease or lesion associated with a mandibular third molar (M3M) is sufficient indication to remove the tooth in order to diagnose or treat the accompanying condition. In practice, the tooth will almost always be extracted although there may rarely be situations in which the tooth can be preserved and allowed to erupt or guided into a functional occlusion, even when associated with a cyst.

The most common conditions that may be associated with impacted M3Ms are pericoronitis, caries and resorption, and these have been discussed in earlier sections and may all mandate extraction as all are likely to be progressive. A wide range of rare jaw conditions may involve impacted teeth by chance but could not be prevented by extraction and these are beyond the scope of these guidelines. This section considers cysts or odontogenic tumours in the context of prophylactic removal because they arise from tissue that is normally either partly or completely removed on extraction. All these conditions can cause significant expansion of the jaw given time and their treatment involves significant morbidity, which is greater with increasing size of the lesion. There are no longitudinal controlled trials to demonstrate the relative risks of retaining disease free impacted M3Ms in situ.

Dentigerous cysts

The cyst most frequently associated with unerupted M3Ms is the dentigerous cyst, which arises from separation of the reduced enamel epithelium from the crown and therefore surrounds the crown. Dentigerous cysts associated with third molars affect the M3Ms almost ten times more frequently than the maxillary third molars. In the UK, the age at presentation appears to be higher than in other parts of the word (including Europe), with patients presenting in the third to sixth decades[1] rather than the third and fourth decades, as reported elsewhere,[2] although it must be recognised that the age distribution is very broad in all series.

Would prophylactic surgery prevent dentigerous cyst formation? The answer to this question must be yes, in principle, because both coronectomy and extraction remove the epithelium required to form the cyst lining. However, there is little good epidemiological data to assess the benefit of removal as a preventive strategy. Assuming that all dentigerous cysts could be prevented, only a maximum of 8–11 individuals per million per year would benefit on an epidemiological basis.[2]

However, such studies do not always take into account the likelihood of impaction. The prevalence of cysts in patients presenting in hospitals varies widely. It has been estimated in a US population that approximately 0.7% of

100 impacted teeth present with a cyst[3] and a previous UK study found an equivalent figure of 0.7%, [4] while the figure in over 9,000 patients studied in Turkey was 2.3%.[5] These estimates are too high however, to be applicable to subsequent development of cysts in molars that are disease free on presentation. Cyst formation is more common in some individuals and those presenting with cysts are probably a susceptible population. The only large study of impacted M3Ms left in situ without treatment, was a radiographic retrospective follow-up study of 3,702 impacted teeth of all types (in 1,576 patients).[6] In this study, only 30 cysts were detected in 29 patients (0.81% of impacted teeth), with a mean follow-up duration of 27 years. Although the radiological criteria were appropriate and relatively stringent, the authors have been careful to use the term 'cyst-like changes' because enlarged follicles mimic cysts radiologically but do not have any long-term significance. Consequently, the risks indicated in these papers must be considered the maximum possible supported by the data.

As it can take several decades to develop and then detect a dentigerous cyst after impaction, formal longitudinal studies are unlikely to detect any relationship between cyst development and prophylactic removal of M3Ms.

Odontogenic keratocysts

Odontogenic keratocysts (keratocystic odontogenic tumours) arise from rests of odontogenic epithelium around the crowns of unerupted teeth, in the adjacent bone and probably below the mucosa. Since odontogenic keratocysts are not associated with specific teeth and often grow to a relatively large size before detection, it is not possible to ascribe origin to a specific tooth. Nevertheless, about half of odontogenic keratocysts arise in the M3M region and a quarter in the maxillary third molar region, all sites together having an approximate age specific incidence of 4–5 cysts per million per year. Age of onset is broad and bimodal in the UK[7] as a result of syndromic presentation.

Unlike dentigerous cysts, in which the tissue of origin is removed on extraction, the source of epithelium of odontogenic keratocysts would not be reliably ablated by extraction. Prophylactic extraction would not be expected to predictably prevent cyst formation although it might reduce it. Histological studies of tissue associated with extracted M3Ms and overlying mucosa often contain rests of odontogenic epithelium, and sometimes these are keratinised, but this does not imply that cyst formation has been initiated. (See below.)

Odontomes

Odontomes are the most common odontogenic tumours and are considered hamartomas. As odontomes develop in sequence with the normal teeth for their site, most will be apparent earlier or synchronously with M3M development. Their significance would be as a trigger for extraction when detected.

Ameloblastomas

Ameloblastomas are the most common benign neoplasm among the odontogenic tumours. The incidence rates for ameloblastomas are 1.2–1.7 per million per year for those of African descent and 0.2–0.4 for those of European descent.[2] The M3M region is the most common site so that ameloblastomas are reported to be associated with impacted M3Ms in a small percentage of cases, up to approximately 2%. However, these ameloblastomas are symptomatic or obvious on radiological examination, triggering extraction for diagnosis or treatment. Recent series are relatively small and different anatomical distributions are noted in different populations. Like the odontogenic keratocyst, no prediction can be made regarding whether prophylactic extraction could prevent development as the site of origin can lie outside the follicle. Ameloblastomas are no longer considered to arise in dentigerous cysts. Although occasional unicystic ameloblastomas can present in a dentigerous relationship, there are insufficient data to draw conclusions for this review.

Microscopic 'precursor lesions'

A number of published studies have examined the follicles and soft tissue associated with extracted M3Ms that were previously asymptomatic and radiologically free of disease. These all demonstrate rests of odontogenic epithelium and reveal a number of microscopic changes that mimic those seen in odontogenic cysts. These include microscopic cyst formation, keratinisation, ghost cell formation and areas that can resemble ameloblastoma, odontogenic myxoma or odontogenic fibroma. However, these are best regarded as involutional changes or developmental stages and have long been recognised to amount to no more than minor developmental anomalies. They should not be interpreted as incipient cysts or tumours. The constituent cells are often not in cell cycle[8] and appear to carry no significant risk of developing into the odontogenic tumours or cysts they resemble. Such changes are very frequent and their existence cannot be used to support prophylactic removal of disease free teeth. Microscopic cystic changes in follicles from asymptomatic, disease free M3M follicles are so frequent[8,9] as to demonstrate that almost all are irrelevant to development of disease.

Summary

Prophylactic removal or coronectomy of disease free impacted M3Ms would prevent development of dentigerous cysts but the number of cysts prevented would be small.

