Risk Factors for Third Molar Extraction Difficulty

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Purpose: The purpose of this study was to measure the difficulty of third molar (M3) extractions and to identify demographic, anatomic, and operative variables associated with extraction difficulty.

Materials and Methods: To address the research purpose, we implemented a prospective cohort study and enrolled a sample composed of patients presenting for M3 removal. Predictor variables were categorized as demographic, anatomic, and operative. The primary outcome variable was difficulty of extraction, measured as extraction time per tooth. The secondary outcome variable was the surgeon's postoperative estimate of M3 extraction difficulty, measured on a 100-mm visual analog scale (VAS). Appropriate univariate, bivariate, and multivariate statistics were computed.

Results: The sample was composed of 82 subjects, having 250 M3s (53.2% mandibular) extracted, with a mean age of 26.2 ± 10.7 years; 57.3% were female, 72.0% were white. The mean operating time per M3 extraction was 6.9 ± 7.6 minutes. The mean estimate of difficulty was 39.6 ± 24.7 mm and was significantly correlated ($r = 0.68$) with extraction time ($P < .01$). Surgical experience, M3 location (maxillary versus mandibular), procedure type, tooth position, number of teeth extracted, and tooth morphology were statistically associated ($P \leq .05$) with extraction time in a multivariate model.

Conclusion: Our model indicates that the difficulty of M3 extractions is governed primarily by anatomic and operative factors with minimal influence from demographic factors.

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Extraction of third molars (M3s) accounts for a large volume of cases in contemporary oral surgical practice and requires much planning and surgical skill, during both preoperative diagnosis and postoperative management.[1] More than 10 million impacted M3s are removed per year in the United States, with an estimated total expenditure of over $2 billion, and it has been estimated that M3 surgeries account for 50% of the cost of all oral surgical procedures.[2,3]

Although extensive literature exists regarding indications for M3 removal and postoperative complications, there is a relative dearth of studies devoted to assessing demographic, anatomic, and operative factors associated with M3 extraction difficulty. It is important that a paradigm for factors associated with M3 extraction difficulty be developed to serve patients more effectively, to plan operations, and to educate students and residents.

Although several studies have identified a plethora of factors associated with extraction difficulty, as measured via a wide variety of proxy variables, there are few studies devoted to the development and implementation of mathematical models that describe difficulty.[4-14] The first attempt to develop a model of this nature was made by MacGregor in 1976.[11,14] Based on panoramic radiographic findings, MacGregor attempted to create a multivariate model to describe the difficulty of M3 extractions. Subsequent investigations have confirmed MacGregor's conclusions regarding the value of radiographic factors and have revealed that a wide variety of nonradiographic variables are associated with difficulty of mandibular M3 extractions. The magnitudes of these variable influences, however, have not been rigorously quantified.[9-11,14]

The purposes of this study were to measure M3 extraction difficulty and to identify risk factors associated with difficulty of M3 extractions. We hypothesized that the length of the operation could be used as a proxy

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Table 1. DESCRIPTIVE STATISTICS FOR STUDY VARIABLES (n_{total} = 82 PATIENTS; k_{total} = 250 TEETH)

