# Evidenced-Based Decision Making: The Third Molar

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Oral and maxillofacial surgery is a surgical specialty based in dentistry and founded upon science. Scientific research is the foundation upon which oral and maxillofacial surgeons are trained, and decisions are made. This has included education and decision-making in the lecture hall, in the operating room, while on rounds, and in the clinical setting. This science, research, and publication are the evidence with which education and decisions are based. While traditional teaching and decision making has included a review and interpretation of the literature, the American Association of Oral and Maxillofacial Surgeons (AAOMS) has been at the forefront of formal evidence-based dentistry with such projects as the *Parameters of Care: Clinical Practice Guidelines for Oral and Maxillofacial Surgeons*, now in its fourth edition;[1–4] the AAOMS Outcomes Assessment Program;[5,6] the AAOMS Third Molar Clinical Trial;[7–37] and the AAOMS "White Paper on Third Molar Data," which is based upon a review of the current literature.[38] This article reviews these evidence-based resources to provide a consensus of opinion for the management of the third molar.

## THE AMERICAN ASSOCIATION OF ORAL AND MAXILLOFACIAL SURGEONS PARAMETERS OF CARE

Recognizing the need to identify and support evidenced-based decision making, the AAOMS in 1986 created a 22-member committee to develop criteria and standards of care for oral and maxillofacial surgery. The product of its first labors was the original *Parameters of Care*.[1] This document contained a section on dentoalveolar surgery that addressed the management of third molars. The publication is now in its fourth

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edition, after sustained scrutiny by thousands of oral and maxillofacial surgeons, other specialty organizations, and communities of interest, and is endorsed by 44 international oral and maxillofacial surgical societies. The current section that addresses third molars is based upon a review of more than 100 peer-reviewed publications. It contains, in outline form, indications for therapy, therapeutic goals, factors affecting risk, therapeutic standards, and outcome assessment indices. They are reproduced as **Boxes 1–5.** This outline addresses the management of third molars from the time the patient enters the office, through diagnosis and definitive therapy, to completion of the case.

### THE AMERICAN ASSOCIATION OF ORAL AND MAXILLOFACIAL SURGEONS AGE-RELATED THIRD-MOLAR STUDY

In response to the ever-changing health care marketplace and increased presence of managed care, the AAOMS, in 1995, commissioned a special subcommittee for outcomes assessment. The charge of this group was to identify high-volume and high-profile oral and maxillofacial surgical procedures, and then to objectively assess their management and the outcomes of each therapeutic modality. One of the first projects was to review the demographics and postoperative results after the removal of third molars in an older population.[5] This was meant to be the largest prospective evaluation of patients 25 years of age or older who had third molars removed. During this study,

**Box 1**
**Indications for therapy for third molars**

- Pain
- Pericoronitis
- Nonrestorable carious tooth
- Facilitation of the management of, or limitation of progression of, periodontal disease
- Nontreatable pulpal or periapical lesion
- Acute or chronic infection
- Ectopic position
- Abnormalities of tooth size or shape precluding normal function
- Facilitation of prosthetic rehabilitation
- Facilitation of orthodontic tooth movement and promotion of dental stability
- Tooth in the line of fracture
- Tooth involved in tumor resection
- Pathology associated with tooth follicle
- Tooth interfering with orthognathic or reconstructive jaw surgery
- Preventive or prophylactic removal, when indicated, for patients with medical or surgical conditions or treatments
- Clinical findings of pulp exposure by dental caries
- Clinical findings of fractured tooth or teeth
- Internal or external resorption of tooth or adjacent teeth
- Impacted tooth
- Need for donor transplant

**Box 2**
**Possible therapeutic goals of third-molar removal**

To prevent pathology

To preserve periodontal health of adjacent teeth

To optimize prosthetic rehabilitation

To optimize management or healing of jaw fracture

To optimize orthodontic results

To aid in tumor resection

To provide healthy oral and maxillofacial environment for patients undergoing radiation therapy, chemotherapy, organ transplantation, or placement of alloplastic implants or other devices

To prevent complications of orthognathic surgery

3760 patients had 8333 third molars removed by 63 surgeons. Age, gender, American Society of Anesthesiologists (ASA) status, chronic conditions, medical risk factors, and the preoperative description of the third molars were recorded. Intraoperative and postoperative complications were also recorded and frequencies tabulated. From among the 3760 patients (52.0% male; 48.0% female), all were 25 years of age or older, with 9845 third molars of which 8333 were removed. A majority of the patients involved in the study were healthy (72.5%). Hypertension and chronic heart disease were the most frequently encountered chronic conditions, representing approximately 10.2% and 4.8% of the patient population, respectively. At least one risk factor, including smoking (16.3%), medications (9.3%) and alcohol use (9.0%), was encountered in

**Box 3**
**Specific factors affecting risk for third-molar removal**

Size and density of supporting bone

Anatomic relationships of tooth or teeth to:

- Maxillary antrum and nasal cavity
- Adjacent nerves
- Adjacent teeth
- Other significant anatomic structures

Anatomic tooth position

Tooth root anatomy

Status of adjacent teeth

Ankylosis of tooth or teeth

Presence of associate jaw fracture

Accessibility

Limited access to oral cavity

Systemic drugs, such as bisphosphonates

Radiation therapy to surgical sites

**Box 4**
**Indicated therapeutic standards for third-molar removal**

History
Clinical examination
Imaging examination
Surgical removal
Surgical exposure
Surgical repositioning, reimplantation, or transplantation
Surgical periodontics
Endodontic therapy
Coronectomy
Marsupialization of associated soft tissue pathology with observation
Observation in cases of unerupted teeth completely covered by bone
Instructions for posttreatment care

greater than 29.2% of the patients. Almost one quarter (20.5%–27.0%) of third molars were absent upon initial patient evaluation. Caries (17.6%–20.3%), periodontal disease (11.6%–17.6%), and infection (6.3%–16.7%) were the most frequently encountered preoperative diagnoses. Intraoperative complications occurred with a frequency of less than 1%. There were no deaths or compromised airways. No patient suffered a mandibular fracture and only 1 a maxillary alveolar fracture. Alveolar osteitis was the most commonly encountered postoperative problem and occurred with a frequency of about 2 or 3 in 1000 encounters for maxillary third molars (0.2%–0.3%) and slightly

**Box 5**
**Known risks and complications for third-molar removal**

Acute or chronic infection
Alveolar osteitis
Acute or chronic osteomyelitis
Injury to adjacent teeth or soft tissues
Presence of foreign body in surgical site
Osteonecrosis, osteoradionecrosis
Presence of portion of tooth intentionally left in alveolus
Presence of portion of tooth unintentionally left in alveolus
Presence of bone fragment or sequestra in surgical site
Exposure of alveolar bone
Mandibular or maxillary fracture
Condition that requires unplanned additional surgery
Oroentral or nasal fistula formation
Displacement of tooth, tooth fragments, or foreign bodies into adjacent anatomic sites
Persistent or new pathology

more than 1 in 10 (11.9%–12.7%) for mandibular third molars. Acute or chronic infections occurred with a frequency of 0.0% to 1.0 % per patient. Inferior alveolar nerve anesthesia/paresthesia was encountered postoperatively with a frequency of 1.1% to 1.7%. Lingual nerve anesthesia/paresthesia occurred with a lower frequency (0.3%), between three and six times that for inferior alveolar anesthesia/paresthesia. Lastly, for almost a third of patients (31.2%–34.1%), inconvenience associated with the extraction was minimal. These patients neither missed work nor had normal activities curtailed. The study concluded that third-molar surgery in patients 25 years old or older is associated with minimal morbidity, a low incidence of postoperative complication, and a minimal impact on the patient's quality of life.

