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Preface
Contemporary Management of Third Molars

Louis K. Rafetto, DMD, PA
Guest Editor

More than 90% of the world's population develops third molars. Particularly in the western world, more people are maintaining their dentition in good health, and with the assistance of orthodontic treatment, good tooth alignment. This leaves limited room for the eruption of their wisdom teeth. As a result, one of the most common decisions faced by oral and maxillofacial surgeons is how to best manage these patients.

Through training and experience, our specialty is uniquely qualified to be the experts in the management of patients with third molars. Unfortunately, we live in an era when less qualified individuals and groups seek to assume the role of "experts" and policymakers when it comes to third molar decision-making. Whether less qualified health care providers, third-party policymakers, government officials, "patient advocates," or members of the media, these individuals and groups present a potential threat to the health and well-being of many of our patients. As a specialty, we must never give up our role as the experts in third molar science, clinical decision-making, and patient management.

This issue of the *Atlas of the Oral and Maxillofacial Surgery Clinics of North America* is intended to promote an organized approach to the application of third molar science to the management of these patients. Fortunately, the past decade has moved us closer to better answering important questions about third molars and elevated the science of third molars in important ways. Consequently, we are certain or reasonably certain about many things concerning their behavior and the risks, benefits, and consequences of both retention and removal. I am pleased to have the opportunity to work with the articles' writers, all of whom bring great experience and expertise to the author's pen. As a result of their efforts, we have been able to put together a valuable resource for practitioners.

In organizing this volume, I attempted to include reviews of clinically relevant topics important to contemporary practice. Articles include a discussion of controversies surrounding the management of third molars, an overview of the factors that make third molars different from other teeth and why these differences have important clinical implications, a review of how to properly evaluate using a science-based approach, an article on decision-making that emphasized an organized approach, a look at the impact (pathology) associated with the retention of third molars, a summary of technical considerations in the surgical management of third molars, a discussion of strategies to minimize morbidity and improve recovery, and a look at complications as they may be associated with third molar surgery. I believe the information conveyed by the authors on these topics will make a difference in how surgeons approach third molars and their management.

In closing, I would like to thank my parents, who emphasized to me the value of trying to do things the right way; my colleagues, who have encouraged me along my professional journey; my Thursday

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morning men's group, who have modeled the pursuit of truth and meaning; and most of all, my daughter, Ali, my son, Austin, and my wife, Christine, who have supported my involvement with organized oral and maxillofacial surgery and inspired me to be better than I otherwise would be.

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The Nature of Third Molars: Are Third Molars Different than Other Teeth?

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Although third molars have similarities with other teeth in the dental arch, in particular molars, they are significantly different in many important ways. They have less functionality than other teeth, are less likely to erupt and contribute to the mastication of food, and have a greater frequency and severity of disease compared with other teeth in the dental arch.

Wisdom teeth are named, *third molars*, because they are the third molar to develop distally in the dental arch sequentially and are the third molar in each of the 4 dental quadrants to erupt. Some languages use alternative terms for third molars. Terms for third molars from various languages include

- English—wisdom tooth, from the theory that these teeth generally erupt in late teen years and early 20s; may refer to the concept that complete cognitive development of the human brain does not occur until approximately the same age
- Turkish—yas disi (twentieth-year tooth) refers to the age at which wisdom teeth appear
- Korean—Sa-rang-nee (love teeth), referring to the young age and the pain of first love
- Japanese—Oyashirazu (literally, unknown to parents), from the idea that they erupt in young adults after they have moved away
- Indonesian—gigi bungsu, for the last teeth to appear, referring to bungsu (youngest child) because these teeth erupt so much later than others, implying that the third molars are "younger" than the rest
- Thai—fan-khut (huddling tooth) due to the shortage of space for eruption
- Spanish—muelas del jucio (literally, judgment molars), referring to the pain they cause as they develop
- Dutch—verstandskies, a literal translation to English is wisdom tooth, but verstands can also mean standing far away, meaning the teeth furthest away from the mouth opening

These terms verify the special nature of the third molar, recognized in many diverse world cultures and languages for pain associated with eruption and presence, age at which these teeth erupt into the dental arch (young adulthood), and the generally insufficient space in the dental arch for the eruption of this tooth.

Similarities of the third molars to other teeth in the dental arch

- Have both a crown and a root, with the anatomy and size of crown of similar size to first and second molars
- Are multirooted teeth
- Mandibular third molars generally have 2 roots and maxillary third molars generally 3 roots, similar to first and second molars
- Composed of enamel, dentin, and cementum and are morphologically most similar to the first and second molars

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- Receive their vascular supply and enervation through the apical foramen of the roots to the dental pulp
- Attached to the alveolar bone of either the maxilla or mandible via the periodontal ligament
- Subject to the same disease processes that can affect other teeth, including periodontal disease and dental caries

Number and location

- Usually 4 in number, 2 on the left and 2 on the right side of the head
- On each side, 1 in the maxilla and 2 in the mandible
- Are the most posterior teeth in the dental arch for the quadrant in which they are located
- Generally follow the rule of the bilaterality of the human anatomy in that there is little if any difference between bilateral structures or organs, such as the left and right kidneys, eyes, maxillary sinus, or appendages
- Third molars in the maxilla are more similar to the maxillary first and second molars than mandibular molars
- Third molars in the mandible are more similar to the mandibular first and second molars than they are to maxillary third molars

Differences of third molars compared with other teeth

There are several significant differences of third molars compared with other teeth in the dental arch. It is these differences that dictate that third molars not considered the "same" as other teeth with respect to their expected behavior. Listed are some of these important differences.

Anatomic location

- As the most distal teeth in the dental arch, third molars are the only teeth that have no dental contact on its distal surface.
- If a third molar is not present, either because it has been removed or did not develop or erupt, the second molar does not have distal contact.
- Third molars are the last teeth in the dental arch to erupt. Secondary teeth begin eruption at approximately age 6, with central incisors generally erupting first and the first molars erupting soon after. Once the eruption sequence of the secondary teeth begins, it occurs continuously until eruption of permanent canines or premolars over a period of approximately 8 years, with some variability, terminating at approximately 14 years of age.
- There is generally a hiatus of tooth eruption after the permanent premolars and canines erupt, for a period of a few to several years until the third molars erupt if there is adequate space and no obstruction in the path of eruption distal to the second molars.
- It is generally accepted that if a third molar has the potential to actively erupt, it does so by age 25.
- Some third molars are prevented from becoming fully erupted because of impaction, which delineates a physical obstruction to the mobility of the tooth to erupt into dental occlusion or the crown to erupt to the occlusal plane.
- The first, second, and third molars erupt without a primary tooth precursor in its place.
- Third molars are the last teeth in the dental arch to erupt chronologically. The dental arch space is generally consumed by all other permanent teeth erupting before the eruption of the third molars. The remaining arch space after all other teeth erupt is often less than the dimensions necessary for third molar eruption.
- The resultant lack of space results in malposed third molars, impacted third molars, or partially erupted third molars.
- Third molars may passively erupt over a lifetime because periodontal disease results in tissue degeneration approximating the coronal aspect of the third molar, allowing the crown to be exposed to the oral environment. The localized tissue degeneration may be due to generalized periodontal disease or specific periodontal disease on the distal aspect of the adjacent second molar.

Differences between maxillary and mandibular third molars

- Because of the special anatomic variations associated with maxillary and mandibular third molars, there are unique situations and challenges associated with their extraction or surgical removal.
- The maxillary third molar is the most distal tooth in the arch and anatomically approximates the floor and posterior wall of the maxillary sinus.
  - There is specific surgical challenge with removal of maxillary third molars due to the proximity to the infratemporal fossa.
  - In some cases, the coronoid process of the mandible presents an obstruction that makes surgical removal or extraction difficult.
- Mandibular third molars are the most posterior teeth in the mandibular dental arch.
  - The roots of the mandibular third molars many times approximate the inferior alveolar nerve, being closer to the nerve than any other mandibular tooth.
  - Mandibular third molars are also closer to the lingual nerve than any other tooth.
  - Removal may be challenged by the position of the tooth in relation to the ascending anterior aspect of the ramus of the mandible.
  - The mandibular third molar is situated posterior to the attachment of the mylohyoid muscle to the mandible, forming the floor of the mouth.
  - The lingual cortical plate of the mandible near the apices of the mandibular third molar teeth may be thin.
  - In most cases, there is less vertical dimension of bone between root apices of the mandibular third molar and the inferior border of the mandible and the mandibular angle.

Frequency of Agenesis

- The maxillary and mandibular third molars are the most frequent to not develop compared with all other teeth in the human dentition.
- Clinical absence requires radiographic or alternative imaging examination.

Failure to Erupt

- Maxillary and mandibular third molars have the highest frequency of failure to erupt (if present).
- Maxillary and mandibular third molars are also the most frequent teeth to fail to fully erupt into function.

Challenges with disease-free maintenance

- Maintenance of the oral health of third molars is more challenging than that of any other teeth.
- Because of their location, third molars are the least visible and least accessible with oral hygiene measures.
- Periodontal pocketing is frequent around third molars because of hygiene challenges.
- Incidence of caries is greater in third molars because of dental hygiene challenges.
- Also because of location, the third molars are difficult to restore if caries or periodontal disease occurs. If the third molars become carious, serious consideration should be given to extraction versus restoration.
- Because, in general, the third molars are nonfunctional, extraction or removal may be more cost effective and allow a healthier oral environment than restoration or maintenance of periodontal health.

Disease and third molars

There is an increased risk over time that disease around third molars will progress and indicate the need for treatment, which is many times more comprehensive, emergent, and expensive than extraction or surgical removal.

Frequency and Severity of Symptomatic Infection

- Eruption of permanent teeth in the adult dentition occurs due to mobility of the tooth toward the occlusal plane associated with development of apical portion of the root structure.

- As the third molars erupt, the remaining tooth follicle surrounding the crown becomes exposed to the oral cavity and transforms into reduced enamel epithelium.
- Exposure of the enamel to the oral cavity allows the tissue surrounding the crown of the third molar to be exposed to the microflora of the oral cavity.
- Percolation of bacteria between the gingival tissues surrounding the third molar contributes to subclinical inflammation and potential infection, which sometimes progresses to symptomatic pericoronitis (inflammation and infection around the crown of the submerged third molar).
- Because the third molars are slow to erupt and may not erupt completely, pericoronitis may resolve and recur.
- If left untreated, the adjacent second molar may be subject to dental caries, which are difficult if not impossible to restore if occurring on the distal aspect of the second molar.
- In addition, recurrent inflammation and infection may lead to periodontal tissue loss on the distal aspect of the adjacent and preceding second molar, putting that tooth at risk for instability, mobility and eventual loss.
- Pericoronitis is more common in the mandibular dental arch compared with the maxillary dental arch.
- Recurring or sustained infection in this area may lead to bacterial migration to adjacent fascial spaces and ultimately to fascial cellulitis and fasical space infection. Although infections associated with diseased first and second molars may compromise health and well-being, the third molars are the teeth most often involved in serious and life-threatening fascial space infections.
- Pericoronitis can recur repeatedly, resulting in need for additional care beyond the initial episode and result in days of disability due to the disease process.

Asymptomaticity of Third Molars

Indolent, insidious periodontal disease, caries, and a polymicrobial environment often with subclinical inflammation frequently exist around third molars. Like other diseases, disease around third molars can progress without major symptoms of inflammation (pain, swelling, heat, and redness).

The concept of waiting for symptoms of pain to occur before evaluating and treating disease around third molars allows disease progression, potential adjacent tooth loss, and significant and life-threatening infection to occur. In addition, chronic subclinical infection and inflammation may have overall adverse effects on systemic health without any symptoms. If unerupted or partially erupted, nonfunctional third molars remain in the oral cavity, there is a significant need for regular observation and surveillance because the prospect for disease is greater than the prospect for acceptable dental and oral health.

Summary

Although third molars have similarities with other teeth in the dental arch, in particular molar teeth, in many ways they are significantly different. They have less functionality than other teeth and are less likely to erupt and become contributory to the mastication of food but have a greater frequency and severity of disease compared with other teeth in the dental arch.

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Evaluation of Third Molars: Clinical Examination and Imaging Techniques

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Third molars are thought to have once been a necessity for early human ancestors in order to efficiently chew and digest the cellulose that comprised the plant foliage, which was an integral part of the dietary intake. Due to evolutionary changes and societal advancements, human diets are less plant based, jaw size has become smaller, and the functional need for third molars minimal [1]. Third molars, or wisdom teeth, however, are still present in the majority of people and often require removal to prevent or treat third molar–associated disease states. Critical to the determination of third molar management is the clinical examination and radiographic analysis.

Clinical evaluation

History

A complete history should be obtained before the physical examination, starting with a patient's chief complaint and history of present illness, which guide the examination and ultimately the treatment. Furthermore, this step triages patients, differentiating elective from more urgent patients, such as one with an odontogenic abscess. For instance, does the patient have pain, drainage, or swelling or was the patient referred due to concerns of an orthodontist about third molar–associated anterior dentition crowding? As with any surgical patient, a patient's past medical history, past surgical history, medications, allergies, and social history should be thoroughly obtained. A past anesthesia history should be discussed as well. Significant comorbidities, anticoagulation, specific medication allergies, and severe dental phobia may alter the treatment algorithm and is critical to patient safety and care.

Physical Examination

General

A thorough head and neck examination should be completed as part of the third molar evaluation. The temporomandibular joints should be assessed to evaluate for any pretreatment findings of temporomandibular disorders, such as clicking, popping, crepitus, laxity, and tenderness to palpation. Such information is of significant importance so as to take the necessary precautions if surgery is planned and to document pre-existing conditions and avoid attributing any temporomandibular disorders to the surgical removal of the third molars. Next, the examination should evaluate for signs of infection, such as edema, erythema, and asymmetry, and the neck should undergo palpation to assess for lymphadenopathy. Intraoral examination should include a global inspection of the oral cavity and well as a focal examination of the third molar areas. Furthermore, a directed anesthesia evaluation should address items, such as the Mallampati classification, neck range of motion, and thyromental distance.

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Third molar specific

Clinical examination of the third molar areas should first assess for whether the third molars are visible in the oral cavity and whether the teeth are impacted or simply not present, because third molar agenesis occurs in up to 20% of patients [2]. Once confirmed present and if not completely impacted, the examination should assess for potential disease states as well as difficulty of access and surgical removal of the third molar teeth.

Examination findings to note as related to third molars:

- Periodontal disease
- Dental caries
- Pericoronitis
- Second molar or adjacent tooth resorption
- First or second molar caries as a predictor for development of third molar caries [3]
- Associated cysts or tumor growth
- Crowding of anterior dentition
- Presence of an oral prosthesis

Findings to note as related to surgical access and third molar surgery:

- Body mass index
- Trismus
- Cheek laxity
- Macroglossia

Radiographic analysis

The management of third molars consists of radiographic evaluation of dentofacial structures and the third molars in particular. Imaging is particularly important because it augments the evaluation by providing further information as to the size, shape, and position of the teeth and their relationship to the surrounding structures. Furthermore, the presence of associated pathology, which has been reported to occur in up to 10% of patients, may be determined [4]. Also, technical considerations regarding the surgical removal may be addressed. Specifically, the relationship of the mandibular third molars to the inferior alveolar canal and the maxillary third molars to the maxillary sinus may be appreciated, providing teaching points for the patient and risk stratification regarding postoperative issues, such as nerve injury, jaw fracture, or oral-antral communications. In cases of impaction, which has been reported to occur in more than 50% of patients, imaging may be the only means to evaluate these teeth [5].

As for the imaging modality itself, some debate has developed over the use of CT versus the orthopantogram, which has been the standard imaging technique for evaluating third molars. The primary impetus behind the use of imaging other than the orthopantomogram is an effort to decrease the frequency of inferior alveolar nerve injury after third molar removal. Specifically, nerve injury associated with third molar extraction has been reported to occur in up to 7% percent of patients [6] and it has been suggested that this can be greatly reduced, especially in high risk patients, via the use of 3-D, enhanced detail imaging, allowing for superior preoperative diagnostic assessment [7]. Furthermore, accuracy of third molar angulation is of importance in surgical planning. Dudhia [8] reconfirmed the presence of distortional inaccuracies with orthopantomograms or panoramic imaging secondary to projection geometry creating discrepancies in angular measurements. Simply, the panoramic image results in the mandibular third molars appearing less mesially inclined, which can have both treatment planning and surgical implications. Digital panoramic images offer significantly greater diagnostic precision over conventional panoramic images but ultimately create only a 2-D image of a 3-D anatomic area [9]. As a result, studies, such as the one by Bouquet and colleagues [10], demonstrated the intuitive conclusion that CT offers increased anatomic precision over orthopantography but with a significant increase in radiation exposure and cost. The advent of cone- beam CT technology (CBCT) has resulted in imaging with decreased radiation exposures and intraoffice practicality versus the medical-grade CT scanners [11]. Tantanapornkul and colleagues [12] demonstrated the CBCT to be superior to panoramic imaging in predicting neurovascular bundle exposure during extraction of impacted third molar teeth (Fig. 1). Specifically, CBCT scanners use narrow, collimated conical radiation beam geometry coupled to 3-D reconstruction algorithms. The result is the generation of an accurate and large volume of data in a short scanning interval

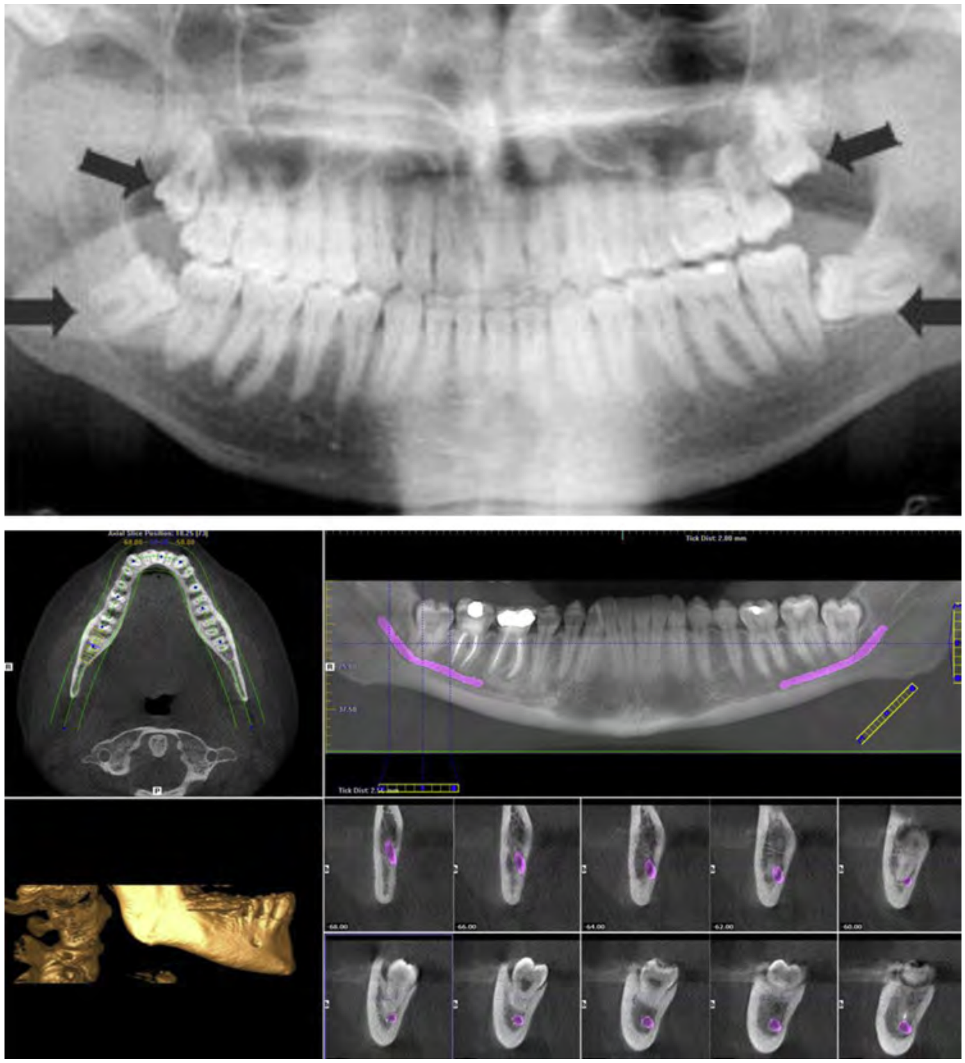

Fig. 1. (*Upper*) 2-D orthopantomogram demonstrating wisdom teeth. (*Lower*) 3-D CBCT with particular emphasis on the inferior alveolar can and its relationship to the third molar mandibular teeth. (*Courtesy of* Queensland X-Ray, Queensland, Australia; with permission.)

[13]. In addition, Ghaeminia and colleagues [14] reported that CBCT elucidated the 3-D relationship of the third molar root to the mandibular canal and allowed for buccolingual appreciation of the inferior alveolar nerve (see Fig. 1). Furthermore, even MRI has been proposed by Tymoflyeva and colleagues [15] as an alternative imaging option for impacted teeth because it results in volumetric morphology while eliminating ionizing radiation, which is especially important in younger patients.

Radiographic Assessment of Surgical Difficulty of Removal of Impacted Third Molars

Orthopantogram specific [16]:

- Root number
- Root morphology
- Tooth position
- Second molar relation
- Size of follicular sac
- Periodontal ligament space

Panoramic radiographic risk factors for inferior alveolar nerve injury [17]:

- Diversion of the inferior alveolar canal
- Darkening of the third molar root
- Interruption of the cortical white line

Classification systems

Evaluation of third molars historically includes radiographic classification systems based on third molar angulation, the relationship to the anterior border of the ramus, and the relationship to the occlusal plane. Such systems allow for more clear communication amongst clinicians as well as further assessment of surgical difficulty and specific surgical techniques for removal.

Angulation

Archer (1975) [18] and later Kruger (1984) [19] pioneered the angulation classification based on the radiographic position of the third molars. The angulations include

- Mesioangular—least difficult removal and most common for mandibular third molars
- Distoangular—least difficult removal for maxillary third molars
- Vertical—most common for maxillary third molars
- Horizontal
- Buccal version
- Lingual version
- Inverted

Relationship to the Anterior Border of the Ramus

The Pell and Gregory classification originated in 1933 and was designed to assess impacted third molars, with particular focus on the relationship to the ramus and the occlusal plane (Fig. 2) [20]. The relationship to the ramus is based on the amount of the impacted tooth that is covered by bone of the mandibular ramus. This suggests the potential likelihood of eruption as well as surgical difficulty with removal. Simply, as the third molar becomes increasingly covered by the ramus, the surgical difficulty increases. Three classes exist:

Class 1: The distance between the second molar and the anterior border of the ramus is greater than the mesiodistal diameter of the crown of the impacted tooth, so that its extraction does not require bone removal from the region of the ramus.

Class 2: The distance is less and the existing space is less than the mesiodistal diameter of the crown of the impacted tooth.

Class 3: There is no room between the second molar and the anterior border of the ramus, so that the entire impacted tooth or part of it is embedded in the ramus.

Relationship to the Occlusal Plane

The occlusal plane analysis was also created by Pell and Gregory to address the depth of impaction or amount of overlying bone with application to further assessment of surgical extraction difficulty [19]. Similar to the relationship to ramus classification, the relationship to the occlusal plan exists in 3 forms and deeper impactions are typically more difficult to surgically remove:

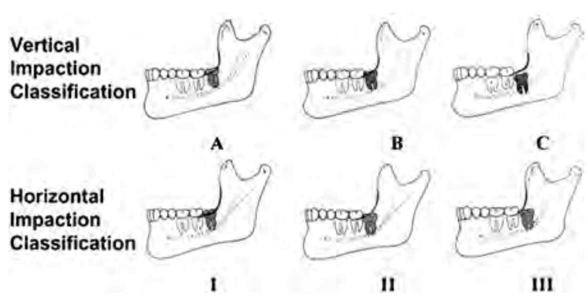

Fig. 2. Composite Pell and Gregory classification of third molar impactions, addressing third molar relationship to the mandibular ramus as well as depth of impaction. (*From* Peterson LJ. Principles of management of impacted teeth. In: Peterson LJ, Ellis E, Hupp JR, et al, editors. Contemporary oral and maxillofacial surgery. St Louis [MO]: Mosby; 1993. p. 229–30; with permission.)

Table 1
Pederson's difficulty index for impacted mandibular third molar removal as a composite of angulation, depth of impaction, and ramus relationship

Classification	Value
Spatial relationship	
Mesioangular	1
Horizontal/transverse	2
Vertical	3
Distoangular	4
Depth	
Level A: high occlusal level	1
Level B: medium occlusal level	2
Level C: deep occlusal level	3
Ramus relationship/space available	
Class 1: sufficient space	1
Class 2: reduced space	2
Class 3: no space	3
Difficulty index	
Very difficult	7–10
Moderately difficult	5–6[a]
Slightly difficult	3–4

[a] In the original index, moderately difficult was graded as 5–7.
Data from Pederson GW. Oral surgery. Philadelphia: WB Saunders; 1988.

Class A: The occlusal surface of the impacted tooth is at the same level as, or a little below, that of the second molar.
Class B: The occlusal surface of the impacted tooth is at the middle of the crown of the second molar or at the same level as the cervical line.
Class C: The occlusal surface of the impacted tooth is below the cervical line of the second molar.

Furthermore, a composite relationship of angulation, ramus relationship, and depth of impaction can provide a surgical extraction difficulty index, as described by Pederson (Table 1) [21].

Other Methods

Winter lines, root division, and WHARFE (Winter's classification, Height of the mandible, Angulation of second molar, Root shape and morphology, Follicle development, Exit path) assessment are additional radiographic-assisted techniques for third molar evaluation and subsequent management (Fig. 3) [22].

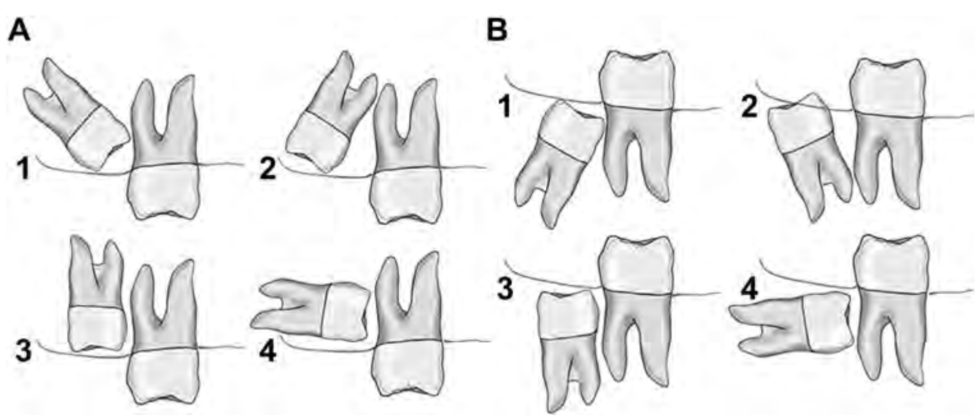

Fig. 3. Angulation classification of impacted teeth. (*A*) Maxillary third molar impactions: mesioangular (1), distoangular (2), vertical (3), and horizontal (4). (*B*) Mandibular third molar impactions: mesioangular (1), distoangular (2), vertical (3), and horizontal (4). *From* Ashoo K, Powers MP. Anesthesia/dentoalveolar surgery/office management. In: Fonseca RJ, editor. Oral and maxillofacial surgery. Philadelphia: WB Saunders; 2000. p. 257, with permission.)

Summary

Successful third molar management requires a comprehensive history and physical examination in conjunction with an appropriate radiographic analysis. Clinical examination can guide treatment options as well as perioperative medical management and the imaging modality is essential in the management of third molars, facilitating surgical planning, informed consent, and overall patient education.

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The Management of the Asymptomatic, Disease-Free Wisdom Tooth: Removal Versus Retention

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Introduction

The management of impacted third molars (M3s) or wisdom teeth is a decision encountered by oral and maxillofacial surgeons (OMSs) daily. The decision-making is usually very straightforward, owing to the presence of disease. A challenging management decision is how to manage the asymptomatic, disease-free wisdom tooth. For these types of M3s, the treatment is essentially a binary choice: (1) operative treatment (eg, extraction) or (2) retention.

Management (ie, extraction versus retention) of the asymptomatic, disease-free wisdom tooth is fiercely controversial, with avid proponents of each treatment option. Because of the risk of future disease, the American Association of Oral and Maxillofacial Surgeons historically advocated "... that wisdom teeth be removed by the time the patient is a young adult to prevent future problems and to ensure optimal healing." The American Public Health Association (APHA) rejects this strategy. APHA "opposes prophylactic removal of third molars, which subjects individuals and society to unnecessary costs, avoidable morbidity, and the risks of permanent injury." However, the management of most asymptomatic, disease-free wisdom teeth lies somewhere between these two polar views. The author recommends that wisdom teeth be evaluated by the time the patient is a young adult to ensure optimal, patient-oriented management.

The traditional evidence-based tool to address a clinical dilemma is the critical appraisal exercise (CAE). The CAE has 4 elements: (1) asking a relevant clinical question, (2) reviewing the literature, (3) assessing the validity of the best information available and answering the clinical question, and (4) applying the findings to enhance patient care. The relevant clinical question for this article is: Among patients with asymptomatic, disease-free M3s, do those patients who choose to retain their M3s, when compared with those who elect M3 removal, have "better" or "different" outcomes? "Better" outcomes primarily include avoiding the costs and risks of an operation. These outcomes, however, are short-term benefits. There are no guarantees that avoiding an operation today assures no operation in the future. As such, the short-term benefits of M3 retention are tempered by the tangible, but unknown, risk for M3 removal at some point in the patient's lifetime with its associated costs and risks.

In executing the second and third steps of the CAE, namely, reviewing and assessing the literature, the author identified a Cochrane systematic review that addressed the clinical question. The reviewers concluded that "no evidence was found to support or refute routine prophylactic removal of asymptomatic impacted wisdom teeth in adults." Well-meaning advocates of both management strategies have used this review to support their positions.

The final step of the CAE is to apply the findings to provide and enhance patient care. However, in the absence of good evidence to support either management position as the predominant strategy, what is the clinician (or policy maker or payor) to do? Evidence-based clinical decision-making is not using the best theoretical evidence to make decisions. For example, without one or more randomized clinical trials, Cochrane reviewers commonly conclude that no recommendation can be made owing

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to inadequate evidence, leaving the clinician at a loss. Evidence-based clinical decision making is characterized as providing care given the best evidence accepting fully that the decisions are being made in the face of relative ignorance. As such, management decisions must incorporate the clinician's experience and expertise, and weigh heavily the patient's wishes and desires regarding extraction versus retention after a careful, balanced review of the risks and benefits of both treatment options. The content of this article reflects largely the author's personal decision-making process based on a careful literature review and clinical experience/expertise. The author admits freely and fully that the quality of the evidence used to support the management of asymptomatic, disease-free M3s is Level 5, namely, expert opinion.

The purpose of this article is to: (1) review the functional definition of impaction used herein, (2) outline a clinical classification system to categorize M3s based on patients' report of symptoms and the presence of clinical or radiographic disease associated with the M3s, (3) introduce an algorithm for managing M3s, and (4) discuss in some detail the rationale for advocating treatment of asymptomatic, disease-free M3s either with extraction (or other appropriate operative interventions) or retention active surveillance.

Definition of an impacted tooth

For the purposes of this article, the working definition of an erupted tooth is one that is fully visible in the mouth, has reached the occlusal plane, all 5 surfaces are accessible for examination, and has attached gingiva around the tooth. An erupted tooth may be functional, malpositioned in the arch, or nonfunctional. An impacted tooth may or may not be visible. Its presence may only be detectable by periodontal probing or on radiographic images. If visible, it does not meet the definition of an erupted tooth. An impacted tooth is not disease. It is simply an anatomic description suggesting that there is inadequate space to accommodate the tooth in the dental arch. An erupting tooth is visible in the mouth and, based on physical and radiographic examinations, appears to have adequate hard and soft tissue space available to become an erupted tooth. An erupting tooth is a dynamic situation. Its status needs to be reevaluated periodically to determine if the tooth has erupted or has become impacted. In this article, there is no working definition for a partially erupted tooth. A tooth is either erupted, impacted, or erupting. These definitions (Table 1) apply to all teeth, not solely to M3s.

Classifying M3s to facilitate clinical decision making

M3s can be grouped into 4 clinical categories based on 2 axes, patients' report of symptoms (present or absent), and clinical or radiographic evidence of disease (present or absent).

During the preoperative visit, clinicians should ask patients about symptoms or concerns that may be related to the M3s. Patients commonly report symptoms of pain, swelling, limitation of motion, bad taste, or smell. Patients also attribute signs of incisor crowding to their impactions. Most data, however, suggest that the crowding is due to insufficient space to accommodate all of the teeth because of a discrepancy between tooth and jaw size, not the result of impacted teeth trying to erupt and "squeeze" into the dental arch by crowding out other teeth.

The clinician then needs to determine if the symptoms are attributable to the M3s. Although usually not a major diagnostic challenge, some patients will mistake masseter muscle pain

Table 1
Classification of M3s based on 2 axes: symptoms and disease status

	Clinical or radiographic evidence of disease	
Symptoms Attributable to M3s	Yes (D+)	No (D−)
Yes (S+)	A	B
No (S−)	C	C

A = Symptoms present (S+) and disease present (D+) or S+/D+.
B = Symptoms present (S+) and disease absent (D−) or S+/D−.
C = No symptoms present (S−) and disease present (D+) or S−/D+.
D = No symptoms present (S−) and disease absent (D−) or S−/D−.

(myalgia) for M3 pain. Other patients with erupting M3s will report pain symptoms that may be due to the inflammatory side effects of teething. In the setting of adequate space to accommodate the M3s, teething pain is a side effect of development, not an inflammatory disease. In the absence of adequate space to accommodate the M3s, teething pain may be sufficiently severe to warrant intervention.

Patients commonly report no symptoms attributable to the M3s and present for evaluation because "My dentist referred me." After completing the history and physical and radiographic examinations, the clinician will need to decide that the patients' symptoms are related to the M3s (symptomatic, abbreviated S+) or that patients have no symptoms or the symptoms are unrelated to the M3s (asymptomatic, abbreviated S−).

Because of the high percentage of asymptomatic disease present in M3s, careful physical and radiographic examinations are indicated. Obvious signs of inflammatory disease such as pericoronitis, caries, or periodontal disease are common. More subtle signs of disease, however, may be present. The following aspects of physical examination are important: (1) eruption status and, if erupted, the position in the arch; (2) functional status of the tooth; and (3) probing status. If the tooth is not visible, probing is important to determine whether the tooth communicates with the oral cavity. If the tooth can be detected on probing, this suggests the tooth is chronically contaminated with oral flora. Probing is also valuable to determine the periodontal health around the M3 and the adjacent second molar (M2). Probing depths (PDs) that are greater than 4 mm are associated with an increased risk of clinically significant (>2 mm) changes in PDs, suggesting a progression of periodontal disease. Specifically, when compared with subjects with PDs less than 4 mm at baseline, those with PDs greater than 4 mm have a nearly 40% increased risk for worsening periodontal health as evidenced by increased PDs after 2 years of follow-up.

After completing the physical examination, the clinician can initially classify the M3 as disease free (abbreviated D−) or disease present (abbreviated D+). A D− M3 can be fully erupted and well positioned in the arch and have PDs of less than 4 mm around the M3, and may be functional. At the other extreme, a D− M3 is not visible in the mouth, cannot be probed, and has PDs of less than 4 mm around the distal aspect of the adjacent M2, and its presence is only confirmed by radiographic imaging.

A radiographic examination is required to confirm the disease status of the M3. Without clinical evidence of M3s, the radiograph will confirm the presence (or absence) of M3. Imaging is also valuable to assess the anatomy of the M3 and its relationship to other local anatomic structures such as the mandibular nerve or adjacent second molar (M2). Although a numerically rare complication of retained M3s, in a tertiary referral practice it is not uncommon to see community patient referrals who are asymptomatic by history and have an unremarkable clinical examination, only to discover on radiographic examination jaw lesions that are several centimeters in diameter (Fig. 1). More commonly, disease radiographically associated with asymptomatic M3s includes inflammatory radiolucent lesions, internal resorption or caries, or caries/resorption of the adjacent M2.