Sample size	n = 82 patients and k = 250 third molars
Demographic variables	
Mean age (yr)* (n = 82)	26.2 ± 10.7 (15–65)
Gender (No. female)† (n = 82)	47 (57.3)
Ethnicity (No. white)† (n = 82)	59 (72.0)
Snore (No. yes)† (n = 80)	27 (33.8)
Apnea (No. yes)† (n = 80)	0 (0.0)
Anatomic variables	
Third molar location in maxilla (No.)† (k = 250)	117 (46.8)
Tooth number (No.)‡ (k = 250)	
1	54 (21.6)
16	63 (25.2)
17	70 (28.0)
32	63 (25.2)
Body mass index (kg/m^2)* (n = 80)	24.4 ± 4.7 (16.9–36.1)
Mouth opening (mm)* (n = 80)	39.6 ± 6.2 (27–55)
Cheek flexibility (mm)* (n = 78)	48.7 ± 7.2 (28–69)
Winter's classification (No.)† (k = 250)	
Vertical	171 (68.4)
Mesioangular	50 (20.0)
Horizontal	12 (4.8)
Distoangular	17 (6.8)
Tooth morphology (No.)† (k = 246)	
Favorable	206 (83.7)
Unfavorable	40 (16.3)
Pell-Gregory ramus classification (No.)†‡ (k = 133)	
Class 1	24 (18.0)
Class 2	100 (75.2)
Class 3	9 (6.8)
Pell-Gregory occlusal classification (No.)†‡ (k = 133)	
Level A	49 (36.9)
Level B	64 (48.1)
Level C	20 (15.0)
Mandibular position composite score*‡§ (k = 133)	5.5 ± 1.5 (3–9)
Angulation (No.)*‡ (k = 131)	66.4 ± 31.3 (0–105)
Root proximity to inferior alveolar nerve canal (No.)†‡ (k = 133)	
Distant	75 (56.4)
Touching	42 (31.6)
Crossing	16 (12.0)
Panoramic radiographic evidence (No.)†‡ (k = 132)	
Loss of cortical outline	48 (36.4)
Narrowing of canal	4 (3.0)
Deviation of canal	5 (3.8)
Darkening of root	1 (0.8)
No evidence	74 (56.1)
Operative variables	
No. of teeth extracted* (k = 250)	3.5 ± 0.87 (1–4)
Procedure type (No.)† (k = 250)	
Erupted, nonsurgical	56 (22.4)
Erupted, surgical	8 (3.2)
Soft tissue impacted	48 (19.2)
Partial bony impacted	49 (19.6)
Full bony impacted	89 (35.6)
Anesthesia type (No.)† (k = 250)	
Local	47 (18.8)
Local + N_2O	38 (15.2)
General	165 (66.0)
Inferior alveolar nerve visualized (No. yes)†‡ (k = 131)	6 (4.6)
Surgical experience (yr)* (k = 250)	8.8 + 11.1 (−7–36)
Outcome variables	
Postoperative estimate of difficulty (mm)* (k = 250)	39.6 ± 24.7 (1–100)
Extraction time (min)* (k = 250)	6.9 ± 7.6 (0.44–44.3)

*Data for continuous variables are reported as mean ± SD (range).
†Data for categorical variables are reported as n or k (%).
‡For mandibular teeth only (k_{mand} = 133).
§For calculation of Mandibular Position Composite score, see Table 2.

FIGURE 1. Measurement of mouth opening. Mouth opening was measured in millimeters as the interincisal distance with a bite-block in place.

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variable for extraction difficulty and that there existed a set of variables that could be identified preoperatively as predictors of M3 extraction difficulty. Our specific aims in this study were to measure the operating time required to remove M3s, to measure the surgeon's postoperative estimate of M3 extraction difficulty, and to identify demographic, anatomic, and operative variables associated with M3 extraction difficulty.

Materials and Methods

STUDY DESIGN AND SAMPLE

To address our research purposes, we implemented a prospective cohort and enrolled a sample of patients who presented to the Massachusetts General Hospital Oral and Maxillofacial Surgery Unit for M3 removal. The sample included patients undergoing all procedures used to remove the M3s under all conditions of anesthesia except those cases treated in the main operating room or the day surgery center. We excluded subjects undergoing M3 extraction in the main operating room or the day surgery center because these cases represent an uncommon event (<2% of all M3 cases) in both our institutional practice and the community.

The sample included all surgeons practicing at the unit (students, interns, residents, and faculty). To reduce variance, only cases where the designated data recorder (S.M.S.) was present were included in the study, thus producing a convenience sample. The project was approved by the institutional review board for human studies.

STUDY VARIABLES: PREDICTORS

The set of predictor variables was divided into 3 groups: demographic, anatomic, and operative (Table 1). Demographic variables were chosen to provide a general description of our sample. Anatomic and operative variables were chosen on the basis of a literature review.[9-22]

The demographic variables were gender, age, ethnicity (white, black, East Asian, Hispanic/Latino, South Asian, Pacific Islander/Hawaiian, Native American, or Alaskan Native), and a history of snoring or sleep apnea.

