Types, Frequencies, and Risk Factors for Complications After Third Molar Extraction

Chi H. Bui, DMD, Edward B. Seldin, DMD, MD,† and Thomas B. Dodson, DMD, MPH‡*

Objectives: The study objective was to identify the types, frequency, and risk factors for complications after third molar (M3) extractions.

Study Design: This retrospective cohort study consisted of patients who had 1 or more M3s removed between 1996 and 2001. Risk factors were grouped into demographic, general health, anatomic, and operative. Outcome variables were operative or inflammatory complications. Data were analyzed using descriptive, bivariate, and multivariate statistics.

Results: The study sample was composed of 583 patients (57.0% male) with a mean age of 26.4 ± 8.4 years. The overall complication rate was 4.6%. Increasing age, a positive medical history, and the position of the M3 relative to the inferior alveolar nerve were associated with an increased risk for complications.

Conclusion: While age, medical history, and M3 anatomy cannot be altered directly, these factors may be modified indirectly, resulting in a potential decrease for postoperative complications.

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Third molar (M3) extraction is one of the most common procedures performed in oral and maxillofacial surgery units. Although the overall complication rate is low and most complications are minor, M3 removal is so common that the population morbidity of complications may be significant.[1,2] As such, efforts to limit intraoperative or postoperative complications may have a great impact in terms of enhancing patient outcome.

The literature on complications associated with M3 removal is voluminous and beyond the scope of this report to review in detail. As such, we limited the articles referenced here to high-quality studies (see Materials and Methods for a summary of methods and results to identify high-quality studies). Overall, M3 complication rates range from 2.6% to 30.9%.[3-5] Variability in the findings is due to varying definitions of complications, study design, different methods of evaluating study variables, and loss of patients to follow-up or misclassification bias.[6,7] Factors reported to be associated with M3 complications include age; gender; medications such as antibiotics, corticosteroids, or oral contraceptives; smoking; previous infection; periodontitis; poor oral hygiene; surgeon experience; difficulty of extraction; length of extraction; inadequate irrigation; number of teeth extracted; and anesthetic technique.[2,4-14] Few studies to date, however, evaluate the multivariate relationships among risk factors and complications.

The objectives of this investigation were to identify 1) the types and frequency of complications after M3 extractions and 2) the risk factors associated with postoperative complications. We hypothesized that we would identify one or more risk factors associated

*Resident-in-Training, Department of Orthodontics, University of North Carolina, Chapel Hill, NC; Formerly, Predoctoral Student, Harvard School of Dental Medicine, Boston, MA.

†Associate Professor, Department of Oral and Maxillofacial Surgery, Massachusetts General Hospital and Harvard School of Dental Medicine, Boston, MA.

‡Associate Professor, Department of Oral and Maxillofacial Surgery, Harvard School of Dental Medicine, Director of Resident Training, Massachusetts General Hospital, Boston, MA.

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Address correspondence and reprint requests to Dr Dodson: Massachusetts General Hospital, 55 Fruit St, Warren 1201, Boston, MA 02114; e-mail: tbdodson@partners.org

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with postoperative complications that may be modified by the clinician to enhance patient outcome. Frequently observed weaknesses of other studies are a predominant use of one anesthetic technique or the results of multiple surgeons being evaluated. We have the unique opportunity to review the cases of an experienced surgeon (E.B.S.) who uses either local anesthesia alone or general anesthesia in the operating room setting to remove M3s.

Materials and Methods

STUDY DESIGN AND SAMPLE

To address our research objectives, we designed a retrospective cohort study. The study sample was derived from the cohort of patients treated by one surgeon (E.B.S.) at the Massachusetts Institute of Technology Health Services Dental Service between 1996 and 2001. To be included in the study sample, patients needed to have one or more M3s (maxillary or mandibular third molars) removed and evidence of postoperative follow-up to assess outcomes. Patients without evidence of postoperative follow-up were excluded from the sample. The appropriate institutional review boards approved the study protocol.

STUDY VARIABLES

The *predictor variables,* that is, risk factors or exposures, were grouped into the following sets of variables: demographic, medical and dental history, anatomic, and operative. To identify variables to evaluate in this study, we searched MEDLINE using readily available search engines: Ovid (Ovid Technologies, Inc, New York, NY) and PubMed. Key words used in the search included "wisdom teeth," "third molar," "extraction complications," "tooth, impacted," "postoperative complications," "risk factors," "alveolitis," "nerve damage," "age," "gender," "smoking," and "tobacco." To identify high-quality articles, we applied a prognostic search filter developed by the University of Rochester and available through Ovid search engine. The search was limited to human subjects and English language. Eleven articles were generated by this search, of which 5 were relevant. Additional articles were obtained from references listed in the 5 articles. In most cases, the literature reviewed was limited to study samples of 500 or more extractions. References from studies with fewer than 500 teeth were used when there were study parameters similar to ours.

DEMOGRAPHIC VARIABLES

The demographic variables included age and gender.

MEDICAL AND DENTAL VARIABLES

Medical history was recorded nominally as positive or negative. Conditions associated with wound healing problems (ie, chronic hepatitis), organ transplant, human immunodeficiency virus infection, diabetes, and other immune disorders or blood dyscrasias (ie, hemophilia) were considered positive findings. A positive dental history was recorded if one or more of the following findings were present: bleeding gums, orthodontic treatment, difficulty with jaw movements, loose teeth, sensitive teeth, and bruxing. In addition, preoperative signs and symptoms, as indicated on the questionnaire or noted by the surgeon in the chart, were recorded. Relevant conditions included pericoronitis, pain, caries, swelling, orthodontic treatment, damage to the second molar, impacted teeth, unfavorable M3 functional anatomy (ie, malopposed, unopposed, or supraerupted teeth, opposing tooth to be extracted), periodontal disease, or infection.