The next paper in the series was designed to estimate the frequency of complications after third-molar surgery, with age as the primary risk factor.[6] This was a prospective cohort study of a sample of subjects having at least one third-molar extracted. The predictor variables were categorized as demographic, health status, anatomic, and pathologic. The outcome variable was overall complications, including both intraoperative and postoperative complications. Appropriate univariate and bivariate statistics were computed. A multiple logistic regression model was used to evaluate the simultaneous effects of multiple covariates. The overall complication rate was 19%. Age above 25 years, gender, ASA classification, number of preoperatively identified risk factors for complication, impaction level of the third molar, evidence of periodontal disease, preoperative infection, and evidence of any pathology associated with the third molar were associated with complications ($P \leq .15$).

## THE AMERICAN ASSOCIATION OF ORAL AND MAXILLOFACIAL SURGEONS THIRD-MOLAR CLINICAL TRIAL

In the late 1980s and early 1990s, the AAOMS invested approximately $2 million in its own dues to conduct research regarding the consequences of the removal of third molars versus their intended permanent retention. From the standpoint of scientific validity, one could question the bias of self-funded research. It is up to the reader to conclude for himself or herself the scientific integrity of the researchers and the investigation. The result has been more than 30 peer-reviewed publications that are summarized in the paragraphs to follow. The rationale for the study was that over 95% of 18-year-olds in the United States have third molars and many are nonfunctional. It is estimated at least 60% will develop pathology, usually caries, periodontitis, or pericoronitis. Thus the study was designed to obtain data to assist patients in decisions regarding third-molar treatment by researching the incidence of third-molar pathology in patients who enrolled with no symptoms. Inclusion criteria included four asymptomatic third molars with adjacent second molars, age 14 to 45 years, ASA categories I and II, American Academy of Periodontology (AAP) categories 1 through 3, and a willingness to commit to study design. Exclusion criteria included ASA III or IV, AAP 4, a history of treatment of a psychiatric disorder within 12 months, or pregnancy. Data were collected from enrolled patients at annual visits until data extending over at least 5 years were collected from each patient, with an attempt to reach 10-year results. The details of the annual and interim clinical visits are listed as **Boxes 6** and **7**.

### *Recovery After Third Molar Surgery*

Numerous studies have been conducted to evaluate patients' perceptions of recovery after third-molar surgery. In one study, 201 patients between ages 13 and 37 underwent surgical removal of third molars.[7] Each patient was given a 21-item Health

**Box 6**
**Annual periodontal clinical analysis**

Full-mouth probe
Bleeding
Plaque index
Gingival crevicular fluid sampled for inflammatory mediators prostaglandin E2 and IL-β
Subgingival plaque sampled for DNA analysis of microorganisms
Vertical bitewings taken for alveolar bone and tooth position
Panoramic radiograph taken for tooth position and pathology
Surgeon assessment
Patient perception
Dental prophylaxis after data collection

Related Quality Of Life (HRQOL) instrument to be completed each postoperative day for 14 days. The instrument was designed to assess patients' perception of pain, oral function, general activity measures, and other symptoms. The impact of each predictor variable, such as age, gender, and length of surgery on recovery, was assessed. On postoperative day (POD) 1, 63.5% of patients reported their worst pain as severe at some time during the day. On POD 7, only 15% of patients reported their worst pain as severe. Twenty-nine percent reported average pain as severe on POD 1, decreasing to 5.5% by POD 7. Patients assumed a normal lifestyle on POD 5. A surgery time of 30 or more minutes, having all third molars below the occlusal plane, and being female were factors related to prolonged recovery period.

Another study surveyed 630 healthy patients to evaluate average HRQOL and clinical recovery after third-molar surgery.[8] Patients had a median age of 21 and median operating time of 30 minutes. The survey was completed on each postsurgery day for 14 days. The instrument assessed perception of recovery in pain, lifestyle, oral function, and other symptoms related to the procedure. Twenty-two percent of

**Box 7**
**Interim periodontal clinical analysis if symptomatic**

Full-mouth probed
Bleeding noted
Plaque index measured
Gingival crevicular fluid sampled for inflammatory mediators prostaglandin E2 and IL- β
Subgingival plaque sampled for DNA analysis of microorganisms
Vertical bitewings taken for alveolar bone and tooth position
Panoramic radiograph taken for tooth position and pathology
Additional treatment specific to presenting condition documented
Patient encouraged to continue in trial even if third molars removed

the patients were treated for delayed healing after surgery. Recovery from pain was delayed relative to other HROOL measures.

Risk factors associated with prolonged recovery and delayed healing after third-molar surgery were evaluated with HROOL and clinical outcome data after removal of all four third molars.[9] This analysis included 547 subjects who were between 14 and 40 years of age. Patients completed two pages of HRQOL diary each postsurgery day for 14 days. The criteria selected for outcomes that separated patients with prolonged recovery from those without. Delayed clinical healing was indicated when the patient had at least one postsurgery visit with treatment. Patients who were female, older than 18 years, and presenting with both lower third molars below the occlusal plane had greater odds of delayed HRQOL recovery. The odds of delayed clinical recovery were higher for patients who were female, who had previous third-molar symptoms, or whose surgery was difficult, according to the surgeon's evaluation.

The impact of intravenous antibiotics on recovery after third-molar surgery was evaluated in a study that included 56 patients of at least 18 years of age with all four third molars below the occlusal plane.[10] Each patient was given intravenous antibiotics just before third-molar surgery. Clinical and HRQOL outcomes of 56 patients were compared with a nonconcurrent control group of 60 patients who did not receive antibiotics. The control group was selected using the same surgical protocol as that for the antibiotic group. The incidence of delayed clinical recovery was defined as a postsurgery visit with treatment. The incidence of delayed clinical recovery was higher in the control group than in the antibiotic group. In the antibiotic group, 4% had one postsurgery visit with treatment and none had two visits. In the control group without antibiotics, 28% had at least one postsurgery visit with treatment and 13% had at least two postsurgery visits with treatment. No statistically significant differences in HRQOL outcomes were found between the two groups. Intravenous antibiotics at surgery improved clinical recovery, but not HROOL recovery, for targeted higher-risk patients.