After reviewing the history and physical and radiographic examinations, the clinician can group the clinical status of the M3 into 1 of 4 categories (Table 1) that inform clinical decision making:

Group A = symptomatic and disease present (S+/D+)
Group B = symptomatic and disease absent (S+/D−)
Group C = asymptomatic and disease present (S−/D+)
Group D = asymptomatic and disease absent (S−/D−)

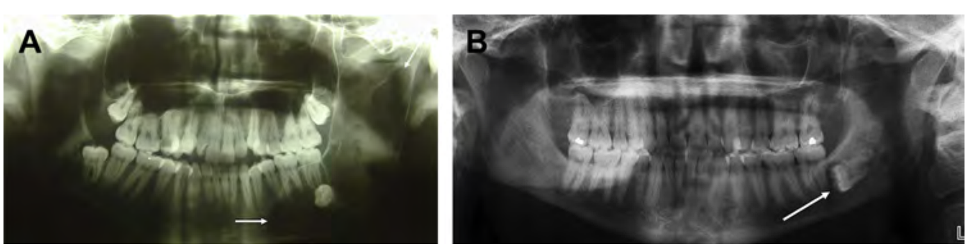

Fig. 1. (*A*) Incidental finding on panoramic radiograph. Mandibular left M3 is not visualized on routine bitewings. Note the multilocular radiolucent lesion (*arrows* marking the anterior and posterior extent of the lesion) associated with the impacted mandibular left M3. (*B*) Incidental findings on panoramic radiograph. Mandibular left M3 is not visualized on routine bitewings. Note the radiolucent lesion (*arrow*) associated with the retained M3 in this 45-year-old man.

Identifying patients with Group A M3s is not difficult. The patient has specific localized pain complaints, and the disease is readily evident on physical or radiographic examination.

Identifying patients with Group B M3s, however, can be a more subtle challenge. Patients in this category have vague complaints of pain with no evidence of disease associated with the M3s. With a redirected history and physical examination, commonly these patients have myalgia involving the masseter muscle or atypical facial pain. Alternatively, patients in this category have pain associated with the erupting tooth (teething pain), but in the setting of adequate space to accommodate the tooth, this is a side effect of normal tooth eruption, not disease. As already noted, an erupting tooth is a dynamic process needing periodic reevaluation to determine if the tooth has erupted into a useful, functional position or has become impacted and needs to be reclassified into Group A, C, or D.

Patients with Group C M3s are common and prove the maxim that the absence of symptoms does not equal the absence of disease. These patients report no symptoms, but clinical or radiographic evidence of disease is readily apparent. Some of the more common clinical findings include a visible tooth that is nonfunctional and nonhygienic, with evidence of gingival inflammation as evidenced by erythema or bleeding on probing, or PDs greater than 4 mm. Sometimes the tooth is not visible but can be readily probed, or PDs along the distal of the M2 are greater than 4 mm. The tooth may be erupted, but malposed in the arch, or there are caries or PDs greater than 4 mm present. Common radiographic findings suggestive of disease include a radiolucency associated with the M3, internal resorption, caries, or resorption on the adjacent M2.

Patients with Group D M3s (Box 1) report no symptoms, and there are no clinical or radiographic findings suggesting disease. On examination the M3 may be completely erupted, well oriented in the arch, and functional, with PDs less than 4 mm. Alternatively the M3 may be impacted, not visible, cannot be probed, and PDs are less than 4 mm. There is no radiographic evidence of disease associated with a Group D M3.

Kinard and Dodson reported their experience with this clinical classification system for M3s. Using a retrospective cohort study design, the investigators enrolled a sample of 249 subjects who presented to a tertiary care referral center for M3 evaluation and management. The study sample's 855 M3s were classified as follows:

Group A, symptomatic and disease present (S+/D+) = 11.0%
Group B, symptomatic and disease absent (S+/D−) = 0.6%
Group C, asymptomatic and disease present (S−/D+) = 51.1%
Group D, asymptomatic and disease absent (S−/D−) = 37.3%

In 11.6% of the subjects, all M3s present were Group D (S−/D−). Conversely, 88.4% of the subjects presenting for evaluation had at least 1 diseased M3 requiring treatment. Of note, among patients with Group D M3s, when offered the choice between retention with active surveillance or extraction, after reviewing the risks and benefits of the 2 treatment alternatives, patients elected extraction 60% of the time.

Box 1. Characteristics of asymptomatic, disease-free (S−/D−) M3s

Patient history:
No symptoms or vague, nonspecific complaints

Clinical examination:
1. Impacted M3 cannot be seen, cannot be probed, and PDs are less than 4 mm
2. Erupting M3 with adequate space to accommodate a functional tooth
3. Erupted M3 has reached the occlusal plane, is functional, hygienic, with PDs less than 4 mm, with no caries, restorable caries, or restored caries; all 5 surfaces can be examined clinically, as well as attached tissue along the distal surface of the tooth

Radiographic examination:
No evidence of radiographic disease is present

M3 management recommendations

After completing the history and physical and radiographic examinations, the clinician needs to categorize each M3 as Group A, B, C, or D, and suggest a management option (Fig. 2). The clinical decision making for patients with Groups A and C M3s (symptoms present or absent, but disease present) is straightforward: treat the disease as indicated. Treatment depends on the diagnosis and can range from the full scope of restorative and hygiene care, to periodontal therapy, to coronectomy, to extraction. Treatment choice depends on factors such as hygiene, eruption status, functionality, anatomic location, risk to local anatomic structures, and patient preference. Although it is beyond the scope of this article to detail the treatment options, it is well within the range of dental services to render the indicated treatments.

Patients with Group B M3s, that is, symptoms thought to be attributable to M3s but without clinical or radiographic evidence of disease, are more challenging to manage. It takes additional time and further diagnostic effort to establish the cause of the symptoms. In the author's experience, Group B patients commonly have myalgia. Other diagnostic considerations include temporomandibular disorders, atypical facial pain, odontalgia, and carious or infected second molar teeth, among others. The treatment rendered should be appropriate for the diagnosis.

A small number of patients with Group B M3s report pain associated with an erupting M3 and have pericoronal soft-tissue inflammation present on clinical examination, while radiographically there appears to be adequate room for the M3s to erupt into a useful functional position. These inflammatory signs and symptoms are not disease, but a side effect of the normal developmental process of teething pain associated with tooth eruption. In general these patients are managed with analgesics, antibacterials, and observation. The clinical judgment that the patient has adequate room for M3s to erupt into a useful, functional position is imperfect. Both clinician and patient need to be prepared to revise the management if the clinical impression is wrong and the tooth becomes impacted.

The management of patients with Group D M3s (asymptomatic and disease-free M3s) is controversial. Given the lack of evidence to support routinely retaining or removing M3s, the clinician needs to review in detail the risks and benefits of both treatment options and weigh these against the patient's preferences, wishes, desires, and perceived risks and benefits.

The risks and costs of M3 removal have been well documented and are not detailed herein. In brief, problems associated with M3 removal include inflammatory complications such as surgical-site infection or osteitis, hemorrhage, injury to local anatomic structures (teeth or nerves), periodontal defects, fractures of the maxillary tuberosity or mandible, persistent oroantral communication, retained roots, and the need for additional treatment to manage the complication. Another consideration, in addition to the direct cost of care, is the indirect cost associated with loss of productivity at work or school.

The risks and implications of M3 retention are less well detailed. Recent studies involving patients who elected to retain teeth demonstrate that retained M3s frequently and unpredictably change position, eruption status, and periodontal status. Depending on the duration of follow-up, 5% (one year followup) to 60% (18 years of followup) of retained M3s are extracted at some future time.

For patients who elect to retain their M3s, the management decisions revolve around the need for and frequency of follow-up visits and who should do the follow-up. There is no good evidence as to the need for or frequency of follow-up visits or who should do the follow-up examinations. As such, the following set of management recommendations is for patients with Group D M3s, based on Level V evidence (expert opinion).

Some patients with Group D M3s are instructed to follow-up when they have symptoms. This is poor advice. As noted earlier, the absence of symptoms does not equal the absence of disease. Many, if not most, diseases, for example, hypertension, cancer, and diseased M3s, are asymptomatic for months to years before symptoms or signs of disease manifest. Because of the documented risk for future disease and the unpredictable behavior of M3s, for those patients electing to retain their asymptomatic, disease-free M3s, active surveillance is recommended.

Active surveillance is a prescribed treatment of monitoring the patient on a scheduled basis, including a review of the patient's history and a complete and careful physical and radiographic examination. Patients who elect active surveillance as their preferred treatment may be committed to a lifetime of monitoring with its associated costs, and no assurance that extraction will be avoided later in life with its associated costs and risks.

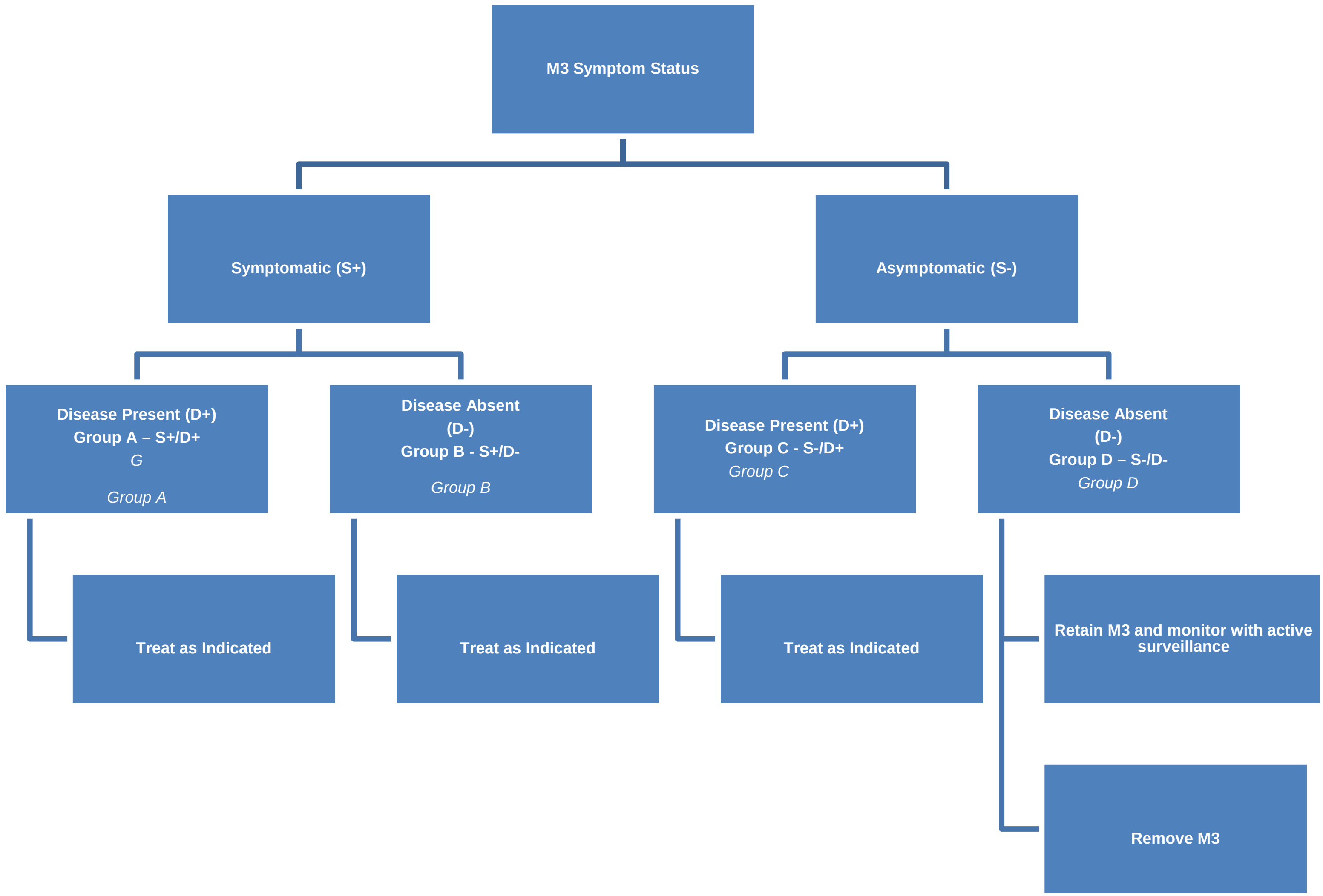

Fig. 2. Protocol for M3 management.

For patients electing M3 retention with active surveillance as their preferred treatment, the appropriate duration between follow-up visits is unknown and depends on the patient's age and history. The author recommends that new patients be seen every 2 years, sooner if they develop symptoms. Biannual visits are chosen for 2 reasons: (1) there can be clinically significant evidence of progression of periodontal disease in 2 years, and (2) the morbidity of extraction, as evidenced by the duration of postoperative recovery, increases as patients age. Reasonable arguments can easily be made for different follow-up intervals.

Is the primary care dentist or the OMS the best person to provide follow-up care? Again, there is no good evidence supporting one type of clinician over another. The author recommends that the follow-up assessments be executed by clinicians competent in the assessment and management of M3s. Others may argue that if specialists do the follow-up there will be an increased bias toward extraction over continued surveillance, and that it is more expensive than seeing the primary care dentist. There are no available data to dispute these assertions (and those supporting these assertions have no data either). Balancing these arguments is the risk that there may be a delay in seeking treatment owing to a lack of skill or experience in detecting and diagnosing subtle or occult disease.

A major unknown in the management of S−/D− M3s is the cost difference between removal and retention. Cross-sectional and short-term assessments suggest that retention is the lower-cost option. These studies, however, fail to account for the lifetime risks associated with M3 retention, and an economic rationale is weak evidence to support M3 retention as the preferred strategy. For extraction the costs are based on the expenses of: (1) removing the tooth, plus (2) missing work, school, regular activities on a planned scheduled basis, plus (3) treating complications. Those who elect retention need to consider both the current and future costs of active surveillance (scheduled follow-up visits with clinicians with appropriate training regarding the assessment of M3s and indicated imaging) and the risk of incurring the costs associated with treating the retained M3, which can range from the full scope of restorative options to extraction on either a planned or unplanned basis, resulting from urgent clinical situations such as symptomatic infection.

Summary

Although M3 management is usually straightforward, the evidence supporting extraction versus retention for asymptomatic, disease-free M3s is lacking. Extreme positions aggressively advocating either treatment option cannot be rationally supported. Initially polite debate on the topic usually degenerates into inane comments, accusations, and sound bites citing rare outcomes as evidence to support a position. Until such time that randomized trials provide the necessary data to guide management decisions, the evidence-based clinician should offer patients both treatment options, including a detailed comparison of the risks and benefits of operative and nonoperative treatments, and lean heavily on patient preference regarding the management choices.

Further readings

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Complications of Retention: Pathology Associated with Retained Third Molars

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Introduction

An impacted tooth is one that either fails to erupt into its nature position or one that is hindered from such eruption by adjacent teeth, dense bone, or an overgrowth of soft tissue. The treatment of impacted teeth is either removal of the obstructing hindrance or removal of the tooth itself.

The most common impacted tooth is the third molar or wisdom tooth. As a general rule, most human populations have 4 wisdom teeth; 2 upper and 2 lower. It is well acknowledged that wisdom teeth are the most commonly congenitally missing teeth and, as such, 10% of the US population has only 3, 8% only 2, and 2% only 1. Approximately 4% have complete agenesis of their wisdom teeth. It should be noted that more wisdom teeth are missing in the maxilla than from the mandible.

The third molar is characterized by variability of morphology, root type, time of formation, and time of eruption. Wisdom teeth formation begins between 3 and 4 years of age. Calcification starts at 7 to 10 years with crown completion between 12 and 16 years of age. Third molar eruption usually occurs in the age group of 17 to 21.

Impacted wisdom teeth are classically characterized by their position within the bone. This classification serves both the clinical presentation and the findings of imaging studies (Fig. 1). Impacted wisdom teeth and their treatment are a major problem for dentistry today. Whether or not to remove these teeth is without a doubt one of the most difficult treatment decisions made by dentists in modern time.

Impacted, partially erupted, and fully erupted wisdom teeth can remain asymptomatic for many years but can ultimately cause acute pain, infection, tumors, cysts, caries, periodontal disease, and loss of adjacent teeth. In addition, there is literature describing relapse after orthodontic retention as well as orthodontic crowding being caused by retained or impacted wisdom teeth.

Tooth development

The primitive oral cavity is lined by an epithelial layer termed ectoderm. This ectoderm consists of a basal layer of columnar cells and a surface or covering layer of more flattened cells. From this

The author has nothing to disclose.

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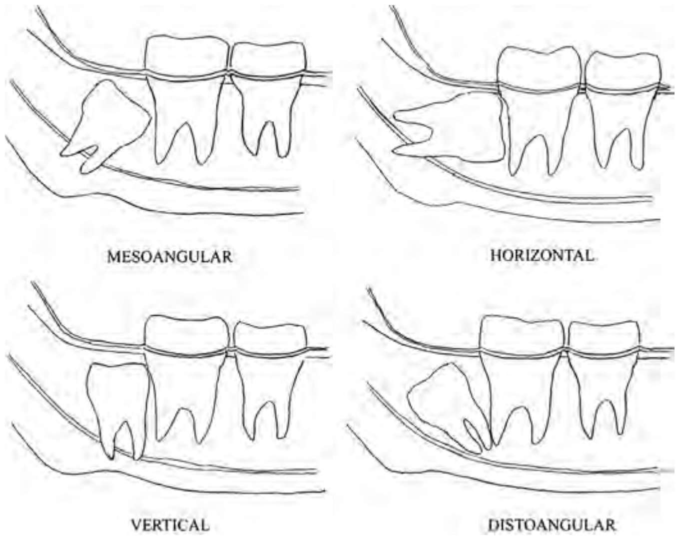

Fig. 1. Classification of impacted wisdom teeth based on clinical location.

epithelial layer, tooth buds form, which in time lead to the development of both primary and permanent teeth.

A tooth bud consists of 3 basic units: (1) enamel organ from which arises enamel; (2) the dental papilla, which in turn gives rise to dentin and the tooth pulp; and (3) the dental sac, which ultimately produces the cementum and periodontal ligament. The enamel organ is ectodermal, whereas both the dental papilla and dental sac are considered ectomesenchymal in origin.

At 2 to 4 weeks of gestation, the embryo develops a band of thickened epithelium termed the dental lamina, which actually forms the outline of the future dental arches. At points along this lamina, there are nodules formed of more active epithelium that press into the underlying mesenchyme. Each of these buds represents the origin of the 10 upper and 10 lower primary teeth.

As the bud progresses to grow, it invaginates deeper into the connective tissue and forms a "caplike" structure (Fig. 2). The concavity of this cap represents the inner enamel epithelium, which is more columnar in nature, whereas the outer or convex portion of the cap is composed of more flattened outer enamel epithelium. The cells that lie between these 2 epithelium layers are larger and filled with mucoid material. This cell grouping is the stellate reticulum, which ultimately protects the more delicate enamel-producing cells. As this combined structure progresses in development, it is termed the enamel organ.

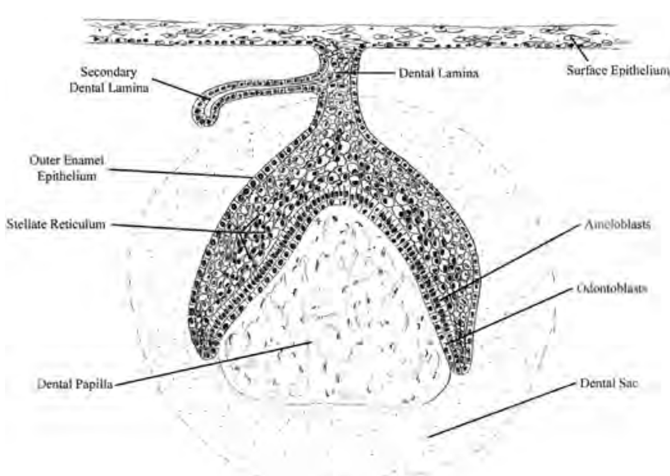

Fig. 2. Cap stage of a developing tooth follicle. Note the arrangement of the ameloblasts and odontoblasts.

As the inner enamel epithelium becomes more organized, it in turn influences the underlying connective tissue to proliferate. As it does so, this connective tissue condenses and forms the dental papilla, which ultimately will form the dentin-producing odontoblasts.

Simultaneously, there is peripheral proliferation and condensation of the mesenchymal tissue surrounding the outer enamel epithelium and the dental papilla. This tissue becomes more organized as the embryo ages and ultimately becomes the more fibrous dental sac.

The dental sac, the enamel organ, and the dental papilla together are the formative tissues of the entire tooth.

As the epithelium continues to invaginate deeper into the mesenchymal tissue, the enamel organ becomes more "bell-like" in configuration. The inner enamel epithelium is now a single layer of tall columnar cells termed ameloblasts. These ameloblasts exert an influence on the adjacent mesenchymal cells, which in turn differentiate into odontoblasts. As a result, these 2 layers begin formation of the enamel and dentin respectively (Fig. 3). During this time, the original dental lamina proliferates and becomes the formative enamel organ of the permanent tooth buds.

Root development begins after enamel/dentin production reaches the cemento-enamel junction. The remaining inner and outer enamel epithelium together become the Hertwig epithelial root sheath and once again induce the mesenchymal tissue to begin formation of the root dentin. Simultaneously, the mesenchymal tissues of the dental sac differentiate into cementoblasts and produce cementum that covers the root dentin. After cementum production is complete, the root apex closes and tooth development is complete.

It is well acknowledged that many of the tissues leading to tooth development are also responsible for the various odontogenic cysts and tumors. Remaining epithelial rests of both the dental lamina and Hertwig root sheath can give rise to the dentigerous, primordial, and lateral periodontal cysts as well as tumors, such as the ameloblastoma and the keratocystic odontogenic tumor. Dental lamina within the gingiva also gives rise to gingival cysts and the peripheral ameloblastoma. The odontogenic myxoma and fibroma are presumed to arise from tissues of the dental papilla, and various fibro-osseous tumors take their origin from the tissues of the dental sac.

Adverse conditions arising from retained wisdom teeth

Tooth formation evolves continuously throughout the first 2 decades of life. As the wisdom teeth are the last permanent teeth to enter the oral cavity, many times these teeth have no space remaining in which to completely erupt. In such cases, wisdom teeth, or third molars, are termed "impacted teeth" and as such are retained or at least partially retained with in the bony or soft tissue confines of the upper and/or lower jaw. Several pathologic conditions can be initiated by this tooth retention.

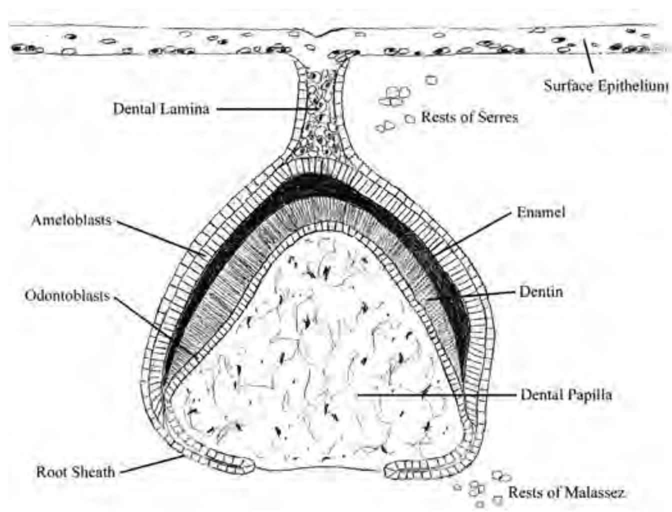

Fig. 3. Developing tooth follicle in bell stage. Note the deposition of both dentin and enamel and well as the early root development.

Inflammatory, mechanical, and neoplastic conditions can and do arise when the wisdom teeth remain impacted, partially erupted, or fully erupted. These adverse situations can be quite diverse in origin as well as their clinical presentation.

Pericoronitis and related infections

Pericoronitis is a localized infectious process usually involving mandibular third molars (Fig. 4). It is the most common acute inflammatory disease that occurs with retention of wisdom teeth. The usual clinical scenario is, first, the crown of a partially erupted lower wisdom tooth becomes incompletely covered by the adjacent oral soft tissue (operculum). Food then becomes lodged beneath this operculum. The resultant soft tissue pocket is then invaded by oral bacteria with a resultant localized infection ensuing (Fig. 5). Patient complaints range from pain and swelling to trismus and fever.

Pericoronitis ranges from a mild form with only localized swelling to a more aggressive form involving a greater amount of adjacent soft tissue. Pericoronitis in its most severe form can allow the localized bacterial infection to become generalized and then spread along the fascial spaces of the head and neck causing extensive tissue involvement with trismus and abscess/cellulitis formation. If left untreated, many of the acute infections become chronic and can often progress into osteomyelitis as the infectious process invades the medullary and cortical bone.

Seasonal variations associated with acute pericoronitis are readily seen, with the peak time being in the spring and fall. This problem appears to reach its lowest level in the winter months. Such differences are difficult to explain but may be related to environmental conditions and their effect on the normal oral flora.

There is no major sex bias in pericoronitis, with females affected only slightly more commonly. Younger people between the ages of 18 and 25 appear to represent the most common groupings of occurrence. Divergent standards of dental care is the most likely reason that pericoronitis occurs commonly in higher socioeconomic groups. Lesser groups often lose teeth much earlier and thus leave space in the dental arch allowing wisdom teeth to completely erupt. Mesioangular impactions are the type most commonly involved with pericoronitis. This is followed by distoangular, vertical, and then horizontal impacted wisdom teeth. Neither the left nor the right side is favored.

Pericoronitis continues to linger and smolder unless treated either symptomatically or by removal of the offending tooth. Most patients left with untreated pericoronitis will suffer at least 2 and often more flare-ups, which can occasionally last up to 21 days. Rarely, a patient must be hospitalized for either a progression of the infection or for intravenous fluid administration.

Initial treatment of pericoronitis involves debriding the pocket beneath the operculum with an irrigating solution. This irrigation removes not only the offending food particles but also decreases the bacterial count in the area. Occasionally, an operculectomy may be of benefit. More severe cases may need surgical incision and drainage, as well as parenteral antibiotics and possibly hospitalization.

After a single episode of pericoronitis, the wisdom tooth should be removed as soon as possible to prevent recurrent and possibly more severe infections. Some literature describes an increased

Fig. 4. Pericoronitis associated with a partially erupted wisdom tooth. Note the enlarged and inflamed soft tissue operculum secondary to entrapped food (*arrowhead*).

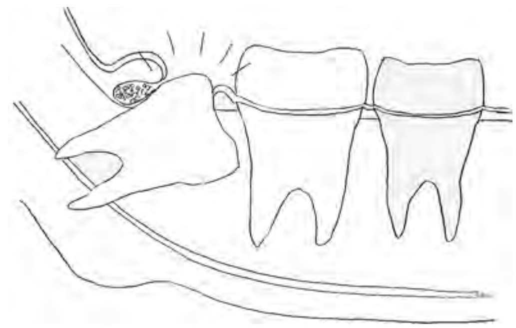

Fig. 5. Pericoronitis associated with a partially impacted wisdom tooth. Note the soft tissue abscess arising beneath the operculum.

incidence of alveolar osteitis (dry socket) if the tooth is removed during an acute episode of pericoronitis; thus, many clinicians choose to wait until the area of the pericoronitis has subsided. Other studies rebuke this thought and stress immediate removal of the offending wisdom tooth.

Orthodontic treatment

For many years, impacted wisdom teeth have been implicated as a leading cause of anterior dental crowding both before and after orthodontic treatment. Despite numerous articles describing the role of wisdom teeth in the development of such malocclusions, the issue remains controversial. In addition, according to several written surveys, there appear to be significant differences between the opinion of orthodontists and oral and maxillofacial surgeons with regard to this problem.

Several theories discuss the mechanism of anterior dental crowding. These include anterior directed pressure from impacted or erupting wisdom teeth; a persistent mesial and occlusion drift of the entire dental arch; contraction and maturation of periodontal soft tissue, specifically the transseptal periodontal fibers; overexpansion of the dental arches during orthodontic treatment; and the containment of the mandibular arch by the maxillary teeth. Each of these theories has been studied extensively but not one proposed cause has proven to be the driving force behind anterior dental crowding (Fig. 6).

A voluminous amount of anecdotal data has been internationally presented by oral and maxillofacial surgeons, orthodontists, pediatric dentists, and general dentists alike. Each specialty group often relates their own personal biases surrounding the removal and nonremoval of asymptomatic wisdom teeth. All groups approve the removal of symptomatic teeth, but the consideration of removing asymptomatic wisdom teeth varies greatly with the specific specialty group involved.

The available literature addressing the removal of asymptomatic wisdom teeth to prevent anterior dental crowding still remains quite controversial. Significant disagreement among practitioners regarding the fundamental issues underlying this controversy continues today. Of all the specialty groups, oral and maxillofacial surgeons are more likely to believe that the removal of asymptomatic wisdom teeth decreases the likelihood of anterior dental crowding. Orthodontists as a whole, but particularly the younger and the more recent residency graduates, are much less likely to subscribe to

Fig. 6. Four impacted wisdom teeth during teenage years. It is proposed that the anterior crowding and/or orthodontic relapse are at least partially caused by the anterior pressure of these erupting teeth.

this theory. Both groups believe that if the possibility of wisdom teeth causing anterior crowding exists, the mandibular teeth are the more likely culprits as opposed to the maxillary wisdom teeth.

Odontogenic cysts

Cystic lesions of the jaws constitute one of the most frequently encountered entities associated with impacted or unerupted wisdom teeth. The literature is divided on the findings of such occurrences, with most published material reporting a 1% to 6% incidence. Other articles claim that this cyst development has been greatly exaggerated or overemphasized.

Very few epithelial-lined cysts occur in bones other than those of the jaws and facial skeleton. The cysts that arise in these areas are considered either developmental or inflammatory. The most common inflammatory cyst is the periapical cyst arising from a nonvital tooth, whereas the dentigerous cyst is by far the most commonly occurring developmental odontogenic cyst.

The dentigerous cyst is always associated with an impacted or unerupted tooth; most commonly a third molar or wisdom tooth. This cyst arises when the follicle separates from the developing tooth. Clinically, the cyst surrounds the crown of the impacted tooth. The epithelial lining of the cyst most likely arises from the reduced enamel epithelium of the developing tooth, although some consideration is given to the premise that occasionally dentigerous cysts arise from remnants of Hertwig epithelial root sheath or the rests of Malassez (Fig. 7).

Dentigerous cysts can originate from any impacted tooth, although most arise from impacted third molars or wisdom teeth. As one would expect, most of these cysts are seen in those between the ages of 10 and 30. More dentigerous cysts are seen in males and are much more common in Caucasians than in the jaws of other races.

Most dentigerous cysts are asymptomatic and are commonly first identified on routine dental or panographic imaging studies. In such studies, the dentigerous cyst appears as a well-defined, unilocular, radiolucent (lytic) area associated with the crown of an unerupted or impacted tooth (Fig. 8).

Such cysts can become large and expand the cortical bone, sometimes causing mild discomfort but rarely numbness. If pain is a presenting symptom, the dentigerous cyst is most likely secondarily infected. The dentigerous cyst is treated with curettement with little if any recurrences anticipated.

The paradental cyst appears to be a form of dentigerous cyst that occurs after a portion of the impacted wisdom tooth erupts. This cyst arises from epithelial rests or reduced enamel epithelium that undergoes proliferation secondary to localized inflammation, such as pericoronitis. Radiographically the paradental cyst is a well-defined, ovoid, radiolucent mass attached to and just distal to the erupting crown (Fig. 9). This cyst is often confused with a hyperplastic dental follicle, which is a far more common radiographic finding in patients with impacted wisdom teeth. The paradental cyst will continue to enlarge while the dental follicle will not. In fact, the follicle radiographically appears to decrease in size as the patient ages (Fig. 10). The paradental cyst is removed in conjunction with the wisdom tooth with no known recurrences noted.

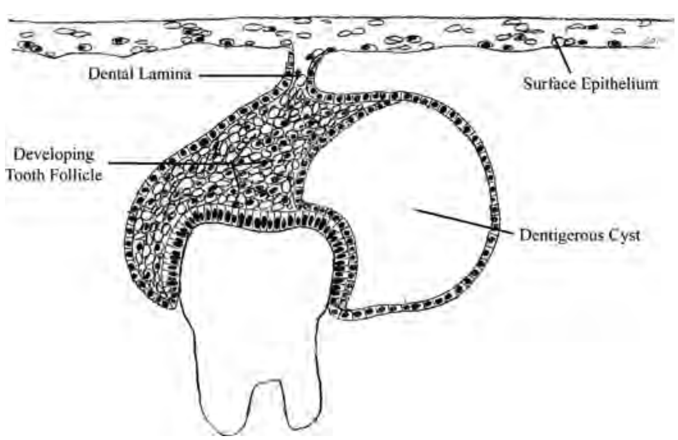

Fig. 7. Dentigerous cyst arising from the reduced enamel epithelium of the developing tooth.

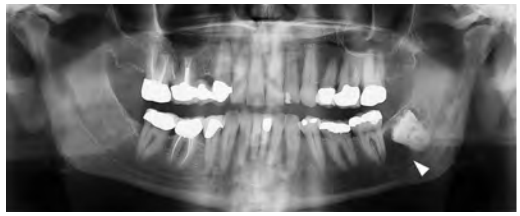

Fig. 8. Dentigerous cyst (*arrowhead*). Note the close association with an impacted wisdom tooth.

The keratocystic odontogenic tumor (KOT), originally termed the odontogenic keratocyst (OKC), is a clinically and histologically unique entity, making up approximately 8% to 10% of all odontogenic cysts. Without a doubt, it is the most aggressive and the most commonly reoccurring odontogenic cyst. As this cyst often demonstrates clinical behavior as both a cyst and a tumor, the World Health Organization in 2005 altered the nomenclature and solidified the use of the current term keratocystic odontogenic tumor.

The KOT arises from either dental lamina rests, reduced enamel epithelium, or from the actual basal cells of the oral epithelium. The cysts arising from the dental lamina appear to demonstrate a much higher recurrence rate when compared with the cysts arising from other epithelium.

Most keratocystic odontogenic tumors arise in individuals between 10 and 40 years of age, although they have been identified in all age groups. Most occur in the mandible and particularly in the third molar area. In the maxilla, these occur in the wisdom tooth area as well, but are also commonly seen in the cuspid area. Both large and small keratocystic odontogenic tumors are for the most part asymptomatic but extremely large ones can demonstrate pain, swelling, and drainage as their primary presenting symptoms.

Radiographically, all KOTs are radiolucent and well defined (Fig. 11). Although most are unilocular, the larger ones are often multiloculated. As the KOT usually expands in a linear direction along the medullary bone cavity, they are often nonexpansile. In fact, this feature is useful in the differential diagnosis, as dentigerous cysts and even periapical cysts usually expand in a more obvious fashion than do KOTs.

The histology of the KOT is unique, and consists of a thin, uniform squamous epithelial lining that produces varying amounts of parakeratin (Fig. 12). Occasionally one will encounter nonkeratinized epithelium in the KOT (Fig. 13). These areas are thought to be metaplasia secondary to inflammation within the cyst wall. In addition, numerous small "daughter" cysts are often seen within the surrounding fibrous wall (Fig. 14). It is proposed that many of the recurrences of the KOT are secondary to these smaller cystic structures.

Recurrences of the KOT are a common occurrence in spite of aggressive treatment regimens. The reported recurrence rate varies between 5% and 60%, although on careful examination of the pertinent literature, it appears the average recurrence rate is closer to 30%. KOT recurrences are explained by many theories, including retaining fragments of residual epithelium following prior surgical treatment, "daughter" cysts within the fibrous wall, extensive collagenase production by the lining cells, and the initiation of new KOTs from activated dental lamina rests from outside of the original cyst wall (see Fig. 14).

The basic approach to treatment of the KOTs is enucleation and curettage. Complete removal of the cyst wall is extremely difficult, as the thin wall often tears and in doing so leaves small epithelial

Fig. 9. Paradental cyst (*arrowhead*). Note its location just posterior to a partially erupted wisdom tooth.

Fig. 10. Multiple tooth follicles (*arrowheads*). Note the relatively small size when compared with a true dentigerous cyst.

remnants within the bone. For this reason, many investigators advise use of chemical cautery or more aggressive surgery to remove these fragments of the cyst wall. In recent times, both decompression and marsupialization have been advocated as fundamental treatment. In addition, a few select authors advocate resection as the treatment of choice, particularly in those KOTs showing multiple recurrences.

Nevoid basal cell carcinoma syndrome (Gorlin syndrome) is an autosomal dominate inherited syndrome exhibiting high penetrance. The chief components of this syndrome are basal cell carcinomas of the skin occurring quite often a young age, recurring or persistent KOTs of the jaws, intercranial calcifications, and vertebral abnormalities. The prevalence is approximately 1 in 60,000 live births. Most patients demonstrate both skin cancers and jaw cysts. Unlike the classic keratocystic tumors, which usually occur in association with impacted wisdom teeth, the syndromic cysts can occur anywhere in the jaws; both with and without contiguous impacted wisdom teeth (Fig. 15).

Odontogenic tumors

Odontogenic tumors arise from the cells of altered odontogenesis. They are a very complex and diverse group of lesions with varied clinical, radiographic and histologic presentations. Each of these tumors arise from the cells that, when mature, produce teeth. At present, odontogenic tumors are classified as epithelial, ectomesenchymal, and mixed epithelial/ectomesenchymal, depending on which tooth element is their primary cell of origin.