We recorded the preoperative use of the following medications: oral contraceptives or hormone replacement therapy, systemic steroids, or antibiotics. The presence or absence of tobacco and alcohol use was also documented.

ANATOMIC VARIABLES

The anatomic variables included the total number and specific tooth or teeth extracted for each patient, M3 position based on the Winter's and Pell and Gregory classification systems, root development, and proximity of the inferior alveolar nerve (IAN) to the M3 apex.[15,16] Root development was grouped as follows: crown only, before furcation development, after furcation development, and complete root formation. Radiographic signs associated with an intimate anatomic association between the M3 and IAN were documented. These signs included deviation or narrowing of the canal, loss of cortical outline, shadow over the canal, and altered root morphology.[17] M3 to IAN proximity was categorized as no superimposition between the roots and IAN canal, superimposition without the radiographic findings listed above, and superimposition with one or more of the above listed radiographic changes.

OPERATIVE VARIABLES

The operative variables included the operation used to remove the M3, anesthetic technique (local or general), and perioperative antibiotic use. The operation used to remove the M3 was classified as nonsurgical, surgical, soft tissue impaction, partial bony impaction, and full bony impaction. The operation was classified based on the description found in the chart. These operative terms were defined as follows: 1) nonsurgical: an erupted tooth removed with forceps

and elevators only, not requiring incision of soft tissue or elevation of a flap; 2) surgical: an erupted tooth removed that required incision of overlying soft tissue, elevation of a flap or requiring removal of bone or the sectioning of a tooth using a surgical drill or chisels; 3) soft tissue: an impacted tooth removed requiring incision of overlying soft tissues and elevation of a flap and the use of forceps or elevators; 4) partial bony: an impacted tooth removed in a manner similar to soft tissue, but requires bone removal to facilitate extraction; and 5) full bony: an impacted tooth removed by the same technique as a partial bone impaction, but requires sectioning of the tooth in addition to bone removal to facilitate extraction.

The anesthetic technique was classified as local anesthesia alone or general anesthesia. Patients having general anesthesia were hospitalized and intubated for the procedure.

OUTCOME VARIABLES

The primary outcome variable was the presence or absence of intraoperative or postoperative complications. To assist in developing our working definitions for complications, we completed a literature search designed to identify high-quality articles. Using the search engines, filters, and limitations described above, we searched on key words "wisdom teeth," "third molar," "extraction complications," "tooth, impacted," and "postoperative complications." A total of 153 citations were identified, and the abstracts of those articles were reviewed for relevance. Nineteen articles were identified and reviewed in detail. Additionally, the references of these 19 articles were also carefully screened for relevant articles.

Complications were further classified as operative or inflammatory. Operative complications included bleeding, nerve injury, oroantral communication, incomplete removal of roots, and fracture of the alveolus, mandible, or tuberosity. Inflammatory complications included alveolitis, delayed healing, persistent oroantral communication, postoperative infection, hematoma, bony spicule, osteomyelitis, pain, or swelling. Alveolitis was operationally defined by the presence of the following conditions: 1) pain occurring 2 to 5 days after surgery that required additional treatment and 2) placement of a dressing. Delayed healing was defined as an extraction site with incomplete coverage by soft tissue within 21 days of the operation. Pain as a complication was defined as that requiring an additional prescription for management more than 7 days after the operation. Similarly, bleeding and swelling were considered complications if additional treatment was rendered.

DATA ANALYSIS

The charts were reviewed and information was abstracted and recorded on a standardized data collection form by one researcher (C.H.B.). The data were entered and a database was created using Microsoft Excel (Microsoft, Inc, Redmond, WA). The database was transferred to Statistical Package for the Social Sciences (SPSS 10.0; SPSS, Inc, Chicago, IL) for statistical analyses. Descriptive statistics were computed for all study variables. We noted consistently when the number of patients treated or teeth extracted was the denominator for calculations. In some cases, data were missing. Calculations were based on the sample available for analyses.

The relationships between the predictor and outcome variables were analyzed using bivariate statistics. Age, gender, and candidate variables based on the bivariate analyses ($P \leq .15$) were selected for inclusion into multivariate models. To estimate sample size, the postoperative complication prevalence was estimated *a priori* to be 10%. Using the rule of thumb of one variable per 10 observations, we estimated that we would need about 500 patients to develop a model that could include up to 5 variables in the multivariate model.

Results

Between 1996 and 2001, 687 patients had one or more wisdom teeth removed by the senior surgeon (E.B.S.). Of these subjects, 104 were excluded due to the inability to find their charts or failure to return for a follow-up visit. The descriptive statistics for the sample are summarized in Table 1. The sample size was 583 patients who had a total of 1,597 M3s removed. The sample's mean age was 26.4 ± 8.4 years, and 57.0% were male. More than 97% of subjects had negative medical histories, whereas 71.6% had positive dental histories. Positive medication, tobacco, and alcohol use was documented to be 21.9%, 8.7%, and 43.8%, respectively.

The average number of teeth extracted per patient was 2.8 ± 1.1, and 81.8% had complete root development. The most common Winter's classifications were vertical and mesioangular, 63.9% and 25.7%, respectively. For mandibular teeth, the most frequent Pell and Gregory classifications were IA and IB, 26.3% and 35.0%, respectively. Almost 75% of the mandibular M3s exhibited radiographic evidence of proximity to the IAN.