The impact of intravenous corticosteroids on patients with a high risk for delayed recovery was evaluated in a study comparing two groups of 60 adult patients each, each patient with four third molars below the occlusal plane.[11] Patients in group 1 were given intravenous corticosteroids immediately before surgery: 37 were given 8 mg of dexamethasone sodium phosphate; 23 were given 40 mg of methylprednisolone sodium succinate. Patients in group 2 were not given steroids. Patients were each given a diary to record their perceptions of recovery in four categories: pain, lifestyle, oral function, and other symptoms. Recovery was defined as the number of days before patient feels little or no trouble or pain. Delayed recovery was defined as a postsurgery visit with treatment. The incidence of delayed clinical recovery (postsurgery visit with treatment) was higher in the control group than the corticosteroid group. In the corticosteroid group, 10% had one postsurgery visit with treatment. In the control group, 28% had one postsurgery visit with treatment. Compared with the control group, patients in the corticosteroid group were bothered less on postoperative day 1 and sleep was improved on postoperative days 1 through 4. Corticosteroids reduced time of recovery by at least 1 day for pain, lifestyle, and oral function.

The impact of delayed healing was evaluated using recovery data for 547 healthy patients between the ages of 14 and 40 after the removal of four third molars.[12] Data was obtained from patients with the HRQOL instrument, which included domains for lifestyle, oral function, and pain items. The data assessed recovery for each of 14 days postsurgery. Prevalence ratios (PR) with 95% confidence intervals were calculated to compare the prevalence of delayed HRQOL recovery between participants with delayed clinical healing and those without. For patients with delayed clinical

healing, the prevalence of delayed recovery for lifestyle nearly doubled (PR 1.7). A higher proportion of those with delayed clinical healing also reported delayed oral function recovery (PR 1.8), late symptoms recovery (PR 2.0), and delayed resolution of pain (PR 1.6). Significant average differences were found between those with delayed clinical healing and those without for sensory intensity of pain and unpleasantness of pain from postsurgery day 3 through day 14.

The impact of topical minocycline on recovery after third-molar surgery was evaluated by examining 63 patients at least 18 years of age, with all four third molars below the occlusal plane.[13] These patients were treated with topical minocycline during third-molar surgery and topical minocycline was placed sequentially in bony defects after third-molar removal. The 63 patients were compared with a control group of 60 patients who did not receive antibiotics. The control group was selected using the same protocol as that for the antibiotic group. Delayed clinical recovery was defined as a postsurgery visit with treatment. The incidence of delayed clinical recovery was significantly lower in the minocycline group compared with that for the control group. In the minocycline group, 10% had one postsurgery visit with treatment and none had two visits. In the control group, 28% had at least one postsurgery visit with treatment and 13% had at least two postsurgery visits with treatment. Recovery time to "no" or "little trouble" with chewing and mouth opening significantly improved in the minocycline group.

To determine if the proximity of a lower third molar to the inferior alveolar canal is a predictor of delayed recovery, data was taken for 579 patients who underwent removal of lower third molars. Radiographic findings were used to identify patients with at least one mandibular third molar below the occlusal plane.[14] Outcomes for patients with one or more radiographic sign indicating the proximity of a lower third molar to the inferior alveolar canal were compared with those with none. After surgery, a questionnaire designed to assess HRQOL recovery was given to each patient to complete daily for 14 days. No significant differences were found between the groups for delayed clinical recovery. However, odds significantly increased for delayed HRQOL recovery for worst pain, lifestyle, and oral function for those patients with close proximity of a third molar to the inferior alveolar canal.

To further develop an understanding of recovery after third-molar surgery, clinical and quality-of-life data pre- and postsurgery were taken from 63 patients with all four third molars below the occlusal plane.[15] During third-molar surgery, each patient was treated with topical minocycline to reduce the incidence of delayed clinical healing. Each patient was given a global Oral Health Impact Profile 14 (OHIP-14) and an HRQOL instrument to assess their recovery. Prevalence, extent, and severity of OHIP-14 scores were calculated pre- and postsurgery for days 1, 7, and 14. The percentage of patients who reported clinically relevant responses detrimental to their quality of life from HRQOL was reported for the same time frame. The median surgery time was 27 minutes with 72% of patients requiring bone removal from both lower third molars. Surgeons gave surgeries an average rating of 14 for difficulty on a scale in which the most difficult surgery is rated 28. Delayed clinical healing was found in 10% of patients. OHIP-14 items "fairly often" or "very often" increased from presurgery to postsurgery day 1, and then decreased on postsurgery day 7 and postsurgery day 14. Clinical (delayed healing) and Oral Health-Related Quality of Life addressed distinctly different outcomes, adding information that could not be assessed by one instrument alone.

Data was taken from 358 patients treated between 1997 and 2002 to determine if completeness of the root formation of lower third molars affected recovery after third-molar surgery. Thus, the root development of each mandibular third molar was

assessed.[16] Patients were categorized as those with complete root formation (both mandibular third molars had 100% complete roots) or as those with incomplete root formation (at least one mandibular third molar not completely formed). Patients were evaluated on whether or not they experienced a delay in recovery. Removing third molars when lower third-molar roots were incomplete conferred no advantage or disadvantage in recovery compared with surgery with roots complete.

### *Epidemiologic/Population Studies*

Several epidemiologic/population studies are cited to evaluate the relationship between third molars and periodontal pathology. In the first of these studies cited in this article, data were obtained on 5831 patients between the ages of 18 and 34 from the Third National Health and Nutrition Examination Survey. The presence of a visible third molar was determined.[17] The presence of periodontal disease was assessed in two randomly selected quadrants (one maxillary, one mandibular) by gingival index, pocket depth, and attachment level on mesiobuccal and buccal sites on up to seven teeth per quadrant (excluding third molars). Associations were determined using odd ratios and 95% confidence intervals. Visible third molar was associated with twice the odds of pocket depth of 5 mm or more on adjacent second molar with controls for other factors. Smoking, age between 25 and 34 years, and African American race were also associated with pocket depth of 5 mm or more.

In a study evaluating older Americans, data were obtained from the Atherosclerosis Risk in Communities Study between 1996 and 1999.[18] Data included 6793 persons between 52 and 74 years of age. The independent variable was visual presence or absence of a third molar. The dependent variable was an assessment of periodontal disease as measured by pocket depth of 5 mm or more. Periodontal measures included gingival recession, pocket depth, and attachment level on six sites per tooth on all other teeth. Second molars were compared for periodontal pathology based on the presence or absence of a visible third molar in same quadrant. Visible third molar was associated with 1.5 times the odds of pocket depth of 5 mm or more on the adjacent second molar with controls for other factors. Male gender, older age, smoking, and irregular/episodic dental visits were associated with pocket depth of 5 mm or more.

Data were taken from a subsample of patients with dental exams in the Piedmont 65+ study to assess third-molar periodontal pathology and caries experience in older adults.[19] All visible teeth were examined and periodontal probing (pocket depth) measures were taken at mesiobuccal and buccal/facial sites. Data on caries experience were taken by visual-tactile examination. This subsample of 342 subjects had a mean age of 73 with at least one visible third molar that could be examined. Pocket depth measures were available for 276 of these subjects. Sixty-three percent of the 342 subjects with at least one visible third molar were African American and 57% were female. Forty-nine percent of 197 subjects with caries experience had affected third molars compared with 87% in non–third molars. Third-molar caries experience was associated with non–third-molar experience. Clinical attachment level greater then 3 mm at enrollment in third molars was found in 68% of subjects and in 96% of subjects for non–third molars. With one exception, clinical attachment level 3 mm or more in third molars was associated with clinical attachment level 3 mm or more elsewhere in the mouth. Seventeen percent of subjects had clinical evidence of both caries and periodontal pathology affecting third molars. Twenty-one percent of subjects were free of periodontal pathology or caries experience.

