How Well Do Clinicians Estimate Third Molar Extraction Difficulty?

Srinivas M. Susarla, AB, and Thomas B. Dodson, DMD, MPH†*

Purpose: The goals of this study were to measure surgeons' abilities to estimate third molar (M3) extraction difficulty and to identify variables associated with errors in estimates of difficulty.

Materials and Methods: To address our research purpose, we implemented a prospective cohort study and enrolled a sample of surgeons who remove M3s. Predictor variables were categorized as either surgeon or subject specific. The primary outcome variable was the error in estimating operative difficulty. Preoperative and postoperative estimates of difficulty were obtained using a 100-mm visual analogue scale. Error was defined as the difference between preoperative and postoperative estimates of extraction difficulty. Appropriate univariate, bivariate, and multivariate statistics were computed.

Results: The sample was composed of 15 surgeons who operated on 82 subjects having 250 M3s (53.2% mandibular) extracted. The mean level of surgical experience was 8.8 ± 11.1 years. The mean age of the subjects was 26.2 ± 10.7 years; 57.3% were female; and 72.0% were white. The mean preoperative and postoperative estimates of difficulty were 44.3 ± 23.4 and 39.6 ± 24.7 mm, respectively. The mean absolute and actual differences between preoperative and postoperative estimates were 15.7 ± 13.6 and 4.8 ± 20.2 mm, respectively. We identified several demographic and anatomic variables statistically associated ($P \leq .05$) with error in estimating difficulty.

Conclusions: Our models indicate that errors in the estimates of difficulty were related to demographic (age, gender, ethnicity, snoring) and anatomic (cheek flexibility, mouth opening) variables, with little or no dependence on radiographic variables or surgical experience.

J Oral Maxillofac Surg 63:191-199, 2005

The extraction of third molars (M3s) is a ubiquitous surgical procedure that has been estimated to account for 50% of the cost of all oral surgical procedures.[1,2] Descriptions of indications for removal, postoperative complications from removal, and factors associated with difficulty of removal for M3 extractions pervade the literature; however, there are few studies that examine the ability of the clinician to estimate difficulty, and fewer still that quantitatively examine factors associated with inaccurate estimates of difficulty.[3-21]

The purposes of this study were to measure errors in the surgeons' estimates of M3 extraction difficulty and to identify risk factors associated with the magnitude and direction, that is, overestimation or underestimation, of the errors. For this study, we defined *error* as the difference between the preoperative and postoperative estimates of M3 extraction difficulty. We hypothesized that the error in estimating difficulty would be inversely correlated with surgical experience; that is, as surgical experience increased, the error would decrease. In addition, we hypothesized that there existed a set of identifiable variables that are associated with a surgeon's ability to estimate accurately M3 extraction difficulty. Our specific aims were to measure the surgeon's preoperative and postoperative estimates of M3 extraction difficulty using a visual analog scale (VAS), to compute error based on the difference between the preoperative and postop-

*DMD Candidate, Harvard School of Dental Medicine, Boston, MA.

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

This work was supported by the Harvard Medical School Office of Enrichment Programs Student Research Award (S.M.S.), the Oral and Maxillofacial Surgery Research Foundation Student Training Award (S.M.S.), the National Institutes of Dental and Craniofacial Research Mid-career Award in Patient-Oriented Research K24-DE000448 (T.B.D.), and the Massachusetts General Hospital Department of Oral and Maxillofacial Surgery Education and Research Fund (S.M.S., T.B.D.).

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

0278-2391/05/6302-0006$30.00/0
doi:10.1016/j.joms.2004.05.220

erative estimates, and to identify surgeon- or subject-specific variables associated with errors in estimates.

Materials and Methods

STUDY DESIGN/SAMPLE

The study methods have been previously described in detail.[3] In brief, we enrolled a sample of surgeons derived from the population of surgeons who extract M3s in the Oral and Maxillofacial Surgery Unit, Massachusetts General Hospital, Boston, MA. The study subjects were derived from the population of patients presenting to the study surgeons for extraction of M3s in the Oral and Maxillofacial Surgery Unit. The project was approved by the Human Studies Institutional Review Board at Massachusetts General Hospital.

STUDY VARIABLES—PREDICTORS

The predictor variables, that is, risk factors or exposures that may be associated with error in estimates of difficulty, were divided into 2 groups: surgeon and subject specific. Surgical experience was the surgeon-specific variable and was defined as the number of years since completion of an Oral and Maxillofacial Surgery residency program—surgeons who had completed residency training were assigned experience scores of 0 or more, whereas those still in training had scores of less than 0.