The ameloblastoma is the most common significant odontogenic tumor. This tumor is benign, albeit aggressive in its clinical presentation. For this reason, most ameloblastomas are treated in a more aggressive fashion than the other odontogenic tumors.

The ameloblastoma is a totally epithelial tumor and, as such, arises from the rests of dental lamina, the epithelium of odontogenic cysts, the epithelial cells of the enamel organ, or from the oral epithelium itself (Fig. 16). As stated previously, these lesions are completely benign but locally invasive and as such demonstrate a significant recurrence rate if inadequately treated originally.

The classification developed around the clinico-radiographic presentation of the benign ameloblastoma describes 3 types. The most common type is the solid/multicystic (conventional) ameloblastoma, which makes up approximately 85% of all cases. The next most common is the unicystic ameloblastoma, which represents 14% of the cases, and finally the soft tissue or extraosseous ameloblastoma, which represents the remainder. In addition, there are 2 malignant variants, which are exceedingly rare.

Fig. 11. Keratocystic odontogenic tumor (*arrowhead*) also known as the odontogenic keratocyst. In this case it represents a residual cyst remaining after removal of the wisdom tooth.

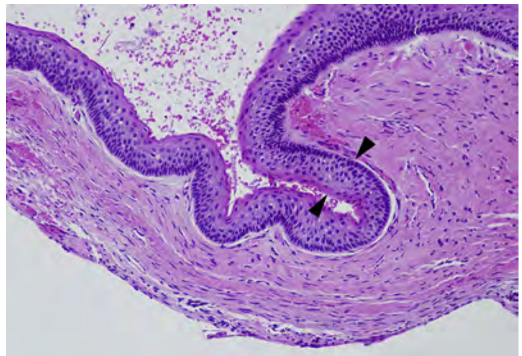

Fig. 12. Histology of keratocystic odontogenic tumor. Note the uniform layer of epithelial cells producing parakeratin (*arrowheads*) (hematoxylin-eosin, original magnification ×200).

The solid/multicystic ameloblastoma has been described in all age groups from age 4 through 96. Most arise in the third to seventh decade with no sex predilection. Approximately 85% occur in the mandible; most often in the third molar or wisdom tooth area. The maxillary ameloblastoma is most common in the third molar area as well.

Few ameloblastomas show clinical symptoms, with the exception of the huge tumors. In fact, most of these tumors are found incidentally on routine imaging studies. Even the largest of these lesions fails to show significant pain or even paresthesia unless infected.

Radiographically, the solid/multicystic ameloblastoma can be multiloculated or unilocular in its presentation (Fig. 17). The multiloculated lesions are often termed "honey-comb" or "soap-bubble" with regard to their imaging characteristics. The tumor margins are generally smooth and occasionally scalloped, especially around tooth roots. More often than not, the ameloblastoma will show cortical expansion as well as tooth root resorption. Occurring in either jaw, the ameloblastoma often is radiographically associated with an impacted wisdom tooth.

The solid/multicystic ameloblastoma will almost always histologically demonstrate both cystic spaces as well as solid components if large enough. The epithelial islands that make up the ameloblastoma are composed of epithelial cells that appear much as the stellate reticulum of the developing tooth follicle. These cells in turn are surrounded by a single layer of columnar cells reminiscent of ameloblasts (Fig. 18). Through the years, pathologists have classified the microscopic appearance of the ameloblastoma into several distinct groups, including the plexiform, the granular cell, the follicular, the basal cell, and the acanthomatous types. At one time, it was thought that there was a clinical distinction among these types, but it is now known that the clinical behavior is not related to the histology of the tumor.

During the years since the initial description of the solid/multicystic ameloblastoma, various treatment regimens have been attempted. These ranged from simple enucleation and local resection to radiation and even chemotherapy. Recurrence rates ranged from 40% to 100% with many of these treatments. At the present time, most authors feel resection with 1.0 to 1.5 cm tumor-free margins is the most reproducible treatment with little chance of recurrence. Still, there are many well-known authorities who feel that with careful treatment planning and advanced imaging studies, one can

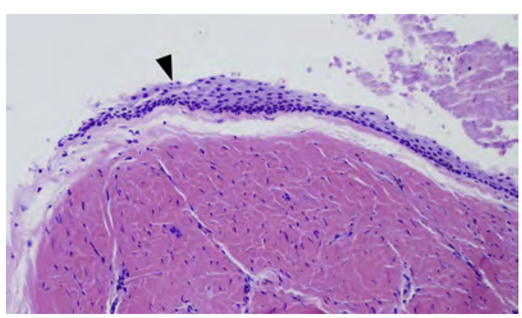

Fig. 13. Histology of keratocystic odontogenic tumor. Note the occasional non–keratin-producing squamous cells (*arrowhead*) (hematoxylin-eosin, original magnification ×200).

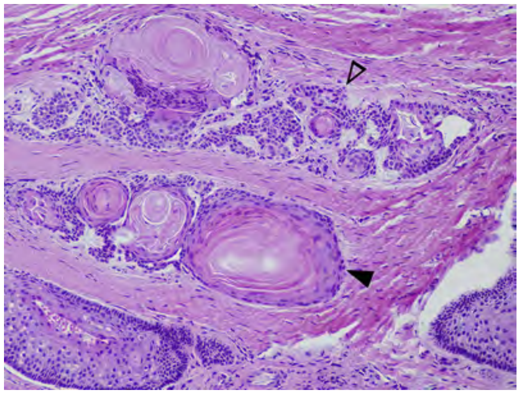

Fig. 14. Histology of keratocystic odontogenic tumor. Note the "daughter" cysts (*dark arrowhead*) and the epithelial rests (*open arrowhead*), both of which may lead to a recurrence (hematoxylin-eosin, original magnification ×200).

curette or enucleate the smaller tumors. This surgery is then followed by a local peripheral ostectomy. When combined with well-programmed follow-up, these same investigators feel they can duplicate the recurrence rates described in those tumors treated with resection. It should be noted, however, that such limited surgery is advocated only in the mandibular ameloblastomas. Maxillary ameloblastomas always need radical resection to prevent recurrence in the skull-base skeleton. Although most solid/multicystic ameloblastomas are not life-threatening, one should always take into account that this tumor is a persistent, infiltrating lesion that can ultimately kill the patient as the ameloblastoma extends into vital structures.

The unicystic ameloblastoma is separated from the more common solid/multicystic variety based on its clinical and radiographic presentation as well as its histology. In addition, in most cases, the surgical treatment approach is quite different.

The unicystic ameloblastoma likely arises from the epithelial wall of an odontogenic cyst, most commonly the dentigerous cyst. They are usually seen in a younger age group with most identified in the second and third decades of life. Ninety percent are found in the mandible with most of these seen in the third molar area. Almost all unicystic ameloblastomas are found incidentally on imaging studies, as they are uniformly asymptomatic.

Radiographically the unicystic ameloblastoma almost uniformly appears as a dentigerous cyst (Fig. 19). The few that are not related to an impacted tooth resemble a primordial or residual cyst. The margins of this unilocular radiolucency are distinct and well corticated, with only occasional cortical erosion noted.

There are 3 histologic variants of the unicystic ameloblastoma: the luminal, the intraluminal, and the mural or transmural types. In the luminal variant, the tumor is confined to the luminal surface of epithelial cyst wall (Fig. 20), whereas in the intraluminal type the tumor cells grow into the lumen of the cystic cavity (Fig. 21). The mural type of unicystic ameloblastoma is the third variant and is probably the most common. In this variant, the tumor cells infiltrate into and often through the fibrous cyst wall (Fig. 22).

Both the luminal and the intraluminal unicystic ameloblastoma are treated with simple enucleation, as is used in the dentigerous cyst. The pathologist must then examine the entire wall of the surgical specimen to rule out the possibility of a mural component. The mural unicystic

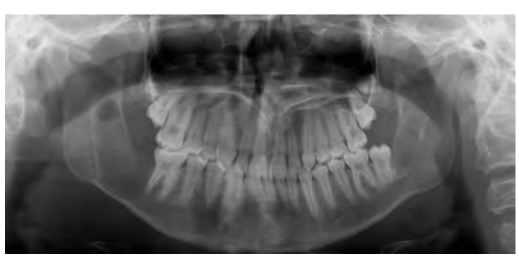

Fig. 15. Basal cell nevus (Gorlin) syndrome. Note the multiple jaw cysts.

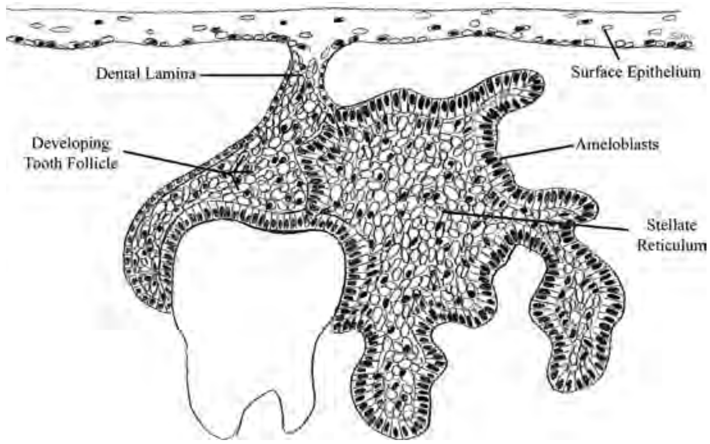

Fig. 16. Developing ameloblastoma. Note the cellular origin similar to that of a dentigerous cyst.

ameloblastoma should be treated as if it represents the more common solid/multicystic ameloblastoma. The early publications describing the treatment of the unicystic ameloblastoma showed little in the way of recurrence. Later articles demonstrate a behavior that may be much more aggressive than earlier thought.

The ameloblastic fibroma is an example of a "mixed" odontogenic tumor. Such a neoplasm has both epithelial and ectomesenchymal components. In this case, elements that resemble the ameloblasts as well of those they resemble the dental papilla are seen. The thought is that the ameloblastic fibroma arises from both of these cell lines derived from a developing tooth.

The ameloblastic fibroma is a tumor of younger people and, as such, is usually seen in the first 2 decades of life. As with many odontogenic tumors, these lesions for the most part arise in the third molar area of the mandible, although they are seen in all areas of both jaws.

Radiographically the ameloblastic fibroma presents as a unilocular or multilocular radiolucency that is clinically asymptomatic. More than two-thirds are seen associated with an impacted tooth; most commonly a wisdom tooth.

Histologically, one identifies the stellate cells of a loosely arranged network, which resembles the developing dental papilla, and occasionally the dental pulp of an adult tooth. The epithelial component resembles the ameloblast and is often arranged in cords or clumps (Fig. 23).

Fig. 17. Ameloblastoma CT. Note the multilocular expansive lesion of the mandible.

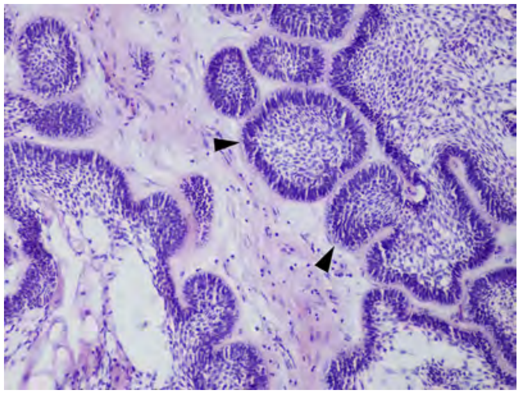

Fig. 18. Histology of ameloblastoma. Note the tumor islands with prominent ameloblastlike columnar cells (*arrowheads*) (hematoxylin-eosin, original magnification ×200).

Curettement has long been the treatment of choice along with the sacrifice of the associated developing tooth. Recurrence rates have been less than 15%. More recent literature has described a higher rate of almost 45%. Still, most authors will primarily use conservative treatment, with more radical surgery reserved for recurrent lesions.

The odontogenic myxoma is a rare odontogenic neoplasm that is of a pure ectomesenchymal origin. It is a completely benign tumor but with growth characteristics similar to the more common solid/multicystic ameloblastoma. This tumor is also a tumor of younger people, with an average age of 25 to 30 years. As with most odontogenic tumors, the myxoma is found most commonly in the third molar area of the mandible but unlike many others, is also frequently seen in the anterior jaws. Similar to most odontogenic tumors, the odontogenic myxoma is predominately asymptomatic and often found on routine imaging studies.

Radiographically the myxoma is for the most part multiloculated, but occasional unilocular lesions are seen as well. The tooth roots can be eroded or displaced depending on the aggressiveness of the specific lesion. This pure radiolucent tumor often contains wisps of residual bone arranged at right angles, which produces the so-call "step-ladder" effect seen in imaging studies.

Histologically, the odontogenic myxoma is much like its cell of origin, the dental papilla or dental pulp, and, as such, appears as a loosely arranged, disorganized mass of stellate spindle cells arranged in a network of gelatinous myxoid tissue (Fig. 24). There is no capsule and thus margins are difficult to ascertain both clinically and under microscopy.

Treatment for smaller odontogenic myxomas is curettement with a very close follow-up needed. More aggressive resection with 1.0-cm to 1.5-cm margins is indicated for larger lesions and for those lesions of the posterior maxilla. Recurrence is presented as approximately 25% with no metastases reported.

Cysts and tumors of odontogenic origin are rare but do develop in a small number of patients with retained or impacted wisdom teeth. Yet, when such lesions do develop, these tumors and their commonly used radical treatment often may frequently cause patients a lifelong persistent morbidity and occasionally a slow but relentless death.

Fig. 19. Unicystic ameloblastoma radiograph. Note the impacted wisdom tooth (*open arrowhead*) and the well-demarcated unilocular lucency (*dark arrowhead*).

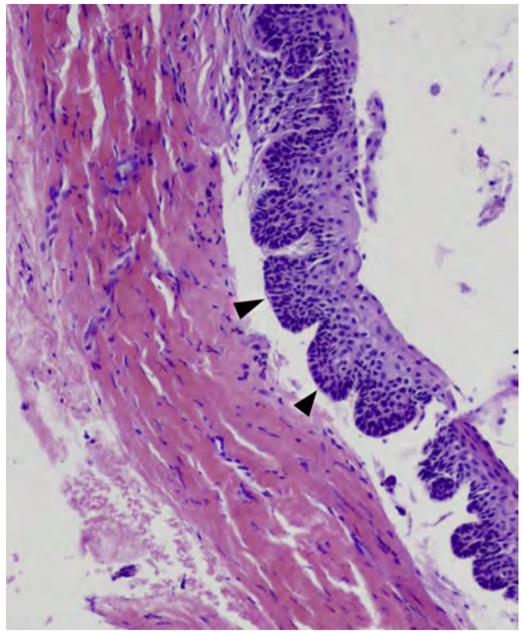

Fig. 20. Histology of luminal unicystic ameloblastoma. Note the ameloblastic change confined to the epithelial lining cells (*arrowheads*) (hematoxylin-eosin, original magnification ×200).

Retained wisdom teeth and mandible fractures

Recent literature points to the acceptance of the postulate that unerupted or impacted mandibular wisdom teeth can weaken the mandible and predispose it to traumatically induced fractures. Studies based on biomechanical models demonstrate that retained mandibular wisdom teeth weaken the mandibular angle by reducing bone mass in the area (Figs. 25 and 26).

The external oblique ridge provides strength to the angle area of the mandible. When a wisdom tooth is in occlusion, the widest part of the tooth supports the mandibular forces and allows the external oblique ridge to remain intact. If the tooth is impacted, the widest part of the tooth is below the ridge and thus the resultant tension line is interrupted. In this manner, the bony mandibular angle is weakened.

As the angle is weakened secondary to impacted wisdom teeth, it is postulated that the condyle/subcondylar area of the mandible is spared from many forces of trauma. In fact, several studies reveal that the mandibular condyle is at highest risk for fracture in the absence of impacted mandibular wisdom teeth. In fact, it appears that the mandibular condyle is 2.5 times more likely to fracture in the absence of impacted mandibular wisdom teeth.

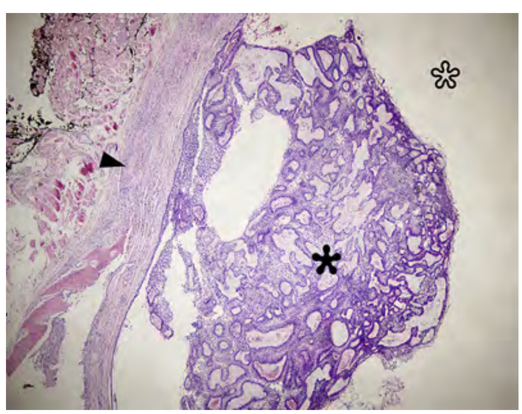

Fig. 21. Histology of intraluminal unicystic ameloblastoma. Note the outer fibrous wall (*arrowhead*), the intraluminal tumor (*dark asterisk*) and the cystic lumen (*open asterisk*) (hematoxylin-eosin, original magnification ×40).

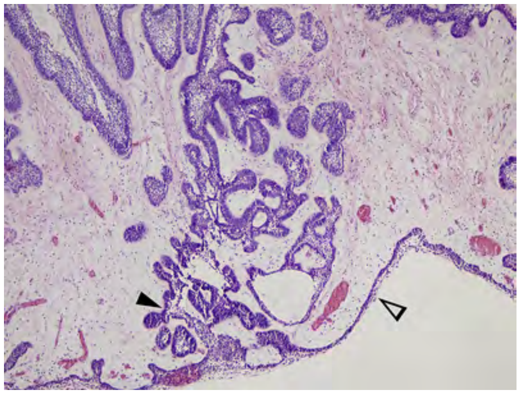

Fig. 22. Histology of mural unicystic ameloblastoma. Note the tumor invading the fibrous wall (*dark arrowhead*) and the uninvolved lumen of the tumor (*open arrowhead*) (hematoxylin-eosin, original magnification ×100).

Fractures of the mandibular condyle are much more difficult to reduce and thus it becomes difficult to predict excellent long-term success. This is in direct opposition to fractures of the mandibular angle, which for the most part are relatively easy to reduce anatomically with excellent long-term success. This postulate has led several investigators to suggest leaving impacted lower wisdom teeth, especially in males, such that trauma would result in angle fractures rather than those of the mandibular condyle.

A second question involving retained wisdom teeth arises when attempting to reduce mandibular angle fractures. The question of removing or leaving the wisdom tooth in situ when reducing the angle fracture is many years old and still without a definitive answer. Multiple investigators from several large trauma centers have presented their opinions. A definitive summary is difficult to ascertain from these writings, but it appears that if a wisdom tooth can be removed without displacing the fracture, this procedure should be entertained (Fig. 27). The alternative is that if the wisdom tooth is helping align the fracture, then it appears best to leave it in place (Figs. 28 and 29).

Dental caries

Dental caries or tooth decay is an irreversible bacterial-induced infectious process that causes demineralization of the calcified tooth elements, including enamel, dentin, and cementum. Following this demineralization, there is destruction of the organic tooth material and ultimately tooth death and/or infection. Even today, dental caries is one of the most common bacterial diseases in the world.

The 2 most common bacterial groups linked to dental caries are *Streptococcus mutans* and *Lactobacillus acidophilus.* These bacterial groups collect around the teeth and gingiva in a biofilm termed dental plaque. The bacteria appear to be acid formers in the presence of fermentable carbohydrate

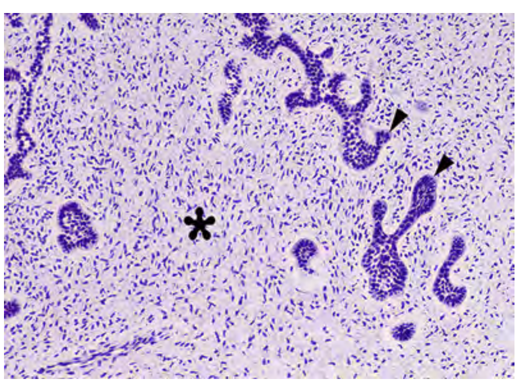

Fig. 23. Histology of ameloblastic fibroma. Note the epithelial derived ameloblastic islands (*arrowheads*) and the ectomesenchymal spindle-cell stroma (*asterisk*) (hematoxylin-eosin, original magnification ×200).

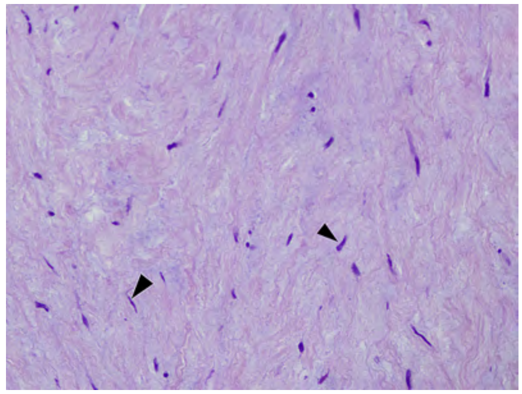

Fig. 24. Histology of odontogenic myxoma. Note the small spindle-shaped cells of the gelatinous stroma (*arrowheads*) (hematoxylin-eosin, original magnification ×200).

substrates, such as sucrose, fructose, and glucose, obtained from consumed food groups. The acids are contained in the pits and fissures of the teeth and thus produce demineralization of the teeth, leading to dental caries.

Saliva acts as a buffering agent to counteract the effects of the bacterial-induced acids and thus facilitates the decrease of dental caries. It appears that as long as there is adequate saliva production, the process of demineralization and remineralization of the teeth stays in equilibrium. When salivary flow is disrupted or decreased, the incidence of caries greatly increases.

For many years, the incidence of dental caries has been closely characterized by dentists, specialty dental groups, and many groups of epidemiologists. As prior collected data did not include wisdom teeth, it has not been until the last 8 to 10 years that the wisdom teeth have been included in such longitudinal epidemiologic studies. This newer data now demonstrate that 22% to 33% of young adults with wisdom teeth erupted to the occlusal plane will be affected by occlusal dental caries. It also appears that the age group older than 25 years will be more at risk.

Increased third molar caries of older age patients is certainly to be expected, as the wisdom teeth are the last teeth to erupt and do not erupt to the level of the occlusal plane until jaw growth is almost complete, which represents the late teens to the early 20s. Once this eruption is complete, dental caries takes time to develop in susceptible patients and even more so in patients exposed to fluoridated water supplies. Rarely is dental caries seen involving a wisdom tooth unless there is caries experience in an adjacent first or second molar tooth. In fact, less than 5% of third molar caries is seen in patients without caries affecting an adjacent molar in the same quadrant.

Risk factors involving wisdom teeth and dental caries have only recently been postulated. It appears that Caucasians are more likely to demonstrate third molar caries than are African Americans. Also, patients with greater than a high school education, those who live in an urban environment, and those who underwent a dental visit within the past 3 years are also more likely to experience increased third molar caries.

After reviewing this current published material, it appears that there is now more uncertainty than ever before on the part of the dental clinician as to the most appropriate treatment of wisdom teeth. The anatomic locations of third molars make dental restoration more technically complicated. This, when coupled with the fact that most patients perform inadequate dental care of these teeth, means

Fig. 25. Angle fracture of the mandible. Note its proximity to the impacted wisdom tooth (*arrowhead*).

Fig. 26. Pathologic fracture of the mandibular angle. Note its relationship to the wisdom tooth socket (*arrowhead*).

that it is likely that wisdom teeth exhibiting dental caries will need multiple restorative procedures over a lifetime. As such, a large number of general dentists will suggest removal of these teeth before any such adjacent restoration projects.

Periodontal disease

Periodontal disease is a specific and well-known localized condition that affects 1 or more of the periodontal tissues, including the alveolar bone, the periodontal ligament, the cementum, or the gingiva. Some investigators propose that to progress toward advanced periodontal disease, gingivitis must first be present. Others disagree and feel that advanced periodontal disease and its sequelae are not based on gingivitis as the presenting problem.

In any event, it does appear that periodontal disease clinically presents in stages based on the types of inflammatory mediators present. As with most inflammatory diseases, the first cell present is the polymorphonuclear leukocyte. These cells are followed by lymphocytes and finally by plasma cells. All of these inflammatory cells act in conjunction with the oral biofilm, dental plaque. The soft tissue surrounding the teeth is attacked first with the development of periodontal pockets and gingival ulcerations. Ultimately, there will be destruction of alveolar bone and periodontal ligament with loss of vertical and horizontal bone, as well as loosening of the teeth. Finally, the teeth will be lost with surrounding marrow fibrosis.

The bacteria principally responsible for most periodontal disease are anaerobic, with more than 250 species identified. The most commonly identified organisms are complexes of *Bacteroides forsythus, Porphyromonas gingivalis,* and *Treponema denticola.* It appears that the deeper these bacteria are found in periodontal pockets, the greater the chance for progressive periodontal disease. Initially, these bacterial complexes are encased in dental plaque, which for the most part is primarily responsible for the initiation of periodontal disease, although there are systemic factors also involved. It is now recognized that periodontal disease is not a single disease state but a combination of multiple disease processes that together share common clinical manifestations.

Wisdom teeth after eruption are often difficult to keep clean and, as such, periodontal pathogens accumulate in the area. Because of the virulence of these pathogens when they occur in this area, the periodontal inflammation is self-perpetuating. If one adds in the altered host's cellular and humeral responses seen in systemic disease, such as diabetes mellitus, the degree of destruction produced by

Fig. 27. Angle fracture of the mandible. Note the wisdom tooth location making it impossible to adequately reduce without removing the tooth (*arrowhead*).

Fig. 28. Angle fracture of the mandible. Note the wisdom tooth location allowing easy reduction of the fracture without removing the tooth (*arrowhead*).

these bacteria becomes self-evident. In fact, the prime candidate for such a scenario is the third molar area, particularly the area of the mandibular wisdom tooth. Not only is this area very difficult to clean, the adjacent thick cortical bone shelf lends itself to the accumulation of dental plaque and the ensuing inflammation.

Increased gingival probing depth is a determinant for the initiation and/or progression of periodontal disease and ultimately loss of teeth and alveolar bone. Recent long-term longitudinal studies have shown that almost 25% of patients with retained and asymptomatic wisdom teeth had probing depths of at least 5 mm on the distal of the second molar and the mesial of the third molar. Also shown was the finding of the probing depths in these areas increased in a relatively short period of time when compared with other erupted teeth. Such studies show that both impacted and fully erupted but asymptomatic wisdom teeth have increased probing depths and may actually demonstrate active inflammatory periodontal disease.

A very recent project analyzed the periodontal data of the third molar site before and after the removal of the wisdom tooth. The prevalence of periodontal inflammatory disease on the distal of the maxillary and mandibular second molars was decreased from 77% before surgery to 23% following removal of the wisdom tooth. This study was primarily in younger patients. In other studies, it appears that removal of wisdom teeth in older patients with preoperative deep pockets on the distal of their second molars did not demonstrate the same pocket resolution as did the younger population. After review of all the available studies, it appears that removal of wisdom teeth at a young age will aid in deceasing the pocket depth and thus periodontal disease involving both maxillary and mandibular second molars.

Studies within the past 15 years have shown that there is a significant relationship between periodontal disease and systemic health. Research has focused on inflammatory periodontal disease and systemic problems, including major cardiovascular disease, diabetes, respiratory disease, and adverse pregnancy outcomes. It appears that patients with more advanced periodontal disease also demonstrate much thicker-walled carotid arteries and that these arteries contain antigens arising from pathogenic periodontal bacteria. Studies also show diabetic patients with severe periodontal disease also exhibit poorer glycemic control than those without such oral disease. The connection between pulmonary disease and periodontal disease is evident. Patients with recurring bacterial pneumonia and/or advanced chronic obstructive pulmonary disease are often related to periodontal changes. It appears that pulmonary pathogens, such as *Pseudomonas aeruginosa,* colonize the gingiva of patients with active periodontal disease. These bacteria are then commonly released into the saliva and aspirated back into the lungs with resultant recurrent pneumonia. In addition, there has been early work

Fig. 29. Well-reduced mandibular angle fracture while leaving wisdom tooth in place. Note the internal fixation plate (*arrowhead*).

describing the fact that periodontal pathogens travel from the gingival sulcus to the placenta, which in turn may stimulate preterm birth. Many of these studies and others like them are continuing at this time, and hopefully in time will decrease the ability of periodontal disease to affect the systemic health of patients.

Summary

It is projected that approximately 95% of US 18-year-olds have wisdom teeth and that many are nonfunctional. It is estimated that almost 60% of this patient group will develop some type of pathology including caries, periodontal disease, or pericoronitis. In addition, according to the scientific literature, wisdom teeth also adversely affect some orthodontic movements, allow the development of odontogenic tumors and cysts, and/or alter the mechanisms of mandibular fractures. Additional information describes much of this pathology, occurring in the presence of clinically asymptomatic wisdom teeth rather than occurring in the more symptomatic cases.

There may always be a debate regarding the removal of asymptomatic wisdom teeth but, on scientific review of many related articles, one becomes acutely aware that asymptomatic often does not mean there is no disease present when discussing retained wisdom teeth or third molars. Ultimately, the treatment decision regarding retained wisdom teeth will be with the treating dentist or surgeon. These decisions will be multifactorial and involve many considerations of present pathology, as well as the possible development of significant future pathology. Such choices should be predictable if one couples current medical knowledge with a thorough clinical appraisal of the patient.

Acknowledgments

The author thanks Dr Samantha Evans for her invaluable help in the preparation of this article. In addition, Dr Evans took time away from her busy pathology residency program to add the artistic renderings presented here.

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Atlas of the Oral and Maxillofacial Surgery Clinics

Surgical Management of Third Molars

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The removal of impacted third molars teeth is one of the most common surgical procedures performed by oral and maxillofacial surgeons. In large part this is because of the high incidence of impacted teeth in modern societies that have effective public health measures and because contemporary science has identified the presence or likely development of pathology associated with a significant percentage of even asymptomatic third molars.

Eruption/impaction of third molars

- A tooth is impacted when it has failed to fully erupt into the oral cavity within its expected developmental time period and cannot reasonably be expected to do so.
- The most significant variable associated with third molar impaction is inadequate hard tissue space, with impacted third molars having space/crown width ratios of less than 1.
- The position and disposition of unerupted teeth is dynamic and unpredictable, with changes in position occurring well beyond the middle of the third decade.
- Proper periodontal support is not ensured even with eruption to the occlusal plane.
- Because there is no completely reliable way to predict pathologic changes associated with impacted teeth, they should be monitored periodically with clinical and radiographic examinations if a decision is made for retention.

A systematic preoperative clinical and imaging evaluation is critical in determining the need for and surgical approach to the removal of impacted third molars.

Classification of impacted teeth

A variety of classification systems have been developed and assess the angulation of the impacted third molar, the relationship of the impacted tooth to the anterior border of the ramus and second molar, and the depth of the impaction. Examples of various impaction types are seen in Figs. 1–6.

Several factors have been implicated in making the extraction process more complex are root morphology, the presence of a follicular sac (which provides more room for access to the tooth), and the position/condition of adjacent structures, such as the second molar.

Pell and Gregory Classification of Impacted Mandibular Third Molar Teeth

Based on relationship of anterior border of the ramus to teeth:

Class I: mandibular third molar has sufficient room anterior to anterior border of ramus to erupt
Class II: half of the impacted third molar is covered by the ramus
Class III: the impacted third molar is completely embedded in the ramus of the mandible

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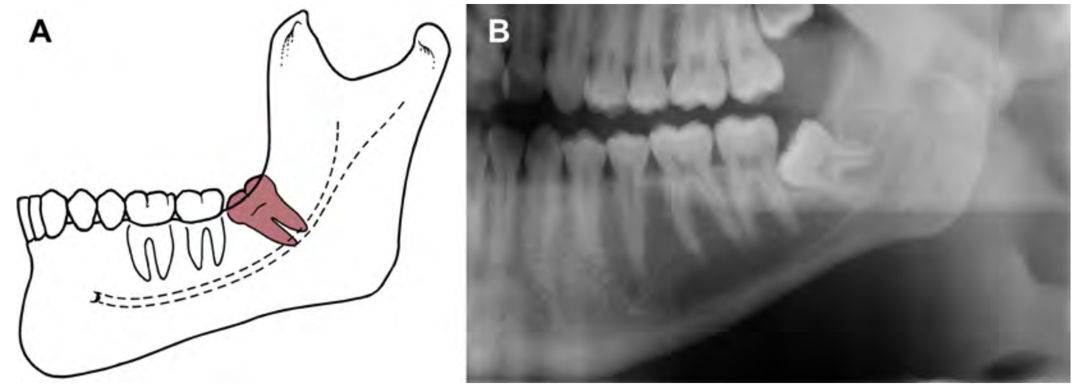

Fig. 1. Classification of impacted third molars according to angulation. This classification describes the angulation of the long axis of the impacted third molar with respect to the long axis of the second molar. (*A*) Mesioangular mandibular impaction—most common and easier impaction to remove. (*B*) Radiograph of mesioangular impacted mandibular third molar. ([*A*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

Pell and Gregory Classification of Impacted Maxillary Third Molar

Based on relationship of occlusal plane of second and third molars:

Class A: occlusal plane of third molar is the same as the second molar
Class B: occlusal plane of third molar is between the occlusal plane of the second molar and its cervical line
Class C: occlusal plane of the third molar is above the cervical line of the second molar

Winter Classification of Impacted Third Molars

Based on radiographic appearance of the third molar and its anatomic position in relation to the long axis of the adjacent second molar:

Mesioangular
Distoangular
Vertical
Horizontal
Buccoangular
Linguoanglar
Inverted

Other systems focus on the degree of impaction and the position of the tooth relative to the overlying tissues (soft and/or hard) (Figs. 7–12).

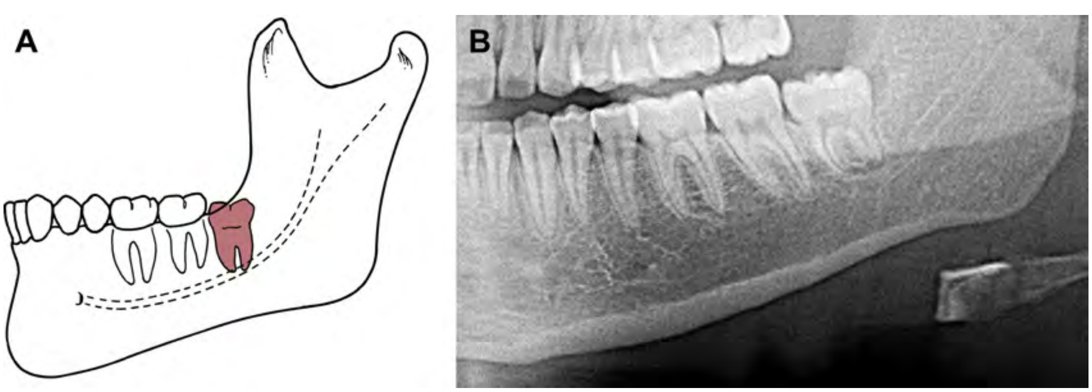

Fig. 2. (*A*) Vertical mandibular impaction—second most common mandibular third molar impaction. (*B*) Radiograph of vertical impacted mandibular third molar. ([*A*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

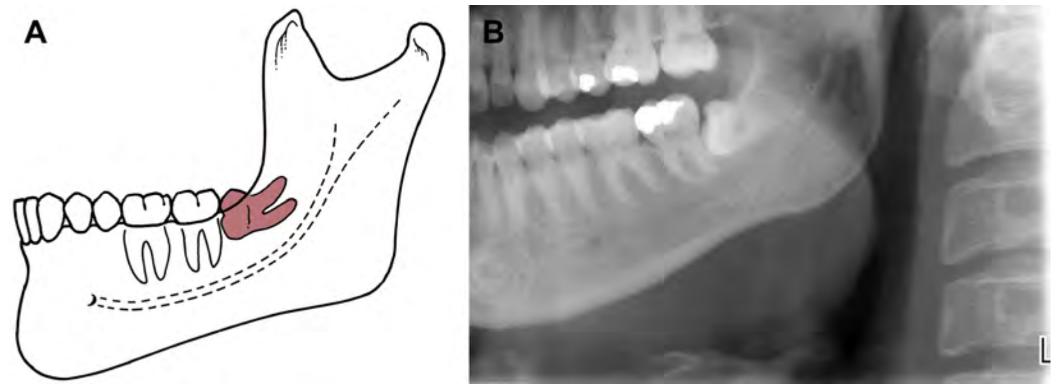

Fig. 3. (*A*) Horizontal mandibular impaction—uncommon and more difficult to remove than a mesioangular impaction. (*B*) Radiograph of horizontal impacted mandibular third molar. ([*A*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

American Dental Association Definitions

Removal impacted tooth–soft tissue: D7220

Occlusal surface of tooth covered by soft tissue: requires mucoperiosteal flap elevation

Removal impacted tooth–partially bony: D7230

Part of crown covered by bone; requires mucoperiosteal flap elevation and bone removal

Removal impacted tooth–completely bony: D7240

Most or all of crown covered by bone; requires flap elevation and bone removal

Removal of impacted tooth–completely bony with unusual surgical complications: D7241

Most or all of crown covered by bone; unusually difficult or complicated due to factors, such as nerve dissection required, separate closure of maxillary required, or aberrant tooth position

Decision making for the removal of third molars

- The decision to remove an impacted tooth must be based on a careful evaluation of the potential benefits versus risks of treatment.
- In situations in which pathology is easy to identify, decision making is straightforward.
- It is often wise to remove third molars before the development of pathology and associated symptoms when the development of such is likely and at an age when surgery is straightforward.