There is insufficient evidence to suggest that intervention would have any significant effect on development of other odontogenic cysts and odontogenic tumours.

If M3Ms left in situ are subject to continued surveillance, it seems likely that cysts and tumours developing subsequently in the molar regions would be detected at a smaller size, facilitating treatment and reducing morbidity of treatment. Radiological monitoring of asymptomatic impacted M3Ms is currently considered not justified, even taking into account the low risk of these sequelae.

Conclusions

The evidence on pathological changes associated with impacted M3Ms to support clinical decisions is level B2 and C only and very limited in extent. Many of the studies are several decades old.

In advising patients about the possible pathological sequelae of leaving disease free impacted M3Ms in situ, the only significant complication frequent enough to merit mention for consent purposes is development of a dentigerous cyst and the risk is less than 0.8% in approximately 30 years (evidence level B2).[6]

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Appendix 4: Modifying factors for patients requiring special care

Selina Master and Vanita Brookes

	Limiting factors	Recommendations	Exemplar
History taking	• Difficulties in obtaining a complete and clear history of symptoms including pain and swelling • Patient may be non-verbal • Patient may have a high pain threshold • Carers may have difficulties in establishing cause of symptoms (eg change in behaviour and eating and/or sleeping patterns)	• Adapt techniques accordingly • Adapt communication techniques • Consider differential diagnosis carefully	• 80-year-old lady with dementia is referred for a second opinion. • Lives at home with her husband, who is her main carer. • Daughter lives nearby and is a regular visitor. • Complaining of one episode of pain and swelling on left-hand side. • Eating well and no obvious symptoms. • Dentist asks carers to keep a detailed diary of eating patterns and to watch closely for any small changes in eating or behaviour that might indicate pain. Discomfort when undertaking oral hygiene or disturbance of sleep pattern may also be indicators of pain.
Oral examination	• Physical access to surgery • Physical access within surgery (eg may be unable to transfer from wheelchair to dental chair, making oral examination more difficult) • Limitations in mouth opening • Difficulties in achieving full oral examination, particularly in posterior region (eg owing to exaggerated gag reflex, anxiety or inability to communicate effectively to the patient regarding the examination and reasons)	• Adapt access to and within the surgery to create an environment that is conducive to surgery. • Try and increase familiarity; may need a couple of visits. • Be aware of possible limitations of oral examination and use a smaller brush to examine. Start on anterior teeth and work back. Do not recline patient too far back.	• Oral examination reveals a carious and partially erupted left mandibular third molar (M3M). • Difficult to examine as patient can vomit on examination. • Multiple roots and carious teeth remaining. • Small brush used for gentle examination; avoids triggering the gag reflex.

	Limiting factors	Recommendations	Exemplar
Diagnostic tests and assessment	• Limitations in obtaining appropriate and high quality radiographic images (These may only be possible under a general anaesthetic.) • The treatment plan may have to change at this stage as more information becomes available to aid decision making. • Assessing long-term prognosis of M3Ms and other risk factors in relation to ability to maintain effective oral hygiene, healthy diet etc • Assessing factors that may impact on healing process such as effective oral hygiene, coping with sutures, after care instructions etc	• Be flexible with radiographic film choices and techniques. • Assess risk factors in relation to periodontal disease. • Put in place a robust and effective preventive programme. • Review compliance with the programme and ability to maintain it. • Reassess risks and benefits of extraction vs monitoring.	• Managed to obtain an adequate dental pantomogram but not intraoral radiographs. • Noted that LL8 is in very close proximity to the inferior alveolar nerve. • Referred to oral and maxillofacial consultant for opinion and possible joint operation.
Consent process	• Patient may not be able to give informed consent. • Consideration needs to be given as to whether extraction is in the patient's best interests. • All treatment options must have been considered and discussed in advance of the operation with risks/benefits clearly outlined. • The Montgomery ruling suggests the consent process must be tailored individually to the patient's needs.	• Requirement to follow the Mental Capacity Act or Adults with Incapacity (Scotland) Act • Second opinion from appropriate senior clinician • Best interests meeting • Requirement for an independent mental capacity advocate	• Organised a best interests meeting with husband, patient and daughter. • Second dental opinion already provided. • Assessed in relation to Mental Capacity Act. • Ensured that family understood all options available.
Operation / treatment provision	• As above, decisions may need to be taken at the time of surgery when full clinical picture is available. • This may require a possible change in treatment plan to be discussed and consent to be obtained during operation.	• Ensure that time is available (during the operation if necessary) to talk over any major changes that may need alterations to the consent. • Ensure family/carers are aware that you may need to speak to them during the operation and so must be nearby with contact numbers.	• Set up joint operation with the oral and maxillofacial team. They surgically removed LL8 and an adjacent root. • Dentist carried out a thorough oral examination and scaling, and took intraoral radiographs.

	Limiting factors	Recommendations	Exemplar
Aftercare	• Oral hygiene may not be adequate to enable trouble free healing of the socket. • Postoperative information must be clear and legible. • Active follow-up should be at 24 hours and 1 week after the operation in order to review patient and to assess patient reported outcome measures (PROMs) and patient reported experience measures (PREMs).	• Ensure support is in place for oral hygiene etc. • Give information for emergency contact that evening and the following day. • Give clear information for postoperative care.	• Advised and briefed whole anaesthetic and recovery team. This helped in planning induction process and also helped to manage immediate postoperative distress as the patient was disorientated when she first became conscious. • Clear and appropriate advice given on managing the sutures, pain and bleeding. • Telephone number given for emergency contact that night and the next 24 hours. • Contacted carers the next day to check on recovery. Patient had not slept well but was very happy on the day of the phone call.
Patient experience	• PREMs as recommended by NHS England's Guide for Commissioning Oral Surgery and Oral Medicine (2015)	• Question 1: Friends and family test – Would you recommend this service to your friends and family? (Yes/No) • Questions 2–6: modified PREMs. This should also be available in an 'easy read' version.	