The anatomic variables were M3 position, tooth morphology, M3 location, body mass index (kg/m^2), mouth opening (mm), and cheek flexibility (mm). M3 position was defined using Winter's classification as vertical, mesioangular, horizontal, or distoangular.[23] Tooth morphology was defined as favorable or unfavorable; for example, unfavorable morphology may include a wide crown and/or fully developed or anomalous roots.[9] M3 location referred to arch location (maxilla or mandible). Body mass index was calculated in units of kilograms per meter squared according to the standard formula. Mouth opening was defined as the working interincisal distance (mm) with a bite-block in place (Fig 1). Cheek flexibility was defined as the distance (mm) between the maxillary dental midline and the cheek retractor during retraction (Fig 2).

The operative variables were anesthetic technique, operation (procedure type), number of M3s extracted, and surgical experience. Anesthetic technique was classified as local, local with nitrous oxide induction, or deep sedation/general anesthetic. The operations used to remove M3s were classified as surgical or nonsurgical for erupted M3s or as soft tissue, partial bony, or full bony for impacted M3s. For erupted teeth, a surgical classification indicated that

FIGURE 2. Measurement of cheek flexibility. Cheek flexibility was measured as the distance, in millimeters, from the maxillary incisal midline to the cheek retractor during retraction.

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an incision was required for removal. Soft tissue impactions were defined as impacted teeth that required elevation of a mucoperiosteal flap and then M3 removal with additional bone removal or sectioning of the tooth. Partial bony impactions were defined as those M3s that required both a flap and bone removal to facilitate M3 extraction. Full bony impactions required a flap, bone removal, and tooth sectioning to remove the teeth. The total number of M3s extracted per subject was recorded and ranged from 1 to 4. Surgical experience was defined relative to completing an OMFS residency (ie, number of years since completion of residency). Experience scores of ≥ 0 were assigned to surgeons who had completed a residency. Surgeons who had not completed a residency were scored <0, ranging from −7 (dental student extern) to −1 (chief resident).

Mandible-specific anatomic variables were tooth position, grouped using the Pell-Gregory classification (ramus and occlusal), tooth angulation, root proximity to the inferior alveolar nerve (IAN) canal, and panoramic radiographic evidence of an intimate anatomic relationship between the M3 and the IAN canal. Pell-Gregory classifications were made according to vertical position of M3 relative to the cementoenamel junction (CEJ) of the mandibular second molar (M2) (occlusal level: A = M3 occlusal surface above the CEJ, B = at the CEJ, C = below the CEJ) and horizontal position of the tooth within the ramus (class: 1 = adequate space for M3 between M2 and the ascending ramus, 2 = inadequate space, 3 = M3 contained completely within the ramus).[16] Based on Pederson, a composite score was computed based on the Winter and Pell-Gregory classification systems.[11-14] The composite score was the sum of the values for Winter's classification, Pell-Gregory occlusal classification, and Pell-Gregory ramus classification (Table 2).

Tooth angulation was measured to the nearest 15° as the angle between the long axis of the tooth and the occlusal plane; teeth that tilted mesially were assigned acute angle measures, and teeth that tilted distally were assigned obtuse angle measures. M3 root proximity to the IAN canal was defined as distant, touching, or crossing, according to the criteria specified by Rud.[20] Panoramic radiographic evidence of intimate anatomic relationships between the M3 and the IAN canal was noted and classified as loss of cortical outline, darkening of the root, and narrowing or deviation of the IAN canal.[21,22]

The mandible-specific operative variable was visualization of the IAN. Intraoperatively, the surgeon was asked if the IAN was visualized in the tooth socket after extraction.

Table 2. COMPOSITE DIFFICULTY SCORE

Parameter	Score
Winter's classification (W_i)	
Distoangular	4
Vertical	3
Horizontal/Transverse	2
Mesioangular	1
Pell-Gregory classification	
Ramus (R_i)	
Class 3	3
Class 2	2
Class 1	1
Occlusal (O_i)	
Level C	3
Level B	2
Level A	1
Composite mandibular position score $= C_i = W_i + R_i + O_i$	Range, 3–10

NOTE. Composite difficulty score is based on anatomic position of mandibular M3. Composite score (C_i) is the simple sum of the 3 categories ($W_i + R_i + O_i$). For example, a distoangular impaction (score = 4) at Level B (score = 2) and at Class 1 (score = 1) would have a composite score of 7.