Subject-specific variables were classified as demographic, anatomic, and operative. The demographic variables were gender, age, ethnicity (white, black, east Asian, south Asian, Hispanic/Latino, Pacific Islander/Hawaiian, Native American, or Alaskan Native), and a history of snoring or sleep apnea.

Anatomic variables were divided into subject- and tooth-specific variables. Subject-specific anatomic variables were body mass index (kg/m^2), working maximal incisal opening (MIO [mm]), and cheek flexibility (mm). Working MIO and cheek flexibility were measured as previously described.[3]

The tooth-specific anatomic variables were position, morphology, angulation, and arch location. Tooth position was specified using Winter's classification.[4] Tooth morphology was defined as favorable or unfavorable.[5] Arch location was the maxilla or mandible.

Operative variables were anesthetic technique, operation type, number of teeth extracted, and extraction difficulty. Anesthetic technique was classified as local, local with N_2O sedation, or deep sedation/general anesthesia. The operations used for extraction were classified as surgical or nonsurgical for erupted teeth and soft tissue, partially bony, or fully bony for impacted teeth. The total number of teeth extracted ranged from 1 to 4.

Extraction difficulty was measured by asking the operating surgeon to estimate difficulty. Difficulty was measured using a 100-mm VAS; scores ranged from 0 (easiest procedure possible) to 100 (most difficult procedure possible).[6] Operating surgeons recorded their estimates of M3 extraction difficulty for each tooth extracted both before and after the operations. To reduce bias, surgeons were blinded as to their preoperative estimates when making their postoperative estimates and the same observer (S.M.S.) measured the estimate scores from the VAS in all cases. We previously showed a statistically significant, positive correlation between extraction time and the surgeon's VAS estimate of difficulty ($r = 0.68$, $P < .01$).[3,7]

Anatomic variables specific to mandibular teeth were ramus and occlusal position (Pell-Gregory classification), tooth angulation, root proximity to the inferior alveolar nerve (IAN) canal, and panoramic radiographic evidence of an intimate anatomic relationship between the M3 root and the IAN canal. Using the values for Winter's classification, Pell-Gregory occlusal classification, and Pell-Gregory ramus classification, we calculated a composite index for mandibular M3 position, based on Pederson.[3,8-10] The instance of visualization of the IAN during extraction was recorded as the mandible-specific operative variable.

STUDY VARIABLES—OUTCOMES

The primary outcome variable was error in estimates of difficulty. For analytical purposes, error was defined as the difference between surgeons' preoperative and postoperative estimates of difficulty. Error was computed 3 different ways, yielding 2 continuous error measures (ie, the absolute and actual error) and 1 binary measure (ie, accuracy). We assessed the overall magnitude of error by computing the absolute value of the difference between preoperative and postoperative estimates. In addition to the magnitude of the error, we were interested in whether the error was an overestimation or an underestimation of the difficulty. As such, we computed the actual value of the difference between the preoperative and postoperative estimates. For the actual error, a positive value indicated an overestimation of difficulty, whereas a negative value indicated an underestimation of difficulty. For both outcomes (absolute and actual), a difference of zero corresponded to a "perfect" estimation of difficulty. Because our VAS was 100 mm in length, each 1-mm change on the scale corresponded to a 1% change; thus, our outcome variables are measures of percent error.

In addition to our continuous measures of error, we created a binary variable—accuracy. We defined an *accurate estimate* as one in which the error estimate was within 1 SD of the mean estimated error. An *inaccurate estimate* was defined as being outside 1 SD.

DATA MANAGEMENT AND ANALYSES

Detailed methods of data collection, management, and analyses have been described in an earlier publication.[3] Data were collected using a standardized collection sheet for each operation where the designated recorder (S.M.S.) was present. These data were subsequently entered into a statistical database (SPSS Graduate Pack 11.0; SPSS Inc, Chicago, IL). Descriptive statistics were computed for each study variable, and bivariate statistics were computed for each study variable with each outcome. The criterion for inclusion in the multivariate models was set at $P \leq .15$ for bivariate analyses. All variables meeting this criterion, as well as biologically relevant variables, such as age and gender, were included in the multivariate regression models, where $P \leq .05$ was used as the criterion for statistical significance.