Appendix 5: Radiological considerations

Nicholas Drage

Preoperative radiological assessment

Conventional radiography

Radiographic assessment is essential when considering the removal of mandibular third molars (M3Ms), with panoramic radiography being the established initial investigation. When any radiographic examination is undertaken, the potential benefit must outweigh the risks. The main detrimental effect to consider is the chance of inducing a malignancy. The International Commission on Radiological Protection suggests an overall radiation induced fatal cancer risk to be 5% per sievert.[1] With the effective dose from panoramic radiography being 2.7–38 microsieverts,[2] it can be seen that the risk of cancer induction is very low. Although the risks are low, all radiographic exposures must be individually justified for each patient. Consequently, a history and clinical examination of the patient are essential prior to any request for radiography.[3]

All radiographic exposures must be fully optimised (ie all doses should be kept as low as reasonably practicable). One way of optimising the radiation dose in panoramic radiography is by using field limitation techniques, which have been shown to considerably reduce the effective dose.[4] However, care must be taken to ensure that the appropriate field limitation programme is selected in order that the region of interest is still included in the radiation field.

It is important that high quality images are used to assess M3Ms since diagnostic yield is proportional to image quality. It is therefore unfortunate that positioning and processing errors are common in panoramic radiography.[5,6] The use of digital radiography eradicates conventional film processing errors.

The majority of new panoramic installations are now digital but this has not led to a significant reduction in radiation dose to the patient.[7] However, the change from conventional to digital radiography does not adversely affect the diagnostic utility of the image,[8–11] with one study showing that digital radiography is more precise than conventional radiography in the preoperative evaluation of M3Ms.[12]

Alternative views to the panoramic radiograph include oblique lateral and periapical views. Unfortunately, there is little evidence to support periapical radiographs in the routine assessment of M3Ms, even though they have better resolution than extraoral views. Periapical image receptors may be difficult and uncomfortable to position in the M3M region, and there is a high risk of missing part of the tooth on the radiograph.[13]

Panoramic radiography provides useful information on:

- M3M: crown and root morphology, angulation of impaction, depth of impaction and any associated disease such as caries or cystic change
- M2M: caries, periodontal condition and root morphology
- Surrounding bone: density of bone and the vertical height of the mandible
- Adjacent structures: proximity of M3M to adjacent structures such as the inferior alveolar nerve (IAN) canal and its branches (retromolar canals) and in the case of maxillary molars, the maxillary sinus

One of the complications of M3M extraction is damage to the IAN. There are seven main radiographic signs associated with IAN injury: darkening of the root, deflected roots, narrowing of the root, dark and bifid root, interruption of the white line of the IAN canal, diversion of the IAN canal and narrowing of the IAN canal.[14] Of these, the three most significant radiological signs are diversion of the IAN canal, darkening of the root and interruption of the cortical white line.[14,15] Several other authors have reported similar radiographic risk factors.[16–18] A new radiographic sign that may also be associated with nerve injury is the juxta-apical area.[19] A recent meta-analysis of eight studies showed that the added value of panoramic radiography for determining the presence of diversion of the canal, loss of the cortical outline of the canal and darkening of the root was sufficient for ruling in the risk of postoperative IAN injury.[20]

Surgical difficulty of M3M removal can be assessed radiographically through seven factors: spatial relationship, depth of impaction, ramus relationship/space available, type of impaction, number of roots, shape of roots, shape of the root tips and relationship of the root to the IAN canal.[21] Although most studies support the use of panoramic radiography in the assessment of surgical difficulty,[22–24] there are a few studies showing that the indices used may not always be reliable in predicting the difficulty of the extraction.[25,26] Some studies have demonstrated that panoramic radiography is inaccurate in classifying M3M angulation.[27,28] One study has shown that panoramic radiographs can distort the true angulation of the M3M. However, the authors conceded that this finding does not invalidate it as the main tool for surgical planning of M3Ms.[29] Bell *et al* found panoramic radiography was poor when used to assess the root morphology of M3Ms.[30] They suggested this is because it is a tomographic projection with poor spatial resolution and the tooth may not necessarily lie centrally within the tomographic layer.

Panoramic radiography may also be used to assess the surgical difficulty of impacted maxillary third molars. Radiographic features associated with greater difficulty include an increased depth of impaction in relation to the cementoenamel junction of the maxillary second molar, root apices in contact with the maxillary sinus, contact with the root of the maxillary second molar and a high position for the application of the elevator tip.[31]

There is no convincing evidence to support the use of panoramic radiography in ‘screening’ unerupted M3Ms.

After a taking a history and performing a clinical examination, panoramic radiography is indicated for M3M assessment when surgical intervention is being considered. Routine 'screening' of unerupted M3Ms is not recommended.

Evidence grade: **B2**
Recommendation: **A (strong recommendation)**

Role of cone beam computed tomography (CBCT) and Medical computed tomography CT) in the management of M3Ms

Traditionally, if the roots of the M3M appear close to the IAN canal on panoramic radiography, periapical views taken at a different vertical angle may establish the relationship between the two structures, using the principal of parallax.[32] Alternatively, parallax radiography using periapical views, stereo-scanography and cross-sectional tomography have been used.[33–36] However, with the advent of CBCT, 3D imaging of the IAN canal is becoming increasingly popular.

Medical computed tomography (CT) has also been used to study the position of the IAN canal.[37,38] However, CBCT has several advantages over medical CT, including better spatial resolution and a lower effective dose.[39] The disadvantage is that the dose arising from CBCT, is still generally higher than for panoramic radiography. Factors affecting radiation dose arising from CBCT include the exposure factors, the volume size (often referred to as the field of view), the voxel size and the number of frames or projections obtained during the exposure. It therefore follows that if CBCT is carried out, the technique should be fully optimised in terms of dose reduction. Finance is another consideration as the cost of CBCT is much higher than for conventional imaging.[40,41]

What do CBCT and CT show?

As expected, CBCT and CT demonstrate the location of the IAN canal, the position and morphology of the M3M, and the morphology of the mandible.[42–44] They may also show anatomical features such as the retromolar canal and other branches of the inferior dental canal.[45–47]

Features on CT and CBCT associated with increased risk of sensory damage

Features associated with a increase in neurosensory damage include narrowing of the IAN canal, direct contact between the IAN canal and the root, fully formed roots, a lingual course of the IAN canal with or without cortical plate perforation and an intraroot course of the canal.[48] The strongest indicators are narrowing of the IAN canal and direct contact of the roots with the canal.[48] An earlier study demonstrated that direct contact of the roots and

the canal is an important factor in IAN injury.[49] The size of the cortical perforation in the IAN canal is also associated with increased neurosensory injury.[50] Two further studies have shown that a dumbbell shaped IAC is an important feature associated with IAN injury.[51,52]