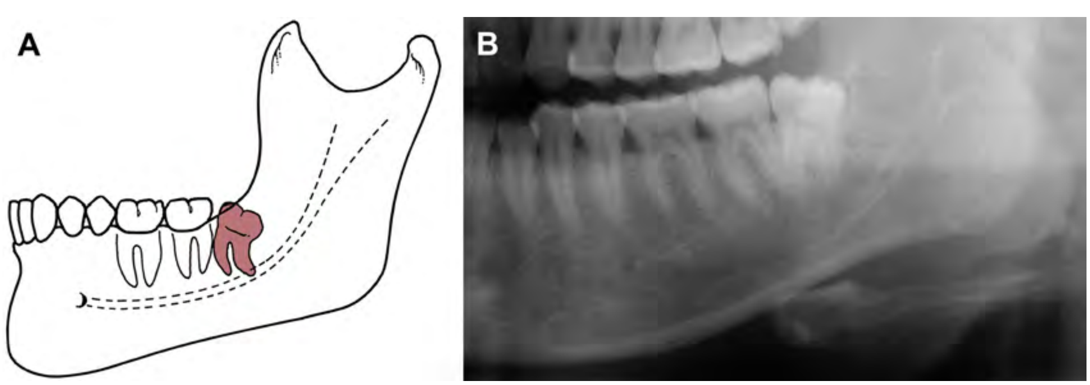

Fig. 4. (*A*) Distoangular mandibular impaction—uncommon and most difficult to remove of the 4 types of mandibular third molar impactions. (*B*) Radiograph of distoangular impacted mandibular third molar. ([*A*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

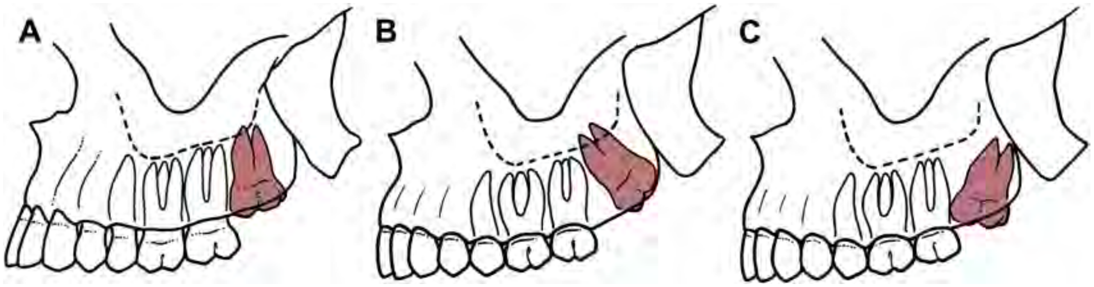

Fig. 5. (*A*) Vertical impaction of maxillary third molar—most common maxillary third molar impaction. (*B*) Distoangular impaction of maxillary third molar. (*C*) Mesioangular impaction of maxillary third molar. ([*C*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

- There are situations in which removal of impacted teeth is contraindicated, including advanced patient age, poor health, and potential for damage to adjacent structures.

Surgical management

As with all invasive procedures, proper planning and respect of basic principles of surgery allow surgeons the best opportunity to execute the procedure effectively and efficiently. In the process, a surgeon does well to understand the unique environment of the third molar and how it has an impact on the surgical approach to be used.

Anatomic Considerations/Mandibular Teeth

- There is relatively dense overlying with nearby muscle attachements.
- Lingual nerve may be intimately associated with the lingual cortical plate in as many as 25% of cases and may be located above the alveolar crest in 10% to 15% of patients.

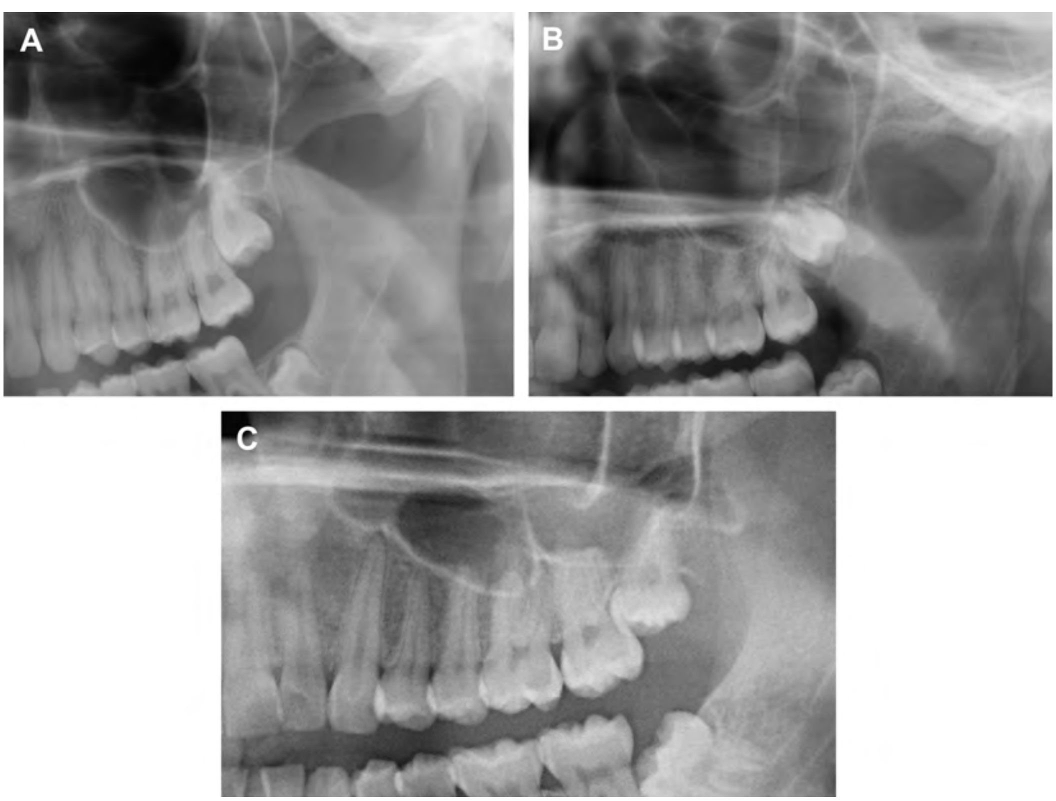

Fig. 6. (*A*) Vertical impaction of maxillary third molar. (*B*) Distoangular impaction of maxillary third molar. (*C*) Mesioangular impaction of maxillary third molar.

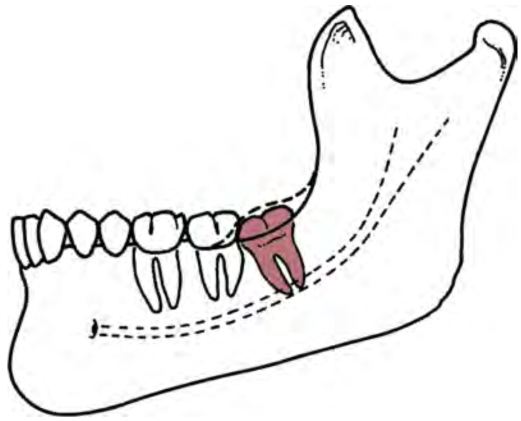

Fig. 7. Classification of impacted third molars according to the type of overlying tissue. This includes 3 types of impactions: (1) soft tissue impaction, (2) partial bone impaction), (3) full bone impaction. Soft tissue impaction in which the height of the tooth's contour is above the level of the alveolar bone. (*Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

- Inferior alveolar nerve may be associated with roots of third molars. Recognized indicators of increased risk include
  - Diversion of inferior alveolar canal
  - Darkening and narrowing of the third molar root
  - Interruption of the cortical line(s)
- Buccal artery may be encountered when creating a releasing incision, leading to bothersome bleeding during the early portion of the procedure and/or prolonged oozing postoperatively.
- Proximity to the submandibular and pterygoid spaces could allow for displacement through the thin lingual plate into these spaces.

Anatomic Considerations: Maxillary Teeth

- Buccal fat pad may be encountered with releasing incision.
- Morphology of the tuberosity may allow fracture or tearing of palatal mucosa.
- Generally thin bone posteriorly separates tooth from the infratemporal fossa.
- Anteriorly/superiorly separates from the maxillary sinus.
- Thin overlying bone with elastic bone surrounding.

A common clinical problem associated with third molars is pericoronitis. Pericoronitis is an inflammatory/infectious process that frequently involves mandibular third molars and is one of the most common reasons to remove such teeth. The most common cause is inadequate physiologic space for the eruption and maintenance of the tooth.

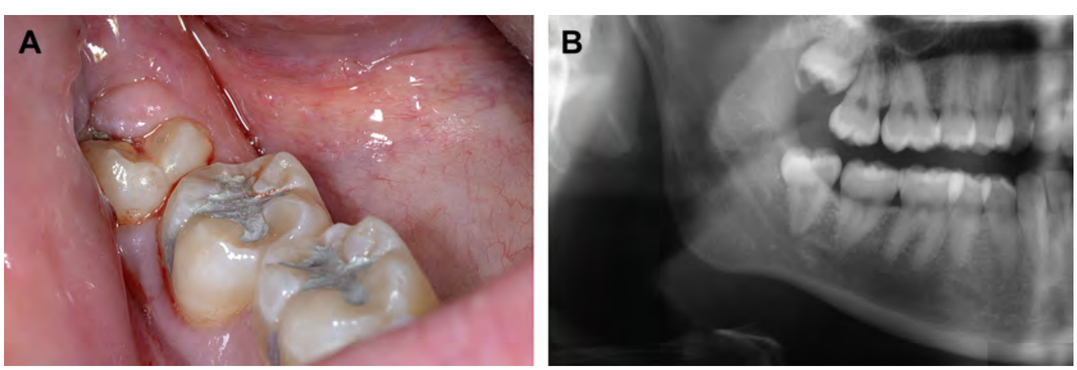

Fig. 8. (*A*) Soft tissue impacted mandibular third molar. (*B*) Radiograph of soft tissue impacted mandibular third molar.

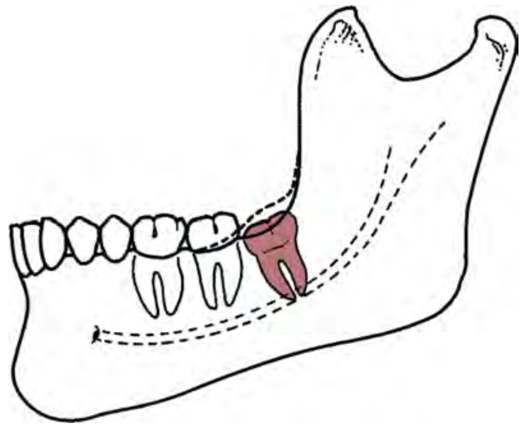

Fig. 9. Partial bone impaction in which the superficial portion of the tooth is covered by soft tissue, but the height of the tooth's contour is below the level of the adjacent alveolar bone. (*Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

Management of Pericoronitis

- Débridement and disinfection of the pocket with an irrigating solution, such as chlorhexidine or hydrogen peroxide.
- Removal of opposing third molar (usually maxillary).
- Consider antibiotic therapy.
- Prevention of recurrence achieved by removal of the involved third molar.
- Although operculectomy has been recommended by some clinicians, soft tissue redundancy usually recurs secondary to inadequate space for eruption and poor soft tissue quality.

General approach for removal of third molars

Once a decision has been made to remove an impacted third molar, the operator must decide which technique and management strategies will provide the best opportunity for an optimal outcome. As with any surgical procedure, careful planning and gentle tissue management are necessary to ensure optimal outcomes. Prior to beginning the procedure, the surgeon must have in mind a step-by-step approach for each tooth with contingency plans if unanticipated problems arise. The strategy for each tooth should be individualized to limit trauma to the residual tissues.

The surgical approach should allow ample access to the underlying bone and tooth through a properly designed and retracted soft tissue flap. Bone removal follows and should be accomplished in an atraumatic and aseptic manner. When necessary, the tooth is then divided and delivered with elevators. Any residual follicle is curetted and removed with a rongeur. A bur or file should be used to smooth any rough sharp edges of the bone and the site thoroughly débrided mechanically and by

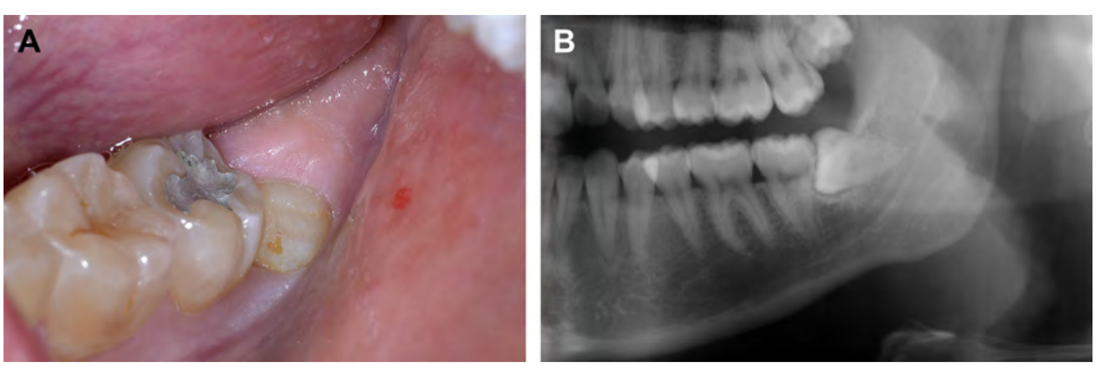

Fig. 10. (*A*) Partial bone impacted mandibular third molar. (*B*) Radiograph of partial bone impacted mandibular third molar.

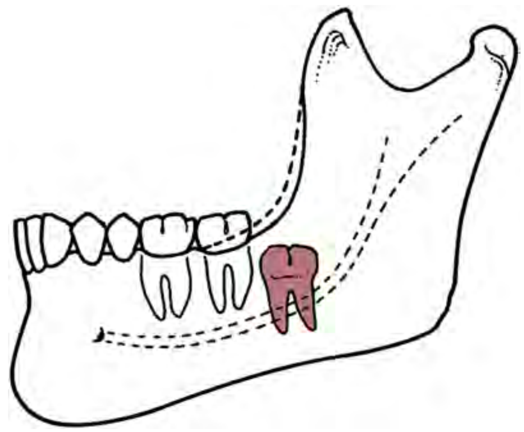

Fig. 11. Complete bone impaction in which the impacted tooth is completely encased in bone. The complete bone impaction is often the most difficult to remove. (*Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

irrigation to provide an optimal environment for healing. Soft tissue closure to restore anatomic integrity completes the procedure.

When there is a periodontal pocket with loss of attachment before the removal of an impacted third molar, the operator should take advantage of the access gained during the procedure to clean the exposed surface of the adjacent second molar.

Soft Tissue Flaps

The soft tissue flap should be one that allows adequate access to the underlying bone and tooth with the degree of soft tissue reflection depending on the depth and type of impaction, quantity of bone removal required, and position of nearby structures.

Several incision designs, each with variations, have been described for accessing mandibular third molars (Figs. 13–15). Many clinicians suggest that an envelope flap is preferred for straightforward impacted third molars with a releasing incision used to gain greater access necessary for removal of more deeply impacted teeth. In the end, the choice depends more on operator preference than published science.

Other details, such as whether to include a papilla in the flap to allow the surgeon to accurately replace and immobilize the flap or whether to leave a rim of attached tissue around the distal of the second molar, are also a matter of surgeon preference.

Once a flap design has been selected, the soft tissue incision should be made with a sharp blade to minimize muscle tearing. Retraction of the flap should protect underlying structures with care taken to avoid excessive retraction that would increase edema and postoperative complications. Although consideration should be given to limiting flap retraction, however, this must not occur at the expense of compromising surgical access or a result in tearing of the flap.

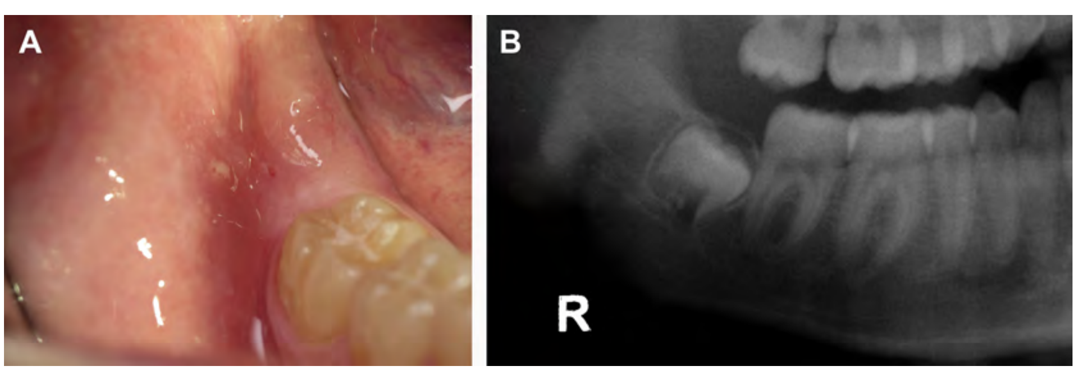

Fig. 12. (*A*) Complete bone impacted mandibular third molar. (*B*) Radiograph of complete bone impacted mandibular third molar.

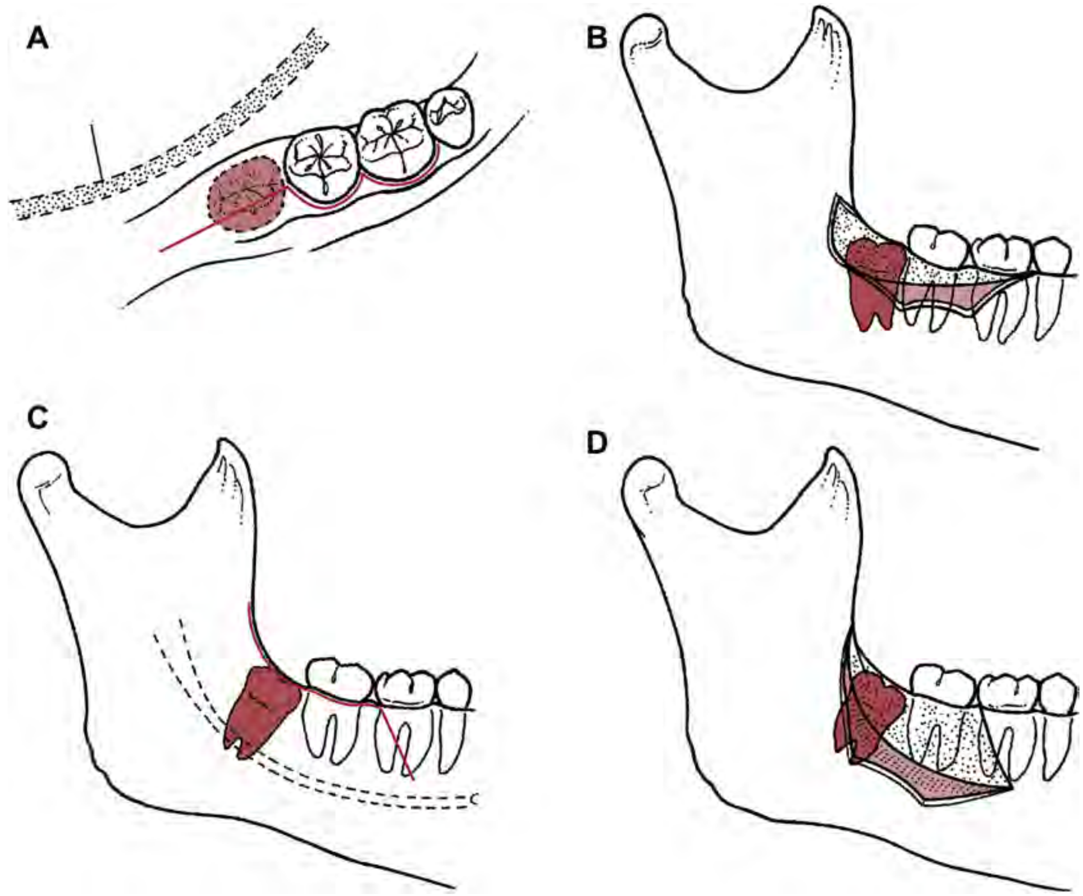

Fig. 13. (*A*) Envelope incision is commonly used to reflect soft tissue for the removal of impacted mandibular third molars. The posterior extension should diverge laterally to avoid injury to the lingual nerve. (*B*) Envelope incision, soft tissue is reflected laterally to expose bone overlying the impacted tooth. (*C*) Three-cornered flap incision, alternative flap whereby a releasing incision is made at the mesial aspect of the second molar. (*D*) Three-cornered flap, lateral reflection of soft tissue exposing bone overlying the impacted tooth. ([*D*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

Closure should be accomplished with the minimal number of sutures necessary to achieve primary closure after irrigation with sterile water or other appropriate agent to remove any osseous and/or tooth chips.

Removal of a distal triangular piece of tissue (distal wedge) is advocated by some surgeons in an effort to eliminate hyperplastic tissue that could contribute to pseudopockets. They believe this allows for better closure with reduced tissue height and improved drainage to lessen postoperative edema.

When there is a periodontal pocket with loss of attachment before the removal of an impacted third molar, it is advisable to take advantage of the access gained during the procedure to instrument and clean the exposed surface of the adjacent second molar.

Flap designs

- Envelope flap*—incision made over crest of the ridge and extended anteriorly around the necks of the adjacent tooth or teeth
- Hockey stick flap*—incision made over crest of the ridge to the distal of the second molar with a releasing incision into the buccal vestibule
- Comma flap—incision made around distal of the second molar, extended into the buccal vestibule and curved posteriorly at its tail

*The posterior leg of the envelope and hockey stick incisions should extend along the lateral aspect of the posterior body/ramus as the mandible diverges laterally.

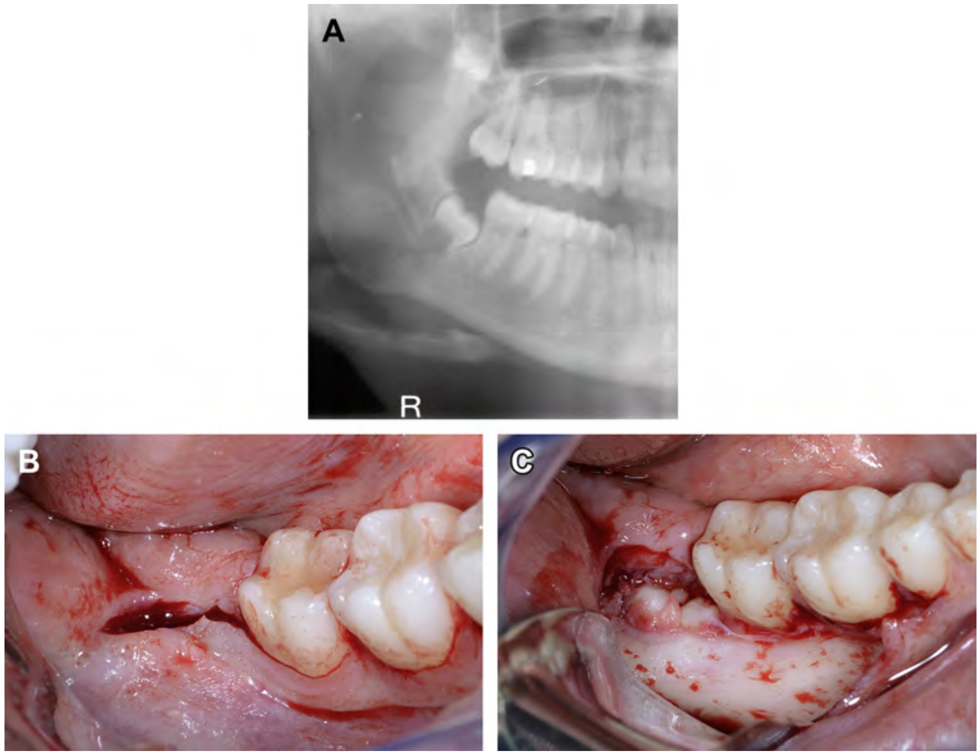

Fig. 14. (*A*) Radiograph of impacted mandibular right third molar. (*B*) Envelope flap with posterior divergent lateral incision. (*C*) Envelope flap, soft tissue reflected laterally.

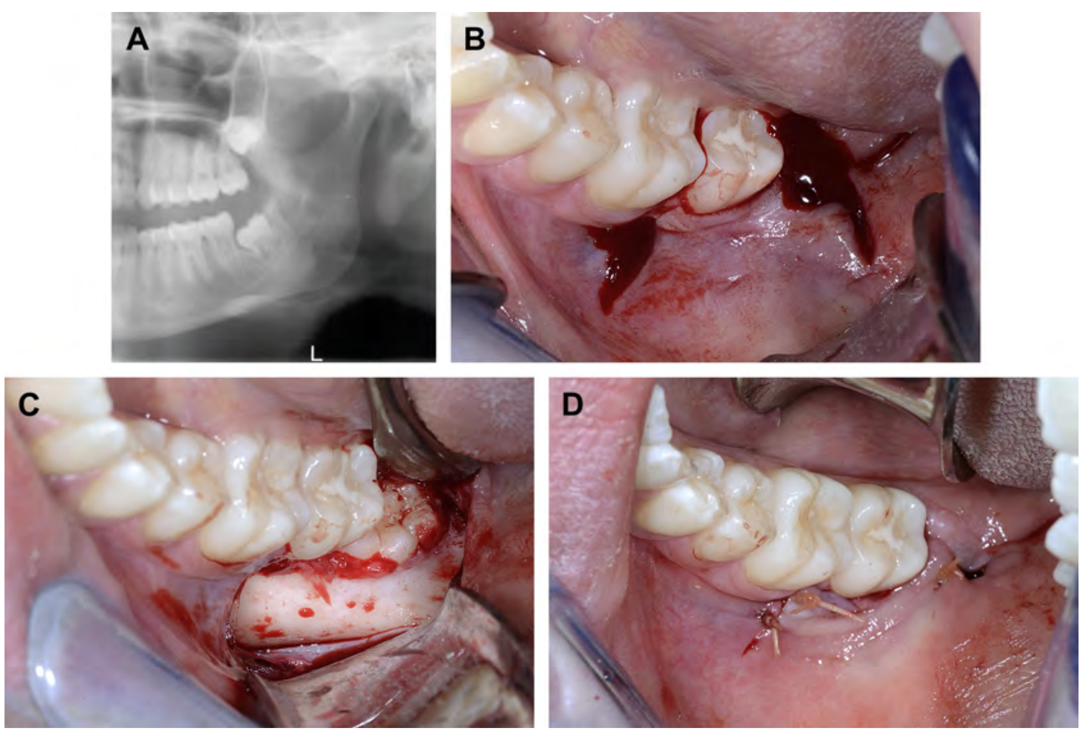

Fig. 15. (*A*) Radiograph of impacted mandibular left third molar. (*B*) Three-cornered flap with anterior vertical release and posterior divergent lateral incisions. (*C*) Three-cornered flap, soft tissue reflected laterally. (*D*) Three-cornered flap sutured.

Bone removal

Removal of bone around the third molar allows access for removal. Most surgeons use a high-speed, low-torque, air-driven hand piece that exhausts air away from the site to prevent tissue emphysema or air embolism, although a few surgeons prefer to use a mallet and chisel.

- Most commonly used burs to remove bone include #6 or #8 round or fissure bur.
- Amount of bone removed varies based on tooth position and anticipated number of parts the tooth is to be sectioned into.
- In general, bone on the occlusal, buccal, and, cautiously, on distal of the impacted tooth is removed to or near the cervical margin of the tooth.
- Removal of bone on the lingual of the mandible avoided because of the possibility of damage to the lingual nerve.
- Given the thin/soft nature of overlying osseous tissue in the maxilla, bone is commonly removed with an elevator or similar instrument using hand pressure.

Tooth sectioning

Sectioning is most commonly performed with a hand piece and bur because it allows a predictable plane of sectioning, although some surgeons use a mallet and chisel for the same purpose. In general, the tooth is cut two-thirds to three-quarters of the way through to the lingual aspect with splitting the remainder of the way with a straight elevator or the like. Limiting the depth of the bur cuts prevents injury to the lingual cortical plate and reduces possibility of damage to the lingual nerve.

Strategies for the location for sectioning should be a part of the preoperative planning and may vary from operator to operator and tooth to tooth. At times, all or a portion of the crown is removed from the associated root complex, although often the tooth is hemisected through the buccal groove to allow sectioning into mesial and distal crown/root segments.

Once the crown has been exposed, the crown is sectioned according to plan. When the section is along the buccal groove, it is important to extend into the furcation if possible so that the root can be removed with the crown. Despite best-laid plans, however, at times the split may be incomplete and require further sectioning.

Purchase points may be used to remove residual roots or even portions of the crown.

Removal of impacted mandibular third molars

The approach to remove an impacted mandibular third molar depends on a variety of factors, including depth and position of impaction as well as the size and morphology of the roots. Even then, variations in strategies and techniques have been described and are acceptable. Such variations include the amount and location of bone to be removed and the lines for sectioning of the tooth (Figs. 16–27).

The following represent some examples of how mandibular impacted third molars may be approached.

Mesioangular Impactions

Mesioangular impactions tend to be among the least difficult to remove. After sufficient occlusal, buccal, and, as necessary, distal bone has been removed, the distal portion of the crown is sectioned along the buccal groove to below the cervical line and, if possible, into the furcation. This portion of the tooth is delivered with an elevator of choice. The remainder of the tooth is then delivered with an elevator placed at the mesial aspect of the crown placed at or near the cervical line. Some operators create a purchase point with a drill and use a crane pick or other pointed elevator to deliver the fragment. In the case of mesioangular impactions that are in a more upright position, removal of a limited amount of distal bone may allow elevation without the need for sectioning. With teeth that are more highly angulated, sectioning becomes more necessary.

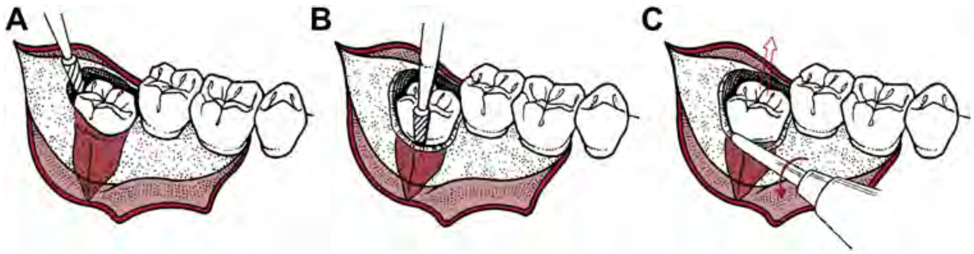

Fig. 16. Surgical removal of impacted teeth. (*A*) Soft tissue flap reflected to expose vertical impacted tooth. If bone is overlying occlusal surface then remove bone with a fissure bur. (*B*) Bone along the buccodistal aspect of the crown of a vertically impacted tooth is removed to the cervical line with a fissure bur. (*C*) The edge of a small straight elevator is placed in the buccal groove of bone and rotated to elevate the tooth upward. ([*C*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

Horizontal Impactions

Horizontal impactions usually require removal of more bone than mesioangular impactions. After removal of occlusal and buccal bone, the crown is sectioned at the level of the cementoenamel junction and separated from the root portion with a straight elevator. The crown is removed to expose the root fragment(s). The root portion(s) is then removed individually or together as necessary.

An alternative approach involves sectioning the crown along the buccal groove to separate the tooth into mesial and distal components. The distal portion is elevated first with its root if possible. An elevator is then used to remove the residual mesial fragment, again with its associated root if possible. If necessary, any root fragment that broke from the crown is removed with a thin straight or pointed elevator.

When horizontal impactions are tightly opposed to the adjacent second molar, it is important to get adequate osseous removal without endangering the distal aspect of the second molar tooth.

Vertical Impactions

The procedure for bone removal and sectioning is similar to that for mesioangular impactions in that occlusal, buccal, and limited distal bone is removed first. The distal half of the crown is sectioned and removed. The tooth is then removed with an elevator positioned at the mesial aspect of the cervical line. The option of preparing a purchase point in the tooth can be used. In some cases, sectioning of the crown horizontally from the roots can be used with elevation of the roots as a whole or separately, depending on their morphology.

Distoangular Impactions

Removal of this impaction is difficult because more distal bone must be removed and the tooth tends to want to be delivered posteriorly into the ramus portion of the mandible. Sectioning is

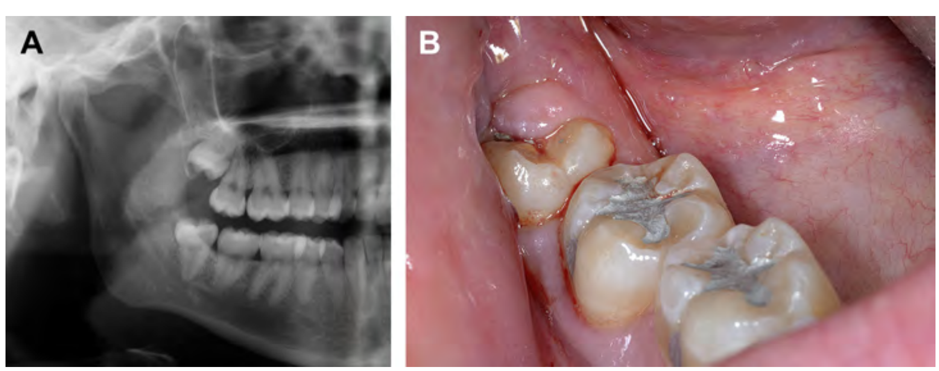

Fig. 17. (*A*) Panorex of vertical soft tissue impaction of mandibular right third molar. (*B*) Vertical soft tissue impacted mandibular right third molar.

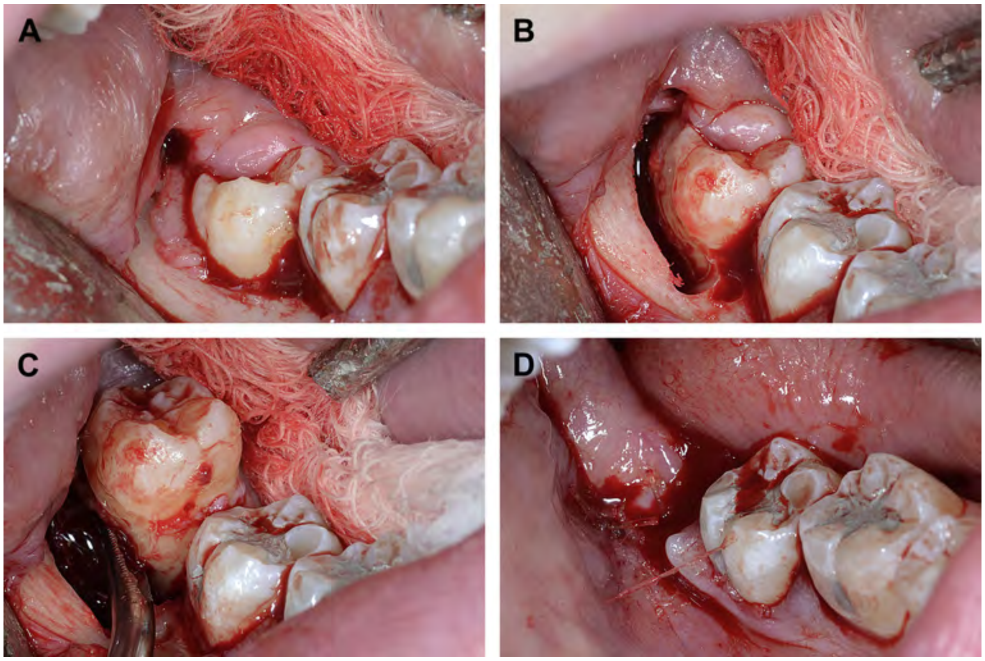

Fig. 18. (*A*) Envelope flap incision for vertical soft tissue impaction of mandibular right third molar. (*B*) Buccodistal bone removed along cervical margin of crown. (*C*) Small straight elevator placed in buccal groove of bone, rotated, tooth elevated upward, and delivered. (*D*) Flap sutured closed.