Results

Between June and August 2002, 15 surgeons with a mean surgical experience of 8.8 ± 11.1 years (range, 7 to 36 years) treated 82 subjects having 250 M3s extracted. The mean age of the subjects was 26.2 ± 10.7 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. The average M3 extraction time was 6.9 ± 7.6 minutes (range, 0.4 to 44.3 minutes), and each subject had an average of 3.1 M3s extracted (range, 1 to 4). The teeth included in the study were approximately evenly distributed by dental arch and position within each arch. The mean preoperative and postoperative estimates of difficulty were 44.3 ± 23.4 mm (range, 2 to 100 mm) and 39.6 ± 24.7 mm (range, 1 to 100 mm), respectively. The descriptive statistics are summarized in Table 1.

The mean absolute and actual errors (defined as the absolute and actual differences between the preoperative and postoperative estimates of difficulty) were 15.7 ± 13.6 mm and 4.8 ± 20.2 mm, respectively. In terms of accuracy, 71% of the estimates for all teeth were considered accurate, that is, within ±1 SD of the mean error estimates. Of note, the actual value of error estimates followed an approximately normal distribution (skewness = −0.4 ± 0.2; kurtosis = 0.9 ± 0.3) (Fig 1). For maxillary teeth, 66.7% of estimates were within 1 SD of the mean (skewness = −0.4 ± 0.2; kurtosis = 0.5 ± 0.4). For mandibular teeth, 73.7% of the estimates were within 1 SD of the mean (skewness = −0.4 ± 0.2; kurtosis = 1.3 ± 0.4).

The bivariate relationships between the predictor variables and errors in estimates are summarized in Table 2. Using the absolute and actual differences in estimates, we developed 3 multivariate models: 1) all teeth, 2) maxillary teeth alone, and 3) mandibular teeth alone. For all teeth, using the absolute difference in estimates as an outcome, the bivariate analyses demonstrated that gender, ethnicity, cheek flexibility, and surgical experience were statistically or near statistically significantly, that is, $P \leq .15$, associated with absolute error. For all teeth, in the multivariate model (Table 3), age, gender, ethnicity, and cheek flexibility were statistically significant ($P \leq .05$) and surgical experience was near statistical significance ($P = .08$).

For all teeth, using the actual difference in estimates as an outcome, age, snoring, mouth opening, and surgical experience met the criterion for inclusion in the multivariate model ($P \leq .15$) (Table 2). In the multivariate model (Table 4), snoring and mouth opening were statistically significant, whereas age was near statistical significance ($P = .07$).

For maxillary M3s alone, using the absolute difference in estimates as an outcome, age, gender, ethnicity, cheek flexibility, tooth morphology, procedure type, and surgical experience met the statistical criterion for inclusion in the multivariate linear regression (Table 2). Gender, ethnicity, and procedure type were statistically significant in the multivariate model (Table 3). Tooth morphology was near statistical significance ($P = .08$). When the actual difference in estimates was used as an outcome (Table 2), age, snoring, mouth opening, tooth morphology, and surgical experience were statistically significant in bivariate analyses. In the multivariate model (Table 4), snoring, mouth opening, tooth morphology, and surgical experience were statistically significant.

Table 2 summarizes the bivariate relationships between the set of predictors and absolute error estimates for mandibular M3s. The variables selected for inclusion in the multivariate model were age, gender, ethnicity, body mass index, mouth opening, cheek flexibility, root proximity to the inferior alveolar canal, procedure type, and surgical experience. In the multivariate model (Table 3), age, gender, ethnicity, body mass index, mouth opening, cheek flexibility, and surgical experience were all statistically significantly associated with operating time. When the actual difference was used as an outcome, age, snoring, tooth morphology, procedure type, anesthesia type, and the instance of visualization of the IAN were statistically significant in bivariate analyses (Table 2). In the multivariate model (Table 4), snoring, tooth morphology, and IAN visualization were statistically significant.