Most M3 extractions were performed under local anesthesia (79.1%). Full bony extraction was the most common operation (55.0%) followed by nonsurgical extraction (28.1%). Preoperative antibiotic use was reported by fewer than 1% of patients. In contrast, postoperative antibiotics were prescribed for patients

Table 1. STUDY VARIABLES GROUPED BY INCLUSION STATUS

Variable	Study Group	Excluded Group	*P* Value
Demographic			
Sample size—patients (%)	583 (84.9)	104 (15.1)	NA
Sample size—teeth (%)	1,597 (88.0)	217 (12.0)	NA
Gender (males), n (%)	332 (57.0)	59 (56.7)	.97
Age (yr), mean ± SD (range)	26.4 ± 8.4; 15.1 to 84.7	31.8 ± 13.7; 17.3 to 83.4	<.001
Medical/dental history (by patient)			
Medical (positive) (684: 580, 104)*	16 (2.8)	3 (2.9)	.94
Dental (positive) (649: 557, 92)	399 (71.6)	63 (68.5)	.54
Medications (yes) (683: 570, 103)	125 (21.9)	22 (21.3)	.66
Smoking (positive) (652: 561, 91)	49 (8.7)	10 (4.6)	.49
Alcohol (positive) (649: 559, 90)	245 (43.8)	45 (50.0)	.27
Anatomic			
Tooth extracted			
Maxillary right M3	387 (24.2)	58 (26.7)	.50
Maxillary left M3	386 (24.2)	59 (27.2)	
Mandibular left M3	418 (26.2)	50 (23.0)	
Mandibular right M3	406 (25.4)	50 (23.0)	
Total M3s removed (per patient)	2.8 ± 1.1	2.1 ± 1.1	<.001
Dental development			
Root development (1,767: 1,552, 215)			
Crown only	10 (0.6)	0 (0)	.67
Before bifurcation	17 (1.1)	3 (1.4)	
After bifurcation	255 (16.4)	35 (16.1)	
Complete root	1,270 (81.8)	177 (81.6)	
Anatomic position of M3			
Winter's classification (1,777: 1,561, 216)			
Horizontal	132 (8.5)	7 (3.2)	<.001
Mesioangular	401 (25.7)	34 (15.7)	
Vertical	997 (63.9)	171 (79.2)	
Distoangular	21 (1.3)	3 (1.4)	
Transverse	10 (0.6)	1 (0.5)	
Pell and Gregory (mandibular M3 only): (904: 805, 99)			
IA	212 (26.3)	48 (48.5)	.002
IB	282 (35.0)	29 (29.3)	
IC	68 (8.4)	4 (4.0)	
IIA	48 (6.0)	2 (2.0)	
IIB	125 (15.5)	10 (10.1)	
IIC	13 (1.6)	1 (1.0)	
IIIA	10 (1.2)	0 (0)	
IIIB	41 (5.1)	4 (4.0)	
IIIC	6 (0.7)	1 (1.0)	
M3 proximity to nerve: (904: 805, 99)			
No superimposition	203 (25.2)	38 (38.4)	.10
Superimposition	50 (6.2)	4 (4.0)	
Superimposition without change	412 (51.2)	39 (39.4)	
Superimposition with change	134 (16.6)	17 (17.2)	
Superimposition with >1 change	6 (0.7)	1 (1.0)	
Operative (by teeth)			
Anesthesia			
Local	1,263 (79.1)	183 (84.3)	.071
General	334 (20.9)	34 (15.7)	
Preoperative antibiotics (yes) (1,799: 1,586, 213)	18 (1.1)	5 (2.3)	.35
Operation: (1,805: 1,588, 217)			
Nonsurgical	446 (28.1)	114 (52.5)	<.001
Surgical	14 (0.9)	1 (0.5)	
Soft tissue	175 (11.0)	20 (9.2)	
Partial bony	80 (5.0)	16 (7.4)	
Full bony	873 (55.0)	66 (30.4)	
Postoperative antibiotics (yes) (1,799: 1,584, 215)	1,493 (94.3)	183 (84.3)	<.001
Mean no. of postoperative visits	1.03 ± 0.7	NA†	NA

*For some variables, data collection was incomplete. The number in parentheses is the sample size available for analysis of that variable and is formatted as total sample available: size of included sample, size of excluded sample (eg, 1,805: 1,588, 217).

†By definition, patients excluded from analyses had no evidence of follow-up visits.

Table 2. COMPLICATION TYPES AND FREQUENCIES

Complication	Episodes, n (%)	Percent by Tooth (n = 1,597)	Percent by Subject (n = 583)
Overall	74	4.6	9.8
Operative	19 (25.7)	1.2	2.2
Bleeding	9 (12.2)	0.6	0.7
Inferior alveolar nerve damage	6 (8.1)	0.4	1.0
Oroantral communication	3 (4.1)	0.2	0.3
Incomplete root removal	1 (1.4)	0.06	0.2
Inflammatory	55 (74.3)	3.4	7.6
Alveolitis	23 (31.1)	1.4	3.4
Delayed healing	11 (14.9)	0.7	1.5
Postoperative infection	8 (10.8)	0.5	0.9
Infected subperiosteal hematoma	7 (9.5)	0.3	0.9
Pain	4 (5.4)	0.3	0.5
Swelling	1 (1.4)	0.06	0.2
Bony spicule	1 (1.4)	0.06	0.2

in 94.3% of extractions. The average number of postoperative visits per patient was 1.03 ± 0.7. Table 1 also compares the samples of patients included and excluded from further analyses. In general, the subjects who were excluded were older, more likely to have vertically erupted teeth that were extracted nonsurgically, have fewer teeth extracted, and less likely to receive postoperative antibiotic treatment than patients included in the study.