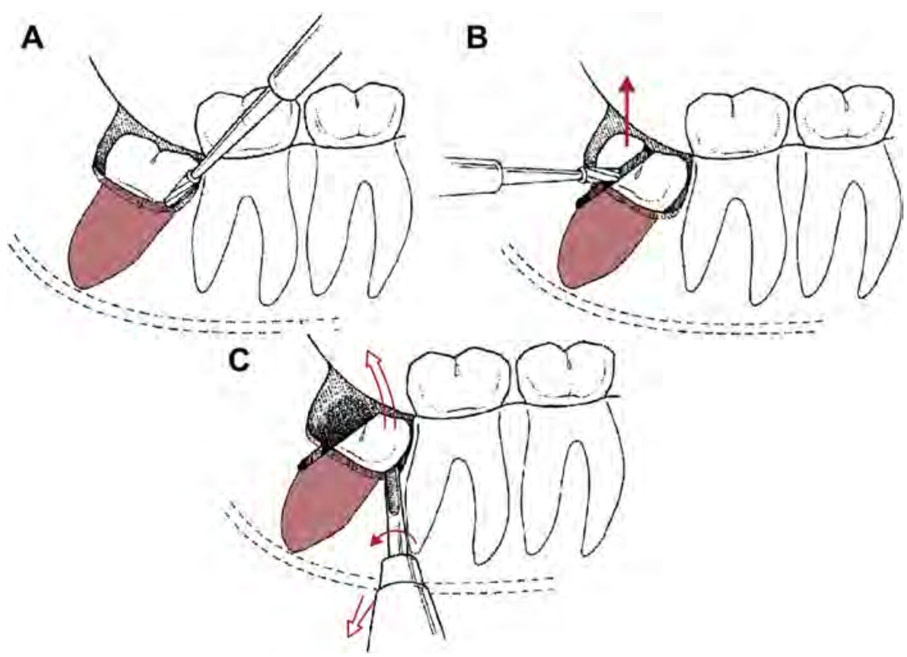

Fig. 19. (*A*) Removal of a slight mesioangular mandibular third molar impaction. Buccodistal bone is removed to expose the crown of the tooth to the cervical line. (*B*) Distal aspect of crown may be sectioned from tooth. (*C*) After distal portion of crown is removed a small straight elevator is inserted into purchase point along the mesial aspect of the third molar. The tooth is delivered with rotational and lever motion of the elevator. ([*C*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

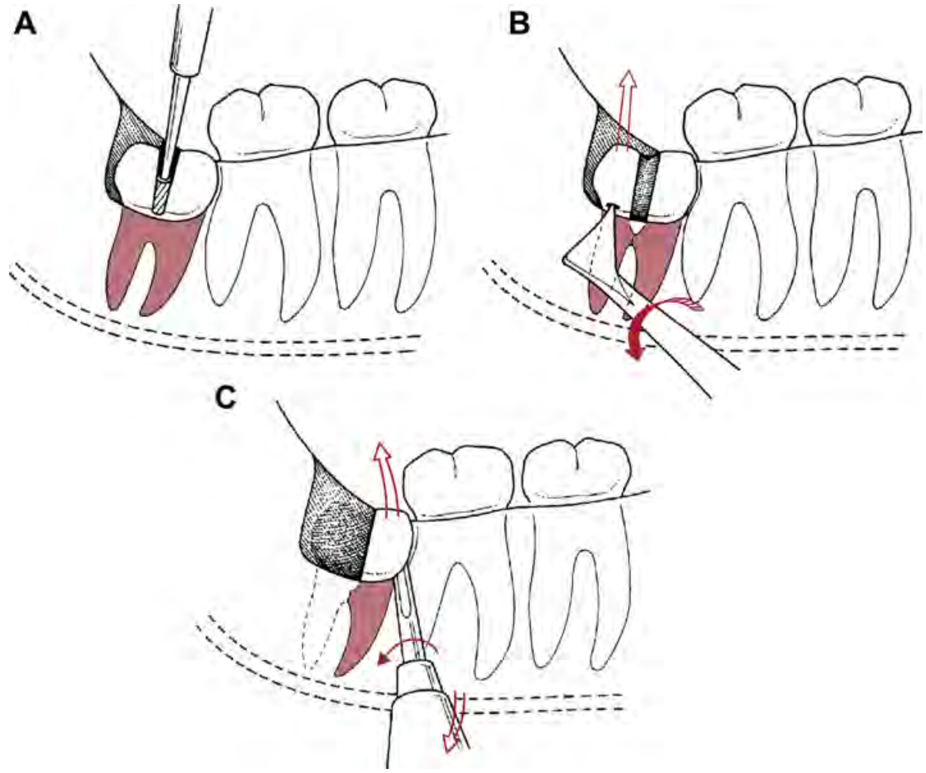

Fig. 20. (*A*) Buccodistal bone removed to expose crown of impacted mandibular third molar. (*B*) Occasionally it is necessary to section the entire tooth into 2 halves. Distal half of tooth removed via elevator. (*C*) Elevator is inserted into a purchase point along the mesial half. The remaining mesial half is delivered with rotational and lever motion of the elevator. ([*C*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

generally accomplished by separating the crown from the roots. The roots can then be removed together or separately using a straight or pointed elevator.

Removal of impacted maxillary third molars

A variety of flaps can also be used when approaching maxillary third molars (Figs. 28–30). The most commonly used incision used for removal of maxillary third molars is an envelope incision that extends posteriorly from the distobuccal line angle of the second molar and anteriorly to the first molar. A releasing incision is not usually necessary unless the tooth is deeply impacted. When the third molar is located palatally, the incision may be made more along the palatal aspect of the tuberosity.

As with mandibular teeth, the approach to removing each tooth should be individualized based on its position and anticipated difficulty. Examples are seen in Figs. 31–33. With maxillary teeth, bone removal is accomplished on the buccal down to the cervical line to expose the crown. In most cases this bone is thin enough to be removed with a periosteal elevator or a chisel using manual pressure. Maxillary third molars are rarely sectioned because the surrounding bone is thin and elastic. In many cases, a straight or similar elevator is placed along the mesial surface of the crown and the tooth elevated to the buccal/distal. Any residual portion of the follicle is then curetted and removed with a rongeur followed by irrigation with closure as necessary.

Deeply impacted maxillary third molars may have only a thin layer of bone separating them from the infratemporal fossa and the maxillary sinus. In patients with thicker bone, the extraction is usually accomplished by removing additional bone rather than by sectioning of the tooth. When sectioning is necessary, chisels should be avoided to limit the possibility of displacing the tooth into the adjacent spaces.

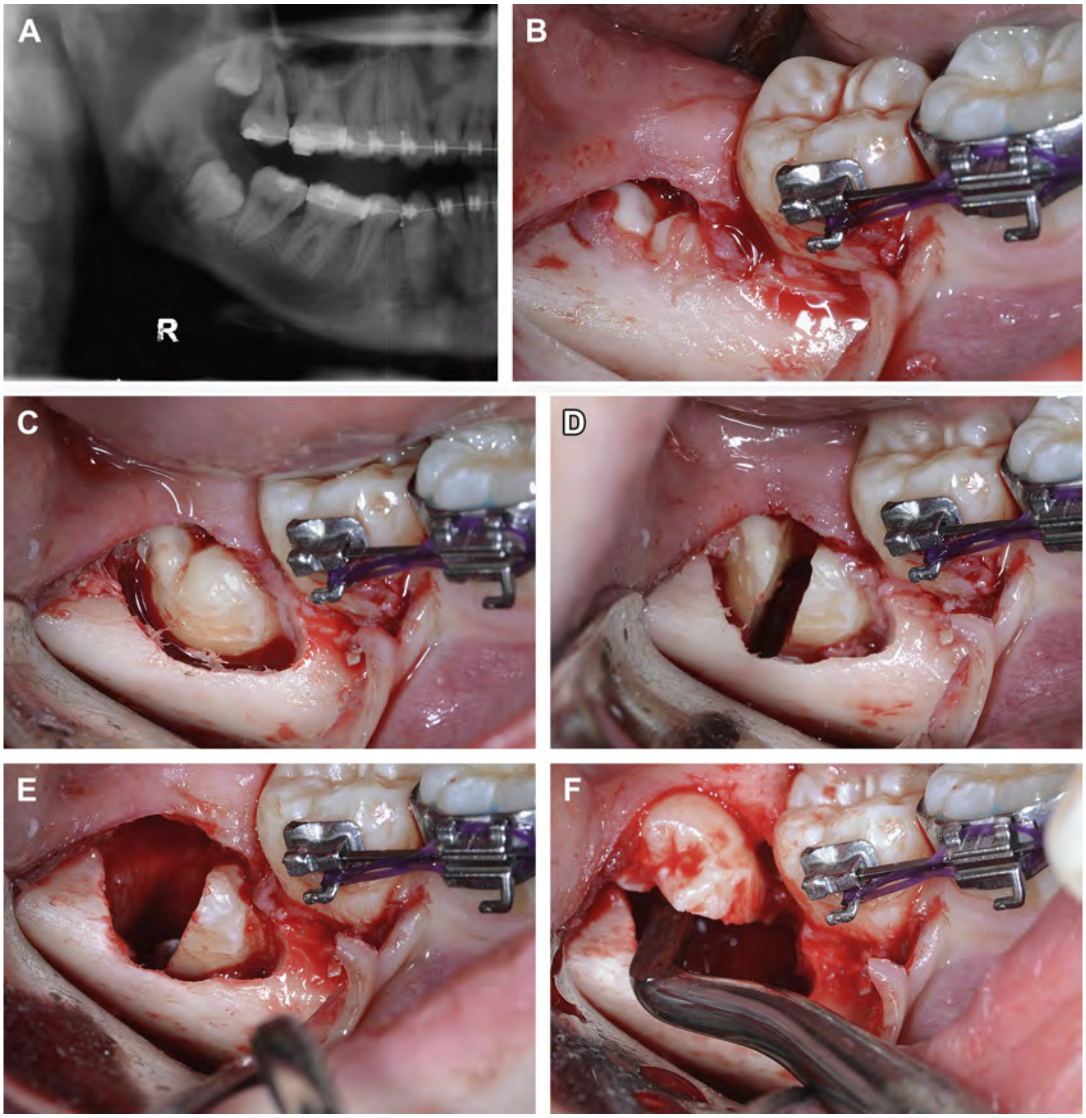

Fig. 21. (*A*) Radiograph of mesioangular impacted mandibular third molar. (*B*) Reflection of soft tissue flap. (*C*) Buccodistal bone removed to expose crown. (*D*) Mesioangular third molar sectioned in half vertically. (*E*) Distal half of crown removed. (*F*) Mesial half of crown removed with elevator.

Perioperative strategies, such as the use of antibiotics (systemic or topical) and steroids, are important in maximizing outcomes and are discussed in the article by Piecuch and Fenton elsewhere in this issue. In addition, patients should be provided both written and verbal instructions and made to understand the important role that they and their support group have in ensuring a good recovery and return to normal activity.

Periodontal considerations related to third molars

There are consequences associated with both the presence of third molars and surgical procedures performed manage them. Consider the following.

Impact of the Presence of Third Molars

- The presence of third molars has an adverse effect on the periodontium of adjacent second molars, including disruption of the periodontal ligament, root resorption, and pocketing with attachment loss.

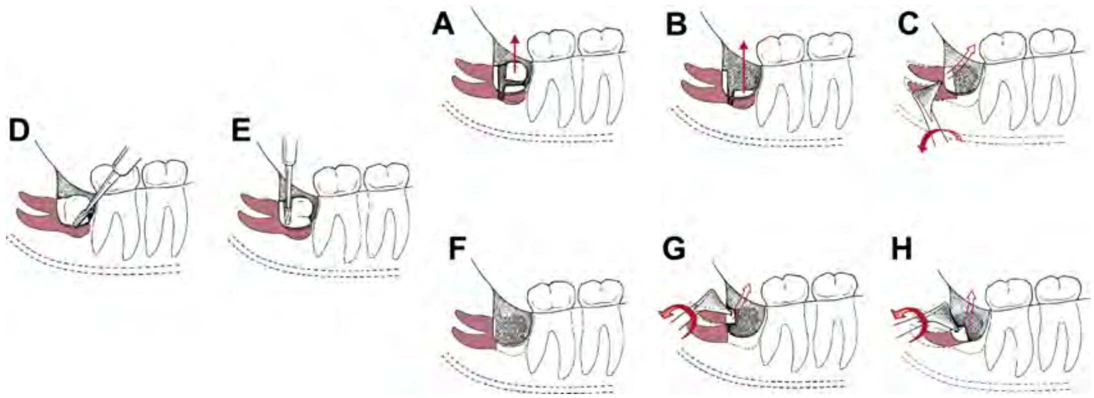

Fig. 22. (*A*) During removal of a horizontal impaction approximately two-thirds to three-fourths of the buccal and distal bone overlying the crown is removed. The inferior third to one-quarter of bone is often left intact. (*B*) Crown is sectioned from the roots and removed if there is enough space available. (*C*) If there is insufficient space for crown removal a second horizontal (T) cut is made through the crown. The superior half of the crown is removed. (*D*) Next, inferior half of the crown is removed with an elevator. (*E*) Roots are removed together via a purchase point at the furca. An elevator is used to advance the roots forward and then delivered from the socket. (*F*) Roots may require separation into 2 parts. Each root is delivered separately with the aid of an elevator and sometimes a purchase point. (*G*) Superior root removed. (*H*) Inferior root removed. ([*H*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

- The presence of visible third molars is associated with elevated levels of periodontitis involving adjacent teeth that is progressive and only partially responsive to therapy.
- An absence of symptoms does not indicate absence of disease.
- Pathogenic bacteria in clinically significant numbers exist in and around asymptomatic third molars.
- Indicators of chronic inflammation are found in periodontal pockets in and around asymptomatic third molars.
- Evaluation of third molars should include assessment of the periodontium associated with the third molar and adjacent teeth, including anatomic limitations to effective hygiene.
- The presence of pocket depths of $>$4–5 mm and/or bleeding on probing likely predicts progression of periodontitis.
- There are likely systemic implications of chronic periodontal disease at and around third molars.

Given the association of an overall increase in disease severity in the presence of visible third molars, the progressive nature of periodontitis when third molars are present, the relationship between visible third molars and bacteria associated with severe and refractory periodontitis, and the negative impact of visible third molars on treatment outcomes, there is support for the concept that the presence of a third molar is a predictor of periodontitis.

Impact of Third Molar Removal

- Removal of impacted third molars can have an adverse effect on the periodontium of adjacent second molars.
- No single soft tissue flap approach to the removal of third molars has been identified to minimize loss of periodontal attachment.
- Scaling, root planning, and plaque control have the potential to reduce postoperative loss of attachment.
- Osseous healing is improved when a third molar is removed before it resorbs the bone on the distal aspect of the second molar and while a patient is young.
- As with bone levels, if the preoperative pocket depth is increased, the postoperative pocket depth is likely to be similar with attachment levels essentially the same level as they were preoperatively.
- In older patients with complete bony impactions, pocket depth and attachment levels may be lower than preoperative levels.
- In a completely impacted third molar in patients older than age 35 years, consideration should be given to monitoring rather than removal unless pathology develops.

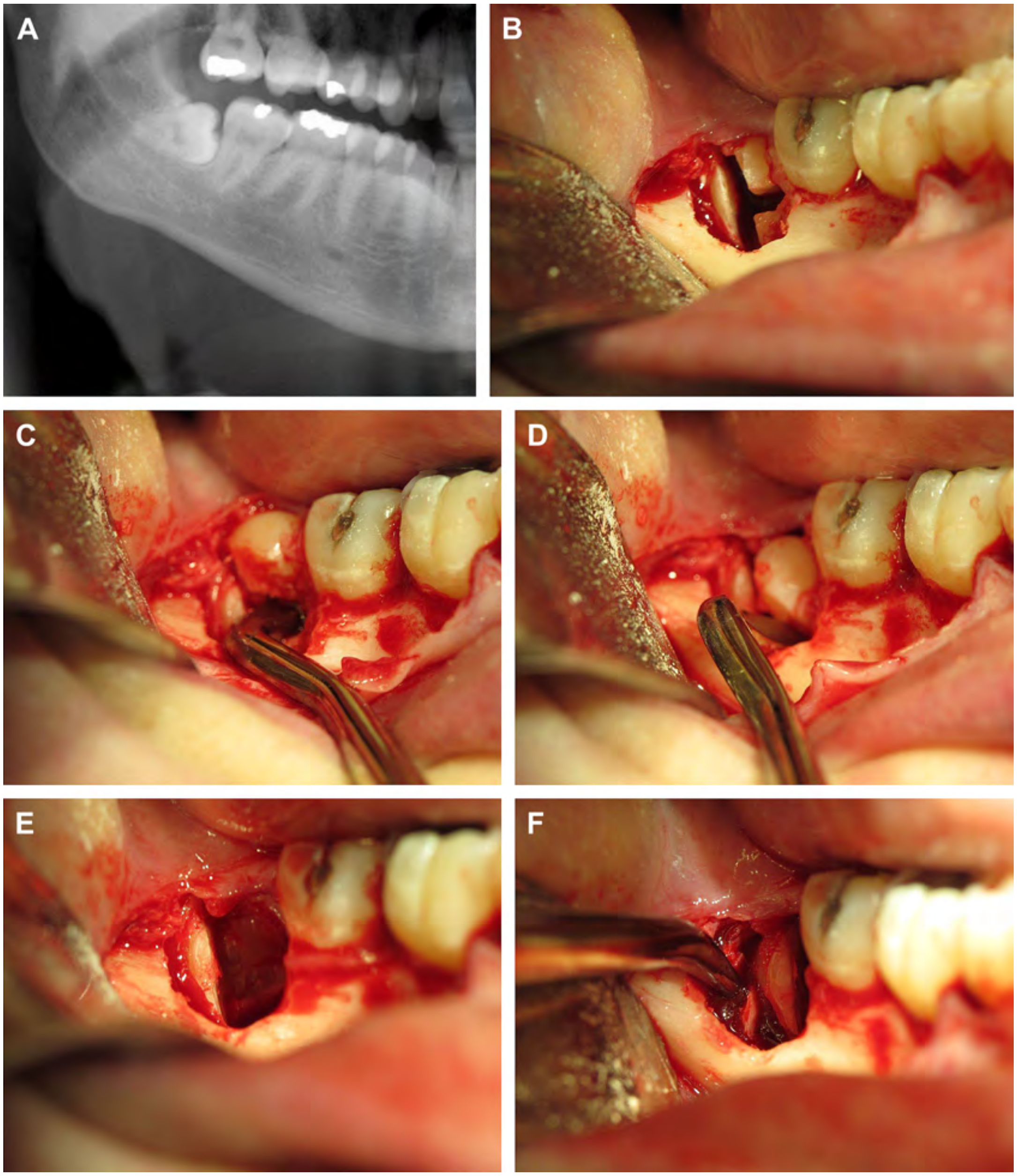

Fig. 23. (*A*) Radiograph of horizontal impacted right mandibular third molar. (*B*) Envelope flap reflected, three-quarters of buccal bone removed overlying crown, vertical and horizontal (T) cut made with fissure bur through crown. (*C*) Superior half of crown is delivered with elevator. (*D*) Inferior half of crown of horizontal impaction removed with elevator. (*E*) Crown has been removed and root structure is visualized. (*F*) Purchase point created in root structure with fissure bur. Pick elevator inserted into purchase point and roots advanced forward into socket.

Grafting the socket after third molar removal

As discussed previously, there are consequences associated with the removal of third molars. Although most third molar sites heal in a predictable manner, a group of patients have been identified who are at risk for clinically significant periodontal compromise after third molar removal. These individuals may benefit from placement of a graft into the socket.

Risk Factors for Suboptimal Healing

- Preoperative periodontal status
- Age of the patient at time of removal ($\geq$26 years)

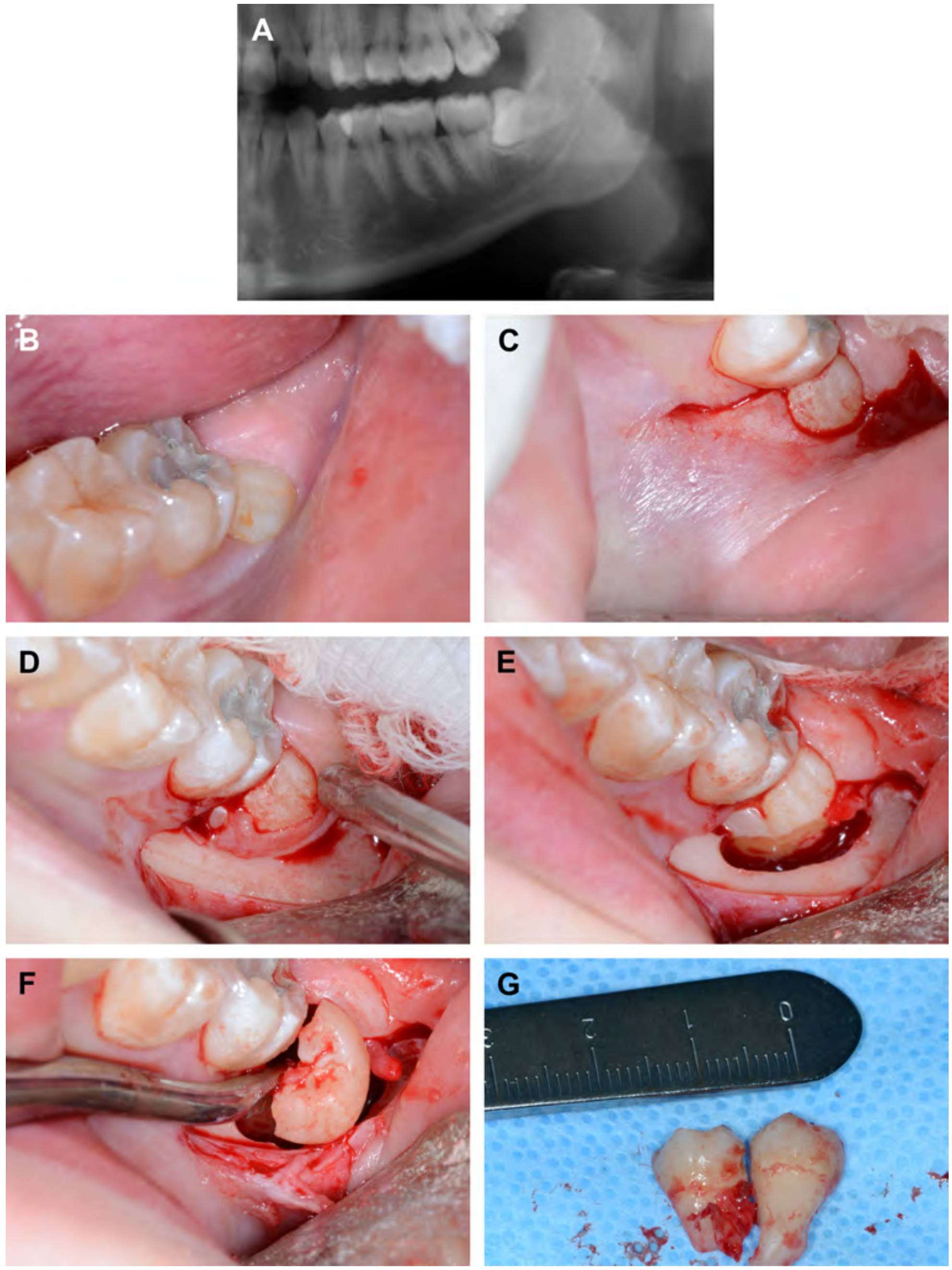

Fig. 24. (*A*) Radiograph of horizontal impacted left mandibular third molar. (*B*) Horizontal impacted left mandibular third molar. (*C*) Envelope flap with anterior vertical releasing incision. (*D*) Soft tissue reflected to access third molar site. (*E*) Buccodistal bone trough made adjacent to crown with fissure bur. (*F*) Crown sectioned in half, superior half along with root removed first. (*G*) Inferior portion of crown removed after superior half.

- Size of contact area between second and third molars
- Root resorption on the second molar
- Position of the third molar (horizontal or mesioangular)
- Pathologic follicle associated with the third molar
- Level of plaque control

Goals of Bone Grafting

- Elimination of osseous defects
- Improvement of periodontal status

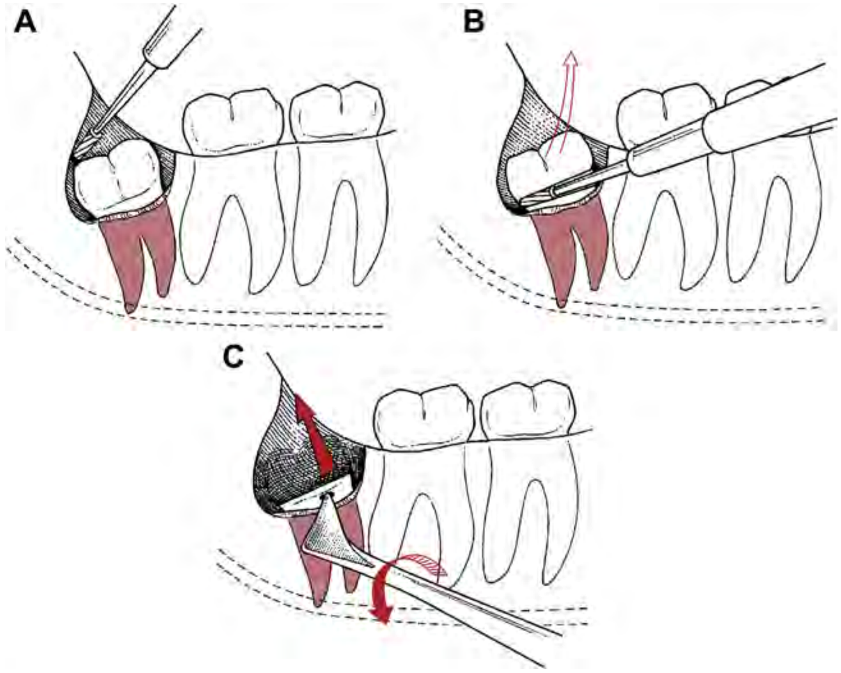

Fig. 25. (*A*) Distoangular impaction. Occlusal, buccal, and distal bone is removed with fissure bur. (*B*) Crown of distoangular impaction is sectioned off with fissure bur, removed with straight elevator. (*C*) Purchase point is made in furca region of remaining root structure. Roots are removed with either a pick elevator or triangular elevator. If roots are divergent they may need to sectioned, separated, and removed separately. ([*C*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

- Provide increased stability for the adjacent second molar
- Elimination of pain and/or infection

Technical Considerations

- Grafting may be performed immediately or at a later time.
- In instances where a permanent defect is most likely, early/immediate intervention is warranted.
- Delayed treatment is indicated more often in patients $<$26 years without other significant risk factors, allowing follow-up to evaluate healing to allow for resolution without intervention.
- Techniques include use of autogenous or freeze-dried bone, platelet-rich plasma, bioactive ceramics, and/or membranes (resorbable or nonresorbable).

Although there may be an improvement in attachment levels and probing depths after third molar removal, no technique has altered the risk of developing a periodontal defect on distal of the adjacent second molar unless the patient has one or more of the identified risk factors. Therefore, there does not seem to be benefit for routine grafting for all patients having third molars removed. Given the current state of knowledge, interventional strategies, such as grafting, should be limited to subjects with significant or multiple risk factors for developing periodontal defects.

Coronectomy (partial odontectomy or intentional root retention)

American Dental Association Definition

Coronectomy—intentional partial tooth removal: D7251
Intentional partial tooth removal is performed when a neurovascular complication is likely if the entire impacted tooth is removed.

When imaging suggests an intimate relationship between the roots of a lower third molar and the inferior alveolar nerve, consideration should be given to coronectomy with retention of the portion of the roots associated with the inferior alveolar nerve. Several investigators have described such an

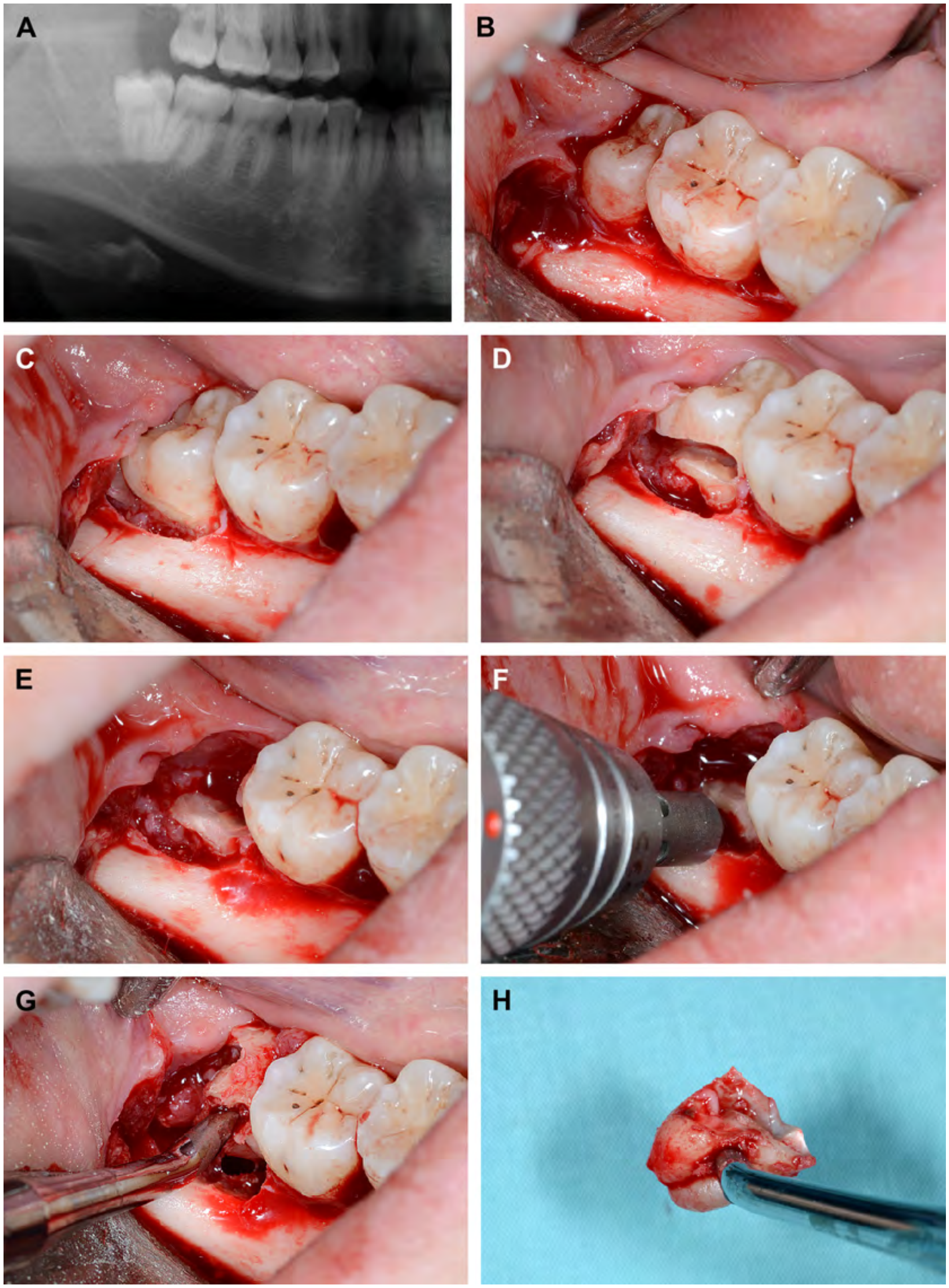

Fig. 26. (*A*) Radiograph of distoangular impacted mandibular right third molar. (*B*) Envelope flap reflection to expose distoangular impaction. (*C*) Buccodistal bone trough. (*D*) Sectioning of crown from roots. (*E*) Crown removed, root structure visualized. (*F*) Purchase point made in furca region of root structure. (*G*) Roots elevated and delivered with pick elevator. (*H*) Roots removed with pick elevator.

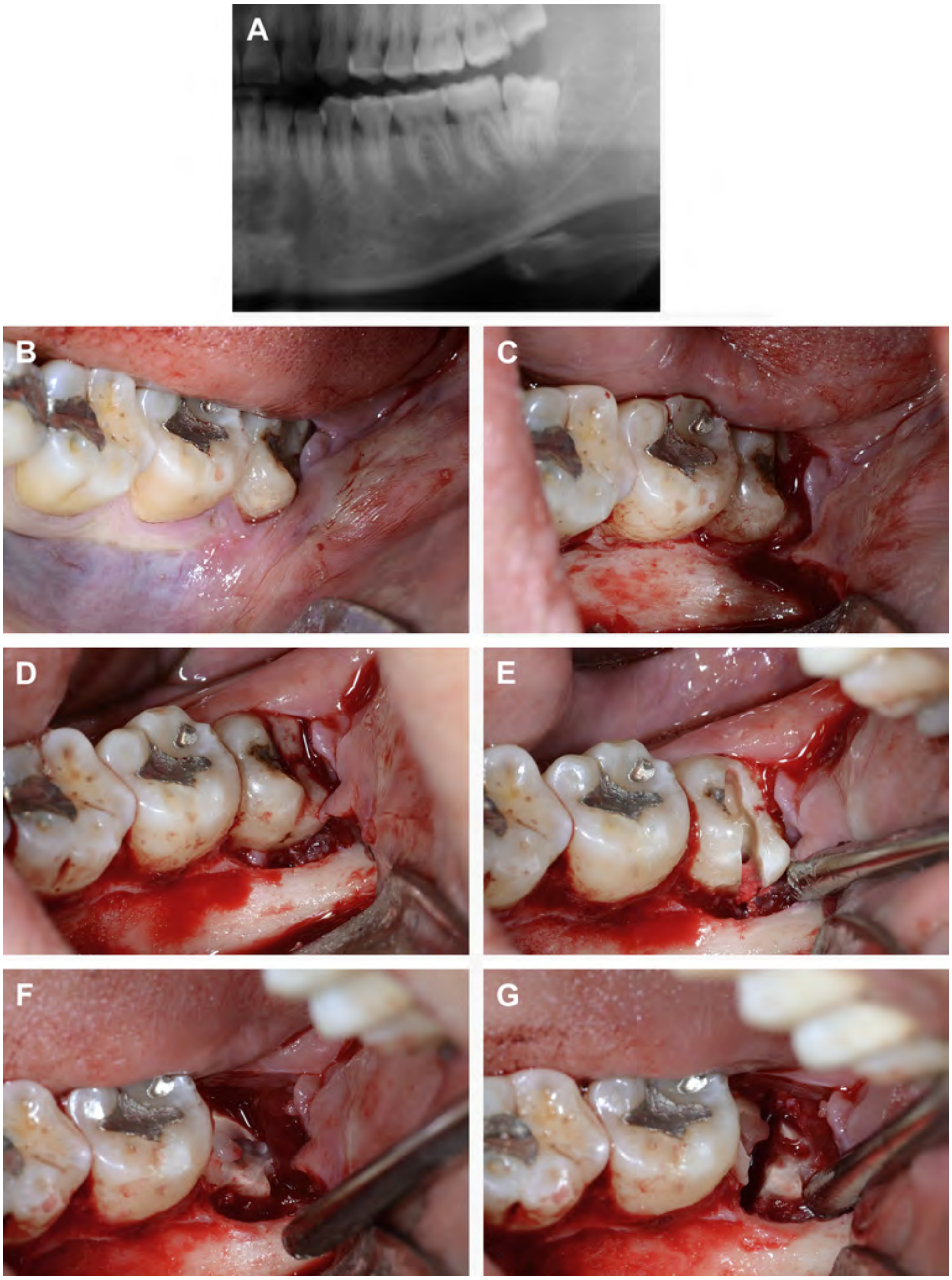

Fig. 27. (*A*) Radiograph of distoangular impacted mandibular left third molar. (*B*) Surgical flap reflected. (*C*) Buccodistal bone trough. (*D*) Distal half of crown sectioned and removed. (*E*) Mesial half of crown removed after failed attempt to mobilize tooth. (*F*) Root structure visualized. (*G*) Roots of distoangular molar are sectioned, separated, and removed separately.

approach with results indicating that coronectomy provides a feasible option for the management of such compromised mandibular impactions.