When using accuracy of estimates as the binary outcome, for all teeth, the predictor variables associated with inaccurate estimates were gender, body mass index, ethnicity, mouth opening, and cheek

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

Sample size	n = 82 patients and k = 250 third molar
Demographic variables	
Mean age* (n = 82)	26.6 ± 10.7 (15 to 65)
Gender† (female) (n = 82)	47 (57.3)
Ethnicity† (white) (n = 82)	59 (72.0)
Snoring† (Yes) (n = 80)	27 (33.8)
Apnea† (Yes) (n = 80)	0 (0.0)
Anatomic variables	
Third molar location† (k = 250)	
Maxilla	117 (46.8)
Tooth† (k = 250)	
Maxillary right third molar	54 (21.6)
Maxillary left third molar	63 (25.2)
Mandibular left third molar	70 (28.0)
Mandibular right third molar	63 (25.2)
Body mass index* (kg/m^2) (n = 80)	24.4 ± 4.7 (16.9 to 36.1)
Mouth opening* (mm) (n = 80)	39.6 ± 6.2 (27 to 55)
Cheek flexibility* (mm) (n = 78)	48.7 ± 7.2 (28 to 69)
Winter's classification† (k = 250)	
Vertical	160 (64.0)
Mesioangular	57 (22.8)
Horizontal	12 (4.8)
Distoangular	21 (8.4)
Tooth morphology† (k = 246)	
Favorable	206 (83.7)
Unfavorable	40 (16.3)
Pell-Gregory ramus classification†‡ (k = 133)	
Class 1	24 (18.0)
Class 2	100 (75.2)
Class 3	9 (6.8)
Pell-Gregory occlusal classification†‡ (k = 133)	
Level A	49 (36.8)
Level B	64 (48.1)
Level C	20 (15.0)
Mandibular position composite score*‡§ (k = 133)	5.5 ± 1.5 (3 to 9)
Angulation (°)*‡ (k = 131)	67.9 ± 33.6 (0 to 180)
Root proximity to inferior alveolar nerve canal†‡ (k = 133)	
Distant	75 (56.4)
Touching	42 (31.6)
Crossing	16 (12.0)
Panoramic radiographic evidence†‡ (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)	3.1 ± 1.1 (1 to 4)
Extraction time* (min) (k = 250)	6.9 ± 7.6 (0.44 to 44.3)
Procedure type (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† (k = 250)	
Local	47 (18.8)
Local + N_2O	38 (15.2)
General	165 (66.0)
Inferior alveolar nerve visualized†‡ (Yes) (k = 131)	6 (4.6)
Surgical experience* (yr) (k = 250)	8.8 + 11.1 (−7 to 36)
Preoperative estimate of difficulty* (mm) (k = 250)	44.3 ± 23.4 (2 to 100)
Postoperative estimate of difficulty* (mm) (k = 250)	39.6 ± 24.7 (1 to 100)

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

Outcome variables	
Absolute difference in estimates (mm) (k = 250)	15.7 ± 13.6 (0 to 66)
Actual difference in estimates (mm) (k = 250)	4.8 ± 20.2 (−66 to 56)
Accurate estimate–yes (k = 250)	174 (70.7)

*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 Reference 3.

Susarla and Dodson. Estimation of Third Molar Extraction Difficulty. J Oral Maxillofac Surg 2005.

flexibility. In the multivariate logistic regression model, gender, age, ethnicity, mouth opening, and cheek flexibility were statistically significantly associated with inaccuracy; body mass index was near statistical significance (P = .08) (Table 5). Similar analyses for maxillary teeth revealed that gender and ethnicity were significantly associated in bivariate analyses and gender was statistically significant in the multivariate analysis (Table 5). For mandibular teeth, variables associated with inaccurate estimates in bivariate analyses were gender, age, body mass index, tooth angulation, mouth opening, and cheek flexibility. In the multivariate analysis, gender, age, body mass index, and cheek flexibility were statistically significantly associated with inaccuracy (Table 5).

Discussion

The ability of surgeons to estimate the difficulty of M3 extractions has, to date, not been quantitatively established using multivariate linear regression models. The use of such modeling may be valuable in identifying factors associated with the accuracy of surgeons' predictions. The purposes of this study were to measure the error of surgeons' estimates of M3 extraction difficulty and to identify risk factors associated with errors in these estimates. We hypothesized that surgical experience would be related to error in estimates. Specifically, as surgical experience increased, the difference in the preoperative and postoperative VAS difficulty estimates would approach zero. Except for 2 of the models, that is, actual differences for maxillary teeth and absolute differences for mandibular M3s, surgical experience was not statistically significantly associated with error. In addition, we hypothesized that we would identify one or more variables associated with absolute or actual errors in estimates. The variables that we identified are summarized in the next section of the discussion.