With medical CT, loss of IAN canal integrity has a high sensitivity for predicting intraoperative IAN exposure during M3M removal[53] and is associated with an increased risk of postoperative paraesthesia.[54]

In a systematic review published by Guerrero *et al* in 2011, only two studies reported on the level of diagnostic accuracy efficacy using intraoperative neurovascular exposure as the reference method.[55] The first study (by Tantanapornkul *et al*) showed the sensitivity and specificity of CBCT in predicting IAN exposure to be 93% and 77%, while for panoramic radiography it was 70% and 63%.[56] The overall accuracy of CBCT and panoramic radiography was therefore 55% and 45% respectively. The second study (by Ghaeminia *et al*) revealed the sensitivity and specificity in predicting IAN exposure to be 96% and 23% for CBCT.[57] For panoramic radiography, the sensitivity and specificity was 100% and 3%, giving an overall accuracy of 80% for CBCT and 64% for panoramic radiography in predicting IAN exposure. Both of these studies demonstrated a high sensitivity using CBCT but Ghaeminia *et al* reported a much lower specificity. Therefore overall, the accuracy of CBCT was no better than that of panoramic radiography. This has been attributed to different case selection in the two studies[58] See also Sedentex CT guidance. [39]
One CBCT study stated that a lingual position of the canal and narrowing of the canal have been shown to be significant risk factors for temporary IAN injury.[58]

Effect of CBCT/CT on management and outcome

In an excellent review of imaging in M3M management, the authors state that any preoperative radiographic examination (including 3D imaging) should be carried out only when the result will influence the treatment decision or when the result may change the treatment outcome.[59]

In a controlled study carried out by Better *et al*, it was concluded that CBCT had very little effect on the final surgical ,s the treatment plan changed only once in 65 cases as a result of the CBCT findings.[60] In contrast, Ghaeminia *et al* showed that in high risk cases, CBCT significantly modified the surgical approach.[61] In another study investigating whether CBCT influenced the treatment plan compared with panoramic radiography combined with stereo-scanography, it was found that the treatment plan changed in 12% of cases following the CBCT.[62] The treatment plan was established by consensus between the radiologist and the two surgeons. It would be useful to repeat the study using more surgeons to see whether this change in the treatment plan is consistent with multiple observers.

CBCT findings have been used to help make the decision on whether coronectomy should be performed rather than surgical removal. Interruption of

the cortical outline and direct contact between the root and the IAN canal were the CBCT features proposed by Monaco *et al* for indication of a coronectomy.[63] Matzen *et al* used direct contact of the canal with the M3M roots combined with canal narrowing and a bending or groove in the root to make the decision to perform coronectomy rather than surgical removal.[62] However, a recent randomised controlled trial demonstrated that in high risk groups, CBCT did not change the resources used for surgery, postoperative treatment or patient complication management.[41]

If the decision to perform coronectomy can been made on panoramic radiography, then clearly there is no need for further CBCT. However, in a number of cases, where the IAN canal appears close to the root apices on panoramic radiography, CT/CBCT has in fact shown no direct contact.[64,65] The significance of this finding is that the preferred surgical option would be extraction rather than coronectomy in these cases. Another argument for requesting CBCT prior to planned coronectomy is that if the roots are mobilised during the procedure, they would then require removal.[66] Root mobilisation happens in 2.3–38.3% of cases.[67] Having 3D information to plan the removal of the roots in this scenario would be helpful.
It is clear that further research is necessary into the benefit of CBCT in these cases.

Some studies suggest that additional CBCT imaging helps reduce postoperative paraesthesia.[48,68] Hasegawa *et al* compared panoramic radiography and CT, and concluded that CT predicted IAN injury more accurately than the panoramic findings.[69] In a study carried out by Umar *et al*, all patients who were high risk for neurosensory damage had CBCT carried out and subsequently, there were no cases of permanent neurosensory deficit.[68] The authors proposed that this was partly due to the surgical planning that was carried out on the CBCT images. One weakness of the study was that there was no control group with which to compare.

CBCT has been broadly recommended when panoramic radiography has shown signs of a close relationship between the IAN canal and the roots of the M3M.[44,70–72] However, there is now increasing evidence that CBCT makes no difference to the outcome for the patient.

In one retrospective cohort study, medical CT did not significantly decrease the risk of producing IAN nerve injury following extraction but the authors did acknowledge that the small sample size in the study was a concern.[73] In a randomised controlled trial by Guerrero *et al*, CBCT was not superior to panoramic radiography in predicting postoperative IAN sensory disturbance or other postoperative morbidity such as infection haemorrhage or alveolar osteitis.[74] Similar findings were shown in another randomised controlled trial.[58] In a Finnish study, it was demonstrated that the increased availability of CBCT did not significantly alter the number of IAN injuries.[75] In two recent randomised controlled trials, the use of CBCT before removal of the M3M did not reduce the number of permanent neurosensory disturbances.[76,77] A recent meta-analysis of these studies concluded that the use of CBCT does not

reduce the risk of IAN injury and CBCT should not be used routinely before M3M surgery.[78]

From the evidence available, it would appear that CBCT provides the clinician with more detailed information that can help inform the patient regarding the risks of surgery. In some cases, it may have an effect on surgical choice but there is no evidence that there is ultimately a change in outcome. In addition, the costs associated with CBCT examination are higher than those for conventional imaging.

Conclusion

The current evidence suggests that CBCT has no effect on outcome. As the radiation dose and financial costs are higher than for conventional imaging, CBCT should not be used routinely in the radiographic assessment of M3Ms.

Evidence grade: **A (evidence based on meta-analysis)**
Recommendation: **A (strong recommendation)**

Where conventional imaging has shown a close relationship between the M3M and the IAN canal, CBCT may be considered in carefully selected cases where the findings are expected to alter management decisions.

Evidence grade: **B2**
Recommendation: **O (open recommendation)**

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Appendix 6: The risk of retaining M3Ms

Tara Renton and Geoff Chiu

In view of the the Montgomery ruling and patient choice, the patient must be made aware of the risks of non-intervention as well as of intervention. Supervised neglect has significant medicolegal implications for the dental profession, particularly with regard to periodontal disease and undiagnosed caries.

In terms of mandibular third molar (M3M) surgery, the important issues to be considered are:

- Is there a risk of harm to the patient if the M3Ms are left in situ?
- Is there evidence that will allow the clinician to present to the patient a valid option of early intervention before harm occurs?