Technique

- Prophylactic antibiotics
- Buccal flap with release and lingual retraction if necessary
- Occlusal and buccal bone removed for access
- Round or fissure bur sections crown at approximately 45°
- Removal of coronal fragment
- Residual root portion trimmed 3–4 mm inferior to residual crest

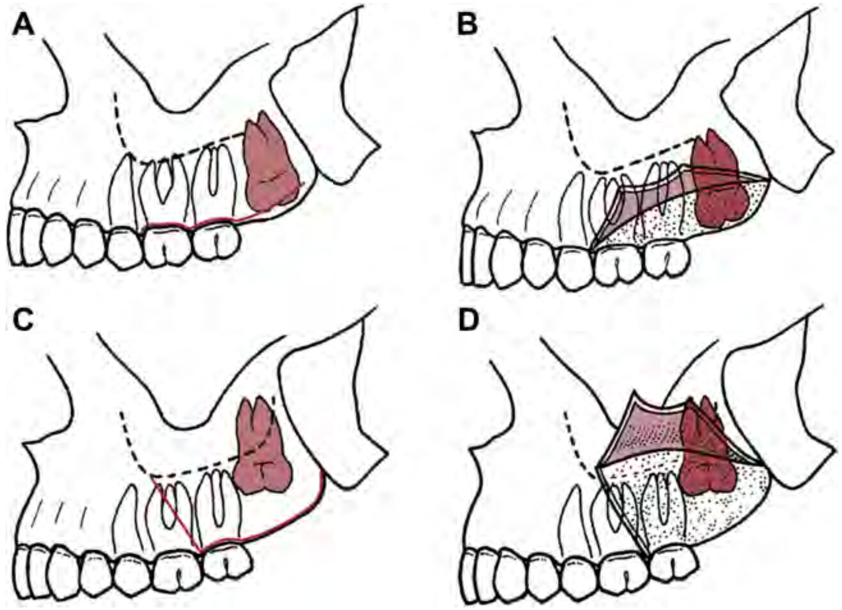

Fig. 28. Surgical access for impacted maxillary third molars. (*A*) Envelope flap incision for removal of maxillary impacted third molar. (*B*) Envelope flap soft tissue reflected laterally to expose bone overlying third molar. (*C*) Three-cornered flap incision used to access deeply impacted maxillary third molar. (*D*) Releasing incision of three-cornered flap provides greater visibility and access to the apical portion of the surgical field. ([*D*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

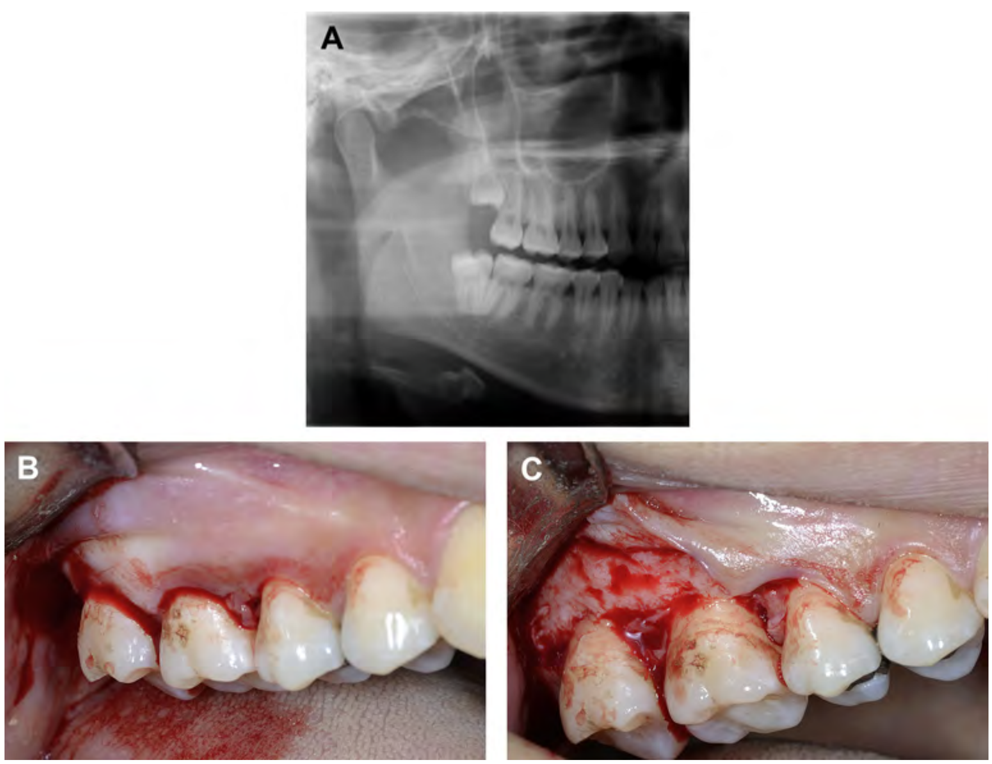

Fig. 29. (*A*) Radiograph of impacted maxillary right third molar. (*B*) Envelope flap incision for removal of maxillary impacted third molar. (*C*) Envelope flap, soft tissue reflected laterally.

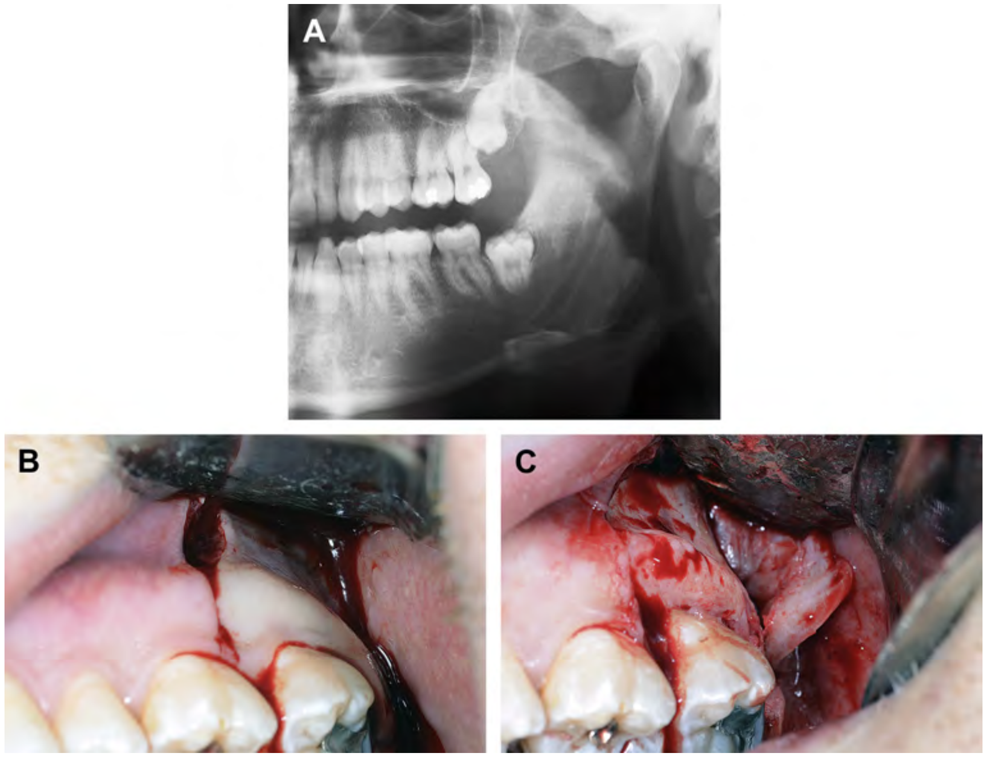

Fig. 30. (*A*) Radiograph of impacted maxillary left third molar. (*B*) Three-cornered flap with releasing incision to access deeply impacted third molar. (*C*) Three-cornered flap soft tissue reflected.

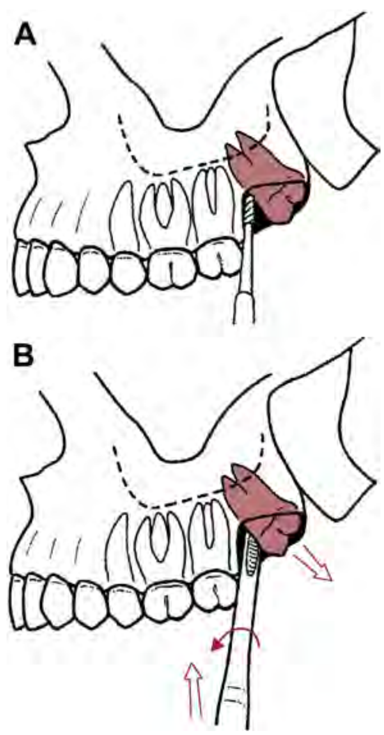

Fig. 31. Removal of impacted maxillary third molar. (*A*) Small amount of buccal bone overlying crown is removed with a bur or mallet and chisel. (*B*) Tooth is delivered with use of either a small straight elevator or a Potts elevator. ([*B*] *Adapted from* Hupp JR, Ellis E III, Tucker MR, editors. Contemporary oral and maxillofacial surgery. 5th edition. St. Louis: Mosby Elsevier; 2008; with permission. Modified by Ion Syrbu.)

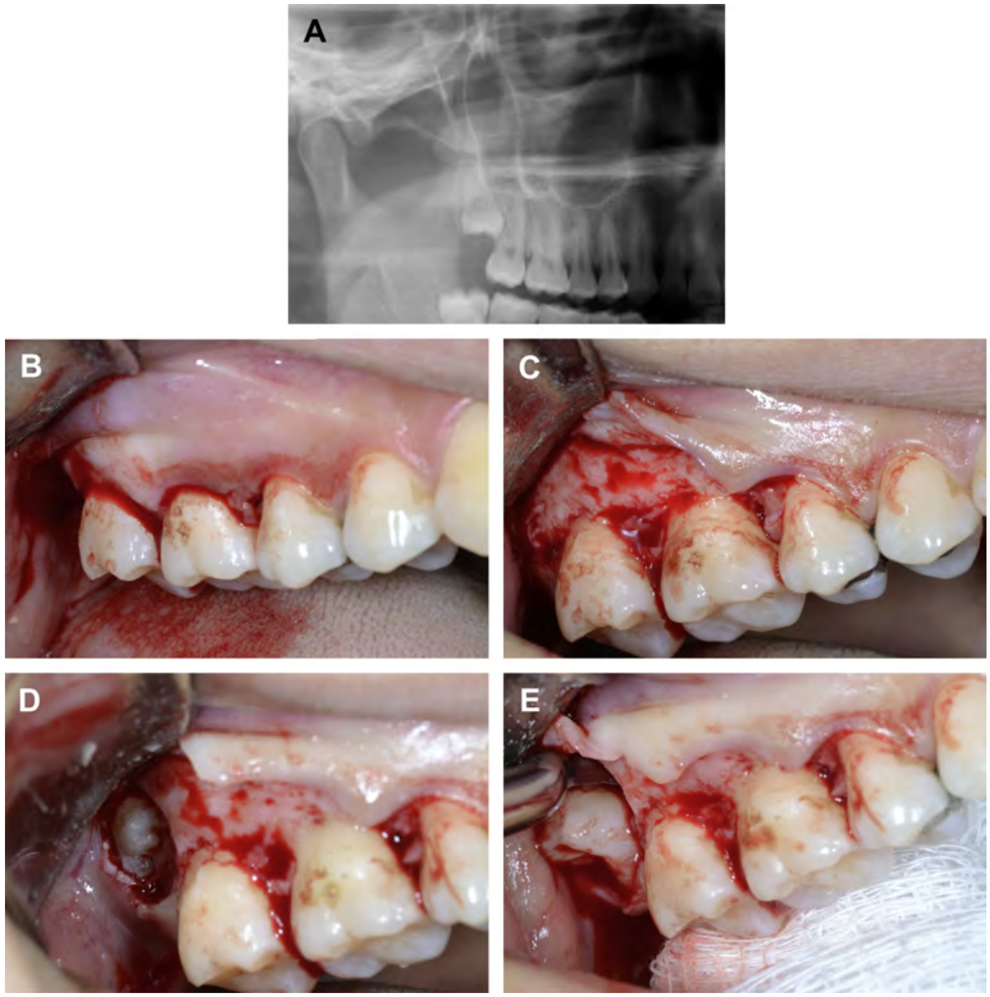

Fig. 32. (*A*) Radiograph of impacted maxillary right third molar. (*B*) Envelope flap incision. (*C*) Reflection of envelope flap to access impacted maxillary third molar. (*D*) Bone removed overlying crown with fissure bur. (*E*) Impacted maxillary third molar delivered via rotation of Potts elevator.

- Water-tight closure
- Although follow-up is advisable, no specific protocol is recognized

Contraindications

- Teeth with active infection (root)
- Mobility of root fragments
- Horizontal impaction (sectioning may endanger nerve)

Expectations

- Reduced incidence of inferior alveolar nerve injury
- No increase in alveolar osteitis or wound infection
- Female patients with conical roots at risk for higher failure rates
- Although migration of residual roots may occur, it is unpredictable and generally results in movement to a "less threatening" position.

Lingual split technique

The lingual split is a technique whereby a mandibular third molar is delivered from the alveolus through the lingual place of bone facilitated by the use of chisels. Although this approach is used by

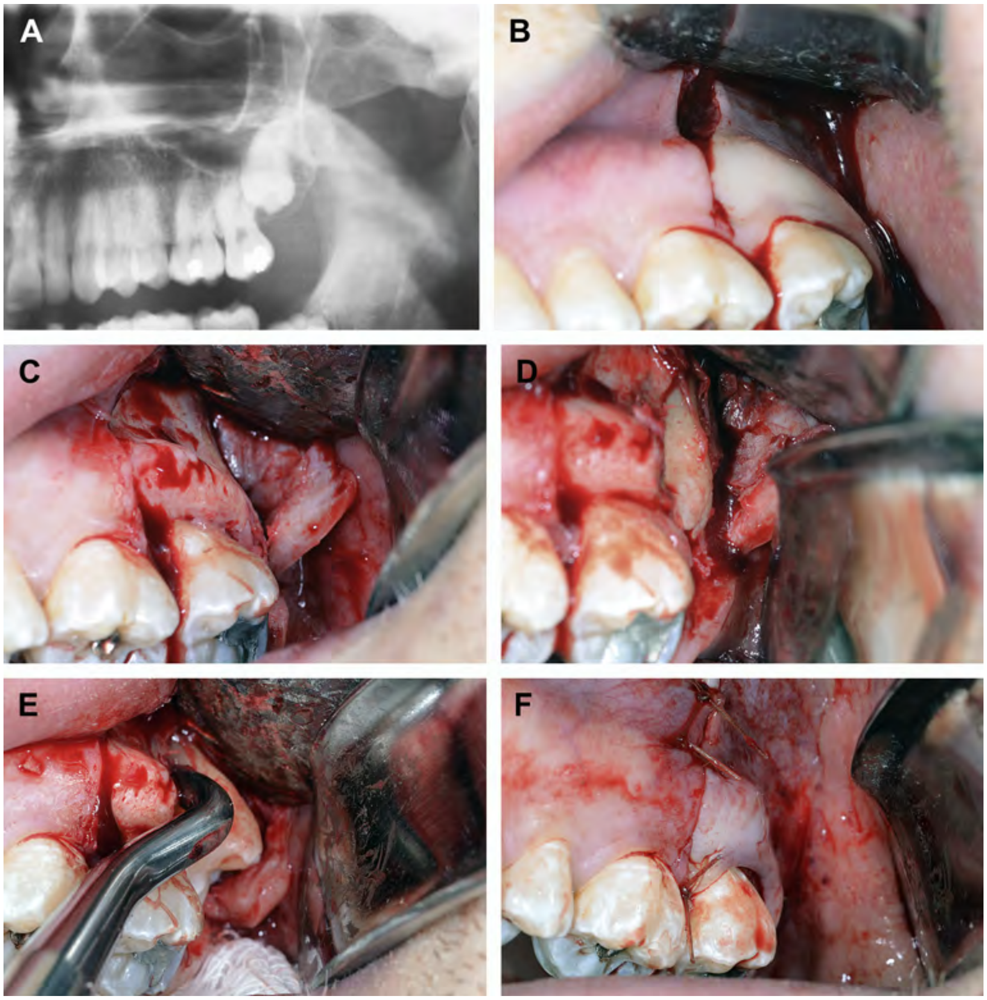

Fig. 33. (*A*) Radiograph of impacted maxillary left third molar. (*B*) Envelope flap with anterior releasing incision. (*C*) Three-cornered flap reflected to expose impacted maxillary third molar. (*D*) Buccal bone overlying impacted third molar is removed. (*E*) Potts elevator used to deliver impacted third molar from site. (*F*) Flap sutured.

some clinicians, it is used infrequently in the United States. The primary concern expressed by those who oppose this technique is a higher incidence of lingual nerve damage. In addition, it requires elevation of large flaps.

Technique

- Incision is made along the crest of the ridge with a releasing component.
- Lingual retractor is placed to protect against injury to the lingual nerve and to keep the tooth from being displaced into the lingual soft tissues. Retractor must be broad, without sharp edges, and kept subperiosteal.
- Vertical and horizontal cuts for access are made on buccal bone distal to second molar tooth.
- Distolingual bone is removed by placing a 5-mm chisel distal to the third molar with beveled side facing upwards and cutting edge parallel to the external oblique ridge.
- Chisel is driven in to the depth depending on the desired level with the direction of cut toward the lingual plate.
- Bone is split obliquely by back twist of the chisel.
- A wedge-shaped piece of bone removed.
- Tooth elevated and delivered in the lingual direction.
- Closure in usual manner.

Transplantation of Third Molars

Transplant of a third molar to another site may be an option for replacement of another tooth indicated for removal or already removed. Although a patient's age is not a major risk factor for successful autoplastic transplantation, epidemiologic data indicate better results are achieved when performed at a younger age because the donor tooth (in this case third molar) is still developing and retains its eruptive potential (Fig. 34).

Advantages

- May provide an alternative to fixed or removable prosthodontics
- Avoids adjacent teeth preparation
- May allow continued development of alveolus in growing patient
- Comparative cost-effectiveness

Disadvantages

- Technique sensitive
- Somewhat uncertain prognosis
- Risk of transplant loss secondary to complications, such as root resorption and loss of attachment

Factors that influence success

- Atraumatic extraction of the transplanted tooth.
- Host site infection and postoperative plaque adversely influence success.
- Minimal handling protects Hertwig root sheath and pulpal tissue.
- Minimize time out of socket to avoid desiccation.
- Appropriate immobilization to allow re-establishment of innervation and vascularity.
- Ideal age for success is 15–19 years.

Contraindications

- Poor oral hygiene.
- Mismatch of alveolar dimension. If recipient site has insufficient space to accommodate donor tooth, resorption of ridge or root may occur.
- Age may present was a relative contraindication.

Impact of root development

- Most recommend root development be between one-half to two-thirds its final length.
- Although higher success rates are achieved with immature roots, they have less root growth after transplantation.
- Although transplantation is feasible for teeth with complete root development, endodontic treatment is usually indicated 7–14 days after transplant.
- Endodontic treatment or apicoectomy during procedure increases the risk of root resorption.

Keys to success

- Minimal trauma with extraction of donor third molar and tooth at recipient site
  - Care to preserve periodontium
  - Replacement root resorption occurs in teeth with cementum injury
- Donor tooth placed with 1–2 mm of periodontal ligament above osseous crest to achieve an ideal biologic width
- Proper splinting technique
- Rinse with chlorhexidine for several days
- Although some studies show no relation between graft survival and use of antimicrobials, many surgeons believe they improve clinical outcomes.

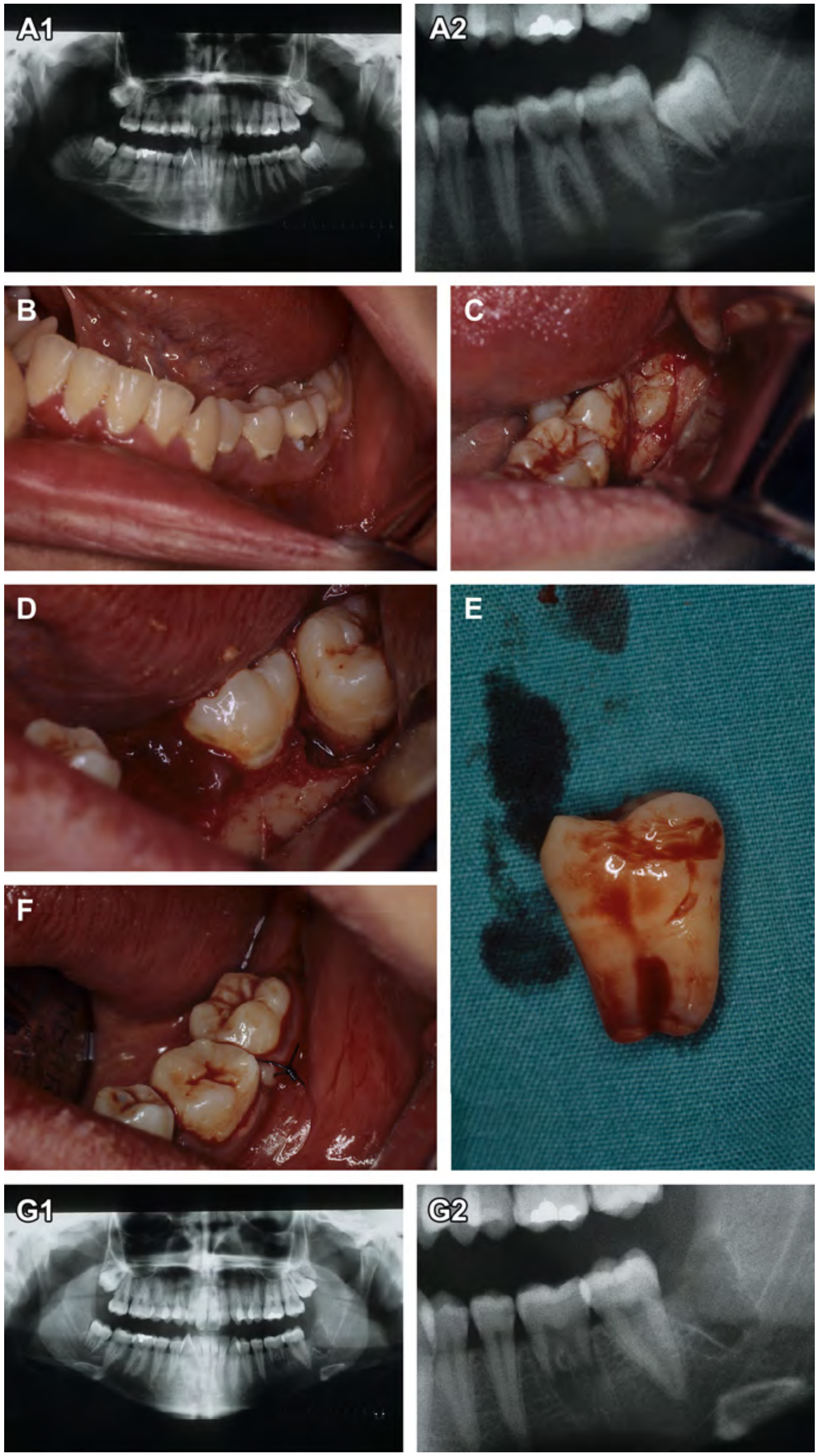

Fig. 34. (*A*) Radiograph of carious, nonrestorable #19, and impacted #17 with partial root formation. (*B*) Photo of carious, nonrestorable #19. (*C*) Surgical access to #17. (*D*) #19 Removed with 23 forceps and #17 elevated and removed from socket. (*E*) #17 Transplant. (*F*) #17 Transplanted to site #19. (*G*) Radiograph post-transplantation of #17.

Splinting

- Excessive time or rigid splinting adversely affects outcome
- Should not force roots against bony walls of the alveolus (may damage the periodontium)
- Flexible with sutures through the mucosa and over occlusal surface for 7–10 days allows functional movement
- Graft with mature roots should be placed slightly subocclusal to prevent trauma
- Graft with immature roots slightly more depressed to allow for eruption; soft diet for the first few days

Further readings

Removal of third molars

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Atlas of the Oral and Maxillofacial Surgery Clinics

Perioperative Strategies for Third Molar Surgery

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Introduction

The removal of third molar teeth is one of the most common procedures performed by oral and maxillofacial surgeons. Third molar extraction is associated with undesirable sequelae and complication. Morbidity is related to pain, swelling, trismus, infection, alveolar osteitis, bleeding, nerve injury, dental injury, jaw fracture, temporomandibular joint dysfunction, lost workdays, and general inconvenience. Many factors and strategies have been studied to minimize the morbidity associated with third molar removal. This article focuses on perioperative strategies that have been suggested to influence the postoperative course after third molar extraction. These include the effect of smoking, chlorhexidine rinses, topical and systemic antibiotic use, and preemptive pharmacotherapies, including corticosteroids, analgesics, and muscle relaxants. Additional factors that may play a role, such as microbial contamination, surgical difficulty, surgeon experience, flap design, extent and closure, presurgical pathology, age, gender, and oral contraceptive use, are not addressed.

Tobacco smoking

The influence of smoking on postsurgical complications is well appreciated. The direct and indirect effects of cigarette smoke have been well described in relation to multiple soft tissue reconstructive procedures, including facelifts, abdominoplasty, breast reconstruction, free tissue transfer, and digit replantation (Table 1) [1]. The dental literature has also shown the detrimental effects of tobacco smoking on the immune response, alveolar bone loss, oral wound healing, and response to therapy (Table 2) [2]. Additionally, a recent systematic review showed that longer durations of perioperative smoking cessation seem to be beneficial, but the ideal period of tobacco cessation could not be specified. Outcome variables such as overall postoperative complications, mortality, pulmonary and respiratory complications, and wound infections were examined. A variety of general surgery procedures and onlay bone grafts and sinus lifts were evaluated, but dental extractions were not reviewed.

The literature relating smoking and third molar extraction is minimal. Al-Belasy [3] investigated the effect of smoking on incidence dry socket after mandibular third molar removal in men, comparing nonsmokers with cigarette and "shisha" smokers. They showed an incidence of 7% in nonsmokers, 31.6% in smokers who refrained the day of surgery, 17.9% in smokers who ceased tobacco use until the second day after surgery, and 10.5% when tobacco cessation continued until the third postoperative day or longer. A statistically significant difference was found between smokers and nonsmokers, but the difference between cigarette and shisha smokers was not found to be statistically significant. Further discussion provides support against the influence of the negative pressure effect of smoking on clot dislodgement and subsequent dry socket, favoring a systemic and local tissue pathogenesis. This finding agrees with the research of Meechan and colleagues [4], who

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Table 1
Effects of cigarette smoke

Substance	Action	Effect
Nicotine	• Direct vasoconstriction • Indirect catecholamine release • ↑ Red blood cells, fibrinogen, and platelet adhesiveness • Thromboxane A2 stimulation • Prostacyclin inhibition	• ↑ Oxygen demand and tissue hypoxia • Tunica media fibrosis and calcification • Thrombogenic state
Carbon monoxide	• ↑ Carboxyhemoglobin	• ↑ Oxygen-binding affinity and tissue hypoxia • Thrombogenic state

showed significant differences in immediate socket filling and postoperative pain in smokers over nonsmokers, especially female heavy smokers. Conversely, reports have shown no significant difference between smokers and nonsmokers in postoperative pain and wound healing.

Additional dental research evaluating periodontal regenerative therapy with an allograft has shown significant differences between smokers and nonsmokers. Rosen and colleagues [5] found that smokers had a 29% improvement in clinical attachment level, whereas nonsmokers had a 42% improvement at 1-year follow-up. This trend persisted long-term, with improvement of 31% and 42% for smokers and nonsmokers at 2 to 5 years, respectively. The adverse effects of tobacco smoking should encourage perioperative tobacco cessation. Grossi and colleagues [6] showed that tobacco cessation improved their patient population's healing response to equate that of nonsmokers, with similar observations on periodontal microbial content. The systemic and local influences of tobacco use are well-known. However, the relationship of smoking and postoperative course in relation to third molar surgery is not completely understood and has not been clearly proven to be causal in nature. Further studies are necessary to elucidate the mechanisms that make smoking a significant risk factor for dry socket. Preoperative and a minimum of two postoperative days of tobacco cessation is recommended for third molar dry socket prevention.

Table 2
Dentoalveolar effects of cigarette smoke

Alveolar bone loss	↑ Amount and severity of destruction (dose-related)
	↓ Estrogen in women leads to ↑ IL-1, IL-6, TNF-α
Immune response	↓ Hemorrhagic responsiveness of the periodontium
	↓ Gingival blood flow
	↓ Neutrophil chemotaxis, phagocytosis, and adherence with ↑ oxidative bursts (direct toxicity)
	↓ IgG, IgG2, T-cell proliferation
Healing and response to therapy	↓ Regenerative potential
	↓ Fibroblast production of fibronectin and collagen
	↑ Collagenase production
	↓ Reduction in probing depth and clinical attachment gain

Abbreviations: IL, interleukin; TNF-α, tumor necrosis factor α.

Chlorhexidine

Chlorhexidine digluconate (CHX) is a commonly used topical antimicrobial agent used in dentistry. It has been shown to be effective in treatment and maintenance for periodontal disease and caries. CHX acts on gram-positive and gram-negative aerobes and anaerobes through membrane disruption. The therapeutic action of CHX is further enhanced by its substantivity, the ability to have a continued effect between dosages. Resistance and pathogen selection have not been shown to occur with use of CHX. Additionally, the adverse effects of CHX are minimal, including allergy, dental staining, increased calculus formation, and mucosal and taste alterations. The role of CHX rinses in prevention of alveolar osteitis (AO) and surgical site infection has also been extensively studied, with evidence for and against its use. The main arguments against CHX use is that a lack of evidence exists to prove its efficacy, failing to justify the associated expense.

In 1991, Larsen [7] performed a prospective, randomized, double-blind, placebo-controlled trial showing a 60% overall reduction of AO with the use of 0.12% CHX 1 week before and after M3 removal. This trial was based on a microbiologic explanation of the fibrinolysis related to AO. In 2005, in a meta-analysis review of human clinical trials involving mandibular third molar extractions only, Caso and colleagues [8] compared a preoperative rinse, preoperative and postoperative rinsing regimen, and control groups. The results showed that the benefit of CHX on the day of surgery alone did not reach statistical significance. However, they did find that an extended rinse period of several postoperative days may reduce AO incidence. In a similar meta-analysis, Minguez-Sera and colleagues [9] concluded that application of a 0.2% CHX paste every 12 hours for a week after mandibular third molar extraction reduced AO incidence. Overall, the studies investigating the efficacy of CHX in reducing third molar extraction postoperative pain and infection have mixed designs and possible cofounders. However, strong support exists for the use of chlorhexidine rinse and intra-alveolar application. Currently, the use of chlorhexidine should be considered in the context of a cost-benefit analysis, and directed by clinical judgment.

Preemptive analgesia

Much of the undesirable nature of third molar surgery is based on patient discomfort and decreased quality of life. Palliation through pharmacologic agents can significantly improve a patient's condition after surgery. Additionally, a proactive strategy to reduce the amount of discomfort has been investigated. Much of the literature is based on preventative or preemptive analgesia for obstetrics, thoracic surgery, and orthopedics. Evidence in relation to third molar surgery is sparse. Preemptive analgesia, defined as a "pharmacologic intervention initiated before a painful stimulus to inhibit nociceptive mechanisms before they are triggered," is a common practice. Attributes of an ideal preemptive analgesia regimen include [10,11]

1. Initiation before surgical trauma
2. Prevention of central sensitization secondary to surgical trauma
3. Prevention of central sensitization secondary to inflammation
4. Palliation throughout the perioperative period
5. Therapeutic effect lasting up to or greater than 10 weeks

Local anesthetic medications and nonsteroidal antiinflammatory drugs (NSAIDs) were shown to be more effective than opioids in a meta-analysis by Cliff [12] investigating the influence of preemptive analgesia on acute postoperative pain after major general surgery. A randomized controlled trial by Nayyar and colleagues [13] showed the preemptive effects of bupivacaine 0.5% with epinephrine 1/200,000 to significantly reduce pain at 6, 12, and 72 hours and 7 days. The effects of tramadol and ketoprofen for M3 surgery have been shown to be beneficial, but only data from 24 hours or less are presented, and postoperative dosing may be better for pain intensity, timing of onset, and degree of opioid requirement.

Santos and colleagues [14] investigated the muscle relaxant cyclobenzaprine as a postoperative medicament in a well-designed prospective, randomized, double-blind, placebo controlled, split-mouth study. They concluded that cyclobenzaprine is not useful in treating pain, swelling, or trismus after third molar removal. Currently, local anesthesia is the only pharmacotherapy that has proven efficacy for preemptive analgesia for third molar extractions. The effect of NSAIDs requires greater research to establish longer-term effects and appropriate timing of administration.

Antibiotic prophylaxis

Antibiotics have changed the influence of microbes on the human condition and infectious and inflammatory pathology. Historically, the fatal conditions are the infectious and inflammatory pathology secondary to microbes before the antibiotic era are now routinely and curatively treated with a combination of directed surgical intervention and antibiotics. The morbidity associated with infectious postoperative complications is also greatly reduced. The concept of prophylactic antibiotics is well accepted in the general surgery literature and in relation to specific postoperative conditions, such as total joint replacement and infective endocarditis. However, the clinical application in relation to third molar surgery, specifically, is not as clear. A plethora of research exists for and against preoperative administration of antibiotics for third molar surgery (Table 3). In addition, the literature available is riddled with study design flaws and errors in conclusion, making critical appraisal difficult. Finally, the type and delivery of the antibiotic are also important to consider. Oral, intravenous, and topical antibiotic administrations have been studied, in addition to differences in specific antibiotic choice and dose. The benefit of any intervention must be examined in relation to societal impact, quality of life, cost, and adverse effects, and not merely statistical efficacy.

Table 3
Mandibular infections with and without antibiotics

Treatment	Number of third molars	Number without infection	Early infection	Late infection	Infection rate number (%)
No antibiotic	332	283	45	4	49 (14.8)
Systemic	1242	1114	96	32	128 (10.3)
Topical TC	1597	1555	28	14	42 (2.6)
Systemic + TC	250	244	3	3	6 (2.4)
Postoperative systemic	9	8	0	1	1 (11.1)
TC + postoperative systemic	13	13	0	0	0 (0.0)
TOTAL	3443	3217	172	54	226 (6.6)

Abbreviation: TC, tetracycline.

Data from Piecuch JF, Arzadon J, Lieblich SE. Prophylactic antibiotics for third molar surgery: a supportive opinion. J Oral Maxillofac Surg 1995;53:53–60.

Research in favor of antibiotic prophylaxis

In 2009 Monaco and colleagues [15] investigated the effect of 2 g of amoxicillin before removal of lower third molars in 59 patients aged 12 to 19 years. This study was randomized and controlled, and showed a statistically significant difference in postoperative pain, fever, wound infection, and consumption of analgesics in the test group. In 2007, Halpern and Dodson [16] published a placebo-controlled, double-blind, randomized clinical trial dividing 118 subjects into two arms investigating the efficacy of penicillin or clindamycin in preventing postoperative inflammatory complications. They found that 8.5% of the control subjects had a surgical site infection, and no infections were seen in the experimental group. Additionally, none of the experimental or control subjects experienced an AO. The results, although statistically significant, must be interpreted with caution, given an unusually low incidence of AO. In a meta-analysis by Ren and Mamstrom [17] also published in 2007, 16 clinical trials comprising 2932 patients found that preoperative antibiotic administration reduced the incidence of AO and wound infection from 6.1% to 4%, with 25 patients needing to be treated to avoid one such complication. Although these data provide statistical support for use of antibiotic prophylaxis, other factors, such as cost and adverse reactions, must be considered for the 24 of 25 patients who theoretically do not gain benefit from the intervention.

In 2004, Foy and colleagues [18] evaluated the Health Related Quality of Life (HRQOL) in 54 experimental and 60 control subjects having four third molars removed. They investigated the impact of preoperative intravenous antibiotics and did not find a statistical difference in HRQOL between the groups. However, they did show a significant difference in the number of postoperative visits requiring treatment; 4% of the experimental group had one postoperative visit with intervention, whereas 28% and 13% of the control group had one and at least two postoperative visits with intervention, respectively. A similar study in 2006 by Stavropoulous and colleagues [19] used the same control group and investigated the impact of topical minocycline. They found their experimental group had a 10% rate of postoperative delayed recovery, requiring one postoperative intervention. This group did, however, show a statistically significant improvement of HRQOL in time to recovery of chewing and mouth opening. The use of systemic versus topical antibiotic administration for prophylaxis is a subject of controversy and debate. The efficacy of each has been studied separately and compared, but not directly investigated in separate arms of a single study. Multiple additional studies have shown efficacy for intrasocket antibiotic administration, including tetracycline, metronidazole, and neomycin-bacitracin. However, concern has been expressed regarding tetracycline-induced neuropathy when used in proximity to the inferior alveolar nerve.