The multivariate model for all M3s suggests that the absolute magnitude of a surgeon's error in estimates will be statistically equal to zero. Factors that alter the estimate were age, gender, ethnicity, and cheek flexibility. The absolute percent error in estimating difficulty increases with minorities, that is, +0% for white, +1.7% for black, +3.4% for east Asian, +5.1% for south Asian, and +6.8% for Hispanic/Latino, and cheek flexibility, that is, +0.31% error in estimates/mm change in cheek flexibility. Absolute error in estimating difficulty decreases with age (−0.13% per year) and gender (−5.4% if female). Absolute error also decreases with increasing surgical experience (−0.13% per year), but this value is not statistically significant.

The multivariate model for all M3s, using the actual difference in estimates as an outcome, shows that surgeons have a tendency to underestimate the difficulty of extraction (constant = −17.2), but this value was not statistically different than zero (P = .07). If a patient snores, the actual error in estimates increases (+8.7% versus nonsnorers). The actual error in estimates also increases as mouth opening increases (+0.56%/mm).

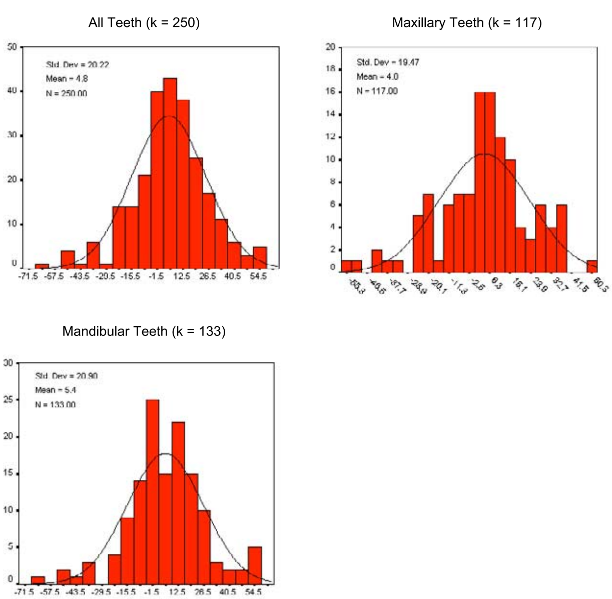

FIGURE 1. Distribution of actual error values.

Susarla and Dodson. Estimation of Third Molar Extraction Difficulty. J Oral Maxillofac Surg 2005.

Table 2. BIVARIATE ANALYSES* OF STUDY VARIABLES VERSUS VALUE OF THE ERROR

	P Value					
	All Teeth (k = 250)		Maxillary Teeth (k = 117)		Mandibular Teeth (k = 133)	
Outcome Variable	Absolute Error‡	Actual Error§	Absolute Error‡	Actual Error§	Absolute Error‡	Actual Error§
Demographic variables						
Age*¶	.20	<.01	.08	<.01	<.01	.04
Gender*¶	<.01	.48	<.01	.86	.10	.26
Ethnicity*	.03	.73	.11	.86	.03	.74
Snoring*	.23	<.01	.81	<.01	.16	.01
Anatomic variables						
M3 Location	.87	.80	NA	NA	NA	NA
Body mass index*	.57	.35	.35	.21	.10	.92
Mouth opening*	.40	<.01	.68	<.01	.13	.18
Cheek flexibility*	<.01	.16	.06	.34	<.01	.31
Winter's class	.99	.87	.65	.72	.96	.59
Tooth morphology*	.51	.41	.13	.02	.16	.04
Tooth angulation‖	NA	NA	NA	NA	.72	.87
Pell-Gregory ramus class‖	NA	NA	NA	NA	.39	.80
Pell-Gregory occlusal level‖	NA	NA	NA	NA	.75	.39
Mandibular position score‖	NA	NA	NA	NA	.41	.82
Root Proximity to inferior alveolar nerve canal*‖	NA	NA	NA	NA	.07	.62
Panoramic radiographic evidence‖	NA	NA	NA	NA	.26	.91
Operative variables						
No. of teeth extracted	0.55	0.40	0.57	0.40	.25	.67
Procedure type*	0.24	0.36	0.03	0.91	.12	.03
Anesthesia type*	0.78	0.28	0.31	0.50	.85	.10
Inferior alveolar nerve visualization*‖	NA	NA	NA	NA	.89	.02
Surgical experience*	<0.01	0.13	0.08	0.01	.03	.84

*Some or all of the *P* values for these variables met the criteria ($P \leq .15$) for inclusion in the multivariate models.
†Bivariate analyses were conducted using either Pearson correlation (continuous variable versus extraction time) or analysis of variance (ANOVA; categorical variable versus extraction time).
‡Absolute error in estimates = Abs [preoperative estimate − postoperative estimate].
§Actual error in estimates = Preoperative estimate − postoperative estimate.
‖Applicable to mandibular teeth only.
¶Biologically relevant variables, included in all multivariate models.