Data from Pederson.[13]

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STUDY VARIABLES: OUTCOMES

The major outcome variable was extraction difficulty, which was measured using 2 different methods. First, extraction time was used as a proxy measure of difficulty.[9,13,14] Extraction time was defined as the interval between the utilization of the first instrument required in the extraction of a particular tooth until the replacement of the last instrument involved in that extraction. Extraction time was measured using a digital timepiece for each case included in the study. To reduce bias, the same individual (S.M.S.) measured all extraction times.

Extraction difficulty was also measured by asking the operating surgeon to estimate difficulty. Difficulty was measured using a 100-mm visual analog scale (VAS) with a score of 0 marked as the easiest possible procedure and ranging to a score of 100, marked as the most difficult procedure possible.[24] Immediately after concluding the operation, the operating surgeons recorded their estimates of M3 extraction difficulty for each tooth extracted and for the operation overall.

DATA MANAGEMENT AND ANALYSES

Data were collected using a universal scoring sheet, and responses to each variable measure were assigned a numerical value. These data were entered into a spreadsheet over the course of the study. With use of a statistical software package (SPSS Graduate Pack 11.0; SPSS Inc, Chicago, IL), descriptive statistics were computed for each study variable. Bivariate statistics were computed to measure the association between the predictor and outcome variables. Variables that were near-significantly associated with extraction time ($P \leq .15$) and biologically relevant variables, eg, age and sex, were included in the multivariate linear regression model. The level of statistical significance for multivariate models was set at $P \leq .05$.

Results

Between June and August 2002, we enrolled a sample composed of 82 subjects having 250 M3s extracted. The sample's mean age was 26.2 years (range, 15 to 65 years), 57.3% were female, 72.0% were white, and the mean body mass index was 24.4 ± 4.7 kg/m^2. On average, each subject had 3.1 M3s extracted, and each extraction took 6.9 ± 7.6 minutes (range, 0.4 to 44.3 minutes). The mean surgical experience score was 8.8 ± 11.1 years (range, −7 to 36 years). Of the teeth included in the study, they were approximately evenly distributed by dental arch and position within each arch.

The average postoperative estimate of M3 extraction difficulty (VAS) was 39.6 ± 24.7 mm (range, 1 to 100 mm). Extraction time was statistically significantly associated with the operating surgeon's postoperative estimate of difficulty (Pearson correlation coefficient = 0.68, $P < .01$).

Table 3. BIVARIATE ANALYSES* OF STUDY VARIABLE VERSUS THIRD MOLAR EXTRACTION TIME (k = 250)

Variable	P Value
Demographic	
Age	.37
Gender	.01
Ethnicity	.26
Snore	.37
Anatomic	
Third molar location	<.01
Body mass index	.21
Mouth opening	.18
Cheek flexibility	.27
Winter's classification	<.01
Tooth morphology	<.01
Operative	
No. of Teeth Extracted	<.01
Procedure type	<.01
Anesthesia type	.05
Surgical experience	<.01
Outcome	
Postoperative estimate of difficulty	<.01

*Bivariate analyses were conducted using either Pearson correlation (continuous variable versus extraction time) or analysis of variance (categorical variable versus extraction time).

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Table 4. MULTIVARIATE MODEL FOR ALL THIRD MOLARS (k = 250)

Variable	Coefficient	P Value
Constant	10.3	<.01
Gender	−1.3	.10
Age	3.7×10^{-4}	.94
Third molar location	3.5	<.01
Winter's classification	1.3	.01
Tooth morphology	−3.8	<.01
No. of teeth extracted	−1.3	.01
Procedure type	1.4	<.01
Anesthesia type	0.5	.29
Surgical experience	−0.2	<.01

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Using extraction time as a proxy for extraction difficulty, we developed 3 multivariate models: 1) a comprehensive model for all teeth, 2) a model limited to maxillary teeth, and 3) a model limited to mandibular teeth. The bivariate relationships between the set of predictor variables and extraction time for all M3s are summarized in Table 3. Gender, M3 location, Winter's classification, tooth morphology, number of teeth extracted, procedure type, anesthesia type, and surgical experience were statistically or near statistically significantly ($P \leq .15$) associated with operating time. In the multivariate model (Table 4), M3 location, Winter's classifications, tooth morphology, number of teeth extracted, procedure type, and surgical experience were statistically significant ($P \leq .05$).