Table 2 summarizes the types and frequencies of intraoperative and postoperative complications, grouped into operative and inflammatory complications. The overall complication rates for extraction sites and subjects were 4.6% and 9.8%, respectively. The operative and inflammatory complication rates were 2.2% and 7.5%, respectively. Complications were generally minor (91.9%) and were managed nonoperatively on an outpatient basis. Major complications (8.1%) were exclusively IAN injuries. There were no cases of lingual nerve damage. All except 1 of the IAN injuries resolved within 1 year, and all except 1 case resolved within 6 months. In 1 case, we could not confirm resolution of the injury due to loss of follow-up. At the time of the last follow-up visit, 3 months postoperatively, the IAN injury had improved significantly.

Table 3 summarizes the bivariate relationships between the predictor variables and complications. The following variables were statistically associated with complications ($P \leq .05$): positive medical history, number of M3s extracted, M3 location (maxillary versus mandibular), IAN proximity to M3, operation performed, and average number of postoperative visits.

We developed a multivariate logistic regression model that included candidate variables found in the bivariate analyses defined as being statistically or near statistically significant ($P \leq .15$) as well as 2 biologically important variables: age and gender. Increasing age (odds ratio [OR] = 1.05, $P = .03$), a positive medical history (OR = 1.04, $P = .004$), and the position of the M3 relative to the IAN (OR = 1.53, $P = .006$) were associated with an increased risk for complications after adjusting for gender, Winter's classification, and operation performed.

Table 4 summarizes the bivariate relationships between the predictor variables and inflammatory or operative complications. The only variables statistically associated ($P \leq .05$) with the type of complication were mandibular teeth, Winter's classification, and M3 proximity to the IAN. Vertical impactions are more likely to be associated with operative complications, whereas horizontal impactions are more likely to result in inflammatory complications. Teeth with 1 or more high-risk radiographic signs of nerve damage are more likely to result in operative complications.

After evaluating Tables 3 and 4, it was apparent and consistent with other reports that the removal of mandibular M3s was much more likely to be associated with complications than the removal of maxillary M3s. Of the 74 complications documented, 58 (78.3%) were associated with mandibular M3s. As such, we limited further analyses to mandibular M3s only. Table 5 summarizes the bivariate relationships between the exposures and complications for statistically significant variables. The results of the multivariate analysis revealed that a positive medical history (OR = 5.04, $P = .003$), Winter's classification (OR = 0.6, $P = .008$), and proximity of M3 to the IAN (OR = 1.6, $P = .002$) were statistically associated with complications after adjusting for age and gender. Age was near statistical significance (OR = 1.04, $P = .06$).

After limiting the sample to mandibular M3s, Table 6 compares the bivariate relationships between expo-

Table 3. STUDY VARIABLES GROUPED BY COMPLICATION STATUS

Variables	Complication Present	Complication Absent	*P* Value
Demographic			
Sample size	74 (4.6)	1,523 (95.4)	NA
Gender (males)	47 (63.5)	843 (55.4)	.17
Age (yr)	26.1 ± 7.0; 15.1 to 84.7	25.1 ± 6.9; 18.0 to 54.4	.25
Medical/dental history			
Medical (positive) (1,587: 74, 1,513)	7 (9.5)	40 (2.6)	.001
Dental (positive) (1,541: 71, 1,470)	55 (77.5)	1,054 (71.7)	.29
Medications (yes) (1,588: 73, 1,515)	11 (15.1)	322 (21.3)	.21
Smoking (positive) (1,545: 71, 1,474)	6 (8.5)	123 (8.3)	.98
Alcohol (positive) (1,540: 71, 1,469)	34 (47.9)	602 (41.0)	.25
Anatomic			
Teeth extracted			
Maxillary right M3	9 (12.2)	378 (24.8)	<.001
Maxillary left M3	7 (9.5)	379 (24.9)	
Mandibular left M3	28 (37.8)	390 (25.6)	
Mandibular right M3	30 (40.5)	376 (24.7)	
Maxillary vs mandibular			
Maxillary M3s	16 (21.6)	757 (49.7)	<.001
Mandibular M3s	58 (78.4)	766 (50.3)	
Right vs left			
Right M3s	39 (52.7)	754 (49.5)	.59
Left M3s	35 (47.3)	769 (50.5)	
Average no. of teeth extracted	2.9 ± 1.2	2.7 ± 1.1	.30
Tooth development			
Root development (1,552: 74, 1,478)			
Crown only	2 (2.7)	8 (0.5)	.30
Before bifurcation	2 (2.7)	15 (1.0)	
After bifurcation	16 (21.6)	239 (16.2)	
Complete root	54 (73.0)	1,216 (82.3)	
Anatomic position of M3			
Winter's classification (1,561: 74, 1,487)			
Horizontal	12 (16.2)	120 (8.1)	<.001
Mesioangular	36 (48.6)	365 (24.5)	
Vertical	26 (35.1)	971 (65.3)	
Distoangular	0 (0)	21 (1.4)	
Transverse	0 (0)	10 (6.7)	
Pell and Gregory (805: 58, 747)			
IA	10 (17.2)	202 (27.0)	.65
IB	21 (36.2)	261 (34.9)	
IC	7 (12.1)	61 (8.2)	
IIA	4 (6.9)	44 (5.9)	
IIB	10 (17.2)	115 (15.4)	
IIC	1 (1.7)	12 (1.6)	
IIIA	0 (0)	10 (1.3)	
IIIB	5 (8.6)	36 (4.8)	
IIIC	0 (0)	6 (0.8)	
M3 proximity to nerve (805: 58, 747)			
No superimposition	6 (10.3)	197 (26.4)	.006
Superimposition	5 (8.6)	45 (6.0)	
Superimposition without change	31 (53.4)	381 (51.0)	
Superimposition with change	14 (24.1)	120 (16.1)	
Superimposition with >1 change	2 (3.4)	4 (0.5)	
Operative			
Anesthesia			
Local	61 (82.4)	1,202 (78.9)	.47
General	13 (17.6)	321 (21.1)	
Preoperative antibiotics (yes) (1,586: 73, 1,513)	1 (1.4)	39 (2.6)	.52
Operation: (1,588: 74, 1,514)			
Nonsurgical	7 (9.5)	439 (29.0)	<.001
Surgical	0 (0)	14 (0.9)	
Soft tissue	4 (5.4)	171 (11.3)	
Partial bony	3 (4.1)	76 (5.0)	
Full bony	60 (81.1)	814 (53.8)	
Postoperative antibiotics (1,584: 74, 1,510)	70 (94.6)	1,423 (94.2)	.90
Mean no. of postoperative visits	1.8 ± 1.6	0.9 ± 0.4	<.001

