Predicting Third Molar Surgery Operative Time: A Validated Model

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Purpose: The purpose of the present study was to develop and validate a statistical model to predict third molar (M3) operative time.

Materials and Methods: This was a prospective cohort study consisting of a sample of subjects presenting for M3 removal. The demographic, anatomic, and operative variables were recorded for each subject. Using an index sample of randomly selected subjects, a multiple linear regression model was generated to predict the operating time. A nonoverlapping group of randomly selected subjects (validation sample) was used to assess model accuracy. $P \leq .05$ was considered significant.

Results: The sample was composed of 150 subjects (n) who had 450 (k) M3s removed. The index sample (n = 100 subjects, k = 313 M3s extracted) had a mean age of 25.4 ± 10.0 years. The mean extraction time was 6.4 ± 7.0 minutes. The multiple linear regression model included M3 location, Winter's classification, tooth morphology, number of teeth extracted, procedure type, and surgical experience (R^2 = 0.58). No statistically significant differences were seen between the index sample and the validation sample (n = 50, k = 137) for any of the study variables. Compared with the index model, the β-coefficients of the validation model were similar in direction and magnitude for most variables. Compared with the observed extraction time for all teeth in the sample, the predicted extraction time was not significantly different (P = .16).

Conclusions: Fair agreement was seen between the β-coefficients for our multiple models in the index and validation populations, with no significant difference in the predicted and observed operating times.

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Because of the frequency and importance of third molar (M3) surgery, a significant body of data has been devoted to indications for M3 extraction, adjunct therapies for the postoperative course, and postoperative complications.[1-3] Additionally, a number of studies have examined the risk factors for M3 extraction difficulty, using measurable outcomes such as extraction time and surgeon assessment of difficulty.[4-7] Although these studies have been useful in identifying variables relevant to estimating M3 extraction difficulty, they did not use multiple regression analyses to establish the magnitude of these variables' influence on measurable outcomes.

The purposes of the present study were to develop a statistical model for predicting the M3 operative time and to validate the model using an independent

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sample. We hypothesized that the magnitude of the difference between the predicted and observed extraction times would serve as a good indication of the accuracy of our model. Our primary aims in the present study were *1*) to develop an index sample to construct a multiple linear regression model for predicting extraction time; *2*) to validate the model by comparing it to a model developed using an independent (ie, validation, sample); and *3*) to compare the extraction times predicted by the index model to the actual extraction times.

Materials and Methods

STUDY DESIGN/SAMPLE

The methods used in the present study have been previously described in detail.[8] In brief, we developed a prospective cohort study and enrolled a sample of healthy subjects from the population of patients presenting to the Massachusetts General Hospital, Oral and Maxillofacial Surgical Unit for M3 extraction. We included all procedures used to remove M3s, under all conditions of anesthesia, with the exception of those cases treated outside the ambulatory care setting. The human studies institutional review board approved the project.

STUDY VARIABLES—PREDICTORS

The predictor variables were categorized as demographic, anatomic, and operative, as previously described.[8] The demographic variables included gender, age, race, ethnicity (African American, East Asian, South Asian, Hispanic/Latino, Pacific Islander/Hawaiian, Native American, or Alaskan Native), and a history of snoring or sleep apnea.

The anatomic variables were subcategorized into subject- and tooth-specific variables. Subject-specific anatomic variables included body mass index, mouth opening, and cheek flexibility. The measurements of mouth opening and cheek flexibility have been previously described.[8] Mouth opening was measured as the working interincisal distance (ie, the interincisal distance measured with a bite block in place). Cheek flexibility was measured as the distance from the maxillary midline to the edge of a Minnesota retractor used to retract the cheek.

Tooth-specific anatomic variables were used to describe the position and morphology of the extracted teeth. Tooth position was specified by arch location (ie, maxilla or mandible) and Winter's classification.[9] For mandibular teeth, Pell-Gregory ramus/occlusal positions and tooth angulation were used in addition to Winter's classification to describe tooth position. The Pell-Gregory and Winter's classification scores were used to create a mandibular position composite score,[8] according to Pederson.[10] Tooth morphology was classified as favorable or unfavorable for all teeth. Favorable morphology was defined as the absence of anomalous crown/root anatomy.[4]

Two additional radiographic variables that described the local anatomy were recorded for mandibular teeth: root proximity to the inferior alveolar nerve (IAN) canal and radiographic evidence of an intimate anatomic relationship between the M3 root and the IAN canal.[11]

The variables related to surgery included operation type, anesthetic technique, number of teeth extracted, and surgical experience. Operation type was either surgical or nonsurgical for erupted teeth and soft tissue, partially bony, or fully bony for impacted teeth. The cases included in the study were performed under local anesthesia, local anesthesia with nitrous oxide induction, or deep sedation/general anesthesia. The number of teeth extracted ranged from 1 to 4. Surgical experience was defined as the number of years since completion of residency; residents had an experience score of less than 0 and faculty surgeons an experience score greater than 0. For mandibular teeth, the instance of visualization of the IAN was recorded as an additional operative variable.