Susarla and Dodson. Estimation of Third Molar Extraction Difficulty. J Oral Maxillofac Surg 2005.

The multivariate model for maxillary M3s indicates that surgeons will have an absolute baseline error of 17.5%; however, this value was not statistically different than zero ($P = .08$). Factors that increase the magnitude of the percent error were ethnicity (+0% for white, +2.1% for black, +4.2% for east Asian, +6.3% for south Asian, +8.4% for Hispanic/Latino) and procedure type (+0% for nonsurgical, erupted; +1.8% for surgical, erupted; +3.6% for soft tissue impacted; +5.4% for partial bony impacted; +7.2% for full bony impacted). Gender was associated with a decreased magnitude of error (−6.8% if female). Using the actual difference in estimates as an outcome, and modeling for maxillary M3s, snoring (+9.9% for snorers versus nonsnorers) and mouth opening (+0.64%/mm) increased the percent error, whereas tooth morphology (−20.2% for favorable morphology) and surgical experience (−0.40% per year) decreased the percent error.

Our multivariate models for mandibular M3s showed that the baseline estimate or constant in the model was statistically equivalent to zero for both the absolute and actual models. The absolute magnitude of percent error in estimates is increased by age (+0.42% per year), ethnicity (+0% if white, +2.0% if black, +4.0% if east Asian, +6.0% if south Asian, +8.0% if Hispanic/Latino), and cheek flexibility (+0.49%/mm). The absolute magnitude of error is decreased for females (−5.5% versus males), body mass index (−0.63% per kg/m^2), mouth opening (−0.49%/mm), and surgical experience (−0.23% per year). Factors that increase the actual value of error in estimates, tending toward overestimation of difficulty, are snoring (+11.2% versus not snoring) and tooth morphology (+10.1% with favorable morphology). Visualization of the IAN decreases the actual value of error in estimates, tending toward underestimation of difficulty (−17.5 % if IAN visualized).

Table 3. MULTIVARIATE MODELS USING ABSOLUTE ERROR* AS AN OUTCOME

Sample Set	All Teeth (k = 250) Coefficient	All Teeth (k = 250) P Value	Maxillary Teeth (k = 117) Coefficient	Maxillary Teeth (k = 117) P Value	Mandibular Teeth (k = 133) Coefficient	Mandibular Teeth (k = 133) P Value
Constant	−1.2	.85	17.5	.08	21.1	.16
Age†	−0.13	.02	−0.09	.52	0.42	<.01
Gender†	−5.4	<.01	−6.8	<.01	−5.5	.03
Ethnicity†	1.7	.02	2.1	.03	2.0	.05
Body mass index†	‡	‡	‡	‡	−0.63	.02
Mouth opening†	‡	‡	‡	‡	−0.49	.02
Cheek flexibility†	0.31	<.01	0.20	.20	0.49	<.01
Tooth morphology	‡	‡	−9.0	.08	‡	‡
Root proximity to inferior alveolar nerve canal§	NA	NA	NA	NA	−1.7	.35
Procedure type	‡	‡	1.8	.02	−0.22	.81
Surgical experience	−0.13	.08	−0.14	.19	−0.23	.03

*Absolute error in estimates = Absolute value of the preoperative estimate − postoperative estimate.
†Some or all of the values for these variables were statistically significant in the multivariate model ($P \leq .05$).
‡Did not meet inclusion criteria ($P \leq .15$ or "biologically relevant") in bivariate analyses.
§Applicable to mandibular teeth only.

Susarla and Dodson. Estimation of Third Molar Extraction Difficulty. J Oral Maxillofac Surg 2005.

Using a binary measure of accuracy (0 = accurate, 1 = inaccurate) as an outcome, our multivariate models showed that variables associated with inaccurate estimates were demographic and nonradiographic anatomic variables. All 3 binary logistic models show that, at baseline, surgeons' estimates will be accurate. For all teeth, the probability of a surgeon's estimates being inaccurate increases with male gender, age, minorities, decreasing body mass index, decreasing mouth opening, and increasing cheek flexibility. The binary logistic model for maxillary teeth indicates that surgeons' estimates will have a higher probability of being inaccurate if the subject is male. For mandibular teeth, the binary logistic model indicates that the probability of inaccuracy increases with male gender, age, decreasing body mass index, and increasing cheek flexibility.