Table 4. STUDY VARIABLES GROUPED BY COMPLICATION TYPE, BY TEETH

Variables	Operative	Inflammatory	*P* Value
Demographic			
Sample size—teeth (%)	25 (1.6)	49 (3.1)	NA
Gender (males, by teeth)	17 (1.1)	30 (1.9)	.57
Age (yr)	26.2 ± 7.1	26.0 ± 7.0	.88
Medical/dental history			
Medical (positive) (1,587: 25, 49)	4 (16.0)	3 (6.1)	.17
Dental (positive) (1,541: 25, 46)	19 (76.0)	36 (78.3)	.83
Medications (yes) (1,588: 25, 48)	3 (12.0)	8 (16.7)	.60
Smoking (positive) (1,545: 25, 46)	2 (8.0)	4 (8.7)	.92
Alcohol (positive) (1,540: 25, 46)	12 (48.0)	22 (47.8)	.99
Anatomic			
Tooth extracted			
Maxillary right M3	6 (24.0)	3 (6.1)	.13
Maxillary left M3	3 (12.0)	4 (8.2)	
Mandibular left M3	8 (32.0)	20 (40.8)	
Mandibular right M3	8 (32.0)	22 (44.9)	
Maxillary vs mandibular			
Maxillary M3s	9 (36.0)	7 (14.3)	.032
Mandibular M3s	16 (64.0)	42 (85.7)	
Right vs left			
Right M3s	14 (56.0)	25 (51.0)	.69
Left M3s	11 (44.0)	24 (49.0)	
Average no. of teeth extracted	2.0 ± 1.3	1.6 ± 1.1	.001
Dental development			
Root development (1,552: 25, 49)			
Crown only	0 (0)	2 (4.1)	.43
Before bifurcation	0 (0)	2 (4.1)	
After bifurcation	7 (28.0)	9 (18.4)	
Complete root	18 (72.0)	36 (73.5)	
Anatomic position of M3			
Winter's classification (1,561: 25, 49)			
Horizontal	0 (0)	12 (24.5)	<.001
Mesioangular	8 (32.0)	28 (57.1)	
Vertical	17 (68.0)	9 (18.4)	
Distoangular	0 (0)	0 (0)	
Transverse	0 (0)	0 (0)	
Pell and Gregory (mandibular M3 only) (805: 16, 42)			
IA	2 (12.5)	8 (19.0)	.79
IB	8 (50.0)	13 (31.0)	
IC	1 (6.3)	6 (14.3)	
IIA	1 (6.3)	3 (7.1)	
IIB	2 (12.5)	8 (19.0)	
IIC	0 (0)	1 (2.4)	
IIIA	0 (0)	0 (0)	
IIIB	2 (12.5)	3 (7.1)	
IIIC	0 (0)	0 (0)	
M3 proximity to nerve (805: 16, 42)			
No superimposition	1 (6.3)	5 (11.9)	.046
Superimposition	2 (12.5)	3 (7.1)	
Superimposition without change	5 (31.3)	26 (61.9)	
Superimposition with change	6 (37.5)	8 (19.0)	
Superimposition with >1 change	2 (12.5)	0 (0)	
Operative			
Anesthesia			
Local	23 (92.0)	38 (77.6)	.12
General	2 (8.0)	11 (22.4)	
Preoperative antibiotics (yes) (1,586: 25, 48)	1 (4.0)	0 (0)	.16
Operation (1,588: 25, 49)			
Nonsurgical	3 (12.0)	4 (8.2)	.84
Surgical	0 (0)	0 (0)	
Soft tissue	2 (8.0)	2 (4.1)	
Partial bony	1 (4.0)	2 (4.1)	
Full bony	19 (76.0)	41 (83.7)	
Postoperative antibiotics (yes) (1,584: 25, 49)	23 (92.0)	47 (95.9)	.48
Mean no. of postoperative visits	1.8 ± 1.6	2.5 ± 1.9	.12