For maxillary M3s alone (Table 5), ethnicity, Winter's classification, procedure type, anesthesia type, and surgical experience met the criteria for inclusion in the multivariate linear regression. Procedure type and surgical experience were statistically significant in the multivariate model (Table 6).

Table 7 summarizes the bivariate relationships between the set of predictors and operating time to remove mandibular M3s. The variables selected for inclusion in the multivariate model were gender, tooth morphology, angulation, mandibular position composite score, root proximity to the IAN canal, number of teeth extracted, procedure type, and surgical experience. In the multivariate model (Table 8), the mandibular position composite score, tooth morphology, number of teeth extracted, procedure type, and surgical experience were all statistically significantly associated with operating time.

Discussion

Identification of factors that influence the difficulty of M3 extractions may be valuable for both planning and

Table 5. BIVARIATE ANALYSES* OF VARIABLES VERSUS OUTCOME—MAXILLARY THIRD MOLARS (k = 117)

Variable	*P* Value
Demographic	
Age	.22
Gender	.79
Ethnicity	<.01
Snore	.22
Anatomic	
Body mass index	.16
Mouth opening	.59
Cheek flexibility	.79
Winter's classification	.14
Tooth morphology	.67
Operative	
No. of teeth extracted	.61
Procedure type	<.01
Anesthesia type	.06
Surgical experience	.02
Outcome	
Postoperative estimate of difficulty	<.01

*Bivariate analyses were conducted using either Pearson correlation (continuous variable versus extraction time) or analysis of variance (categorical variable versus extraction time).

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scheduling procedures and in the training of students and residents. Our study purpose was to identify risk factors associated with difficulty of M3 extractions. We hypothesized that the duration of the operation could be used as a proxy measure for extraction difficulty and that there existed a set of identifiable variables that could serve as predictors of M3 extraction difficulty.

In brief, the mean operating time to remove M3s was 6.9 ± 7.6 minutes. Based on a 100-mm VAS, the mean estimate of M3 extraction difficulty was 39.6 ± 24.7 mm. Extraction time and surgeon's estimate of difficulty were statistically correlated, with a correlation coefficient of 0.68 ($P < .01$). Based on the multivariate models, we identified a set of variables that were statistically associated with M3 extraction difficulty (M3 location, Winter's classification, tooth morphology, number of teeth extracted, type of procedure, and surgical experience).

Table 6. MULTIVARIATE MODEL FOR MAXILLARY THIRD MOLARS (k = 117)

Variable	Coefficient	*P* Value
Constant	1.5	.17
Gender	−0.3	.54
Age	2.8×10^{-2}	.37
Ethnicity	8.2×10^{-3}	.97
Winter's classification	-7.9×10^{-2}	.82
Procedure type	0.8	<.01
Anesthesia type	0.3	.37
Surgical experience	−0.1	<.01

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Table 7. BIVARIATE ANALYSIS* OF VARIABLES VERSUS OUTCOME—MANDIBULAR THIRD MOLARS (k = 133)

Variable	*P* Value
Demographic	
Age	.41
Gender	.04
Ethnicity	.35
Snore	.41
Anatomic	
Body mass index	.18
Mouth opening	.24
Cheek flexibility	.25
Winter's classification†	<.01
Tooth morphology	<.01
Angulation	.09
Pell-Gregory ramus classification†	<.01
Pell-Gregory occlusal classification†	.07
Mandibular position composite score	<.01
Root proximity to inferior alveolar nerve canal	.03
Panoramic radiographic evidence	.12
Operative	
No. of teeth extracted	<.01
Procedure type	<.01
Anesthesia type	.16
Inferior alveolar nerve visualization	.20
Surgical experience	<.01
Outcome	
Postoperative estimate of difficulty	<.01

*Bivariate analyses were conducted using either Pearson correlation (continuous variable versus extraction time) or analysis of variance (categorical variable versus extraction time).

†Although these variables met the criteria for inclusion in the multivariate model ($P \leq .15$), they were not included in the multivariate model due to the inclusion of their linear sum, the mandibular position composite score (see Table 2).