The key question that must be raised is how to minimise patient harm related to M3M surgery. One option is leaving the M3M in situ and not putting the patient through the risks of surgery and recovery. However, the attendant risks of chronic recurrent or acute infections and possible distal M2M caries, must be understood by the patient.

What is the fate of M3Ms?

The longest longitudinal study reporting on the long-term follow-up of M3Ms was published by a Finnish group led by Professor Irja Ventä.[1,2] The study aimed to follow the clinical changes in M3M status during an 18-year period in 118 university sudents (37 men and 81 women). At baseline, the mean age was 20.2 years (standard deviation [SD]: 0.6 years), and at the end, it was 38.6 years (SD: 0.6 years).

In the Finnish study, panoramic radiographs were taken at baseline and at age 38 years.[1,2] Of the initially unerupted, partially erupted and erupted M3Ms, 10%, 33% and 50% respectively were erupted at age 38 years (maxilla and mandible together). At 38 years of age, only 31% of M3Ms remained. However, it must be mentioned that at the time of the study, there was no Finnish equivalent of the National Institute for Health and Care Excellence guidance for M3Ms. Only 28% of the study cohort had any symptoms. The remainder had their M3Ms removed on the recommendation of the dentist and/or on the student's own initiative. The study noted that a significant proportion of the M3Ms were removed at the age of 27 years and recognised that as the study cohort comprised students, they would have had access to Finnish dental care at a very low fee until the age of 27 years.

Kruger *et al* followed the eruption patterns of M3Ms over a four-year period.[3] A cohort of 821 patients with a total of 2,857 M3Ms were followed up from the age of 18 to 22 years. Of the 45% of the M3Ms that were deemed impacted at

age 18 years, 37% had subsequently erupted by the age of 22. Among the patients with M3Ms that were mesioangularly impacted at age 18 years, 39.3% of the maxillary teeth and 20.4% of the mandibular teeth had fully erupted by age 26 years whereas almost a third of each had been extracted. Of the distoangularly impacted M3Ms, 20.4% of the maxillary teeth and a third of the mandibular teeth had erupted by age 26 years, with 21.6% of the maxillary teeth and 31.6% of the mandibular teeth having been extracted. None of the horizontally impacted teeth found at 18 years erupted by age 22 years. In conclusion, based on impaction found radiographically at age 18 years, there is no indication for the prophylactic removal of M3Ms as the majority of them erupt.

The Cochrane review published in 2020[4] states that the available evidence was insufficient to tell us whether or not asymptomatic disease-free impacted wisdom teeth should be removed.

The included studies did not measure health-related quality of life, costs or side effects of taking teeth out. One study (the cohort study), which was at serious risk of bias, found that keeping asymptomatic disease-free impacted wisdom teeth in the mouth may increase the risk of gum infection (periodontitis) affecting the adjacent second molar in the long term, but this evidence was very uncertain. In the same study, the evidence was insufficient to draw any conclusions about the effect on the risk of caries in the adjacent second molar. The other study (the RCT) was also at high risk of bias. It measured crowding of the teeth in the mouth, and found that this may not be significantly affected by whether impacted wisdom teeth are kept in the mouth or removed.

Retaining certain M3Ms may cause harm

There is a strong consensus in the literature that mesioangularly and (to a lesser extent) horizontally impacted M3Ms are associated with distal caries on the mandibular second molar (M2M). Examples of such studies are given below.

Allen *et al* found the incidence of distal caries in the M2M with an adjacent M3M to be 19%.[5] Of these, 42% were associated with mesially angulated M3Ms. McArdle *et al* reported that among 288 patients who had distal caries on their M2Ms, 89% had M3Ms that were mesially angulated between 40 and 80 degrees.[6] The mean age at presentation was 32.1 years (range: 20–65 years). This study noted that in comparison with patients five years younger, the caries rate on the distal aspect of the M2M rose from 4% to about 30% in the older patient group, representing a 7.5-fold increase. Garaas *et al* also reported in 2012 that the M3M caries risk is associated with patient age, with older patients (age ≥25 years) having a 2.5-fold increased risk for caries compared with patients younger than 25 years.[7]

In a study by Fernandes *et al*, it was shown that distoangular, partially erupted M3Ms have a relatively higher association of pericoronitis (24.69%) compared with the other angulations (vertical 10.29%, mesial 5.48% and horizontal 3.34%).[8]

The 2012 report of an American Association of Oral and Maxillofacial Surgeons taskforce stated that 25–60% of asymptomatic patients (depending on their age and gender), had clinical evidence of periodontal inflammatory disease, as evidenced by periodontal probing depths of at least 4 mm.[9] The report also noted that depending on the duration of follow-up, 3–40% of patients with erupted M3Ms and healthy periodontal tissues will develop clinical signs of periodontal inflammatory disease.

The surgical morbidity of removing M3Ms increases with age

In 1992, it was reported that there is lower postoperative morbidity in younger patients.[10] A study of 4,004 patients published in 2007 showed that a patient having a M3M removed was 1.5 times more likely to experience a complication if they were over 25 years of age than a younger patient.[11] Similarly, in a 2003 study of 583 patients, age was correlated with risk.[12] Other studies also show that postoperative risks increase with increasing age.[13,14] Together with depth of impaction, unfavourable root formation and the experience of the surgeon, a consensus of the literature supports the concept that postoperative risks from M3M removal increases with age. These risks include infection, dry socket, increased pain and longer recovery time.

Conclusion

M3Ms frequently and unpredictably change position, eruption status and periodontal status. There is a risk of harm if a global non-intervention M3M strategy is used. This harm mainly relates to partially erupted mesially angulated and horizontally impacted M3Ms. The risk of harm associated with mesially impacted M3Ms is estimated to be as high as 30%, presenting at a mean age of 32 years. The risk of complications increases with the age of the patient above 25 years.

Recommendation

Patients with partially erupted mesioangular or horizontally positioned M3Ms, should be identified and notified of the risk of disease occurring. Management options must be provided along with their risks. If it is the patient's decision to retain the M3M, then close clinical review is required with radiographic investigation, when indicated. The patient must also be informed that delaying the removal of the M3M until they are older, increases the risk of postoperative complications.