The risk factors for periodontal disease and third-molar caries were assessed using data taken from a subset of the Piedmont 65+ study, including 340 subjects with at

least one visible third molar examined for caries.[20] At enrollment, pocket depth measures were taken for 277 of the subjects. All visible teeth were examined. Pocket depth measures were taken at mesiobuccal and buccal/facial sites. Clinical data on caries experience were gathered by tactile examination. African American subjects were more likely to have a visible third molar, periodontal pathology, and clinical attachment levels of 3 mm or more on third molars. Subjects who used tobacco were also more likely to have periodontal pathology and clinical attachment level of 3 mm or more. Caucasian subjects, subjects with education beyond high school, and subjects who had visited a dentist within the past 3 years were more likely to have third-molar coronal caries experience (actual caries detected via visual or tactile examination or the presence of a restoration).

The relationship between third molars and periodontal pathology during pregnancy was a topic of interest. Consequently, data was taken from 360 patients with a mean age of 27.3 years from the patients in the Oral Conditions and Pregnancy study.[21] A full-mouth periodontal examination was conducted at six sites per tooth for each visible tooth. This was completed at less than 26 weeks of pregnancy and within 72 hours postpartum. The primary outcome was periodontal progression between enrollment and postpartum examinations. Progression was defined as four or more probing sites with an increase in pocket depth of 2 mm or more. Primary predictors at enrollment were at least one pocket depth of 4 mm or more around third molars and the upper tertile of the number of third molar probing sites recorded as bleeding on probing. One hundred twenty-two subjects (34%) experienced periodontal progression. These subjects included 74 of 176 (42%) subjects in whom a third-molar pocket depth of 4 mm or more was detected at baseline and 48 of 184 (26%) without third-molar pocket depth of 4 mm or more. Progression was found in 40 of 77 (52%) subjects in the upper tertile of the number of third-molar probing sites experiencing bleeding on probing at enrollment compared with 82 of 203 (29%) in lower tertiles. Third-molar pocket depth of 4 mm or more at enrollment or third-molar bleeding on probing was associated with periodontal disease progression.

In another study on periodontal pathology and pregnancy, data were collected from the study on Oral Conditions and Pregnancy.[22] Examinations were conducted on 1020 patients at enrollment and 891 at postpartum. Visible third-molar data were available for 405 patients at enrollment and 360 at term. Full-mouth periodontal examinations were conducted at more than 24 weeks of pregnancy and within 72 hours of delivery. Mean pocket depths by visible tooth and by jaw were calculated at enrollment and postpartum. Subjects were categorized into three broad levels of periodontal health. The primary predictor of periodontal health was the presence or absence of a visible third molar. Mean pocket depth in the mandible or maxilla at term was considered an indicator of possible risk of systematic exposure, which increases the odds of preterm birth. At enrollment and postpartum, subjects with visible third molars were significantly more likely to have moderate or severe periodontal disease than those with no visible third molars (23.5% versus 8.5% and 18.3% versus 9.4% respectively). Mean pocket depth was significantly greater for maxillary and mandibular molars than for more anterior teeth. In both jaws, mean pocket depth tended to be progressively greater from first molars to third molars. Preterm birth and elevated serum C reactive protein at term were associated more with periodontal pathology on maxillary than on mandibular third molars.

### *Retain Third Molars Trial: Pericoronitis*

The impact of treatment for pericoronitis was evaluated by analyzing data taken from 20 patients with all third molars who exhibited minor signs or symptoms of

pericoronitis.[23] Gingival crevicular fluid and plaque samples were taken from the distal of second molars and the mesial of first molars to measure the inflammatory response and identify microorganisms present. Radiographs were taken to assess alveolar bone height on the distal of second molars and the inclination/degree of eruption of the third molar. Full-mouth periodontal probing was conducted to determine pocket depths and clinical attachment levels. Pain was assessed with Gracely verbal descriptor scales and 10-cm visual analog scales. Symptomatic third-molar sites were treated with debridement and irrigation after data collection. Data were collected 1 week later and 3 months after the removal of all third molars. Gingival crevicular fluid IL-1b levels were elevated at the distal of second molars adjacent to symptomatic third molars compared with those at asymptomatic second or third molars. Alveolar bone and clinical attachment levels on the distal of second molars were normal. After 1 week, symptoms and IL-1b levels were reduced, but microbial counts were still high. After 3 months, pain was gone and alveolar bone levels and clinical attachment levels returned to initial levels.

The impact of third-molar pain, symptoms, and swelling on quality of life was assessed using data taken from 480 patients with four third molars scheduled for removal.[24] A presurgery questionnaire was administered to assess medical/dental history, reasons for seeking third-molar removal, and sociodemographic characteristics. An Oral OHIP questionnaire was administered to measure adverse impacts on oral health–related quality of life. The primary outcome variable was the percentage of people reporting 1 or more of 12 non–pain specific OHIP items "fairly often" or "very often" during the 3 months before enrollment. One third of the patients sought third-molar surgery because of current or previous symptoms of pain or swelling. Seventeen percent reported one or more non–pain specific OHIP items. The odds of one or more impacts were 2.9 times greater for people who presented because of symptoms, 1.9 times greater for people over 24 years of age, and 2.9 times greater for people with a self-reported history of tooth loss due to pathology/trauma.

### *Retain Third Molars Trial: Periodontitis*

The association between periodontitis and asymptomatic third molars was studied in a trial that included 329 patients 14 to 45 years of age with four asymptomatic third molars and adjacent second molars.[25] Patients were enrolled for 30 months. Full-mouth periodontal probing was conducted. This probing included third molars at six sites per tooth. Pocket depth classified at 5 mm or more was an indication of periodontal pathology. Third-molar degree of eruption and degree of angulation were compared with those of the adjacent second molar analyzed by radiograph. Radiographs were used to analyze alveolar bone levels in relation to the cementoenamel junction on the distal of second molars. Demographic data on patients were collected. Twenty-five percent (82 of 329) of enrolled patients and 34% (14 of 41) of black patients had one or more pocket depth of 5 mm or more on the distal of a second molar or around a third molar. Pocket depth of 5 mm or more was associated with periodontal attachment loss of 1 mm or more. Pocket depth of 5 mm or more was associated with periodontal attachment loss of 2 mm or more in 80 of 82 patients. A higher proportion of patients 25 or older had pocket depth of 5 mm or more on the distal of second molars or around third molars compared with patients under 25 (33% to 17%). Distals of second molars and third molars in the mandible were affected more than those in the maxilla (25% to 5%).