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Table 8. MULTIVARIATE MODEL FOR MANDIBULAR THIRD MOLARS (k = 133)

Variable	Coefficient	*P* Value
Constant	7.8	.12
Gender	−1.1	.40
Age	9.5×10^{-3}	.89
Tooth morphology	−4.1	.01
Angulation	3.1×10^{-2}	.19
Mandibular position composite score	1.5	.01
Root proximity to inferior alveolar nerve canal	0.88	.37
No. of teeth extracted	−2.0	<.01
Type of procedure	1.5	.01
Surgical experience	−0.32	<.01

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Historically, estimates of extraction difficulty have been based on radiographic features, with little or no emphasis on demographic or operative variables or maxillary teeth.[9-14,16,17,25,26] Classically, the assessment of difficulty of extraction has been based on angulation, depth of impaction, and ramus and occlusal positions.[9-14,25] Using radiographs, MacGregor was the first to develop a model to predict operative difficulty, using length of operation as a proxy for surgical difficulty.[11,14] Preliminary evidence from this experiment indicated the radiographic evidence could be used to assess the difficulty of extractions. MacGregor enhanced his analysis by assessing which particular variables were utilized from orthopantomograms in assessing difficulty. The initial analysis of factors included 600 variables, of which 144 were statistically significant in bivariate analyses with extraction time ($P \leq .05$).[11,14] Although MacGregor was unable to develop a multivariate model of predictive value from the comprehensive set of variables, he was able to construct a semiquantitative model based on relatively few radiographic factors that were not interrelated. The resulting model showed that an increase in radiographic scoring of difficulty according to the WHARFE classification system (Winter's classification, Height of the mandible, Angulation of M2, Root shape and development, Follicle morphology, and Exit path) was associated with increased operating time.[11,14]

Our multivariate model for all M3s suggests that, in the absence of any information regarding demographic, anatomic, or operative variables, a third molar extraction will take 10.3 minutes. Factors that increase the extraction time include mandibular teeth (+3.5 minutes), procedure type (ranging from +0 minutes if erupted, nonsurgical to +5.6 minutes if full bony impacted), and Winter's classification (+0 minutes if vertical; +1.3 minutes if mesioangular; +2.6 minutes if horizontal; +3.9 minutes if distoangular). Factors that decrease extraction time include surgical experience (−0.2 min/yr), tooth morphology (−3.8 minutes with favorable morphology), and number of teeth extracted (−1.3 min/tooth).

Our results confirm the common clinical observation that mandibular M3s are more difficult to extract than are their maxillary counterparts. It is very likely that this effect is due to the greater cortical bone density in the mandibular arch relative to that in the maxillary arch and the additional caution required to avoid IAN injury. As surgical procedure changes from no incision (erupted) to incision required (erupted or impacted), and as depth of impaction increases from soft tissue to full bony, a greater degree of surgical manipulation is required for extraction, thereby prolonging operating time and, by proxy, difficulty. Deviation of teeth from a vertical alignment increases operating time, with distoangular teeth requiring the most time for extraction; this is likely due to the difficulty of crown/root access in horizontal and distoangular teeth compared with vertical and mesioangular teeth. As tooth morphology becomes more favorable, root access and crown positioning are more conducive to extraction and extraction time decreases.[27] It is an intuitive result that increasing surgical experience decreases extraction time—experienced surgeons will have performed more extractions and have a higher skill level than those with less experience or those in training.

The multivariate model limited to maxillary M3s suggests that the extraction of a maxillary M3 will take 1.5 minutes. The type of procedure will increase operating time (+0 minutes if erupted, nonsurgical; +0.8 minutes if erupted, surgical; +1.6 minutes if soft tissue impacted; +2.4 minutes if partial bony impacted; +3.2 minutes if full bony impacted), whereas surgical experience will decrease operating time (−0.06 min/yr of surgical experience).

The multivariate model applied to mandibular M3 extraction difficulty is partially consistent with reported results.[9-11,14] For mandibular teeth, the model predicts that, in the absence of any demographic, anatomic, or operative information, a surgeon should plan that a mandibular M3 extraction will take 7.8 minutes. Factors that increase this time include type of operation (+0 minutes if erupted, nonsurgical; +1.5 minutes if erupted, surgical; +3.0 minutes if soft tissue impacted; +4.5 minutes if partial bony impacted; +6.0 minutes if full bony impacted) and Mandibular Position Composite Score (+1.5 min/unit increase in mandibular position composite score). Factors that decrease operating time include surgical experience (−0.32 min/yr), tooth morphology (−4.1 minutes for favorable morphology), and number of teeth extracted (−2.0 min/tooth).