Evidence grade: **B1**
Recommendation: **A (strong recommendation)**

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Appendix 7: Considerations in prescribing coronectomy

Tara Renton

Introduction

The incidence of mandibular third molar (M3M) impaction ranges from 36% to 59%. Full or partial retention may lead to pathology such as caries, pericoronitis, cyst formation or tumours.[1] M3M extractions are the most commonly performed procedures in the field of oral surgery.[2] M3M is a challenging surgical procedure because of the close proximity to anatomical structures such as the inferior alveolar nerve (IAN) and the lingual nerve. IAN injury is avoidable and should be prevented where possible as trigeminal sensory neuropathies result in long-term chronic pain and disability for 70% of patients.[3]

Risk assessment

When assessing patients before M3M extraction, a thorough clinical examination should be performed, including radiological examination. Normally, a panoramic radiograph is sufficient to show the M3M and the relationship to the IAN. However, if cone beam computed tomography (CBCT) is required, the smallest field of view compatible with the clinical need should be selected to keep the radiation dose as low as possible. Plain film radiographic signs on panoramic radiographs indicative of possible IAN risk injury include:

- diversion of the canal
- darkening of the root
- interruption of the cortical white line

When patients are identified as having 'high risk' M3Ms, CBCT may be required to determine the proximity of the root and the IAN in all three dimensions.[5] This allows the surgeon to further scrutinise the need for modified surgery or intentional coronectomy.[6] The use of CBCT for high risk M3Ms may also be associated with reduced morbidity to the IAN.[5,7] However, a recent randomised controlled trial showed that the use of CBCT before removal of M3Ms does not reduce the number of neurosensory disturbances.[8] Thus, the benefit of CBCT in planning for coronectomy has a limited evidence base.

In a study of 50 high risk cases, M3Ms were assessed by means of panoramic radiographs and then compared with CBCT scans.[7] The 78% of teeth showing darkening of roots in the panoramic radiograph revealed loss of cortication on CBCT in 68% of cases, leading to increased risk on extraction of the M3M. Two-thirds (66%) of cases displayed thinning or loss of the lingual cortical plate, a third (33%) of which were related to the inferior dental canal and just under a third (30%) to the tooth itself. In another study, the authors claimed that owing to the high variability of the anatomical relationship

in high risk teeth, CBCT should be performed for thorough case planning.[5] Furthermore, when using CBCT, unnecessary coronectomies may be avoided since up to 30% of high risk teeth as seen on plain film radiography are found to be distant from the inferior dental canal on CBCT and should therefore be extracted in their entirety.[5]

Indications for coronectomy

Key criteria for coronectomy include:

- high risk of IAN injury
- vital M3M (or other tooth at high risk of nerve injury)
- healthy non-immunocompromised patient
- access to care for (and understanding of) related coronectomy risks

If local aggressive pathology dictates total removal of a tooth, then coronectomy may not be appropriate.
Coronectomy should only be undertaken to prevent IAN injury when there is a need for extraction. 2% of cases will experience permanent nerve injury on removal and ideally, the imaging investigations should be specific and sensitive enough to identify this 2%. Explicit criteria for requesting CBCT based on risk assessment of the panoramic radiograph are not yet available. Nor are there explicit criteria for recommending coronectomy based on CBCT findings.

In one systematic review, the authors stated that coronectomy could be used in clinical practice for M3M extractions, with a high risk of nerve injury.[10] The risks of failed coronectomy could be reduced by improving surgical procedures and by monitoring radiographic risk factors. A second systematic review reported that coronectomy is indicated when the M3M is in contact with the IAN and complete removal of the tooth may cause nerve damage.[11]

Possible complications of coronectomy

The patient must understand the potential risk of their chosen intervention. Potential complications of coronectomy include:

- mobilisation of the roots intraoperatively[12]
- early recurrent dry socket and need for early removal of roots following coronectomy[13]
- late eruption and possible infection of retained roots[14]
- injury to the lingual nerve and IAN (These have been reported after failed coronectomies.)

Therefore, coronectomy should be undertaken when all possible information is available to prevent unnecessary complications.

Efficacy of coronectomy reducing IAN injury related to M3M surgery

Two randomised controlled trials and a review reported a lower incidence of IAN injuries using coronectomy than for complete extraction of the high risk M3M.[10,12,15] Furthermore, two prospective cohort studies (one case controlled study and one retrospective study) also confirmed reduced incidence of IAN injury related to coronectomy procedures.[16–18] In all of these studies, a clear benefit was found regarding IAN injuries for high risk M3Ms. In the two randomised controlled trials, the incidence of IAN injuries ranged from 0% to 0.65% for coronectomy and from 5.1% to 19% in the control group, where teeth were extracted conventionally.[12] The only patient who suffered from IAN injury in the coronectomy group recovered within 12 months, whereas 33.3% of the patients who had complete tooth extraction had permanent IAN injury from which they had not recovered after a 12-month period.

Coronectomy is an accepted method for management of high risk teeth[19] and is effective in minimising IAN injury in teeth intimately related to the inferior dental canal.[10,11,20]

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Appendix 8: Quality indicators for M3M surgery

Tara Renton

Quality of care is defined by three pillars: efficacy, patient safety and patient experience; these are outlined in more detail below. It is the intention of this document to recommend routine outcome measures, patient safety assessment and quality indicators for mandibular third molar (M3M) surgery. These would apply to all M3M procedures undertaken in any healthcare setting. With the introduction of the Getting It Right First Time programme being applied to secondary care dentistry in 2017, the application of the appropriate diagnostic, interventional and outcome coding for routine dental extractions will become part of routine practice in the future. Until all healthcare workers are encouraged to use consistent diagnostic, interventional and outcome coded data, learning from the high volume National Health Service (NHS) activity will remain limited.

NHS England's Guide for Commissioning Oral Surgery and Oral Medicine (2015) recommended using patient reported outcome measures (PROMs) and patient reported experience measures (PREMs) for the assessment of quality of care. These were trialled by the British Association of Oral Surgeons, resulting in recommendations specifically for PROMs and PREMs relating to dental extractions. [1]

Quality outcomes in M3M surgery are addressed under the subtitles:

- Efficacy
- Patient experience
- Patient safety

Efficacy

Measuring efficacy is impossible while there remains a lack of clarity with current clinical coding (diagnostic, treatment and outcome), which varies between different healthcare settings. This must be the same for all healthcare procedures, no matter what the setting, in order to enable quality assessment of care and clinical audit. In addition, there is no appropriate coding for the following:

Infection:
Acute or chronic pericoronitis (only chronic periodontal disease)
Local spreading infection

Caries:
High risk of development of caries/damage in adjacent tooth
No ability to differentiate whether caries is in M3M or M2M

Adjunctive treatment:

There are no treatment codes for local anaesthesia, sedation, general anaesthesia, or additional operative therapy or medication.