Data were taken from 295 patients with asymptomatic third molars to determine the microbial complexes present in the third-molar region. Subgingival plaque samples were taken from the distal of second molars.[26] Probing depths at six sites per tooth

were obtained to determine periodontal status. Levels of 11 bacterial species were determined with whole chromosomal DNA probes and checkerboard DNA-DNA hybridization. Detected species were grouped into "red" or "orange" complex microorganisms based on their association with periodontitis. For patients with pocket depths of 5 mm or more with periodontal attachment loss at the distal of second molars or around third molars, $10^5$ or more "orange" and "red" microorganisms were detected. For patients with pocket depths of less than 5 mm in third-molar region, "orange" and "red" microorganisms were detected at levels equal to or greater than $10^5$ more frequently than anticipated for patients without periodontal disease.

Three hundred sixteen healthy patients, between 14 and 45 years of age with four asymptomatic third molars and adjacent second molars were examined to determine the relationship between pocket depths and inflammation.[27] Full-mouth periodontal probing at six sites per tooth was conducted. Gingival crevicular fluid samples were taken from the mesial of all first molars and the distal of all second molars. Evaluation occurred over a 30-month period. For pocket depths less than 5 mm, inflammation for 32% of patients was negligible, for 35% midrange, and for 33% elevated. For pocket depths of 5 mm or more, inflammation for 18% of patients was negligible, for 37% midrange, and for 45% elevated.

Data were taken from 254 patients with four asymptomatic third molars and adjacent second molars to evaluate the progression of periodontal disease in the third-molar region.[28] Patients had a minimum of two annual follow-up visits and a mean age of 27.5 years at baseline. Full-mouth periodontal probing was conducted to determine periodontal status at baseline and follow-up. Radiographs were analyzed for angulation and degree of eruption of third molars. Patients were categorized as those exhibiting 2 mm or more of change in pocket depth between baseline and follow-up in the third-molar region (distal of second or around third molar) and those exhibiting less than 2 mm of change. Fifty-nine percent of the subjects had at least one pocket depth of 4 mm or more in the third-molar region and 25% had pocket depth of 5 mm or more at enrollment. Twenty-four percent of subjects had one or more teeth that had increased pocket depth 2 mm or more in the third-molar region at follow-up. Of the subjects who had at least one pocket depth of 4 mm or more at baseline, 38% had at least one pocket depth deepen by 2 mm or more at follow-up. Three percent of those subjects with all teeth with pocket depth less than 4 mm at baseline exhibited a change of 2 mm or more.

Two hundred thirty-seven healthy patients, between age 14 and 45, with four asymptomatic third molars and adjacent second molars were analyzed to examine changes in angulation and periodontal pathology.[29] Full-mouth periodontal probing was conducted to determine periodontal status at follow-up. Radiographs were analyzed for angulation and eruption of third molars. Pocket depths of 4 mm or more in the third-molar region (distal of second or around third molar) were considered clinically important at follow-up. Median follow-up was at 2.2 years. Forty-four percent of impacted maxillary and 26% of impacted mandibular third molars changed angulation/position. One third of vertical/distal impacted third molars in both jaws and 11% of mesial/horizontal mandibular third molars erupted to the occlusal plane during follow-up from baseline. At follow-up, 11% of 125 impacted maxillary third molars and 29% of 133 impacted mandibular third molars had pocket depths of 4 mm or more. Eleven percent of 307 maxillary third molars at the occlusal plane had pocket depths of 4 mm or more.

The reliability of probing depths and the impact of third-molar periodontal pathology were assessed on 41 patients.[30] Full-mouth periodontal probing examinations were conducted at less than 24 weeks of pregnancy. Periodontal status, moderate/severe

periodontal disease (15 or more sites with pocket depths of 4 mm or more), and upper quartile of extent of pocket depth for third molars alone with pocket depth of 4 mm or more were considered as possible predictors of systemic inflammation and preterm birth. Data (1020 obstetric patients) for association between oral inflammation with periodontal pathology were taken from Oral Conditions and Pregnancy study. The reliability of pocket depth within 1 mm was excellent for both third molars and non–third molars. Eighteen percent of obstetric patients delivered preterm, at less than 37 weeks. Moderate/severe periodontal disease (excluding third molars) was significantly associated with preterm birth. This was more significant when third molars were included. The deeper the third-molar pockets, the greater are the chances for preterm birth.

The relationship between inflammation and the progression of periodontal pathology was examined by evaluating 254 subjects with four asymptomatic third molars and adjacent second molars.[31] Full-mouth periodontal probing was conducted at enrollment and follow-up. Enrollment levels of gingival crevicular fluid inflammatory mediators and periodontal pathogens were assayed as indicators of the degree of inflammation. Subjects were characterized as those who did or didn't have a change of 2 mm or more in pocket depth between baseline and follow-up in the third-molar region. Statistical analysis was used to indicate relationships between baseline pocket depth, levels of periodontal pathogens, levels of gingival crevicular fluid IL-1β, and the proportion of subjects with 2-mm or more change in pocket depth versus those with change of less than 2 mm. Twenty-four percent of 254 subjects experienced changes in pocket depth in the third-molar region from baseline to follow-up. Ninety-five percent of these subjects had a baseline pocket depth of 4 mm or more. Levels of "orange" and "red" complex bacteria $10^5$ or more and pocket depth of 4 mm or more were both significantly associated with a change in pocket depth of 2 mm or more.

The change in third-molar and non–third-molar pathology over time was evaluated by analyzing 195 healthy subjects with a median age at enrollment of 26.2 years and a median follow-up of 5.9 years.[32] All subjects involved in the study had four asymptomatic third molars. Full-mouth periodontal probing at six sites per tooth was conducted to determine periodontal status at baseline and at longest follow-up. The third-molar region was defined as including pocket depth for six sites around third molars and two sites on the distal of second molars. Primary outcome measures were an occurrence of pocket depth of 4 mm or more and an increase in pocket depth of at least 2 mm in the third-molar and non–third-molar regions. The proportion of subjects with at least one involved site in non–third molars increased significantly from baseline to follow-up (36% to 49%). Most of these were changes in mandibular non–third molars (33% to 48%). Of the 122 subjects with one or more sites with pocket depth of 4 mm or more at baseline in the third-molar region, the proportion of subjects with one or more involved sites in non–third molars increased significantly from baseline to follow-up (48% to 59%). This also reflected mostly changes in mandibular non–third molars (44% to 59%).

An assessment was made of changes over time in third-molar position relative to the occlusal plane and in the periodontal probing status of third molars in asymptomatic subjects who had at least one third molar below the occlusal plane at baseline and retained all third molars to follow-up.[33] Between 1998 and 2002, 146 subjects who had at least one third molar not fully erupted at baseline with at least 2-year follow-up were analyzed. At baseline and longest follow-up, full-mouth periodontal probing at six sites per tooth, including third molars, was conducted. A pocket depth greater than or equal to 4 mm in the third-molar region was considered indicative of periodontal pathology. Panoramic radiographs were analyzed to assess whether unerupted third molars

erupted to the occlusal plane. To assess descriptively the influence of age and length of follow-up on the change in third-molar position and periodontal status, subjects were stratified by age at enrollment as younger (<25 years) or older (≥ 25 years) and by length of follow-up as shorter follow-up (2 to <4 years), or longer follow-up (4 or more years). Because of the small sample sizes in each stratum, analyses are limited to descriptive statistics only. The anatomic position of third molars was not static over time even if subjects were more than 25 years old. Thus, unerupted third molars should be monitored for changes in position and periodontal pathology as long as the teeth are retained.