Research against use of antibiotic prophylaxis

In a split-mouth, double-blind, randomized, placebo-controlled trial with detailed evaluation of surgical and patient variables, Bezerra and colleagues [20] found no difference in postoperative inflammatory or infectious complications after third molar removal when 34 patients were given 500 mg of amoxicillin preoperatively or a placebo. One can argue that this study lacks power, and a larger study population is required to establish a clinically applicable conclusion. This argument is supported by the overall decreased rate of complications the patients experienced. Additionally, the dosage of 500 mg may not have been adequate to provide significant prophylaxis, limiting the impact of their study variable. A split-mouth, double-blind study by Siddiqi and colleagues [21] that randomly assigned 100 patients to receive 1 g of amoxicillin preoperatively, 1 g of amoxicillin preoperatively followed by 500 mg of amoxicillin every 8 hours for 2 days postoperatively, or placebo, separated by 3 weeks, failed to show any statistical significance. Finally, in 2007, Kaczmarzyk and colleagues [22] also evaluated 100 subjects, divided into three groups. Their prospective, randomized, double-blind, placebo-controlled trial did not show any prevention of postoperative inflammatory complications with either single-dose preoperative clindamycin or preoperative plus 5-day postoperative administration of clindamycin. These reports provide evidence that antibiotic prophylaxis does not limit postoperative complications of third molar extraction. However, their conclusions can be questioned given weaknesses in study designs.

Piecuch and colleagues [23] performed a retrospective analysis of 2134 patients in a group practice who underwent extraction of 6713 third molar teeth over a 9-year period. Of these patients, 2031 had a postoperative clinical examination documented an average of 7 to 10 days after surgery. The remaining had clear documentation of telephone calls at 48 hours and at 7 days.

The infection rate for maxillary third molars was 9 of 3270, or 0.3%; the infection rate for mandibular third molars was 6.6%. No cases of severe infection, hospitalization, need for intravenous antibiotics, or external incision and drainage occurred. Considering mandibular third molars alone, extraction without antibiotics resulted in a 14.8% infection rate, whereas systemic (generally oral) antibiotics decreased the infection rate to 10.8%, and topical tetracycline reduced the infection rate to 2.6%. Patients who received tetracycline topically and systemic antibiotics had an infection rate of 2.4% (Table 4).

Systemic antibiotics did not benefit patients undergoing maxillary third molar surgery alone. However, topical tetracycline significantly decreased the infection rate for erupted mandibular third molars. Systemic antibiotics and topical tetracycline reduced postoperative infections for mandibular partial and full bony third molars, but topical tetracycline was more effective. Clinical judgment was recommended for antibiotic use with soft tissue–impacted mandibular third molars.

Zuniga and Leist [24] raised the issue of tetracycline-induced neuritis, occurring after tetracycline contacts an exposed nerve. Subsequently, the same authors performed a prospective study in rats, showing that a nerve with an intact epineurium does not develop an inflammatory response to tetracycline; rather, an intense inflammatory response occurs only when the epineurium is damaged [25]. Gelfoam may protect the damaged nerve from the topical effects of tetracycline, without additional risk.

Table 4
Recent articles: do antibiotics provide benefit or not?

Year	Author	Journal	Method	Benefit	Preoperative Antibiotic
1999	Monaco [37]	Eur J Oral Sci	Oral	No	No
2004	Poeschl [38]	JOMS	Oral	No	No
2004	Foy et al [16]	JOMS	IV	Yes	Yes
2006	Stavropoulous et al [17]	JOMS	Topical	Yes	Yes
2007	Kaczmarzyk et al [19]	IJOMS	Oral	No	Yes
2007	Halpern & Dodson [14]	JOMS	IV	Yes	Yes
2009	Monaco et al [13]	JOMS	Oral	Yes	Yes
2010	Siddiqi et al [18]	IJOMS	Oral	No	Yes
2011	Pasupathy [39]	J Craniofac Surg	Oral	No	Yes
2011	Bezerra et al [11]	JOMS	Oral	No	Yes

Abbreviations: EUR J Oral Sci, European Journal of Oral Sciences; IJOMS, International Journal of Oral and Maxillofacial Surgery; IV, intravenous; J Craniofac Surg, The Journal of Craniofacial Surgery; JOMS, Journal of Oral and Maxillofacial Surgery.

In conclusion, despite some conflicting evidence, antibiotic prophylaxis clearly significantly decreases the occurrence of postoperative AO and SSI. However, surgeons must also consider issues regarding antibiotic resistance and systemic toxicity raised by Kaczmarzyk [26]. The use of antibiotics in cases of active infection; medical compromise that specifically requires systemic antibiotic prophylaxis, such as total joint prostheses; or specific cardiac conditions are completely different situations requiring dedicated research and investigation.

Corticosteroids

A plethora of literature is available on the role of corticosteroids in preventing postoperative morbidity.

In the dental field, Shafer [27] studied the effects of cortisone on postextraction wound healing in the rat model. Thirty-five experimental animals were given 2.5 mg of cortisone on the day of extraction of an upper molar, and 2.0 mg/d afterward. Histologically, no difference was seen in healing versus nonmedicated controls at 2, 4, 5, and 7 days. However at 10 days, soft tissue healing was impaired in the experimental animals. Clearly the exogenous steroid should not be continued for long periods. Although the use of steroids to decrease edema after oral surgery became common, it was not until the early 1970s that Hooley and colleagues [28] showed that a short course of corticosteroids only temporarily depressed endogenous steroid production in humans. In 1980, using a metapyrone test, Williamson and colleagues [29] noted that the hypothalamic-pituitary-adrenal axis returned to normal in 7 days in 10 consecutive patients who received 8 mg of dexamethasone intravenously immediately after oral surgery procedures.

Ross and White [30] presented the results of their randomized controlled trial in which 39 oral surgery patients were given 40 mg of hydrocortisone twice daily the day before, four times daily the day of surgery, and twice daily for 2 days postsurgery, compared with 22 placebo-controlled subjects. The authors noted a statistically significant decrease in edema and trismus in the experimental group. Pain was also less in the experimental group, but the difference was not statistically significant.

In 1964, Nathanson and Seifert [31] reported on the effects of betamethasone with various surgical procedures in their prospective randomized controlled trial in which 110 patients received 0.6 mg of betamethasone four times daily for 4 days, beginning immediately postoperatively, and 100 control patients received placebo. All subjects were examined by one of the authors daily for 5 days. The experimental group showed a significant reduction in edema and a trend toward decreased pain, with no difference in trismus. Because edema presented before the first dose was given, and resolved after that dose, their recommendation was modified to initiate therapy before the surgery and to continue 3 days postoperatively. Hooley and Francis [32] used Nathanson and Seifert's [31] dose recommendations for their split-mouth, self-controlled prospective randomized controlled trial of 476 patients undergoing removal of impacted mandibular third molars. They compared 1.2 mg of betamethasone orally the evening before surgery, then 1.2 mg four times daily the day of and 2 days after surgery. Tetracycline cones were placed into each extraction socket. These authors were the first to use cephalometric-positioned photographs for objective measurement of edema. Their findings showed that the controls had six times as much edema and twice as much trismus, and required twice as much pain medication as the experimental group. These authors additionally commented that they had used betamethasone for more than 2000 patients in the previous 8 years without any systemic complications. Numerous articles compare various steroids with placebo, including triamcinolone, dexamethasone, prednisone, methylprednisolone, and betamethasone. The details of these studies are thoroughly discussed in Gersema and Baker's 1992 review [33] of this topic. Although almost all of these studies were prospective randomized controlled trials, many also suffered from low subject numbers, inconsistent procedures, and subjective observation of results. Nevertheless, Gersema and Baker [33] concluded that "based on these studies, the use of perioperative corticosteroids appears to be a safe and rational method of reducing postoperative complications of edema, and possibly trismus and pain, following the removal of impacted third molars." These authors recommended a single preoperative 125-mg dose of methylprednisolone, given either intravenously or intramuscularly.

In a prospective randomized controlled trial, Buyyukurt and colleagues [34] compared 25 mg of prednisolone intramuscularly, 25 mg of prednisolone plus diclofenac intramuscularly, and control, given immediately after third molar surgery. Each group had 15 patients. Pain intensity was measured on a visual analogue scale (VAS) and edema was measured objectively on the patient on days two and seven. These authors found significantly decreased edema and trismus at both day two and seven in the prednisolone and prednisolone-diclofenac groups compared with controls. Pain was studied only on the day of surgery and was significantly decreased in both the prednisolone and prednisolone-diclofenac groups, with the prednisolone-diclofenac combination more effective. These authors recommended a steroid/NSAID combination as more effective than steroid alone.

Dionne and colleagues [35] investigated this potentially synergistic effect of steroid plus NSAID versus control in a model of acute inflammation. This prospective randomized controlled trial had three groups: (1) preoperative dexamethasone/postoperative ketorolac, (2) preoperative dexamethasone/postoperative saline placebo, and (3) preoperative saline placebo/postoperative saline placebo.

The steroid was administered at 4 mg orally 12 hours before surgery and 4 mg intravenously 1 hour presurgery. The postoperative dose of 30 mg of ketorolac or saline placebo was given at pain onset, usually approximately 2 hours after the procedure. No difference was seen in pain onset in the dexamethasone or control groups. Pain reduction was significant in the dexamethasone/ketorolac group only. No difference was seen in pain between the steroid/placebo and placebo/placebo groups. Unfortunately, these authors did not compare the dexamethasone/ketorolac group with another group of placebo/ketorolac. Markiewicz and colleagues [36] published their study in 2008, titled "Corticosteroids Reduce Postoperative Morbidity After Third Molar Surgery: A Systematic Review and Meta-Analysis." The authors asked one simple question: "Among patients undergoing [third molar] removal, does peri-operative corticosteroid administration, when compared with similar control, decrease postoperative edema, trismus, and pain in the early (1–3 days) and late (>3 days) postoperative periods?" Twelve articles met their inclusion criteria. Their data confirmed that corticosteroids reduce edema and trismus in the early and late postoperative periods. In terms of pain, even fewer papers qualified for analysis because most papers focused on number of analgesic doses and analgesic dosage rather than on VAS scale. Consequently, the reduction of pain by corticosteroids in the early postoperative period is not statistically significant.

Summary

In conclusion, despite a plethora of papers on the various topics covered in this paper, actually very little definitive information is available. There does seem to be consensus that tobacco cessation, use of chlorhexidine, prophylactic antibiotics, and corticosteroids are of benefit in reducing complications and improving the postoperative quality of life after third molar surgery. However, the specifics of their implementation into patient care protocols remains to be specified. The most interesting area for future research is preemptive analgesia.

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Complications of Third Molar Surgery and Their Management

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Complications are inevitably associated with the surgical management of third molars and invasive and noninvasive interventions in general. The frequency and severity of untoward events associated with surgical procedures are influenced by multiple factors that may be related to the procedure, patient, and/or surgeon (Boxes 1–3). Complications associated with the removal of third molars and their management are discussed in this article.

Perioperative anesthesia problems accompanying third molar surgery may or may not be directly related to tooth removal. Intraoral surgery, by its location and nature, poses a threat to the airway. Events related directly to the procedure, such as aspiration of a tooth fragment or a laryngospasm caused by poorly controlled irrigation fluids, can result in life-threatening consequences. Surgical misadventures are more likely to occur when the circumstances of an operation are adversely influenced by patient factors such as obesity, obstructive sleep apnea, large tongue, dense bone, and/or small mouth. Factors that contribute to poor visibility and accessibility increase the likelihood of surgical misadventures. A surgeon who is struggling to comfortably access a third molar site and persists in advancing the surgery increases the likelihood of an untoward surgical or anesthetic event. A fractious patient who is responding poorly to an office heavy sedation or general anesthetic introduces a cascade of negative influences that are likely to result in a surgical or anesthetic misadventure.

Not all third molar surgeries are alike. Not every third molar needs to be removed. Full bony impacted lower third molars that are well below the cervical margin of the second molar crowns should be considered for retention. Careful clinical examination should include periodontal probing of the distal surface of the second molar to rule out pocket depths of 4 mm or greater, which would indicate chronic periodontal inflammation [1].

Removal of lower third molars with dilacerated roots that extend below the inferior alveolar canal or into cortical bone at the inferior bone border with radiographic evidence of a disorder predicts inferior alveolar nerve damage and/or jaw fracture. Complications related to third molar removal are often related to errors of omission rather than commission. For example, complications are more likely to occur when the surgeon fails to perform an adequate preoperative patient evaluation and surgical site assessment. Careful patient selection and adherence to well-established indications for third molar removal reduce the more serious complications (lip and tongue numbness, fractured jaw) by, when indicated, choosing nonsurgical treatment.

This article provides an overview and listing of the common complications related to third molar surgery, their management, and prevention. Undesirable surgical outcomes may or may not be the result of poor surgeon judgment or technique. Complications are identified by their seriousness, reversibility, contributing factors, preventive measures, and management. Prudence and a noncavalier attitude toward third molar surgery are strongly encouraged.

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Complications related to the procedure

Box 1. Complications related to the procedure

Poor surgical access and visibility
Malfunctioning surgical drills or wrong anesthetic technique
Timing of surgical procedure
Aberrant tissue consistency
Wrong venue
Wrong or unnecessary procedure

Intraoperative complications

In general, surgeons express the greatest concern about the more serious complications (broken jaw, numb lip/tongue, deep space infection) associated with third molar removal.

For the purposes of this analysis, in addition to the well-established intraoperative misadventures, any deviation from normal healing, including undue pain, swelling, and altered soft tissue and bony contour at the surgical site, is considered to be a complication.

Gingival clefting
Second molar loss of attached gingiva
Distal bone loss/periodontal pocket second molar
Persistent pain and tooth sensitivity
Temporomandibular disorder (TMD)/internal derangement
Lip lacerations
Corner-of-mouth abrasions

Reflecting a buccal mucogingival flap is usually the initial surgical intervention when removing impacted third molars. The flap should be carefully and delicately reflected to avoid tearing the margins of the gingival crevice and losing keratinized gingiva (Fig. 1). Avoiding gingival clefting and loss of attached gingiva after third molar removal requires careful reflection of the buccal flap attached to the more anterior teeth. Torn buccal gingiva is more likely to occur when the interdental papillae are thin and minimally keratinized. Loss of superior buccal plate and periodontal pocket defects with associated periodontal inflammation increase the likelihood of injuring the gingiva. Immediate repair may reduce the prospect of long-term gingival contour loss. Vertical releasing incisions should be precisely sutured and the envelope flap positioned snuggly to the cervical margins of the more anterior teeth.

Dental papillae should be delicately reflected, avoiding crushing or tearing. Failure to maintain flap integrity delays healing, invites greater swelling and pain, results in loss of gingival contour and quality (keratinized gingiva), and contributes to gingival clefts and chronic irritation. Sharply incising

Box 2. Complications related to the patient

Systemic comorbidities
Age of patient
Patient size
Unfavorable anesthetic candidate
Poor perioperative compliance
Limited space to deliver the luxated tooth
Large tongue
Small mouth
Limited jaw opening
Large, thick cheeks
Limited maxillary labial vestibule space

Box 3. Complications related to the surgeon

Errors in patient selection
Errors in choosing procedure
Poor surgical technique
Failure to honor patient's complaints
Delay in identifying complications and introducing interventions
Unnecessary or imprudent surgery
Failure to thoroughly examine the patient clinically and radiographically

into the gingival crevice and using a pointed instrument such as a wax spatula rather than a molt 9 periosteal elevator facilitates uncovering the third molar surgical site (Fig. 2).

Visibility and accessibility of the impacted tooth determine the extent and mobility of the flap to avoid tearing and compromised surgical access. The back edge of the scalpel blade can lacerate the lower lip when exposing maxillary third molars in patients with limited surgical access, or can the mouth commissures can be abraded with retractors (Fig. 3). Damaged retractors or suction tips can cause cheek and mouth floor soft tissue injuries while exposing the surgical field and keeping it dry. Loss of gingival contour or substance may require gingival grafting (Fig. 4).

Distal bone loss at the second molar site and periodontal pocket inflammation following third molar removal are more likely to occur when a fully developed lower third molar crown is located below the cervical margin of the second molar in intimate proximity to the root structure of the erupted molar. Intraoperative inspection of the distal surfaces of the second molar should be routinely enacted. Wide exposure of the distal root surface of the second molar is an indication for immediate socket preservation. Loss of soft tissue and bone at the distal margin of the second molar invites pain and tooth sensitivity. Defects on the distal margin of the second molar after lower third molar removal are less likely when the third molar's crown and cervical root third are developed [2].

Complications related to the surgeon

Injudicious extraction forces, excessive opening of the mouth with props, and preexisting internal derangements of the temporomandibular junction invite post–third molar TMD. Surgeon and assistant stabilization of the mandible when forceps and elevator forces are being exerted is necessary. Mouth opening should not exceed the patient's comfortable interincisal distance.

Abrasions, lacerations, and burns to the lip and corner of the mouth can be extensive enough to cause permanent skin and/or commissure scarring. Removing superiorly positioned impacted upper third molars under conditions of limited access and visibility invites soft tissue injury (Fig. 5). An overheated handpiece can cause substantial scarring and lip disfigurement. Marred retractors and suction tips made sharp and irregular during previous surgeries should be screened for and replaced.

Fig. 1. Buccal gingival tear during development of an envelope flap to expose impacted tooth 17.

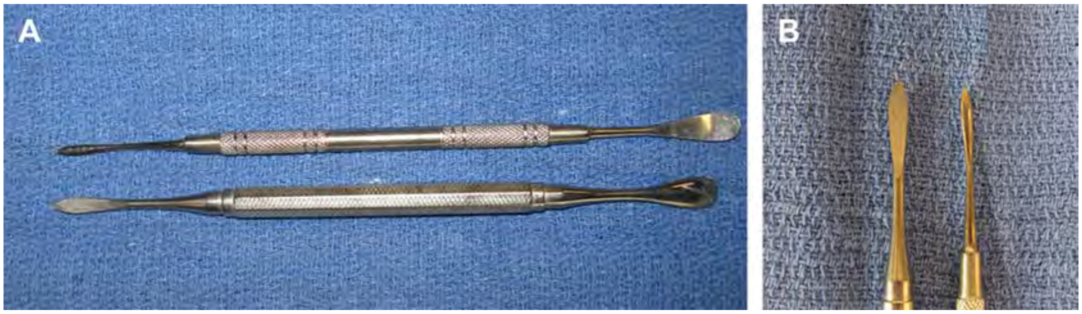

Fig. 2. (*A*) Soft tissue flaps to expose impacted third molars may be reflected less traumatically by using a wax spatula in place of a 9 periosteal elevator. (*B*) Note the small size of the spatula compared with the periosteal elevator.

Fig. 3. One week following removal of 4 third molars, the patient complains of abraded corners of her mouth. The patient had a small mouth and surgical access to the upper third molars was limited. The surgeon should be aware of the potential tissue injury related to retractors remote from the surgical site.

Fig. 4. The back noncutting edge of the scalpel blade can injure the lower lip during development of an upper third molar surgical flap. The surgeon and assistant should be mindful of this potential injury and protect the lip as the incision is completed.

Fig. 5. Retractors and suctions tips get damaged during surgery with rotary instruments. Note the sharp edge of the Austin retractor. Unnecessary trauma to reflected tissues can result when faulty equipment goes undetected.

Fractured mandible
Numb lip
Numb tongue
Displacement of upper third into the infratemporal fossa
Displacement of upper third into the maxillary sinus

Risk factors for mandible fracture

Fractures of the mandibular angle associated with third molar removal are generally avoidable when precise preoperative clinical and radiographic evaluations are completed. Factors that increase the risk of jaw fracture are shown in Box 4. The more risk factors present, the more likely a mandibular angle fracture will occur. When the risk of fracture is high, the indications for removal of a lower third molar should be compelling. Preoperative discussions informing the patient of the increased risk of a broken jaw are critical. Performing the surgical procedure in the hospital operating room (OR) with the patient nasally intubated allows the surgeon to concentrate on the third molar removal, and this is the best venue to immediately repair the fracture should one occur. Judicious bone removal and applying modest elevator forces to the carefully sectioned tooth are vital. Removing less bone and sectioning the tooth into multiple pieces may be a reasonable surgical approach. Root tips lodged in the dense cortical inferior mandibular bone or in the inferior alveolar canal may be best left in place. Application of arch bars and maxillomandibular fixation may be prudent when the mandible is still intact after third molar removal but is at risk for postoperative fracture under normal chewing function and physical activities (Figs. 6–8).

Risk factors for altered sensation in lower lip

Altered sensation in the lower lip associated with third molar removal occurs in approximately 4 per 1000 patients (3.9%) in the early postoperative period [3,4]. Long-term altered lower lip sensation is reported to be approximately 1 per 2500. The risk for early postoperative lingual nerve injury is between 1% and 2.6%. Risk factors associated with injuries to the lingual and inferior alveolar nerves and long-term altered sensation are listed in Boxes 5 and 6. Avoiding long-term nerve injury may be impossible when the risk factors associated with third molar are increased (Figs. 9–12). In the case of the patient shown in Fig. 12, the third molar and the associated disorder warranted surgical intervention and acceptance of the consequences of altered sensation of lip related to the extent of the surgical extirpation. Tooth 17 in the same patient is not symptomatic and shows no radiographic or clinical evidence of disorder, and was left in place to be observed.

Risk factors for altered sensation in the tongue

Altered sensation of the lingual nerve is functionally disabling to patients. Loss of taste, loss of feeling, and speech problems are less tolerated than loss or altered sensation of the lower lip [5].

Box 4. Risk factors for mandible fracture

Older patient
Dilacerated and flared roots
Dense bone
Metabolic bone disease
Osteomyelitis
Small mandible
Third molar occupies the height of the jaw
Associated odontogenic disorders
Injudicious surgical forces

Fig. 6. Preoperative panographic view of impacted lower third molars. Note the size and shape of 17 relative to the dimensions of the surrounding bone. The third molar occupies bone from the crest of the alveolus to the edge of the inferior cortical bone of the mandible. The apical third of the root is bulbous and extends below the inferior alveolar canal.

Fig. 7. Extracted tooth 17 (seen in Fig. 6). Note the bulbous curved root.

Fig. 8. Panographic view of the mandible seen in Fig. 6 following a closed reduction of a left mandibular angle fracture that occurred during the removal of 17 (shown in Fig. 7).

Box 5. Risk factors for altered sensation in lower lip

Older age
Dilacerated root tips in close proximity to the inferior alveolar canal (IAC)
Apical root thirds extending into the IAC
Narrowing of the IAC as it passes the apical root third
Extension of the apical root third inferiorly to the IAC
Increased radiolucency of the root portion contacting the IAC
Dense bone
Poor surgical access
Caustic dry socket medicaments
Lower jaw fracture

Box 6. Risk factors for altered sensation in the tongue

Lingual surgical approach
Superiorly positioned lingual nerve
Perforation of the lingual plate during surgical third molar removal
Lingual positioning of third molar
Root apices extending into the lingual plate
Displacement of lingual plate of bone or tooth fragment into the sublingual space

Fig. 9. Panographic view showing the apices of a mandibular third molar extending inferior to the inferior alveolar canal. Note the change in radiodensity where the nerve crosses tooth structure.

Fig. 10. Right mandibular third molar with roots that are associated with a curving inferior alveolar canal with loss of cortical outline. (*From* Marciani RD. Third molar removal: an overview of indications, imaging, evaluation, and assessment of risk. Oral Maxillofacial Surg Clin North Am 2007;19:8; with permission.)

Fig. 11. Right mandibular third molar with roots that are intimately related to a narrowed inferior alveolar canal. (*From* Marciani RD. Third molar removal: an overview of indications, imaging, evaluation, and assessment of risk. Oral Maxillofacial Surg Clin North Am 2007;19:7; with permission.)

Fig. 12. Panographic view showing a large radiolucency associated with impacted tooth 32 and the intimate relationship of tooth mass to the inferior alveolar canal. Note the severe root dilacerations of tooth 17 and its relationship to the inferior alveolar canal.

Prevention is the key, and surgical repair should be considered early in the postoperative course. Careful sectioning of lower third molars, avoiding perforation of the lingual plate and being aware of the variable positioning of the lingual nerve in the sublingual space, lessens the likelihood of neurologic injury [6,7]. Prudent preoperative decision making that is clinically and radiographically supported fosters correct choices for surgical or nonsurgical treatment of lower third molars. The record should reflect the subjective and objective findings that support the decision to leave or remove a high-risk third molar:

For removal: persistent pain, swelling, inflammation, distal second molar periodontal probing depth greater than or equal to 4 mm, caries in molar teeth, bone disorder.

For no removal: older age; full bony impaction; asymptomatic, medically compromised patient responding to noninvasive local measures.

Displacement of upper third molar into the infratemporal fossa
Displacement of upper third molar into the maxillary sinus

Avoiding displacing an upper third molar into the infratemporal fossa or the maxillary sinus is related to patient age, surgical access, maxillary sinus anatomy, tooth position and anatomy, and the presence of odontogenic cysts or tumors (Fig. 13). Asymptomatic upper third molars located above the roots of the second molars without evidence of a bony disorder should be considered for removal at a later time. An upper third molar in an unfavorable position that requires removal should be considered for scheduling in the hospital OR under general anesthesia. Surgical technique is depicted in Fig. 14. Should the tooth be displaced into the maxillary sinus or the infratemporal or buccal space independently of the surgical venue, the following steps may prove helpful for retrieval:

Fig. 13. Coronal cut computed tomography (CT). Bony window of a maxillary third molar 01 displaced into the right infratemporal fossa. (*From* Bouloux GF, Steed MB, Perciaccante VJ. Complications of third molar surgery. Oral Maxillofacial Surg Clin North Am 2007;19:124; with permission.)

Fig. 14. Superiorly positioned incompletely developed maxillary third molar. Displacing a tooth of this dimension and compromised location into the infratemporal fossa or the maxillary sinus can be avoided by creating a wide soft tissue and bony exposure and visualizing as much of the tooth structure as possible. Elevator forces should be directed anteriorly and inferiorly.

Establish with reasonable certainty the location of the tooth.
Attempt removal through the original surgical defect.
Judiciously enlarge the bony opening at the extraction site.
Flushing the sinus with saline and suctioning the sinus may create the opportunity to secure and remove the tooth.
A Caldwell-Luc procedure should be initiated and the tooth removed through a more anterior opening should the attempt through the original surgical site fail.

Tooth structure displaced into the buccal or infratemporal spaces may be more difficult to locate and retrieve, particularly in the office ambulatory setting. A generous buccal gingival flap with a releasing incision(s) should be made and the flap amply reflected. The tooth is often displaced under the buccal flap in the proximity of the original extraction site. Palpating the buccal soft tissue and fixing the tooth location while carefully exposing the tooth allows delivery into the oral cavity. Failure to identify or retrieve the tooth from the infratemporal fossa prompts scheduling a second procedure, which is best done in the hospital OR under intubated general anesthesia. Appropriate imaging to locate the tooth should be done before further surgical intervention.

Risk factors for maxillary fracture

Fractured tuberosity/pterygoid plate
Fracture maxillary alveolus

Fracture of the tuberosity/pterygoid plate with the inevitable tearing of the palatal mucosa when removing an erupted maxillary third molar is more likely to occur when 1 or all of the factors listed in Box 7 are present (Figs. 15 and 16). Fracture of the maxillary alveolus mesial to the third molar is also more likely when the factors presented in Box 7 are present. Avoiding this complication begins with a precise clinical and radiographic evaluation of the upper third molar that will encourage

Box 7. Risk factors for fracture of the tuberosity/pterygoid plate and palatal soft tissue injury tear when removing an erupted maxillary third molar

Large patient
Dense bone
Flared roots with the palatal root extending palatally
Distalized position of the third molar
Poor surgical access
Forceps extraction
Failure to remove buccal bone
Difficulty sectioning tooth
Distal luxation forces
Limited tooth delivery space

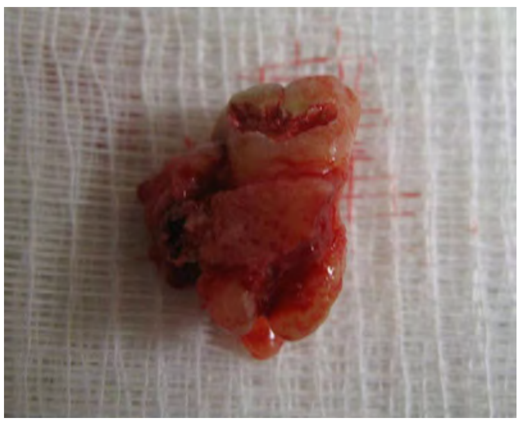

Fig. 15. Extracted maxillary third molar with attached tuberosity of bone and soft tissue.

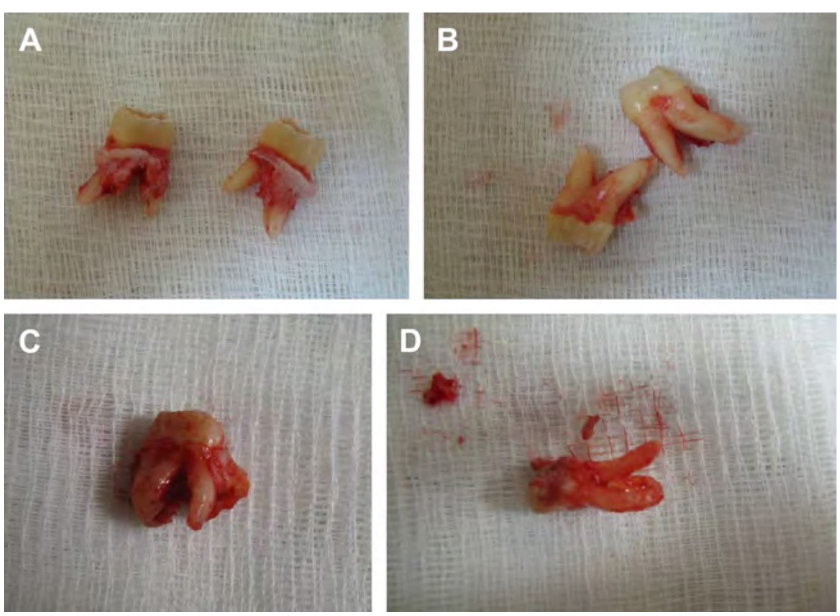

Fig. 16. (*A–D*) Examples of maxillary third molars with flared and curved roots. Teeth were surgically removed with ample removal of labial bone. Standard panographic surveys may not alert the surgeon to the root configurations pictured.

a surgical removal of the third molar. The radiographic survey of the posterior maxilla often does not predict dense bone and does not herald the contour and size of the roots. Once a simple extraction technique is attempted with little or no movement of the upper third molar, the surgeon should initiate surgical removal of the tooth. A generous buccal flap should be reflected and the distal and palatal attached tissue should be released well below the gingival margins. Labial bone should be generously removed to the apical surface of the roots. Luxation of the tooth should be attempted. Failure to effectively mobilize the tooth is an indication to section the roots. Tuberosity fracture and palatal soft tissue tear cause increased postoperative pain and difficulty swallowing. Healing of the palatal tissue is usually delayed, prolonging the patient's postoperative course (Figs. 17–19). The adverse consequences of this complication and the increased pain and suffering to the patient are compelling reasons to initiate a surgical approach to an erupted maxillary when clinical and radiographic findings suggest that simple extraction is imprudent.

Laceration of lingual tissue
Perforation or fracture of the lingual plate
Displacement of tooth structure into the sublingual space

Tearing lingual tissue

Laceration of lingual tissue during removal of mandibular third molars usually occurs when the factors presented in Box 8 are present. Sublingual abrasions and lacerations are painful and can occasionally injure the lingual nerve and cause the patient increased postoperative pain and swallowing difficulties. Careful repair of the soft tissue injury, when indicated, is appropriate. Injury to the deeper submandibular duct should be ruled out. Care must be taken when repairing the lacerated mouth floor not to suture the duct and create an obstruction of salivary flow. An injured duct may be best treated by tacking the overlying mucosa tissue and ensuring continued salivary flow by having the patient massage the submandibular triangle multiple times in the early postoperative period.

Perforation or fracture of the lingual plate during removal of lower third molars generally can be avoided with careful surgical technique. A low horizontally impacted molar with the crown lingually and inferiorly positioned under the cervical margin of the second molar occasionally invites fracture or perforation of the lingual plate. A mobile lingual fragment with minimal periosteal tissue should be carefully removed, making certain that the lingual nerve is not anatomically positioned superiorly and attached to the plate. Perforating the lingual plate during sectioning of the crown or roots is more likely to occur when third molars are lingually positioned. Poor anesthesia control of the patient inviting patient movement can misdirect even the most securely positioned rotary instrument. Perforations generally are superficial and self-limiting. The risk of injury in the lingual nerve is always present.

Displacing a tooth fragment into the sublingual space most often occurs when a root segment is in close proximity to the lingual plate and the apical third of the root is dilacerated or not easily

Fig. 17. Palatal soft tissue wound associated with distopalatal bone loss created during removal of tooth 16.

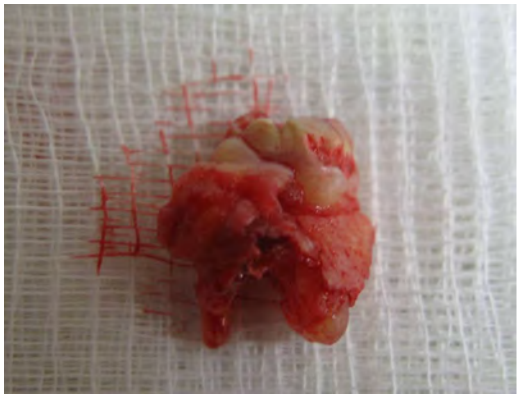

Fig. 18. Maxillary third with flared roots that was removed with difficulty, resulting in a unilateral tuberosity fracture and palatal soft tissue loss, as seen in Fig. 17.

Fig. 19. Repaired palatal soft tissue injury sustained with removal of tooth 1 10 days following surgery. Patient experience prolonged palatal pain and swallowing difficulties. Note the abrasions of the right lower lip.

Box 8. Risk factors for tearing lingual tissue when removing lower third molars

Obese patient
Thick, large tongue
Lingual of partially erupted third molar extends into the mouth floor
Obstructed airway tendencies of sedated patient
Poorly sedated patient with tongue and mouth floor movement related to patient talking and/or moving
Difficulty retracting or poorly displacing the mouth floor when sectioning tooth with a rotary instrument
Uncontrolled movement of the rotating bar during tooth sectioning

dislodged, for whatever reason. Fracture or perforation of the lingual plate may be unavoidable and the displacement of tooth mass into the sublingual space unpreventable. Prevention is aided by first identifying during surgery the clear and present danger. The surgeon or the assistant may prevent sublingual displacement by placing a fingertip against the lingual plate to block displacement of tooth structure during manipulation of the residual root structure (Fig. 20). Retrieving dislodged tooth structure from the sublingual space can be facilitated by using the same fingertip approach to first palpate the fragment and then massage the overlying mucosa to direct the fragment toward the opening in the lingual plate for retrieval. Failure to identify and/or remove the fragment prompts floor-of-mouth imaging and further planned surgical intervention to remove the foreign body.

Damaging second molars

Fracture of adjacent roots
Fracture of adjacent crowns
Dislodgement of adjacent tooth restorations
Displacement of adjacent tooth

Successful completion of a third molar removal without complications is predicated on presurgical imaging observations, surgical site visibility and accessibility, judicious appropriately directed forces, and a surgically compliant patient. Damage to adjacent teeth and/or restorations is at times unavoidable but usually predictable. Alerting the patient before surgery of the potential for damage to an adjacent tooth or restoration structure should not allow for bad surgical practices but rather encourage more careful surgical technique. Clinical and radiographic findings that herald increased chances of violating the neighboring tooth are shown in Box 9. The surgeon controls the choice of instruments and force size and direction. Case scenarios inviting injury to the second molar, and steps to avoid the problem, are discussed later.

Case 1. A 14-year-old boy advised to have 4 third molars removed and upper impacted maxillary second molars exposed. The location of the third molar is most likely behind the second molar (Fig. 21). Surgical access is judged to be limited. Steps to successful removal of the third molars without injury, displacement, or loss of the second molars include (1) three-dimensional imaging, (2) choice of procedure venue (OR or ambulatory office procedure with patient intubated), (3) wide exposure of the impacted teeth, (4) intraoperative inspection of the impacted teeth to establish the morphology of the teeth (should the second molars be fused to the third molars or malformed), and (5) consider removing the second molars to allow the third molars to erupt into the second molar position.

Case 2. A 46-year-old man scheduled for removal of endodontically treated tooth 18 (Fig. 22). Note the crown restoration of 19. Interproximal elevator placement was avoided and 18 was extracted solely with a cowhorn forceps without injury to 19. Surgical removal of 18 would have been prudent to include buccal plate reduction and hemisectioning had forceps extraction failed.

Fig. 20. Forefinger placed into the retromolar area sublingual space adjacent to the lingual plate of bone of an impacted third molar. This action can prevent a lingually positioned root tip from being displaced into the sublingual space during removal. A tooth fragment dislodged into the lingual tissue can be prevented from being pushed deeper into the sublingual space by the same finger placement. Massaging the fragment toward the opening in the lingual plate facilitates retrieving the potential foreign body.

Box 9. Risk factors for damaging second molars during third molar removal.