STUDY VARIABLES—OUTCOMES

The primary outcome variable was the observed extraction time. The extraction time was defined as the interval between the first incision required to remove a particular tooth and the placement of the last suture. To reduce bias and produce a convenience sample, the same observer (S.M.S.) recorded the extraction time for every case included in the present study.

DATA MANAGEMENT AND ANALYSES

Details regarding the collection, management, and analysis of data were described previosuly.[8] Data were collected using a standardized form for each operation in which the designated recorder (S.M.S.) was present. The data were stored in a statistical database (SPSS Graduate pack, version 11.0, SPSS, Chicago, IL), and descriptive statistics were computed for each study variable.

The sample size was determined by examining the mean extraction time for a cohort of observations and determining the sample size necessary to detect a difference of 2 minutes ($\delta = 2.0$ minutes) between the predicted and observed extraction times for M3s. For the cohort population of M3s we selected, the extraction time was 6.8 ± 7.2 minutes ($\sigma = 7.2$). We subsequently calculated a σ/δ ratio (the ratio of the predicted error standard deviation to the original observed standard deviation) to assess the sample size necessary to detect a difference of δ, with standard parameters set at $\alpha = 0.05$ and $\beta = 0.80$. For the parameters we chose ($\sigma/\delta = 3.6$, $\alpha = 0.05$, and $\beta = 0.80$), the appropriate sample size was approximately 400 observations (300 for index and 100 for validation).

Two data sets were created from the original sample. The index sample, composed of randomly selected subjects equal to 66.7% of the original sample, was used to construct the original multiple model. The validation sample, composed of the remaining subjects, equal to 33.3% of the original sample, was used to assess the stability of the multiple model. No overlap was present between the subjects selected for the index sample and those selected for the validation sample. We examined the variables within the 2 data sets, looking for statistically significant differences, using χ^2 tests for categorical variables and independent samples *t* tests for continuous variables.

To produce the index multiple linear regression model, bivariate statistics were computed for each study variable, with the extraction time as the outcome. All variables with $P \leq .15$ in the bivariate analyses and "biologically relevant" variables (eg, age and gender) were included in the computation of the multiple linear regression model. Variables that were not statistically significant in the multiple linear regression model were iteratively removed to achieve the most parsimonious model, defined as the point at which the R^2 value for the model was maximized with the fewest number of variables. The resulting model was analyzed for violations of the assumptions of normality, linearity, and independence of variables using residual plots, collinearity statistics (Eigenvalues, condition indexes, and tolerance values), and Pearson correlation coefficients. We subsequently validated the index model by examining both stability and accuracy. To assess model stability, we compared the values for the standardized β-coefficients (the measures of effect size that result when the unstandardized coefficients are divided by their respective standard deviations) from the index sample model to the values for the same factors in a model developed from the validation sample. The multiple regression model constructed from the index sample was also used to compute the predicted extraction times for all M3s in the sample. To assess the accuracy of the model, the predicted extraction times were compared with the observed extraction times using a paired samples *t* test.

Results

From June 2002 to August 2003, we enrolled a sample of 150 patients who had 450 M3s (54.0% mandibular) extracted. The sample was divided randomly into 2 groups, the index sample ($n_{index} = 100$ patients, $k_{index} = 313$ teeth) and the validation sample ($n_{valid} = 50$ patients, $k_{valid} = 137$ teeth). The index sample's mean age was 25.4 years (range 14 to 64), 60.0% were female, 67.0% were white, and the mean body mass index was 24.1 ± 4.9 kg/m^2. An average of 3.1 M3s was extracted per subject; the mean extraction time was 6.4 ± 7.0 minutes (range 0.08 to 44.3). The mean level of surgical experience was 8.4 ± 10.8 years (range -7 to 36). The teeth included in the study were approximately evenly distributed by dental arch and location within each arch. For the variables we examined, no statistically significant differences were found between the index and validation sets (Table 1).

MODEL FOR ALL M3s

The bivariate relationships between the predictor variables and extraction time for the index sample of all M3s ($n_{index} = 100$ patients, $k_{index} = 313$ teeth) are summarized in Table 2. Using this population, gender, ethnicity, M3 location, mouth opening, Winter's classification, tooth morphology, number of teeth extracted, procedure type, anesthesia type, and surgical experience all met the criteria for inclusion in the multiple model. M3 location, Winter's classification, tooth morphology, number of teeth extracted, procedure type, and surgical experience were included in the multiple linear regression model (Table 3) after iterative elimination ($R^2 = .58$).