Treatment:
There is no treatment code for coronectomy (**Appendix 7**).

Oral surgery quality assurance minimum standard data collection and reporting

Standard data collection and reporting should reflect the main objectives of the implementation of the quality framework for dentistry (Dental Quality and Outcomes Framework, 2011) and national commissioning (ie the implementation of patient pathways that include consistent commissioning and maintain high quality care).

Clinical effectiveness Should be based on clinical codes	Specific guide should include: • OPCS diagnosis codes • ICD-10 treatment codes • ICD-10 outcomes codes • reported patient safety events in order to measure quality and effectiveness
NICE Quality and Outcomes Framework Indicator	https://www.nice.org.uk/standards-and-indicators/qofindicators/

Patient experience

PREMs and PROMs as recommended by NHS England's Guide for Commissioning Oral Surgery and Oral Medicine (2015) are detailed in the tables below:

Friends and family test	
Question 1: Would you recommend this service to your friends and family	Yes / No

Modified PREMs	
Question 2: Did the clinical team (clinician) speak to you in in terms that you can understand?	Scale 0–10 (0 = absolutely dissatisfied, 10 = extremely satisfied)
Question 3:	Scale 0–10

Did you receive information that you can understand before the operation?	(0 = absolutely dissatisfied, 10 = extremely satisfied)
Question 4: Was your pain managed well during the procedure?	Scale 0–10 (0 = absolutely dissatisfied, 10 = extremely satisfied)
Question 5: Was your anxiety managed well during the procedure?	Scale 0–10 (0 = absolutely dissatisfied, 10 = extremely satisfied)
Question 6: Did you receive information you can understand for care after the operation?	Scale 0–10 (0 = absolutely dissatisfied, 10 = extremely satisfied)

Modified PROMs		
Question 7: Did you need to seek advice or assistance hours/days after the procedure?	Yes / No / Unsure	List for data recorder (not shared with the patient unless clarification or prompts needed) Interested in: • uncontrolled bleeding (? %) • inadequate pain relief that needed further medication (dry socket? 5%) • infection that needed further treatment (? %) • damage to other teeth/fillings (? %) • nerve injury altered sensation (1%) • temporomandibular disorder? Include ICD-10 codes
Question 8: Have you had to have additional surgery subsequent to this treatment?	Yes / No / Unsure	If yes, what is the problem? • Fractured jaw • Unintentional root retention • Bone infection • Nerve injury (1%)

		Include ICD-10 codes
Question 9: Time taken to achieve restoration of normal activities or appearance		Days Weeks Months

Patient safety

Reporting patient safety incidents is part of the cycle of recognising and learning from adverse events. Near misses are the key to improving patient care and for every 300 no-harm near miss events there will be a serious event. Underpinning this learning culture there has to be a supportive no-blame culture to allow for openness, collegiate working and support, and that is yet to reach primary care dentistry. Curently, there is no single simple mechanism for reporting these events in dentistry which is similar to the sophisticated systems available for use in secondary care and within medical primary care practice.

Patient safety can be enhanced by minimising wrong site surgery in relation to M3M surgery and by recently recommended local safety standards for invasive procedures. Other notifiable events relating to dentistry will also provide an indication of patient safety (**see Appendix 8).**

Quality outcome

Details of all notifiable events related to dental practice

1. Duty of candour applies to obligatory reporting of all notifiable events.

Dental teams confront a complex array of notifiable events in practice and minimal guidance and variable support may be available. A recent paper by Renton and Master highlighted the complexity of patient safety reporting systems in UK Dentistry. [2]
NHS Guidance on reporting serious incidents is provided in the following links:
How to report serious incidents:
https://improvement.nhs.uk/resources/report-patient-safety-incident/

2. **Serious Incident Framework (2018**) (which has replaced the National Framework for Reporting and Learning from Serious Incidents Requiring Investigation (2010). Never events are a subset of serious incidents. For dentistry, they include:

- wrong site surgery (permanent dentition under any anaesthetic)
- wrong implant
- retained foreign object
- wrong site surgery of deciduous teeth under general anaesthetic
- overdose of extra strength midazolam

https://improvement.nhs.uk/resources/never-events-policy-and-framework/ -h2-revised-never-events-policy-and-framework-and-never-events-list-2018)

3. NatSSIPS and LocSSIPs

National Safety Standards for Invasive Procedures (NatSSIPs) advised local implementation, with development of Local Safety Standards for Invasive Procedures (LocSSIPs). A LocSSIPs Toolkit for dental extraction ha been developed.

4. Commissioning for Quality and Innovation (CQUIN)

NHS trusts report quarterly on:

- number (%) of emergency readmissions within 30 days of discharge from hospital
- number (%) requiring revision of procedure
- number of days spent in hospital
- associated medical complications (eg deep vein thrombosis, pulmonary embolism)
- number (%) with hospital acquired infections (eg MRSA)
- time taken to achieve restoration of function (included in PROMs)
- extent of return to function (included in PROMs)

5. Care Quality Commission (Registration) Regulations 2009

Regulations 15, 16, 17, 18, 20 and 21 make requirements that the details of certain incidents, events and changes that affect a service or the people using it, are notified to the Care Quality Commission (CQC)
The CQC collates data on reported serious events and governance as well as PROMs and PREMs. The events listed below must be reported to the CQC within 21 days by the provider or registered manager:

- Abuse or allegations of abuse
- Serious injuries (physical or psychological damage to service user >28 days)
- Applications to deprive a person of their liberty
- Events that prevent or threaten to prevent the registered person from carrying on an activity safely and to an appropriate standard
- Deaths of service users
- Incidents reported to or investigated by the police
- Unauthorised absence of a service user detained or liable to be detained under the Mental Health Act

6. Medication and Healthcare products Regulatory Agency

- Report adverse drug reactions using the Yellow Card Scheme. (For any drug related serious incident, see below.)
  http://www.mhra.gov.uk/Safetyinformation/Reportingsafetyproblems/
- Medical history checked
- Appropriate drug prescription

7. **Data Protection Act 1998:** In all cases when reporting Patient Safety Incidents (PSIs), providers must comply with locally agreed and documented Caldicott data protection and information governance requirements.