Large, poorly contoured restorations
Endodontically treated molar
Crowned tooth
Palatally positioned upper third molar
Upper third molar with dilacerated roots surrounded by dense bone
Distoangular mandibular third molar with mesial root closely in contact with the distal root of the second molar
Mesial or horizontally impacted lower third molar located below the cervical margin and tucked under the distal bulge of the second molar
Forcing elevators between third and second molars to create a purchase point

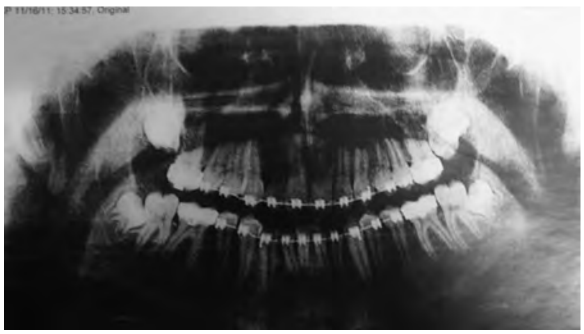

Fig. 21. Note the superior position and the overlapping relationship of impacted teeth 1, 2, 16, and 15. Also note the mesially inclined impacted lower third molars in a locked relationship with the distal cervical surfaces of the second molars.

Fig. 22. Tooth 18 is scheduled for extraction. Note the close contact of the restored crowns of 18 and 19. The restored crown of 19 can easily be displaced should an elevator engage the interproximal area between 18 and 19. Extraction of 18 was completed only using a forceps. Surgical removal would have been indicated had the forceps technique failed.

Case 3. A 16-year-old girl scheduled for third molar removal. Impacted 32 is mesially inclined and located well below the distal bulge of the second molar (Fig. 23). Failure to fully clear the undercut created by the crown contour of the second molar when removing 32 invites fracture and/or displacement of the second molar. Careful sectioning and removing the crown in multiple pieces will reduce the likelihood of injury or dislodging 31. Should 31 become dislodged or displaced, it should be repositioned in its socket and stabilized. The lower third molars of the patient presented in Fig. 21 are also inferiorly positioned with the mesial portions of the crowns lodged under the distal cervical margins of the adjacent second molars.

Postoperative complications

Intense pain
Extensive swelling
Ecchymosis
Subperiosteal abscess
Chronic sinusitis
Postoperative infection

Pain and discomfort are usual and expected patient complaints following third molar surgery. Evaluating the intensity level and the legitimacy of persistent and escalating patient discomfort in the hours and days after wisdom teeth removal is both challenging and frustrating. Many confounding variables can create secondary gains that influence a patient to voice complaints that the surgical team thinks are disproportionate in the absence of clinical and radiographic findings. Drug seeking, time off work assuming the sick role, and malingering can create an extended postoperative course characterized by multiple office visits and phone calls. Patient, surgeon, and office staff can become mistrustful and annoyed. All caregivers must be guided by the simple rule of honoring all patient complaints. Office staff and surgeon should be supportive, empathetic, and sincere without enabling. Careful clinical examination and documentation of positive and negative findings are essential. Pain unassociated with fever, trismus, swelling, delayed wound healing, or other untoward findings is the most perplexing. Two scenarios are possible: pain response without positive findings, or unrecognized clinical findings that are yet to be fully declared (infection, delayed wound healing, buccal plate fracture, TMD). Be alert to trismus in the early postoperative period and do not dismiss swelling and reduced jaw opening as surgical edema. Developing lateral pharyngeal and deep space infection may not be readily apparent in the early postoperative period. Angle of the mandible tenderness with minimal swelling may herald a developing deep space infection. Observe for lateral pharyngeal wall and uvula deviation. Invalidating a patient's complaints that are subsequently supported by clinical findings invites the strongest recrimination of the surgeon and staff. Experienced surgeons are likely to have experienced a serious deep space head and neck infection following a supposedly simple removal of third molars (Fig. 24). Persistent trismus with pain that persists for days and weeks following third molar surgery may be signs of a smoldering temporal or infratemporal space infection (Figs. 25–27).

Fig. 23. Mesially and inferiorly positioned impacted teeth 17 and 32. The crowns of teeth 1 and 16 are developing and are in a superior position relative to the occlusal plane.

Fig. 24. The crown of impacted tooth 32 surgically uncovered under the cervical distal margin of 31.

Perioperative strategies to minimize infections include preoperative and postoperative oral rinses, antibiotics, and associated antiinflammatory medications. The lack of consensus for infection prevention associated with third molar removal speaks to the lack of strong scientific data for or against their usage [8,9]. In the absence of science, surgeons often rely on prudence and intuition when making perioperative judgments. Patients who present with a history of lower molar pericoronitis and antibiotic treatment in the recent past or who have advanced periodontal inflammation and poor oral hygiene may warrant preoperative antibiotics.

Subperiosteal infection commonly occurs 3 to 6 weeks following the removal of mandibular third molars. Patients report that a recurrent swelling presented in their lower jaw is often associated with pain and trismus. The timing of the swelling, the location, and the tenderness strongly indicate a local infection under the buccal periosteum adjacent to the lower third molar surgical site. Clinical examination findings include labial vestibule swelling that may extend into the buccal or masticator spaces, pus expressing under the marginal gingival, pain on palpation, and trismus. Prompt surgical

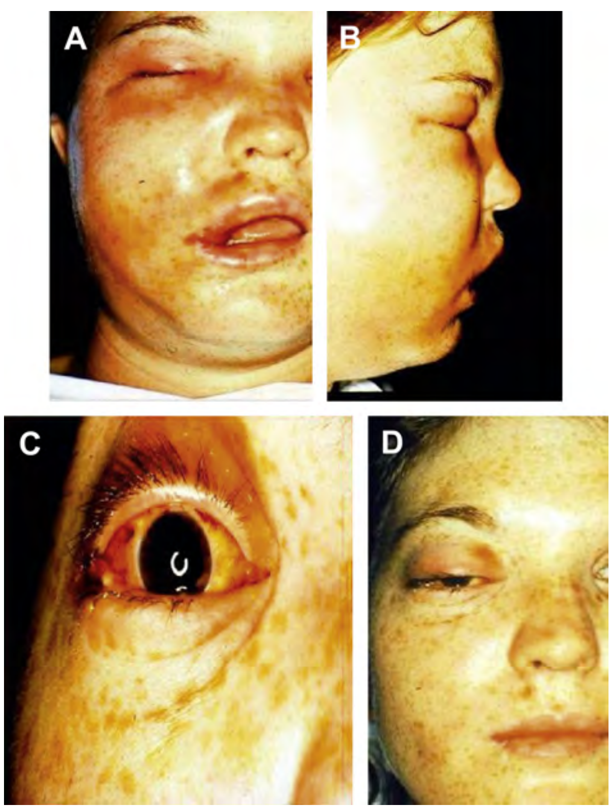

Fig. 25. Patient 4 days following "simple" removal of 4 third molars. Patient developed increased periorbital pain, swelling, and trismus 2 days after surgery, and presented in the emergency department with signs of superior orbital fissure syndrome that progressed to an orbital apex syndrome. Note the severe right periorbital and buccal swelling (*A*), the postsurgical intervention fixed dilated right pupil (*B*), and the eyelid ptosis (*C*). The patient lost vision in the right eye (*D*).

Fig. 26. Five-months pregnant patient with a hematocrit of 20 2 weeks following simple removal of tooth 1. The patient was previously treated with antibiotics and incision and drainage of right temporal space. Pain and swelling persisted. CT of head and face showed deep temporal space abscess.

intervention is the most predictable treatment, supplemented by antibiotics. A full-thickness buccal mucoperiosteal flap extending from the anterior border of the ramus in a sulcular fashion anterior to the bicuspid area generously exposing the buccal surface of the lower jaw usually vents pus. Foreign bodies such as tooth or bone fragments, suture fragments, food debris, and/or associated granulation tissue should be diligently observed for and removed. A Penrose drain may be placed when the buccal and or masticator spaces are involved. Persistent recurrent pain and swelling in the paramandibular region suggests the presence of an unidentified foreign body, buccal plate, or mandibular angle

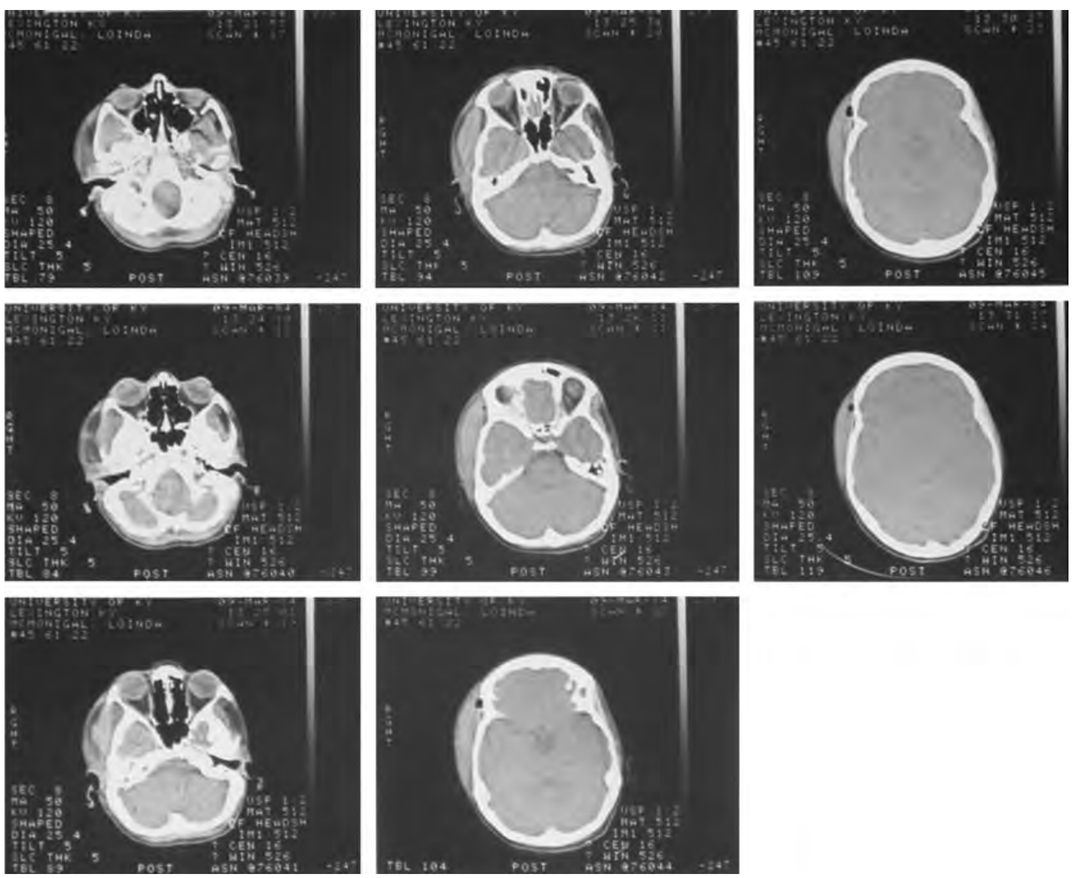

Fig. 27. Head and face CT of the patient seen in Fig. 26. Note the right deep temporal space abscess.

fracture, or a more serious osteomyelitis that requires more extensive surgical and antibiotic treatment.

Sinusitis following upper third molar removal in the absence of a preexisting condition is treated by antibiotics and sinus precautions. Small oral antral openings are self-limiting and close spontaneously. Larger defects created by bone loss and or tooth displacement into the sinus require soft tissue flaps and long-term antibiotics.

Ecchymosis with or without swelling may be expected following third molar removal in older patients, patients with increased intraoperative bleeding, prolonged wound oozing, or bleeding from any cause. Local bleeding control measures (pressure packs, Gelfoam, observing postoperative instructions) limit the problem. Persistent bleeding and ecchymosis may be evidence of an underlying bleeding and clotting disorder that warrants hematologic work-up.

Alveolar osteitis (loss of the extraction site blood clot and the associated pain and discomfort, commonly called dry socket) is more frequently found in a lower third molar socket. The diagnosis is likely when the patient complains of radiating jaw pain that extends preauricularly, has an onset several days after the original surgery; irrigation of the socket produces fine necrotic debris with a characteristic odor and the condition is relieved by sedative dressings. Alveolar osteitis prolongs the postoperative course and can be disconcerting to the patient. It has a frequency of 0.2% to 12.7% [10]. Patient risk factors are reported as smoking, feminine gender, birth control medications, and injudicious postoperative oral habits. The previously mentioned risk factors are the common findings associated with the presumed diagnosis of dry socket: these findings are often hard to objectify, especially when the patient's complaints are vague and inconsistent. The surgeon makes a case for establishing alveolar osteitis by the timing of the emergence of pain and the clinical findings previously mentioned. Irrigation and sedative packing are more important in pain management than analgesics. Use of commercial or surgeon-created medicaments can be harmful. Caution should be exercised when the inferior alveolar nerve was likely exposed and or the patient reports altered sensation in the lower lip or tongue. Ingredients in sedative pastes and liquids, such as eugenol, may be irritating to the nerve or surrounding soft tissues, contributing to neurologic injury. Packs left in place or medicaments that are late to dissolve may become foreign bodies that create infection and prolong the postoperative course. Can the frequency of delayed socket healing and dry socket pain be reduced or modulated using antiinflammatory medication, antimicrobial rinses, and/or socket poultices? There is a body of studies supporting preextraction and postextraction socket treatment [11–13].

Summary

Third molar surgery has a predictable postoperative course of pain, swelling, decreased jaw opening, and lost gainful activity in the 3-day to 5-day range for the average patient [14,15]. During the immediate postoperative period, patients may experience nausea and vomiting, persistent bleeding, difficulty swallowing, dehydration, and the gastrointestinal consequences of narcotic analgesics [16]. Lethargy and delayed recovery may represent the complexity and duration of the surgical procedure, the response of the patient, or a developing adverse consequence. Surgeon and patient expect postoperative swelling and pain that is difficult to precisely normalize. Normal swelling and pain are characterized by being more intense on the day of surgery and the subsequent 2 days, with a likely decline of subjective and objective evidence of the surgery 3 to 5 days after the surgery. Persistent pain and swelling may be the first indicators of a developing complication. Patients call their surgeon concerned about increased swelling on the second or third postoperative day, pain, fever, and feeling poorly. When should the patient be advised to return to the office for evaluation? What are the determinants of significant bleeding? How do the office staff and/or the surgeon judge the seriousness of the patient's concerns and initiate the appropriate response?

The extremes of postoperative untoward events do not pose a dilemma whether to see or not to see the patient. The patient is advised to return to the office or perhaps the hospital emergency room if the circumstances warrant such action. It is difficult to cast an absolute set of office responses to a concerned patient's or caregiver's inquiry without seeing the patient. When it is apparent that the patient and family are concerned, they should be instructed to return to the appropriate venue for examination. When the surgeon finds the report of the patient's problem to be either equivocal or substantive, the doctor should see the patient.

Surgical complications are often unavoidable independently of surgeon or venue. Factors conspire to produce an untoward event in spite of the best of surgical care. Poor diagnostic or surgical judgment creates unnecessary problems that are related to the skill set and acumen of the surgeon. Not all numb lips, fractured jaws, and upper third molars displaced into the infratemporal fossa are unavoidable. More problematic are surgeons' errors of omission. Failure to honor a patient's complaint or a delay in intervention of a developing postoperative issue fosters patient mistrust and prolongs resolving the problem. Surgeons must recognize before surgery the potential for a complication and advise the patient of the risk/benefit of the scheduled surgical event. The prepared surgeon and the informed patient may together minimize the extent and the time necessary to limit the damage from procedural mischief.

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Controversy, Evidence, and Third Molar Management

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Given the prevalence of third molars, high incidence of associated pathology, and cost of care (surgical or active surveillance), decision-making and management strategies for third molars have received a great deal of attention. Understandably, there are controversies that surround wisdom teeth, including the optimal time for treatment, if and when to prescribe medications such as antibiotics, steroids, and analgesics, the actual costs (financial and otherwise) of treatment and retention, and what constitutes monitoring of retained teeth. The "gorilla in the room," however, involves what are appropriate indications for the removal of third molars, particularly those that are asymptomatic. The debate has intensified as proponents of retaining asymptomatic third molars have focused their concerns on cost containment (Fig. 1).

It is not surprising that not all parties of interest (patients, families, surgeons, and third-party payers) see things in the same way.

Typical desires/perspectives:

Patients and families
- Best treatment at most convenient time
- Minimal risk
- Least eventful recovery
- Minimal expense
- Minimal red tape

Providers
- Freedom to recommend and provide the best treatment
- Fair compensation
- Minimal red tape

Third parties
- Manage costs
- Keep purchasers and insured satisfied

Some of the discord between parties represents honest disagreement, some results from a lack of information or experience, and some reflects self-interest. Added to this is the impact of media, politicians, and "advocates," all of whom have perspectives and agendas of their own. Unfortunately, agendas and self-interest are a reality of life. Reality dictates that excellence is retarded and care compromised when the ability to make the best possible choice is influenced by agendas and self-interest (Fig. 2).

Misconceptions, misunderstandings, and vague terminology also contribute to the confusion surrounding decisions to be made concerning third molars. Examples include:

Terminology

- "Asymptomatic" does not indicate the absence of disease—merely a lack of symptoms.
  - There is a significant difference between disease-free and asymptomatic.

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Fig. 1. A 16-year-old girl with 4 unerupted and asymptomatic third molars. Clinical examination is necessary to help ascertain physiologic space for eruption and maintenance of these teeth, including quantity and quality of available space. Informed discussion should include possible consequences of surgical management as well as retention, and the impact of age on risks of treatment.

  - Because pathology always precedes symptoms and because dental disease often progresses without symptoms, it is prudent for decision making to include the presence (or likely development) of pathology as opposed to being asymptomatic.

Misconception

- Many simplify decision making to consist of either removal or retention.
  - The management of wisdom teeth is a complex topic with options including removal, partial removal (coronectomy), or retention with subsequent clinical and radiographic surveillance. Surgical exposure, repositioning, transplantation, surgical periodontics, and marsupialization of associated soft-tissue pathology with observation and possible secondary treatment are also possible choices for surgical management.

Misunderstanding

- Some critics suggest that oral and maxillofacial surgeons should not be involved in the decision-making policy for third molars on the grounds that it represents a conflict of interest.
  - The dental profession in the United States is made up of about 80% general dentists, and most of the remaining 20% are not surgeons. Therefore, most patients who seek third molar consultation have been referred from a different dental professional who has nothing at stake other than the well-being of their patients.
  - Leaving policy making to those lacking the experience and expertise of an oral and maxillofacial surgeon replaces their input with that of someone less qualified.

It is important to consider what different professional organizations say about the indications for surgical management of third molars. Examples include:

- The American Association of Oral and Maxillofacial Surgeons (AAOMS) Parameters of Care 2012 (ParCare 2012) lists more than 20 specific indications for removal of categories of third molars along with goals for therapy. This document recognizes the benefit of removal to prevent disease and the role of the treating surgeon as the one best able to determine care for an individual patient. Therapeutic goals listed in the ParCare document include "prevention of

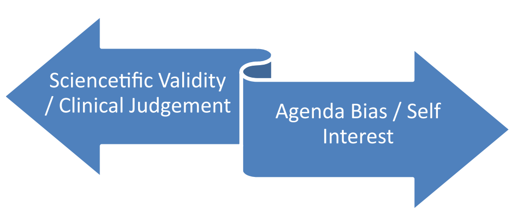

Fig. 2. Agenda bias and self-interest is counterproductive to arriving at the best possible choice(s) for care.

pathology," "preservation of periodontal health of adjacent teeth," and "optimization of prosthetic rehabilitation." Along with specific indications are the following statements:

> Given the following and the desire to achieve therapeutic goals, obtain positive outcomes, and avoid known risks and complications, a decision should be made before the middle of the third decade to remove or continue to observe third molars knowing that future treatment may be necessary based on the clinical situation. There is a growing body of knowledge suggesting that retention of third molars that are erupted or partially erupted contribute to a higher incidence of periodontal disease. This persistent periodontal disease has both dental and medical consequences for the host and therefore, may be an indication for prophylactic removal.

and

> An unerupted third molar is an embedded tooth that will probably erupt by the middle of the third decade. An impacted third molar is so positioned that it will probably not erupt by the middle of the third decade and may lead to disease with dental and medical consequences. To limit known risks and complications associated with surgery, it is medically appropriate and surgically prudent to remove these impacted third molars before the middle of the third decade and before complete root development. An impacted tooth with completed root formation that is totally covered by bone in a patient beyond the third decade that does not meet the following indications for removal should be monitored for change in position and/or development of disease, which may then indicate its removal [1].

- The AAOMS authored the following "anchor statements" to be used in its publications:
  - "Predicated on the best evidence-based data, impacted teeth that demonstrate pathology, or are at high risk of developing pathology, should be surgically managed. In the absence of pathology or significant risk of pathology, active clinical and radiographic surveillance is indicated."
  - "All third molar teeth should be managed deliberately using an evidence-based approach. Appropriate management of third molar teeth may include removal, partial removal or retention followed by active clinical and radiographic surveillance to make sure that pathology does not develop."
  - "Third molar therapy is an evidence-based treatment paradigm. It includes radiographic surveillance to assess tooth position, pathology and possible need for removal. Retention of all third molars requires periodic follow-up."
- The American Dental Association (ADA) policy is less detailed but supports in principle the guidelines contained in the AAOMS ParCare document. Written policy comments include:

> Your dentist or specialist may also recommend removal of teeth to prevent problems or for others reasons, such as….
>
> In addition, the condition of your mouth changes over time. Wisdom teeth that are not removed should continue to be monitored, because the potential for developing problems later on still exists. As with many other health conditions, as people age, they are at greater risk for health problems and that includes potential problems with their wisdom teeth.

- A Cochrane systematic review found:

> General agreement exists that removal is appropriate in case of symptoms of pain or pathologic conditions. Controversial statements exist with regard to the prophylactic removal of asymptomatic or disease-free impacted third molars. This review found no evidence to support or refute routine prophylactic removal of asymptomatic impacted wisdom teeth in adults; no studies of adults met the criteria for inclusion. However, it found some reliable evidence that suggests that the prophylactic removal of impacted third molars in adolescents to reduce or prevent late incisor crowding cannot be justified. Such removal neither reduces nor prevents late incisor crowding [2].

- The United Kingdom's National Health Service (NHS) introduced a policy to restrict the removal of third molars based on recommendations issued by the National Institute of Clinical Evidence (NICE) in an effort to restrain short-term costs.

> The routine practice of prophylactic removal of pathology-free impacted third molars should be discontinued in the NHS.

and

> Surgical removal of impacted third molars should be limited to patients with evidence of pathology. Such pathology includes unrestorable caries, non-treatable pulpal and/or periapical pathology, cellulitis, abcess and osteomyelitis, internal/external resorption of the tooth or adjacent teeth, fracture of tooth, disease of follicle including cyst/tumour, tooth/teeth impeding surgery or reconstructive jaw surgery, and when a tooth is involved in or within the field of tumour resection.

The consequences of this policy lack long-term follow-up of the real costs (financial and otherwise) associated with retaining third molars over time [3].

- The national health service in Finland has a similar policy to that of the United Kingdom, despite the fact that a highly regarded Finnish researcher has published data from a long-term retention study documenting that a large majority of patients who retain their third molars will eventually have one or more removed based on the development of pathology. Furthermore, their methodology allows many patients with retained third molars to have associated pathology even if overtly asymptomatic [4].
- The US Military supports removal of third molars based on the findings/recommendation of the treating surgeon. Attendees of the military academies are required to have their third molars removed before entrance in recognition of the benefits of prophylactic treatment.
- The 2008 American Public Health Association (APHA) policy statement opposes "prophylactic" removal of wisdom teeth [5]. This recommendation was not formulated using an evidence-based approach and did not benefit from input from experts in wisdom tooth management. It was based on opinions provided by an age-old critic of dentistry who has been crying out against the removal of third molars for more than 3 decades, treats all wisdom tooth extractions as unnecessary, and extrapolates isolated cost and complication data across this global data set to (erroneously) imply that there would be great financial impact, ignoring a balanced consideration of active surveillance and the costs associated with ignoring the long-term effects on health and quality of life. While such arguments have lacked traction among the informed dental community and are contrary to the positions of expert professional organizations, from time to time they have motivated those with self-interest in the matter, usually financial.

While perhaps well intended, attempts by organizations such as the APHA and NICE to summarize the literature and provide guidelines intended to apply to all patients is misguided at best and likely harmful to many. Such approaches are biased given that they emphasize the outcomes of treatment (third molar removal) while overlooking the costs and outcomes associated with retention, because that is where the majority of available data exist.

In an effort to develop consensus on best-practice approaches to clinical practice, attention has been focused on the concept of evidence-based clinical practice. Although the term evidence-based has been used carelessly by some, evidence-based clinical practice should be characterized by the merging of the best available relevant evidence (not just that which supports a preconceived idea or agenda) derived from the current literature with the clinician's knowledge, experience, and abilities, and incorporating the patient's preferences, assessment of risks and benefits, and perceived costs and consequences, to arrive at the best management decision for an individual patient. Such evidence should be fairly interpreted by clinicians who are expert and experienced in the management of patients with third molars. To do so requires an organized approach to evaluate the validity and clinical relevance of evidence (Figs. 3 and 4, Table 1).

Historically there was a shortage of compelling evidence to definitively answer other important questions, particularly as it applies to the fate of retained third molars. Most of the available literature focused on limited aspects of third molar behavior. Absent were well-designed studies comparing the long-term and short-term consequences of retention versus removal, in large part because such investigations are expensive and difficult to conduct. The few long-term nonintervention studies available were limited to looking at the most basic of outcome variables such as the presence or absence of a given third molar. These studies did not look at more important but difficult-to-measure variables and outcomes, such as the presence of associated soft-tissue pathology, let alone its

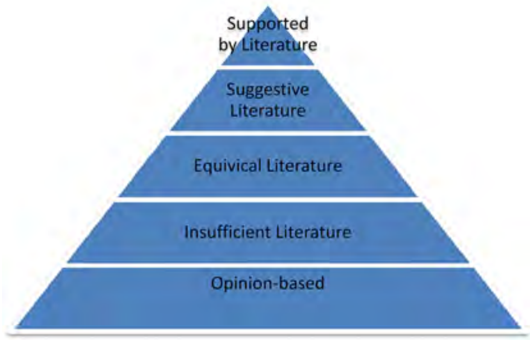

Fig. 3. Hierarchy of clinically relevant evidence.

consequences. Also missing was an appreciation of the long-term costs and consequences of retaining third molars. As a result, clinicians had to rely on their experiences perhaps as much as the literature when making treatment decisions.

Nonetheless, some basic aspects about third molars and their behavior have been well accepted by all but the most biased of parties. For example, it is well accepted that third molars can be of functional value in some patients. It is also known that third molars can be associated with pathology of one type or another.

Well-known pathologies associated with retained third molars

- Periodontitis
- Pericoronitis
- Caries
- Tumors
- Cysts
- Local and deep space infections
- Root resorption
- Mandible fractures

The last few decades have moved us closer to answering other important questions about third molars. Central in this effort has been the contribution of the Third Molar Clinical Trials, a series of investigations that are prospective and longitudinal, and conducted by investigators from a variety of disciplines at multiple sites. This research has resulted in more than 125 articles and abstracts in peer-reviewed journals. Another advancement was the 2010 Multidisciplinary Conference on Third Molar

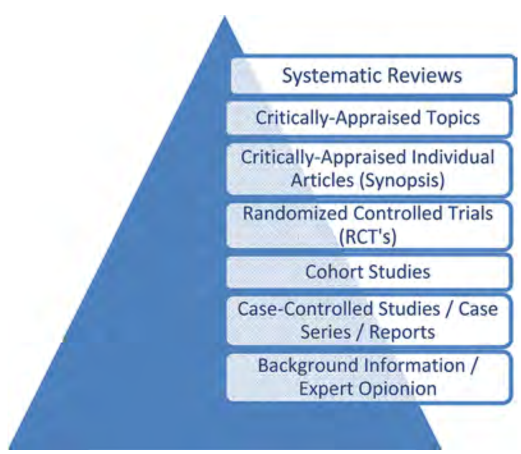

Fig. 4. Hierarchy of clinically relevant evidence.

Table 1
Level of recommendations and evidence

Strength of recommendation	Definition
Class I	Evidence and/or general agreement that a given treatment or a diagnostic approach is beneficial, useful, and effective
Class II	Conflicting evidence and/or a divergence of opinions about the usefulness/efficacy of a treatment or a diagnostic measure
Class IIa	Weight of evidence/opinion is in favor of usefulness/efficacy
Class IIb	Usefulness/efficacy is less well established by evidence/opinion
Class III	Evidence or general agreement that the treatment/diagnostic measure is not useful/effective and in some cases may be harmful
Level of evidence	**Available evidence**
A	At least 2 randomized trials supporting the Recommendation
B	Single randomized trial and/or a meta-analysis of nonrandomized studies supporting the recommendation
C	Consensus opinion of experts based on trials and clinical experience

Science (the synopsis of which is to be published in an upcoming issue of the *Journal of Oral and Maxillofacial Surgery*), where representatives of dental, medical, governmental, and third-party organizations interested in learning the facts about third molar pathology and the systemic implications for patients met. Experts from the United States, Canada, Finland, and the United Kingdom presented and reviewed the latest research findings on third molar extraction and retention, patient surveillance, potential risks, and attendant costs. Given these efforts and other advances in third molar science, our understanding of the behavior of third molars has never been greater.

A practical and user-friendly way to consider the aforementioned kinds of relevant evidence is how evidence trends from absent to certain in answering clinical questions (Fig. 5).

Based on the best available evidence, the following can be considered as certain when it comes to third molar science, behavior, and management:

- Third molars are different from other teeth in significant ways.
- An absence of symptoms associated with third molars does not equal the absence of disease. Therefore, to accurately determine a clinical problem, both the presence of symptoms and disease status must be assessed.
- Retained wisdom teeth frequently and unpredictably change position, eruption, and periodontal status.
- The microbial biofilm associated with partially erupted third molars and pericoronitis is conducive to the development of periodontal disease.
- Periodontal disease in the third molar area begins with third molar eruption.
- Pocketing around wisdom teeth is an important indicator of periodontal disease, especially when bleeding occurs on probing.
- Third molars with probing depths greater than 4 mm increase the risk for developing increased pocketing anteriorly.

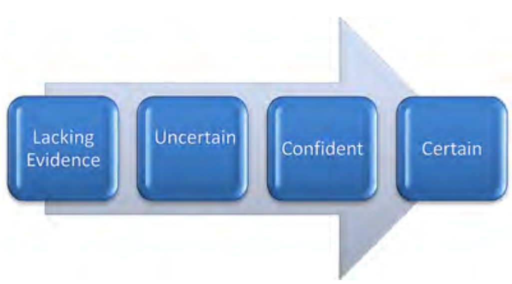

Fig. 5. Progress of confidence in available clinically relevant evidence from lacking to certain.

- Extraction of a third molar reduces the risk for periodontal disease in young adults.
- There are identifiable risk factors for delayed healing and for surgical complications associated with third molar surgery.
- Extraction of third molars after the age of 25 years is itself a risk factor for complications.
- Removal of third molars after the age of 25 years is a risk for prolonged and incomplete healing.
- There are identifiable ways to improve postoperative healing and recovery.
- Not all wisdom teeth need to be extracted, but all require management.
- The decision to retain wisdom teeth is a lifetime decision.
- Retention of third molars with pocketing may increase the risk for broader conditions that are associated with increased systemic inflammation.
- The majority of patients with retained, asymptomatic wisdom teeth eventually require surgical management.
- When patients elect to retain their third molars, the frequency of future disease is sufficiently high that active surveillance is a superior management strategy when compared with symptomatic (as needed) follow-up.

The following statements have evidence that suggest their validity but require more study before they can be considered as certain.

- While it is likely that most third molars will develop pathology over time, we are not certain how to identify those that will not.
- Monitoring retained wisdom teeth may be more expensive than extraction in the long term, although the data are lacking.
- Some suggest that systemic diseases are linked to the oral inflammation associated with third molars. Although this may turn out to be true and while it does make biological and clinical sense, current evidence for a cause-and-effect link is suggestive rather than definitive.

Even with the most sophisticated evidential approach to clinical dilemmas, it is rare for all the answers to "be in". Often our understanding of what represents "truth" is a moving target, and relevant evidence may be difficult to interpret or implement. Regarding whether to remove a third molar or how to monitor a retained one, uncertainty may come into play as with many real-world clinical questions. The hallmark of an excellent clinician is the ability to deal with uncertainty in a responsible and effective manner. Expert clinicians have an ability to think critically with a disposition to evaluate and thoughtfully consider the problem at hand, understanding that not everyone might agree with him or her. This ability is developed over time based on experience, an attention to detail, and the careful application of the best available external evidence from clinically relevant research. No formula can replace the role of the expert clinician in determining the best care for a patient.

To assist the expert clinician, appropriately developed guidelines can help identify productive approaches for good care. Such protocols are best when they take the form of guidelines rather than directives, and should be based on clinically relevant evidence (Fig. 6).

In the end, the following statements regarding treatment recommendations are supported by clinically relevant evidence:

- Surgical management of third molars is appropriate when there is evidence of pathologic changes.
- Surgical intervention or removal of third molars before the development of periodontal pathology should be considered in patients who have insufficient physiologic space for eruption and

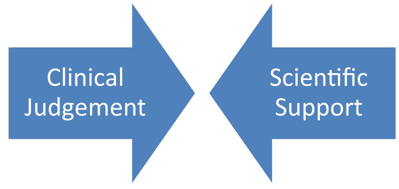

Fig. 6. The intersection of good clinical judgment and reliable evidence is where patients (individuals and groups) are provided the best opportunity for an excellent management decision or policy.

maintenance at a time when the postsurgical healing is optimal and the risk of postoperative complications is lowest.

- To limit the known risks and complications associated with surgery, it is medically appropriate and surgically prudent to remove third molars in patients with demonstrated pathology before the middle of the third decade and before complete root development.
- Given that third molars have been shown to be dynamic in their behavior and position, patients choosing to monitor them are committed to a lifetime of follow-up. The known variables of active surveillance include the cost of regular imaging and follow-up visits, the uncertainty regarding the future behavior of the teeth, the risk for developing active or occult inflammatory dental disease, and a statistically significant increased risk with age for operative or postoperative complications if extraction or other treatment becomes unavoidable. In fact, over time in cohorts where wisdom tooth retention is the "prescribed" treatment, most will have them removed in the ensuing decade.
- Third molars that are completely erupted and functional, symptom-free, free of caries, in hygienic position with a healthy periodontium, and without other associated pathologic conditions do not require extraction, but do require routine maintenance and periodic clinical and radiographic surveillance.
- An impacted tooth with completed root formation that is totally covered by bone in a patient beyond the third decade that is not associated with pathology should be monitored for change in position and/or development of disease, which may then indicate its removal.

Despite all efforts, at present there is no one recognized management strategy for third molars, particularly asymptomatic disease-free third molars. Common sense dictates that the optimum strategy must balance between the extremes of removal of all versus retention of all, and be patient centered. Before a management decision is made, the surgeon should assess tooth position and room available for eruption, presence or absence of pathology, and the likelihood of pathology developing. Several factors should be considered when evaluating for the management of a patient with asymptomatic third molars, including risks of removal, risks of retention, age and developmental considerations, and protocol for active surveillance. The surgeon should then review the risks and benefits of both operative and nonoperative approaches, and stress the importance of active surveillance with periodic clinical and radiographic examination for third molars that are retained. Patients should be informed of the greater difficulty and increased rate of complications with wisdom tooth removal as they age, as well as the increased risk of periodontal disease associated with retained wisdom teeth. When it is appropriate, patients should be told that if they retain their disease-free wisdom teeth, it is possible that they could live their entire lives without problems.

In the end, while the removal of third molars does present some risks to patients, this must be balanced against the lifetime health and cost benefits from prevention and elimination of potential and real pathologic processes associated with retention. This advice is best given by a wise and experienced clinician armed with the best available evidence as it applies to a given individual patient. It cannot be replaced by recommendations issued by any organization, no matter how well meaning.

Controversies surrounding third molars must be resolved if we are to fulfill the goal of providing patients with the best possible care. This resolution will require a concerted effort by all parties working together, with emphasis on sound and clinically relevant evidence interpreted and applied by those with expertise and experience in the management of patients with third molars. Where good science exists, proper attention must be given to its interpretation and application to patient care. Where there is an absence of conclusive evidence, the available evidence should be responsibly interpreted and used to "connect the dots" in a manner that provides guidance in making treatment decisions. Furthermore, areas that require more study should be identified, with adequate resources allotted to design and conduct clinically relevant research, such as modeled by the Third Molar Clinical Trials. At all times, oral and maxillofacial surgeons must assume a leadership role as those most experienced and expert in the science of third molar management.

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