Estimates of extraction difficulty and risk factors associated with extraction difficulty have historically indicated tooth position, as specified by angulation, impaction depth, and Pell-Gregory classification, and operative variables, such as surgical experience as associated with difficulty of extraction.[3,5,7-9,11-21] Our models indicate that the error in estimating difficulty

Table 4. MULTIVARIATE MODELS USING ABSOLUTE ERROR* AS AN OUTCOME

Sample Set	All Teeth (k = 250) Coefficient	All Teeth (k = 250) P Value	Maxillary Teeth (k = 117) Coefficient	Maxillary Teeth (k = 117) P Value	Mandibular Teeth (k = 133) Coefficient	Mandibular Teeth (k = 133) P Value
Constant†	−17.2	.07	4.8	.77	−20.1	.14
Age	−0.26	.07	−0.35	.10	−0.16	.45
Gender	1.6	.54	−1.4	.71	0.85	.81
Snoring‡	8.7	<.01	9.9	<.01	11.2	<.01
Mouth opening‡	0.56	<.01	0.64	.02	§	§
Tooth morphology‡	§	§	−20.2	.01	10.1	.02
Procedure type	§	§	§	§	−1.1	.44
Anesthesia type	§	§	§	§	0.44	.86
Inferior alveolar nerve visualization‖	§	§	§	§	17.5	.04
Surgical experience‡	−0.09	.42	−0.40	.01	§	§

*Actual error in estimates = Preoperative estimate −postoperative estimate.
†A positive value for the coefficient indicates an overestimation of difficulty, while a negative value indicates an underestimation of difficulty.
‡Some or all of the values for these variables were statistically significant in the multivariate model ($P \leq .05$).
§Did not meet inclusion criteria ($P \leq 0.15$ or "biologically relevant") in bivariate analyses.
‖Applicable to mandibular teeth only.

Susarla and Dodson. Estimation of Third Molar Extraction Difficulty. J Oral Maxillofac Surg 2005.

Table 5. MULTIVARIATE ANALYSES OF PREDICTOR VARIABLES USING ACCURACY AS A BINARY OUTCOME (0 = ACCURATE, 1 = INACCURATE)

	All Teeth (k = 250)		Maxillary Teeth (k = 117)		Mandibular Teeth (k = 133)	
Sample Set	Coefficient	*P* Value	Coefficient	*P* Value	Coefficient	*P* Value
Constant	−0.66	.72	0.16	.81	−3.1	.34
Gender*	−1.4	<.01	−1.1	<.01	−1.8	<.01
Age*	0.03	.05	−0.01	.66	0.09	<.01
Ethnicity*	0.33	.02	0.20	.23	NA	NA
Body mass index*	−0.07	.08	NA	NA	−0.16	.03
Tooth angulation	NA	NA	NA	NA	0.01	.15
Mouth opening*	−0.07	.03	NA	NA	−0.06	.23
Cheek flexibility*	0.07	<.01	NA	NA	0.12	<.01

*Some or all of the values for these variables were statistically significant in the multivariate model ($P \leq .05$).

Susarla and Dodson. Estimation of Third Molar Extraction Difficulty. J Oral Maxillofac Surg 2005.

of extraction was predominantly influenced by demographic factors such as gender, ethnicity, and the incidence of snoring and by nonradiographic anatomic factors such as body mass index, cheek flexibility, and mouth opening. Most surprisingly, however, surgical experience does not appear to be related to percent error in estimates for the majority of our models. Our models indicate that inexperienced surgeons will have a greater tendency to overestimate the difficulty of maxillary M3s and have a greater absolute magnitude of error in their estimates of difficulty for mandibular M3s.

The prevalence of demographic and nonradiographic anatomic variables as associated with inaccurate estimates may be consistent with the notion that, while surgeons use a plethora of factors when estimating the difficulty of an extraction, radiographic and operative factors, such as procedure type, may be considered as the most important. Because these factors are considered the most important by surgeons, and the instructors who trained them, we hypothesize that instances where estimates are inaccurate are less likely to be dependent on these factors. Instead, inaccurate estimates are, in our models, related to factors that surgeons may not use, consciously or unconsciously, when estimating difficulty. It may be precisely because surgeons do not use or underuse these factors that they are associated with inaccurate estimates. In addition, surgical experience does not appear to play a significant role in the ability of a surgeon to accurately estimate operative difficulty. This may be consistent with a hypothesis that experienced surgeons consider factors in estimating difficulty that are precisely the same factors inexperienced surgeons will use and factors neglected by experienced surgeons in estimating difficulty will also be neglected by inexperienced surgeons.