The last study relating to periodontitis cited in this paper was conducted to assess the clinical impact of risk factors for third-molar and non–third-molar periodontal pathology over time.[34] Subjects included 195 healthy adults with four asymptomatic third molars who had a median age at enrollment of 26.2 years and a median follow-up of 5.9 years. Full-mouth periodontal probing data were gathered to determine clinical measures of possible periodontal pathology. The third-molar region was defined as including pocket depth for six sites around third molars and for two sites on the distal of second molars. The non–third-molar region was defined as all remaining probing sites. Subjects were grouped based on having all pocket depth less than 4 mm (no disease), one to three pocket depths 4 mm or more (incipient disease), or at least four pocket depths 4 mm or more (early disease). Periodontal pathogen levels and gingival crevicular fluid inflammatory mediators at baseline were assayed as risk factors for periodontal pathology. Subjects who had early disease or incipient disease in the third-molar region at baseline were significantly more likely to have an indication of periodontal pathology at follow-up in both the third-molar and non–third-molar region in comparison to those who had no disease at baseline. Thus, the presence of periodontal pathology in the third-molar region at baseline was predictive of periodontal pathology in the third-molar and non–third-molar regions at follow-up for young adults.

### *Retain Third Molars Trial: Occlusal Caries*

Occlusal caries experience was evaluated in patients with asymptomatic third molars. Three hundred three healthy patients with four asymptomatic third molars and adjacent second molars were evaluated.[35] Patient age ranged from 14 to 45. The presence and absence of caries experience on the occlusal surface of third molars and on any surface of first and second molars was recorded during clinical and radiographic examinations. The occurrence of caries experience for younger and older subjects was compared. The association of occurrence in the maxilla and mandible as well as the association between caries experience in third molars and caries experience in first and second molars was assessed. At baseline, 28% of 303 asymptomatic patients (39% of those age 25 years or more) had at least one third molar with occlusal caries. Lower third molars were more often affected than upper. Fewer than 2% of third molars had occlusal caries if the first and second molars were caries-free.

The incidence of occlusal caries in patients who had asymptomatic third molars was also evaluated in a study comparing patients who had one or more third molars at the occlusal plane with data from baseline and from the most recent of at least two follow-up visits.[36] Two hundred eleven healthy patients, of mean age 26.6 years, with asymptomatic third molars were included. The presence or absence of caries experience on the occlusal surface of any molar was recorded during clinical and radiographic examinations. Twenty-nine percent of patients were affected by third-molar occlusal caries at baseline. This percentage increased to 33% at follow-up. Ninety-eight percent and 99% of patients with third-molar caries had caries in first and second molars respectively. Older patients had more caries in their third molars at baseline than younger

(under 25 years of age) patients (43% versus 9%). Patients who were younger at baseline were more likely to develop caries in third molars at follow-up (9% versus 19%). Lower third molars were affected more often than upper third molars: 25% versus 19% at baseline and 29% versus 22% at follow-up.

The prevalence of periodontal pathology and third-molar occlusal caries was evaluated on 49 patients, of median age 20.5 years, whose third molars erupted late.[37] Teeth were considered erupted once they reached the occlusal plane. All patients had at least one third-molar below the occlusal plane at baseline that erupted by the follow-up. Visual-tactile exams were conducted to assess caries experience on the occlusal surface of third molars. Periodontal pathology was indicated by at least one pocket depth of 4 mm or more in the third-molar region. The third-molar region was defined as including pocket depth for six sites around third molars and two sites on the distal of second molars. At baseline, none of the patients had occlusal caries experience in a third molar and 51% of patients had at least one pocket depth of 4 mm or more in a third-molar region. At follow-up, 27% of the patients had occlusal caries experience in at least one erupted third molar and 61% had at least one pocket depth of 4 mm or more in a third-molar region. Twenty-nine percent had occlusal caries in at least one erupted third molar and at least one pocket depth of 4 mm or more in a third-molar region. Thirty-seven percent had no third-molar occlusal caries and pocket depths less than 4 mm in all third-molar regions. Periodontal pathology was found to be more prevalent than occlusal caries in third molars that erupted late.

## AMERICAN ASSOCIATION OF ORAL AND MAXILLOFACIAL SURGEONS "WHITE PAPER ON THIRD MOLAR DATA"

In 2007, the AAOMS convened a seven-member task force to review the current literature related to third-molar therapy. In conducting the review, the task force selected from four major electronic databases—Ovid Medline, PubMed, Google Scholar, and the Cochrane Database. From this, 205 peer-reviewed publications were selected to reference the compilation of the task force's finding.[38] A synopsis of these findings follows.

Regarding the natural history of third molars, the most significant variable associated with third-molar impaction is inadequate hard-tissue space. It is possible to measure this space for eruption radiographically. Unerupted teeth can change position even beyond the third decade of life. Because no reliable way has been found to predict pathologic changes associated with impacted teeth, they should be monitored periodically through radiographs. Eruption to the occlusal plane does not ensure adequate physiologic space for good periodontal health.

When considering the periodontium, root resorption of the second molar occurs more frequently when that molar is adjacent to impacted third molars, and that frequency increases with age and with mesioangular and horizontal impactions. There is an even higher frequency of periodontal ligament disruption without root resorption. There is also a greater probability of pocket depth of 5 mm or more distal of second molars when a third molar is present, and of loss of attachment of 1 mm or more. The removal of impacted third molars may negatively impact the attachment level, pocket depth, or alveolar bone height of the distal surface of adjacent second molars. The presence of intrabony defects at the time of surgery, a large contact area between the third and second molars, and inadequate postoperative plaque control may contribute to postextraction periodontal pathology in these areas. Those with healthy preoperative periodontium were also at risk for loss of attachment or increased pocket depth after third-molar surgery. No single surgical approach to the removal of third

molars (flap design, tooth sectioning, or ostectomy) will minimize the loss of periodontal attachment. Guided tissue regeneration and demineralized bone allograft may be beneficial in instances where there is evidence of significant preexisting attachment loss. Further research is needed in this area. Scaling, root planing, and plaque control have the potential to reduce postoperative loss of attachment. The presence of third molars is associated with more severe periodontal disease, progressive loss of attachment on non–third molars (second molars), and more periodontal microflora, especially putative pathogens and molecular markers of inflammation.

Regarding symptomatic second and third molars, the inflammation associated with eruption and pericoronitis is associated with pain, swelling, erythema, and, perhaps, purulence. The most common bacteria identified are α-hemolytic streptococci and the genera *Prevotella, Veillonella, Bacteroides*, and *Capnocytophaga*. Yet over 440 microorganisms have been implicated. On occasion, such infections can progress to life-threatening infections. Antimicrobial therapy and surgery are indicated.