Although each model has distinct factors that influence the difficulty of extractions, some factors are common to all three models: type of procedure and surgical experience. In addition, there is a pair of secondary predictors of difficulty that are common to both the model for all teeth and the model for mandibular teeth. These factors are tooth morphology and number of teeth extracted. Our analyses have shown that position of the mandibular M3 within the oral cavity, as measured by the composite position score, is statistically significantly associated with extraction time. This finding is partially consistent with previously published works.[11,14,19] None of the panoramic radiographic signs associated with increased risk for IAN injury were statistically significantly associated with extraction difficulty in the multivariate model.[22]

There are efficiencies associated with removing multiple M3s at one sitting, but there has been no reported relationship between the number of teeth extracted and operating time. We hypothesized that operating times would decrease as the number of teeth extracted per subject increased, due to a "learning curve" that the surgeon experiences with each subject. Specifically, all things being equal, the first tooth extracted in a series would be the most difficult because the surgeon has not yet adapted to subject-specific factors such as mouth opening, cheek flexibility, or variation in bone density among subjects. Our findings, however, did not support this proposed hypothesis. We observed a statistically significant positive correlation between the postoperative estimate of extraction difficulty and order of extraction (Pearson coefficient = 0.13, P = .04). These data suggest that, although order of extraction was not statistically related to operating time (P = .29), postoperative estimates of extraction difficulty increased in succession with each M3 extracted. Based on this observation, we hypothesized that surgeons do anticipate experiencing a "learning curve" while performing an extraction upon a patient and thus leave the more difficult extractions for the end of the case.

This study shows that although there are a wide variety of factors that are associated with operating time as a measure of extraction difficulty, there are few variables that are universal predictors of extraction difficulty. Of particular importance is the observation that difficulty is influenced in our models mainly by anatomic and operative factors, with little influence from demographic factors. This finding contrasts with a previous study by Renton et al,[9] who reported that age, patient weight, and ethnicity were associated with extraction times for mandibular teeth, and studies by MacGregor,[11,14] who reported that gender was associated with difficulty. This disagreement in outcomes may be the result of differences in measurement of surgical experience and estimates of difficulty, as well as differences in surgical approach. In the study by Renton et al,[9] only 3 surgeons with similar clinical designations were included, estimates of difficulty were measured as categorical variables, the multivariate model was based on a mixture of both buccal and lingual approaches, and all procedures were conducted under general anesthesia. The models presented herein were developed using continuous measures of surgical experience for 15 surgeons (7 attending surgeons, 7 resident surgeons, and 1 dental student) and estimates of difficulty, as well as a variety of anesthetics and a buccal approach for extraction. In addition, 2 of our 3 models identified number of teeth extracted as an independent predictor of difficulty—previous models have been developed based on unilateral extraction procedures.

Because we excluded cases performed in the main operating room, there exists a concern for selection bias; that is, the sample is biased toward easier cases. One indication for using general anesthesia for M3 removal is the anticipated difficulty of the operation. We elected to exclude M3 cases managed in the main operating room or day surgery center because they represent a small subset of the patient population (<2%) and do not reflect standard practice at our institution or the community. There are a variety of indications for using the non–office-based ambulatory anesthesia; difficulty of extraction is an uncommon indication for using the operating room. More common indications for using the operating room are insurance, patient preference, and comorbid conditions, such as obesity or airway compromise.

In this study, extraction time was used as a proxy measure of M3 extraction difficulty and a number of variables were identified as predictors of surgical difficulty. Although these factors are somewhat variable depending on the type of tooth extracted, general conclusions about difficulty are that mandibular teeth will be more difficult to extract than their maxillary counterparts, increasing surgical experience will decrease extraction time, and increasing the amount of surgical intervention required for removal will increase extraction time. In addition, for mandibular teeth, favorable morphology and a lower mandibular position composite score will decrease extraction time, relative to unfavorable morphology and higher composite scores, respectively. In the future, we aim to identify factors that are associated with inaccurate estimates of surgical difficulty, as measured by VAS. Future efforts will also be directed at developing and validating a predictive model for M3 extraction difficulty by enrolling a similar cohort of subjects.

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