In this study, extraction difficulty was estimated both preoperatively and postoperatively by 15 practitioners with various levels of clinical experience. We examined the relationship between both the absolute and actual values of the difference between preoperative and postoperative estimates, looking for variables associated with increased percent errors in estimates, in both magnitude and direction. We have successfully identified a number of factors that are associated with changes in the magnitude and direction of the percent error in estimates. Although these factors vary according to the type of tooth being extracted, a general observation is that demographic and anatomic (nonradiographic) factors have a more profound effect on both the magnitude and direction of error in estimating difficulty, whereas radiographic anatomic variables and operative variables, including surgical experience, exert little or no influence on either the magnitude or direction of the error. Further investigations will examine the factors that surgeons themselves consider important in estimating difficulty, in an attempt to establish a hierarchy of factors used in estimating difficulty, so as to refine our interpretation of variables associated with inaccurate estimates.

Acknowledgments

The authors would like to thank the faculty, staff, and students at the Massachusetts General Hospital Oral and Maxillofacial Surgery Unit for their willingness to participate in this study. The authors would also like to personally acknowledge the valuable contributions of Dr Meredith August.

References

1. Flick WG: The third molar controversy: Framing the controversy as a public health issue. J Oral Maxillofac Surg 57:438, 1999
2. Friedman JW: Containing the costs of third molar extractions: A dilemma for health insurance. Public Health Rep 98:376, 1983
3. Susarla SM, Dodson TB: Risk factors for third molar extraction difficulty. J Oral Maxillofac Surg 62:1363, 2004
4. Winter GB: Principles of Exodontia as Applied to the Impacted Third Molar. St Louis, MO, American Medical Books, 1926
5. Renton T, Smeeton N, McGurk M: Factors predictive of difficulty of mandibular third molar surgery. Br Dent J 190:607, 2001

6. Guyatt GH, Townsend M, Berman LB, et al: A comparison of Likert and visual analogue scales for measuring change in function. J Chronic Dis 40:1129, 1987
7. Susarla SM, Dodson TB: Risk factors for third molar extraction difficulty. Presented at the 2003 American Association of Dental Research Annual Session, San Antonio, TX, March 10, 2003
8. Pell GJ, Gregory BT: Impacted mandibular third molars; classification and modified techniques for removal. Dent Dig 39:330, 1933
9. Chandler LP, Laskin DM: Accuracy of radiographs in classification of impacted third molar teeth. J Oral Maxillofac Surg 46:656, 1988
10. Pederson GW: Oral Surgery. Philadelphia, PA, Saunders, 1988
11. Brann CR, Brickley MR, Shepherd JP: Factors influencing nerve damage during lower third molar surgery. Br Dent J 186:514, 1999
12. Santamaria J, Arteagoitia I: Radiographic variables of clinical significance in the extraction of impacted mandibular third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 84:469, 1997
13. Yuasa H, Kawai T, Sugiura M: Classification of surgical difficulty in extracting impacted third molars. Br J Oral Maxillofac Surg 40:26, 2002
14. American Association of Oral and Maxillofacial Surgeons: Report of a workshop on the management of patients with third molar teeth. J Oral Maxillofac Surg 52:1102, 1994
15. Garcia AG, Sampedro FG, Rey JG, et al: Pell-Gregory classification is unreliable as a predictor of difficulty in extracting impacted lower third molars. Br J Oral Maxillofac Surg 83:585, 2000
16. Santamaria J, Arteagoitia I: Radiologic variables of clinical significance in the extraction of impacted mandibular third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 84:469, 1997
17. Rud J: Third molar surgery: Relationship of root to mandibular canal and injuries to the inferior dental nerve. Tandlaegebladet 87:619, 1983
18. Rood JP, Shehab BA: The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg 28:20, 1990
19. Blaeser BF, August MA, Donoff RB, et al: Panoramic radiographic risk factors for inferior alveolar nerve injury after third molar extraction. J Oral Maxillofac Surg 61:417, 2003
20. MacGregor AJ: The Impacted Lower Wisdom Tooth. Oxford, England, Oxford University Press, 1985
21. MacGregor AJ: The radiological assessment of ectopic lower third molars. DDSc Thesis, University of Leeds, Leeds, England, 1976