Table 5. COMPLICATIONS OF MANDIBULAR TEETH

Variables	Complication Present	Complication Absent	*P* Value
Demographic			
Sample size—teeth (%)	58 (7.0)	766 (93.0)	NA
Medical/dental history			
Medical (positive) (819: 58, 761)	5 (8.6)	22 (2.9)	.018
Anatomic			
Anatomic position of M3			
Winter's classification (805: 58, 747)			
Horizontal	12 (20.7)	113 (15.1)	.027
Mesioangular	34 (58.6)	315 (42.2)	
Vertical	12 (20.7)	309 (41.4)	
Distoangular	0 (0)	5 (0.7)	
Transverse	0 (0)	5 (0.7)	
M3 proximity to nerve (805: 58, 747)			
No superimposition	6 (10.3)	197 (26.4)	.006
Superimposition	5 (8.6)	45 (6.0)	
Superimposition without change	31 (53.4)	381 (51.0)	
Superimposition with change	14 (24.1)	120 (16.1)	
Superimposition with >1 change	2 (3.4)	4 (0.5)	
Operative			
Mean no. of postoperative visits	2.5 ± 1.9	1.0 ± 0.4	<.001

sures and types of complications grouped as inflammatory or operative for the sets of statistically significant variables. Exposures statistically associated with the type of complication were Winter's classification and nerve proximity to the IAN ($P \leq .05$).

Discussion

The specific aims of this investigation were to identify 1) the types and frequency of complications after M3 extractions and 2) risk factors associated with postoperative complications. The overall complication rate was 4.6%. The majority of complications were inflammatory, with alveolitis being the most common. The operative complication rate was 1.2%, with bleeding being the most frequent complication. Risk factors associated with overall complications were age, positive medical history, removal of mandibular M3s, and IAN proximity to M3s.

The complication rates documented in this study were within the ranges reported in the referenced literature. Under study conditions similar to those used in this investigation, such as mean age of the patients, medical status, and indications for surgery, Chiapasco et al[10] found a 4.3% complication rate in the mandible and 1.2% in the maxilla among healthy patients, while Muhonen et al[4] reported an overall complication rate of 9%.

Table 6. STUDY VARIABLES GROUPED BY COMPLICATION TYPES FOR MANDIBULAR TEETH

Variables	Operative	Inflammatory	*P* Value
Demographic			
Sample size (%) (824)	16 (1.9)	42 (5.1)	NA
Anatomic			
Anatomic position of M3			
Winter's classification (805: 16, 42)			
Horizontal	0 (0)	12 (28.6)	<.001
Mesioangular	7 (43.8)	27 (64.3)	
Vertical	9 (56.3)	3 (7.1)	
Distoangular	0 (0)	0 (0)	
Transverse	0 (0)	0 (0)	
M3 proximity to nerve (805: 16, 42)			
No superimposition	1 (6.3)	5 (11.9)	.046
Superimposition	2 (12.5)	3 (7.1)	
Superimposition without change	5 (31.3)	26 (61.9)	
Superimposition with change	6 (37.5)	8 (19.0)	
Superimposition with >1 change	2 (12.5)	0 (0)	

The 4 most common postoperative complications reported in the literature were alveolar osteitis, infection, bleeding, and paresthesia.[18] The reported frequency of alveolitis ranged from 1% to 3% for all extractions, but was as high as 30% in cases of impacted mandibular M3s.[18-21] Consistent with previous studies, alveolitis was the most common complication identified in this study. The rate of alveolitis was 3.4% of all M3 extractions and accounted for 31.1% of all complications. This rate is slightly higher than the cited range and probably reflects the liberal definition used. It compares favorably with Oikarinen and Räsänen,[22] who reported alveolitis in 5% of the cases under similar study conditions.

Reported infection rates range from 0.9% to 4.3%.[6,10,18] In this study, the infection rate was 0.8%. Our findings are within the range reported by Chiapasco et al[10] (1.5% in the mandible and 0.2% in the maxilla) and lower than that of Herpy (3.4%).[18] In addition, the frequency of clinically significant bleeding (0.6%) in our study compares favorably with the reported ranges of 0.2% to 5.8%.[4,10] Variability in reported infections and bleeding rates are at least partly due to varying definitions.

IAN or lingual nerve damage may result in considerable morbidity and litigation. In the literature, IAN injury ranges from 1.3% to 5.3%, and lingual nerve injury ranges from 0% to 23%.[9,23-31] In this study the IAN and lingual nerve injury rates were 0.4% and 0%, respectively.

Most reports focus on frequently occurring or seriously morbid complications. As such, there are sparse data available on the other complications. The rates of the other less commonly cited complications in this study are consistent with those reported in Chiapasco et al.[10] Both studies found the rate of oroantral communication and excessive bleeding to be less than 1%. We did not, however, encounter complications such as fractures of the alveolar bone or tuberosity or damage to the adjacent molar, which were reported in their study.