However, the absence of symptoms does not indicate absence of disease or pathology. Pathogenic bacteria ("red" and "orange" complexes) exist in clinically significant numbers around asymptomatic third molars. Periodontal disease (pocket depth $\geq$ 4 mm) exists around asymptomatic third molars, and indicators of chronic inflammation in periodontal pockets exist in and around asymptomatic third molars. Periodontal disease progression is often asymptomatic.

When considering the effects of age on various parameters relating to third molars, symptoms (pain, swelling, discomfort from food impaction, and purulent discharge) generally increase with advancing age. Periodontal defects of third molars (and adjacent second molars) are more common with advancing age. Caries prevalence in third molars increases with advancing age. Postoperative morbidity and HRQOL indicators deteriorated with advancing age (mean age for third-molar fracture is 45 years). Germectomy may be associated with a lower incidence of periodontal defects and other morbidity.

Many practitioners feel that consideration of the third molar is a necessary component of orthodontic treatment planning. However, a recent Cochrane review concluded that there is compelling evidence that impacted wisdom teeth do not contribute to crowding of the mandibular incisors.[39] The definitive answer to this question probably requires further study.

When considering the prosthodontic treatment plan, asymptomatic third molars may erupt or change position over time, even with advancing age. The potential for the development of pathology is well documented. Yet, not all teeth under a removable prosthesis develop pathology. Increased difficulty and morbidity occur if removal is deferred until later in life. Because pathology is unpredictable, impacted third molars should be monitored with periodic clinical and radiographic examinations.

Panoramic radiography remains the standard imaging technique for evaluating third molars. Its sensitivity is fair and specificity quite high. Yet other techniques may be important for high-risk third molars. High-risk third-molar signs include:

Superimposition of inferior alveolar nerve canal and third molar
Greater than normal distance from inferior alveolar nerve to third molar
Loss of cortical lines of canal
Darkening of the third-molar root
Narrowing or diversion of inferior alveolar nerve as it passes the third molar
Dark or bifid root apex

CT and "cone-beam" technology can give valuable information regarding the high-risk impaction detected with panoramic radiography.

Partial tooth removal (coronectomy) may be indicated in cases of high-risk third molars with an absolute necessity for tooth removal. There is no standard of care for this procedure because only five legitimate papers exist in the literature. The surgeon should consider using antibiotics, performing a primary closure, protecting the lingual nerve, and removing the crown while leaving the roots in place. This procedure is not without morbidity. Second surgery is often required and the consequences of surgery are frequently root migration and lingual and inferior alveolar nerve paresthesia.

Regarding the lingual flap technique, most third molars can be removed with a buccal approach. Lingual flap reflection and use of a lingual retractor are acceptable in select situations. A retractor with a suitable size and shape (broad, curved, thin, without sharp edges) must remain subperiosteal and on bone throughout the procedure. Yet, these characteristics of the retractor may or may not make any difference.

When considering whether anything should be placed in the socket, routine application of interventions is not indicated for all subjects. Those at "high risk" for periodontal defects postoperatively (age $\geq$ 25 years, attachment level $\geq$ 3 mm, pocket depth $\geq$ 5 mm) may benefit. The use of resorbable and nonresorbable membranes and platelet-rich plasma is more effective than no intervention.

Nerve damage is infrequent, but is a real concern. Inferior alveolar nerve paresthesia has a 1% to 1.5% frequency 1 to 7 days after surgery. Persistent involvement (still present after 6 months) occurs with a frequency of 0% to 0.9% and a mean of 0.3%. Lingual nerve paresthesia occurs with a frequency of 0.4% to 1.5% 1 day after surgery, with persistent involvement occurring with a frequency of 0% to 0.5%. Regarding the long buccal nerve, there are no specific reports in the literature. The mylohyoid nerve has a paresthesia frequency as high as 1.5%. Steroids do not help with prevention or recovery. Spontaneous recovery occurs 50% to 100% of the time for both inferior and lingual nerves.

The appropriate examination for assessment of a damaged nerve begins with mapping out and photographing the area involved. Testing light touch or tactile sensation with von Frey's hairs are for evaluation of A-beta fibers and pressure receptors. Two-point discrimination is used to test larger myelinated fibers. Direction sense assesses A-alpha and A-beta fibers. Pinprick sensation (pain sensation) evaluates A-delta and C fibers. Taste with the four primary tastes—sweet, sour, salty, and bitter—is also part of the assessment. Data about accuracy or variability of these tests do not appear in the literature.

When considering nerve repair, at least 50% of cases recover spontaneously. For lingual nerve repair, 50% to 90% show some recovery. Tactile sensation tends to improve while taste tends not to. For inferior alveolar nerve repair, 55% to 92% show some recovery. Data suggest that the sooner the repair (between 4.5 and 7 months), the better the results. Yet improvement can occur with late (even 47 months) repair.

## SUMMARY

Not every patient has four third molars. Some have none. Not every third molar needs to be removed. Indications for the removal of symptomatic third molars are obvious. Indications for the removal of third molars to facilitate concomitant dental or medical therapy are obvious. Asymptomatic third molars may harbor a great number and diversity of microbes that may result in significant morbidity and may contribute to systemic disease. Asymptomatic third molars may contribute to the development of periodontal defects and root resorption of second molars. Associated morbidity increases with mesioangular and horizontal impactions, as well as with advancing

age. Elective removal of third molars is a safe procedure and is associated with minimal morbidity and minimal adverse impact on the quality of life. Alveolar osteitis is the most frequent postoperative problem. Postoperative anesthesia/paresthesia is the most troublesome postoperative problem. Postoperative problems increase with advancing age. Most postoperative anesthesias/paresthesias resolve. Nerve repair is a helpful adjunct for those that do not resolve. Minimal flap design is effective in reducing morbidity. Systemic antibiotics may or may not help. Systemic corticosteroids result in less swelling and a more positive experience without added risk. Routine postoperative clinic/office visits are not necessary. Patients prefer postoperative telephone follow-up. Resorbable and nonresorbable membranes and platelet-rich plasma are more effective than nothing for significant osseous defects. Topical tetracycline may improve the rate of infection and alveolar osteitis.