8. **Control of Substances Hazardous to Health Regulations 2002 (COSHH 2002)**

9. **Human Rights Act 1998 and Equality Act 2010**

10. **Mental Capacity Act 2005 and Mental Health Act 2007** monitoring duties as well as our responsibilities under the Health and Social Care Act 2008

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13. **Sharps regulations, 2013: HTM 07-01 (healthcare waste)**

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Appendix 9: Restorative considerations

Karun Dewan and Karl Bishop

Mandibular third molars (M3Ms) generally erupt into the mouth between the ages of 17 and 24 years. [1,2] Comparing other teeth in adult dentition, M3Ms often fail to erupt or only partially erupt. [2] Impaction can be defined as where complete eruption into a normal functional position is prevented.

Partial eruption occurs when the tooth is visible in the dental arch of the lower jaw but has not erupted into a normal functional position.[3] An impacted M3M is called trouble free or asymptomatic if the patient does not experience signs or symptoms of pain or discomfort associated with it. [4,5]

Removal of M3Ms is one of the most common surgical procedures performed in the UK. In the past, the removal of impacted M3Ms causing pathological changes was accompanied by prophylactic removal of pathology free impacted M3Ms. [6] This is contrary to the National Institute for Health and Care Excellence guidance published in 2000, which indicated that the practice of prophylactic removal of pathology free impacted M3Ms should be discontinued. [7]

Wide variations in the rates of removal of M3Ms suggest that in the past, up to 44% of M3M removals and prophylactic surgery may have been inappropriate. [7] However, there is value in the removal of impacted M3Ms when they are associated with pathological changes. [3,7,8]

A) Restorative considerations and indications (diagnoses) for removal of M3Ms

1. Unrestorable caries in the M3M[3,7-13]

The M3M is deemed unrestorable if restorative treatment is unable to bring the tooth back into functional use, or to re-establish its contour so that it can be restored to the former, original or normal condition. If it is difficult to restore a carious impacted M3M, then this tooth should be extracted unless there is a very high risk of complications associated with the removal of that tooth. [14,15]

Evidence grade: B2

Recommendation: A (strong recommendation)

2. Caries in the adjacent M2M, which cannot satisfactorily be treated without the removal of the M3M [7,9,11]

The M2M is deemed unrestorable if the presence of the M3M restricts access and prevents adequate restoration of the adjacent M2M and it is therefore, not possible to bring back the tooth into functional use, or to re-establish its

contour in order to restore it to the original or normal condition. In a review of 1,001 patients aged 13–75 years who's M3Ms were removed, van der Linden et al reported caries in 7.1% of impacted M3Ms and in 42.7% of adjacent molars.[16]

Evidence grade: B2

Recommendation: B (recommendation)

3. **Untreatable pulpal and/or periapical pathology** [3,7-9,17]

Removal of any symptomatic M3M should be considered, particularly where there is untreatable pulpal/periapical pathology.

There are reasons for removal of M3Ms where there is pathology in and around the M3M. It is considered good practice and reasonable to assume that recurrent acute attacks of infection associated with M3Ms necessitate the early removal of the affected teeth. [18-20] There is some evidence to suggest that a decision should be made to remove M3Ms where there is a likelihood of infection.

There is no evidence to show that it is in the patient's best interests to wait until infection arises. [14,21,22]

The results of a retrospective study looking into the indications for removal of impacted M3Ms showed that out of 439 patients who had their M3Ms removed, pulpitis/caries of the third/second molar (31%) was the second most common reason after recurrent pericoronitis. [23]

Evidence grade: B2

Recommendation: A (strong recommendation)

4. **Internal/external resorption of M3M or adjacent teeth** [3,7-10,12,24-27]

Removal of the M3M should be considered where it appears to be causing external resorption of the M3M or of the M2M.

Studies which reviewed the indications for surgical removal of M3Ms, showed a prevalence range of 2–5% of resorption affecting the M3M teeth as the reason for removal. [18,28,29] Another study reported root resorption of the adjacent molar as an indication in 4.7% of cases out of 2,630 extracted impacted M3Ms. [30] External resorption of the M3M or of the M2M is relatively rare. [9] Root resorption occurs principally in the 21–30-year-old age group. The incidence is remote after the age of 30 years. [26]

A study has suggested that cone beam computed tomography (CBCT) is indicated for the diagnosis of external root resorption in M2Ms when direct contact between these teeth and M3Ms has been observed on panoramic radiography, particularly in mesioangular or horizontal impactions. [31]

Furthermore, considering the propensity of these teeth to cause external root resorption in second molars, M3M prophylactic extraction could be indicated. The study found that a significantly greater number of cases of external root resorption were diagnosed from CBCT (22.88%) than from panoramic radiography (5.31%).

Evidence grade: B2

Recommendation: A (strong recommendation)

5. **Fracture of M3M** [3,7,8,17,32]

The presence of a fracture in the M3M increases the risk of pulpal and periapical infection, particularly when that tooth has been rendered non-vital.

Evidence grade: C

Recommendation: A (strong recommendation)

6. **Facilitation of restorative treatment on M2M** [3]

Extraction of M3Ms is recommended if they are causing food impaction and/or difficulty in accessing the M2Ms for the purpose of restoration.

Occurrence of distal caries in M2Ms has been associated with impacted M3Ms, particulary mesioangular impactions. [32] Partially impacted mesioangular M3Ms showed a high incidence (27.4%) of caries or periodontal bone loss of the adjacent second molar. [33]

Evidence grade: B2

Recommendation: O (open recommendation)

B) Restorative considerations and indications (diagnoses) for retention of M3Ms

1. **Asymptomatic non-functional M3M**

In the absence of any pathology associated with a non-functional erupted or partially erupted M3M, there is no evidence in the literature for its removal.

With no opposing M3Ms, there is a potential for the maxillary molar to overerupt and cause occlusal interference. A study on occlusal changes following posterior tooth loss in adults shows positional changes, which may alter arch forms and occlusal planes. [34]

Evidence grade: B1

Recommendation: B (recommendation)

2. Poorly prognostic M2M

If the M2M is deemed to have poor long-term prognosis of retention, it would be beneficial to retain the M3M to avoid mandibular free end saddle distal extension scenarios for prosthetic stability and support for potential fixed or removable prostheses. Erupted M3Ms that can be maintained in a state of health may be retained as potential abutment teeth or for the maintenance of vertical dimension. [8]

Evidence grade: C

Recommendation: A (strong recommendation)

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