This project's second major goal was to identify risk factors associated with adverse outcomes. Frequently cited risk factors for complications arising from M3 extraction include age, gender, site of extraction, tobacco use, oral contraceptive use, anesthesia, and surgeon experience.[2,4-13] Other factors that may be associated with increased complications were medical history, indications for extractions, and anatomic position. Although many of these variables are often cited as risk factors, the relevant data are equivocal. Many of these variables are interrelated, such as gender and oral contraceptive use, producing confounded results. Furthermore, many studies report only descriptive data, making interpretation difficult due to inadequate analyses.[1,4,10,13,18,23,27,28,32,33]

Age is commonly cited as a risk factor for postextraction complications. In our multivariate logistic regression analysis, age was found to be significantly associated with complications. This positive correlation may be related to increased bone density, which may result in more manipulation during the operation.[34] In addition to changes in bone density, increased age is associated with complete root formation and diminished wound healing capacities, which can result in higher operative and inflammatory complications. Increased incidence of alveolitis, root fracture, and nerve damage has been reported in previous studies.[25]

The results of this study found that a positive medical history was associated with an increased risk of complications, especially of the operative complications. Although our findings were consistent with other studies that documented an association between compromised medical status and postoperative complications, the subgroups composed of specific diagnostic categories were too small for further analyses.[7,35]

Consistent with other studies, our results indicated that mandibular M3s were associated with an increased frequency of complications relative to maxillary M3s.[10,22] Secondary analyses limited to mandibular M3s revealed that positive medical history, Winter's classification, and nerve proximity were associated with complications. Mesioangular impactions were associated with the highest risk for complications, which is consistent with Wofford and Miller[32] but inconsistent with other studies.[24,25]

This study did not find significant associations between gender, tobacco use, or anesthetic type and risk for complications. Gender was often cited as a risk factor for complications. Many studies reported increased complications among females associated with oral contraceptive use.[20,36,37] However, consistent with our findings, Heasman and Jacobs[19] and Larsen[20] did not find gender or oral contraceptive use to be associated with complications. It is possible that gender was not associated with complications in this study because of a selection bias; the majority of the subjects in this study were healthy college students.

Tobacco use as a risk factor for postoperative complications after M3 removal has been extensively documented.[33,38-40] We failed to confirm this relationship in this study. It is possible that smoking was not a significant risk factor in this study because of the method of data collection. The information on smoking history was obtained from a questionnaire; such self-reports may be inaccurate due to the lack of information on duration and frequency of use.

General anesthesia has been cited as a risk factor for postoperative complications.[31,41,42] Possible explanations for the increased complication rate under

general anesthesia include supine position, selection bias (ie, more difficult extraction or patient with compromised medical status), and greater surgical force. We had the unique opportunity to investigate the relationship between operative setting and the risk for complications. The senior surgeon (E.B.S.) removes M3s in only 2 settings: 1) local anesthesia in the office or 2) in the operating room under general anesthesia. This study failed to confirm the hypothesis that operative setting is a significant risk factor for complications after M3 removal. While the opportunity to remove M3s under a full general anesthesia is becoming unsual, it may afford the surgeon the luxury of feeling less obliged to operate quickly as in the setting of office sedation/anesthesia. If the complication rate was influenced by the need for speed, one would expect to see little difference between the general anesthesia and local anesthesia groups in this study.

The strengths of this investigation were the consistency of operator and data collector. The other unique aspect is that the surgeries performed under local anesthesia did not involve additional intraoperative analgesics, such as nitrous oxide or intravenous sedation. This factor, combined with a single highly experienced surgeon, enabled us to compare the effects of local anesthesia and general anesthesia with less confounding factors.

Because this is a retrospective study, some of the data recorded may have been misclassified since we used a low threshold of complications in the study. That is, any case that resulted in additional treatment, such as placement of a dressing or administration of antibiotics, during the follow-up visit was regarded as a complication. Moreover, pain, as defined in this study, may lead to a higher complication rate because there may be different reasons that patients may request additional analgesics. Furthermore, the screening health questionnaire is self-reported and lacks details.

We hypothesized that we would identify one or more risk factors associated with postoperative complications that may be modified by the clinician to enhance outcomes. This study failed to identify any variables that could be directly modified by the clinician. We identified 3 variables, however, that may be indirectly modified: age, anatomic position of molars, or planned operation. For example, the surgeon may recommend M3 removal at the earliest age possible, or alter the clinical setting or anesthesia technique for patients with positive histories. For patients with an increased risk for IAN injury based on radiographic findings, a careful review of the indications and necessity for M3 extractions with the patient would be recommended. Also, additional imaging techniques, modifying the surgical technique, or deferring extraction may be considered if the risk for IAN injury is high.[43]