## REFERENCES


1. Kelly JF. Parameters of care for oral and maxillofacial surgery. A guide for practice, monitoring and evaluation (AAOMS Parameters of Care-92). American Association of Oral and Maxillofacial Surgeons. J Oral Maxillofac Surg 1992; 50(7 Suppl 2):1–174.
2. Helfrick J. Parameters of care for oral and maxillofacial surgery: a guide for practice, monitoring, and evaluation (version 2.0). J Oral Maxillofac Surg 1995;(53 Supp).
3. Haug RH, editor. Parameters and pathways: clinical practice guidelines for oral and maxillofacial surgery. AAOMS ParCare 01 (Version 3.0). Philadelphia: WB Saunders Co; 2001.
4. Carlson E, Haug RH, editors. Parameters and pathways: clinical practice guidelines for oral and maxillofacial surgery. AAOMS ParCare 07 (Version 4.0). New York: Elsevier Publishing; 2007.
5. Haug RH, Perrott DH, Gonzalez RM, et al. The AAOMS age-related third molar study. J Oral Maxillofac Surg 2005;63(8):1106–14.
6. Chuaung S-K, Perrott DH, Susarla SM, et al. Age as a risk factor for third molar surgery. J Oral Maxillofac Surg 2007;65(9):1685–92.
7. Conrad SM, Blakey GH, Shugars DA, et al. Patients' perception of recovery after third molar surgery. J Oral Maxillofac Surg 1999;57(11):1288–94.
8. White RP Jr, Shugars DA, Shafer DM, et al. Recovery after third molar surgery: clinical and health-related quality of life outcomes. J Oral Maxillofac Surg 2003; 61(5):535–44.
9. Phillips C, White RP Jr, Shugars DA, et al. Risk factors associated with prolonged recovery and delayed healing after third molar surgery. J Oral Maxillofac Surg 2003;61(12):1436–48.
10. Foy SP, Shugars DA, Phillips C, et al. The impact of intravenous antibiotics on health-related quality of life outcomes and clinical recovery after third molar surgery. J Oral Maxillofac Surg 2004;62(1):15–21.
11. Tiwana PS, Foy SP, Shugars DA, et al. The impact of intravenous corticosteroids with third molar surgery in patients at high risk for delayed health-related quality of life and clinical recovery. J Oral Maxillofac Surg 2005;63(1):55–62.
12. Ruvo AT, Shugars DA, White RP Jr, et al. The impact of delayed clinical healing after third molar surgery on health-related quality-of-life outcomes. J Oral Maxillofac Surg 2005;63(7):929–35.

13. Stavropoulos MF, Shugars DA, Phillips C, et al. Impact of topical minocycline with third molar surgery on clinical recovery and health-related quality of life outcomes. J Oral Maxillofac Surg 2006;64(7):1059–65.
14. Hull DJ, Shugars DA, White RP Jr, et al. Proximity of a lower third molar to the inferior alveolar canal as a predictor of delayed recovery. J Oral Maxillofac Surg 2006;64(9):1371–6.
15. Shugars DA, Gentile MA, Ahmad N, et al. Assessment of oral health–related quality of life before and after third molar surgery. J Oral Maxillofac Surg 2006;64(12): 1721–30.
16. Noori H, Hill DL, Shugars DA, et al. Third molar root development and recovery from third molar surgery. J Oral Maxillofac Surg 2007;65(4):680–5.
17. Elter JR, Cuomo CH, Offenbacher S, et al. Third molars associated with periodontal pathology in the Third National Health and Nutrition Examination Survey. J Oral Maxillofac Surg 2004;62(4):440–5.
18. Elter JR, Offenbacher S, White RP Jr, et al. Third molars associated with periodontal pathology in older Americans. J Oral Maxillofac Surg 2005;63(2):179–84.
19. Moss KL, Beck JD, Mauriello SM, et al. Third molar periodontal pathology and caries in senior adults. J Oral Maxillofac Surg 2007;65(1):103–8.
20. Moss KL, Beck JD, Mauriello SM, et al. Risk indicators for third molar caries and periodontal disease in senior adults. J Oral Maxillofac Surg 2007;65(5):958–63.
21. Moss KL, Ruvo AT, Offenbacher S, et al. Third molars and progression of periodontal pathology during pregnancy. J Oral Maxillofac Surg 2007;65(6):1065–9.
22. Moss KL, Serlo AD, Offenbacher S, et al. The oral and systemic impact of third molar periodontal pathology. J Oral Maxillofac Surg 2007;65(9):1739–45.
23. Blakey GH, White RP, Offenbacher S, et al. Clinical/biological outcomes of treatment for pericoronitis. J Oral Maxillofac Surg 1996;54(10):1150–60.
24. Slade GD, Foy SP, Shugars DA, et al. The impact of third molar symptoms, pain, and swelling on oral health–related quality of life. J Oral Maxillofac Surg 2004; 62(9):1118–24.
25. Blakey GH, Marciani RD, Haug RH, et al. Periodontal pathology associated with asymptomatic third molars. J Oral Maxillofac Surg 2002;60(11):1227–33.
26. White RP Jr, Madianos PN, Offenbacher S, et al. Microbial complexes detected in the second/third molar region in patients with asymptomatic third molars. J Oral Maxillofac Surg 2002;60(11):1234–40.
27. White RP Jr, Offenbacher S, Phillips C, et al. Inflammatory mediators and periodontitis in patients with asymptomatic third molars. J Oral Maxillofac Surg 2002;60(11):1241–5.
28. Blakey GH, Jacks MT, Offenbacher S, et al. Progression of periodontal disease in the second/third molar region in subjects with asymptomatic third molars. J Oral Maxillofac Surg 2006;64(2):189–93.
29. Nance PE, White RP, Offenbacher S, et al. Change in third molar angulation and position in young adults and follow-up periodontal pathology. J Oral Maxillofac Surg 2006;64(3):424–8.
30. Moss KL, Mauriello S, Ruvo AT, et al. Reliability of third molar probing measures and the systemic impact of third molar periodontal pathology. J Oral Maxillofac Surg 2006;64(4):652–8.
31. White RP Jr, Offenbacher S, Blakey GH, et al. Chronic oral inflammation and the progression of periodontal pathology in the third molar region. J Oral Maxillofac Surg 2006;64(6):880–5.
32. Blakey GH, Hull DJ, Haug RH, et al. Changes in third molar and nonthird molar periodontal pathology over time. J Oral Maxillofac Surg 2007;65(8):1577–83.

33. Phillips C, Norman J, Jaskola M, et al. Changes over time in position and periodontal probing status of retained third molars. J Oral Maxillofac Surg 2007; 65(10):2011–7.
34. White RP Jr, Phillips C, Hull DJ, et al. Risk markers for periodontal pathology over time in the third molar and non-third molar regions in young adults. J Oral Maxillofac Surg 2008;66(4):749–54.
35. Shugars DA, Jacks MT, White RP Jr, et al. Occlusal caries experience in patients with asymptomatic third molars. J Oral Maxillofac Surg 2004;62(8):973–9.
36. Shugars DA, Elter JR, Jacks MT, et al. Incidence of occlusal dental caries in asymptomatic third molars. J Oral Maxillofac Surg 2005;63(3):341–6.
37. Ahmad N, Gelesko S, Shugars D, et al. Caries experience and periodontal pathology in erupting third molars. J Oral Maxillofac Surg 2008;66(5):948–53.
38. Pogrel MA, Dodson TB, Swift JQ, et al. White paper on third molar surgery. Available at: www.aaoms.org/docs/third_molar_white_paper.pdf. Accessed September 3, 2008.
39. Mettes TG, Nienhuijs MEL, van der Sanden WJM, et al. Interventions for treating asymptomatic impacted wisdom teeth in adolescents and adults. Cochrane Database Syst Rev 2005;18(2):CD003879.