References

1. Lopes V, Mumenya R, Feinmann C, et al: Third molar surgery: An audit of the indications for surgery, post-operative complaints and patient satisfaction. Br J Oral Maxillofac Surg 33:33, 1995
2. Berg TI, Boe OE: Predictor evaluation of postoperative morbidity after surgical removal of mandibular third molars. Acta Odontol Scand 52:162, 1994
3. Calhoun NR: Dry socket and other postoperative complications. Dent Clin North Am 15:337, 1971
4. Muhonen A, Iventä I, Ylipaavalniemi P: Factors predisposing to postoperative complications related to wisdom tooth surgery among university students. J Am Coll Health 46:39, 1997
5. Osborn TP, Frederickson G Jr, Small I, et al: A prospective study of complications related to mandibular third molar surgery. J Oral Maxillofac Surg 43:767, 1985
6. Capuzzi P, Montebugnoli L, Vaccaro MA: Extraction of impacted third molars. Oral Surg Oral Med Oral Pathol 77:341, 1994
7. Dodson TB: HIV status and risk of post-extraction complications. J Dent Res 76:1644, 1997
8. Sisk AL, Hammer WB, Shelton WD, et al: Complications following removal of impacted third molars: The role of the experience of the surgeon. J Oral Maxillofac Surg 44:855, 1986
9. Bataineh AB: Sensory nerve impairment following mandibular third molar surgery. J Oral Maxillofac Surg 59:1012, 2001
10. Chiapasco M, De Cicco L, Marrone G: Side effects and complications associated with third molar surgery. Oral Surg Oral Med Oral Pathol 76:412, 1993
11. Renton T, Smeeton N, McGurk M: Factors predictive of difficulty of mandibular third molar surgery. Br Dent J 190:607, 2001
12. Monaco G, Staffolani C, Gatto MR, et al: Antibiotic therapy in impacted third molar surgery. Eur J Oral Sci 107:437, 1999
13. Brann CR, Brickley MR, Shepard JP: Factors influencing nerve damage during lower third molar surgery. Br Dent J 186:514, 1999
14. Edwards DJ, Horton J, Shepard JP, et al: Impact of third molar removal on demands for postoperative care and job disruption: Does anesthetic choice make a difference? Ann R Coll Surg Engl 81:119, 1999
15. Winter GB: Principles of Exodontia as Applied to the Impacted Mandibular Third Molar: A Complete Treatise on the Operative Technique With Clinical Diagnoses and Radiographic Interpretations, St Louis, MO, American Medical Book Co, 1926
16. Pell GJ, Gregory BT: Impacted mandibular third molars: Classification and modified techniques for removal. Dent Dig 39: 330, 1993
17. Rood JP, Shehab BA: The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg 28:20, 1990
18. Herpy AK: A monitoring and evaluation study of third molar surgery complications at a major medical center. Mil Med 156:10, 1991
19. Heasman PA, Jacobs DJ: A clinical investigation into the incidence of dry socket. Br J Oral Maxillofac Surg 22:115, 1984
20. Larsen PE: Alveolar osteitis after surgical removal of impacted mandibular third molars: Identification of the patient at risk. Oral Surg Oral Med Oral Pathol 73:393, 1992
21. Fridrich KL, Olson RA: Alveolar osteitis following surgical removal of mandibular third molars. Anesth Prog 37:32, 1990
22. Oikarinen K, Räsänen A: Complications of third molar surgery among university students. J Am Coll Health 39:281, 1991
23. Chye EP, Young IG, Osborne GA, et al: Outcomes after same-day oral surgery: A review of 1,180 cases at a major teaching hospital. J Oral Maxillofac Surg 51:846, 1993
24. Kipp DP, Goldstein BH, Weiss WW: Dysesthesia after mandibular third molar surgery: A retrospective study and analysis of 1,377 surgical procedures. J Am Dent Assoc 100:185, 1980

25. De Boer MP, Raghoebar GM, Stegenga B, et al: Complications after mandibular third molar extraction. Quintessence Int 26:779, 1995
26. Black CG: Sensory impairment following lower third molar surgery: A prospective study in New Zealand. N Z Dent J 93:68, 1997
27. Goldberg MH, Nemarich AN, Marco WP: Complications after mandibular third molar surgery: A statistical analysis of 500 consecutive procedures in private practice. J Am Dent Assoc 111:277, 1985
28. Alling CC III: Dysesthesia of the lingual and inferior alveolar nerves following third molar surgery. J Oral Maxillofac Surg 44:454, 1986
29. Mason DA: Lingual nerve damage following lower third molar surgery. Int J Oral Maxillofac Surg 17:290, 1988
30. Smith AC, Barry SE, Chiong AY, et al: Inferior alveolar nerve damage following removal of mandibular third molar teeth: A prospective study using panoramic radiography. Aust Dent J 42:149, 1997
31. Blackburn CW, Bramley PA: Lingual nerve damage associated with removal of lower third molars. Br Dent J 167:103, 1989
32. Woffard DT, Miller RI: Prospective study of dysesthesia following odontectomy of impacted mandibular third molars. J Oral Maxillofac Surg 45:15, 1987
33. Sweet JB, Butler DP: The relationship of smoking to localized osteitis. J Oral Surg 37:732, 1979
34. Bruce RA, Frederickson GC, Small GS: Age of patients and morbidity associated with mandibular third molar surgery. J Am Dent Assoc 101:240, 1980
35. Raut A, Huryn JM, Hwang FR, et al: Sequelae and complications related to dental extractions in patients with hematological malignancies and impact on medical outcome. Oral Surg Oral Med Oral Pathol 92:49, 2001
36. Catellani JE, Harvey S, Erickson SH, et al: Effect of oral contraceptives on dry socket. J Am Dent Assoc 101:777, 1980
37. Cohen ME: Effects of gender-related factors on the incidence of localized alveolar osteitis. Oral Surg Oral Med Oral Pathol 79:416, 1995
38. Meechan JG, MacGregor ID, Rogers SN, et al: The effect of smoking on immediate post-extraction socket filling with blood and on the incidence of painful socket. Br J Oral Maxillofac Surg 26:402, 1988
39. Sweet JB, Butler DP: Effect of smoking on the incidence of localized osteitis following mandibular third molar surgery. Quintessence Int 9:9, 1978
40. MacGregor AJ: Aetiology of dry socket: A clinical investigation. Br J Oral Surg 6:49, 1968
41. Edwards DJ, Brickley MR, Horton J, et al: Choice of anesthetic and healthcare facility for third molar surgery. Br J Oral Maxillofac Surg 36:333, 1998
42. Holland IS, Stassen LF: Bilateral block: Is it safe and more efficient during removal of third molars? Br J Oral Maxillofac Surg 34:243, 1996
43. Feifel H, Reidiger D, Gustof-Aerckerle R: High resolution computed tomography of the inferior alveolar and lingual nerves. Neuroradiology 36:236, 1994