The model suggests that, on average, it takes 13.2 minutes to extract 1 M3. Factors associated with increasing extraction time were mandibular teeth (+1.9 minutes), Winter's classification (+0 minutes for vertical; +1.4 minutes for distoangular; +2.8 minutes for mesioangular; and +4.2 minutes for horizontal), and procedure type (+0 minutes for nonsurgical erupted; +1.4 minutes for surgical erupted; +2.8 minutes for soft tissue impacted; +4.2 minutes for partial bony impacted; and +5.6 minutes for full bony impaction). Factors associated with a shorter operating time were a favorable tooth morphology (−5.4 minutes relative to unfavorable morphology), number of teeth extracted (−1.6 minutes/tooth), and surgical experience (−0.20 minutes/year).

To assess the stability of our model for all teeth, we examined the values of the standardized β-coefficients for factors in the index population ($k_{index} = 313$ teeth) and the validation population ($k_{valid} = 137$ teeth). On examining the models for all teeth (Table 3), we found that M3 location, tooth morphology, procedure type, and surgical experience were statistically significant in both the index and the validation linear regression models. The β-coefficients for Winter's classification and number of teeth extracted were not statistically significant in the validation model. The β-coefficients for M3 location in the 2

Table 1. DESCRIPTIVE STATISTICS FOR STUDY VARIABLES (n_{TOTAL} = 150 PATIENTS; k = 450 TEETH)

Variable	Sample Size		*P* Value*
	n_{index} = 100 Patients; k_{index} = 313 Teeth	n_{valid} = 50 Patients; k_{valid} = 137 Teeth	
Demographic			
Age (yr) (n_{index} = 99, n_{valid} = 50)			.68
Mean	25.4 ± 10.0	26.2 ± 9.3	
Range	14-64	15-65	
Gender (female) (n_{index} = 100, n_{valid} = 50)	60 (60.0)	28 (56.0)	.64
Ethnicity (white) (n_{index} = 100, n_{valid} = 50)	67 (67.0)	38 (76.0)	.39
Snore (yes) (n_{index} = 100, n_{valid} = 50)	44 (44.0)	16 (33.3)	.22
Apnea (yes) (n_{index} = 100, n_{valid} = 50)	0 (0.0)	0 (0.0)	NA
Anatomic			
M3 location (maxilla) (k_{index} = 313, k_{valid} = 137)	145 (46.3)	62 (45.3)	.83
Tooth number (k_{index} = 313, k_{valid} = 137)			.92
1	68 (21.7)	30 (21.9)	
16	77 (24.6)	32 (23.4)	
17	82 (26.2)	40 (29.2)	
32	86 (27.5)	35 (25.5)	
Body mass index (kg/m^2) (n_{index} = 100, n_{valid} = 50)			.70
Mean	24.1 ± 4.9	24.4 ± 4.4	
Range	17.2-44.4	16.9-33.1	
Mouth opening (mm) (n_{index} = 99, n_{valid} = 49)			.29
Mean	39.8 ± 6.2	37.5 ± 5.1	
Range	28-60	27-50	
Cheek flexibility (mm) (n_{index} = 99, n_{valid} = 47)			.87
Mean	49.1 ± 6.8	45.3 ± 7.9	
Range	30-69	28-65	
Winter's classification (k_{index} = 313, k_{valid} = 137)			.21
Mesioangular	69 (22.0)	39 (28.5)	
Horizontal	15 (4.8)	6 (4.4)	
Vertical	202 (64.5)	75 (54.7)	
Distoangular	27 (8.6)	17 (12.4)	
Tooth morphology (k_{index} = 313, k_{valid} = 137)			.88
Favorable	261 (83.4)	115 (83.9)	
Unfavorable	52 (16.6)	22 (16.1)	
Pell-Gregory ramus classification† (k_{index} = 168, k_{valid} = 75)			.53
Class 1	36 (21.4)	12 (16.0)	
Class 2	109 (64.9)	54 (72.0)	
Class 3	23 (13.7)	9 (12.0)	
Pell-Gregory occlusal classification† (k_{index} = 168, k_{valid} = 75)			.25
Level A	71 (42.3)	27 (36.0)	
Level B	75 (44.6)	32 (42.7)	
Level C	22 (13.1)	16 (21.3)	
Mandibular position composite score†‡ (k_{index} = 168, k_{valid} = 75)			.40
Mean	5.9 ± 1.2	5.9 ± 1.3	
Range	3.0-9.0	3.0-8.0	
Angulation† (k_{index} = 168, k_{valid} = 75)			.28
Mean	68.7 ± 33.1	64.0 ± 34.6	
Range	0-180	0-105	
Root proximity to IAN canal† (k_{index} = 168, k_{valid} = 75)			.29
Distant	98 (58.3)	40 (53.3)	
Touching	47 (28.0)	28 (37.3)	
Crossing	23 (13.7)	7 (9.3)	
Panoramic radiographic evidence† (k_{index} = 121, k_{valid} = 58)			.78
Loss of cortical outline	51 (42.1)	29 (50.0)	
Narrowing of canal	5 (4.1)	2 (3.4)	
Deviation of canal	13 (10.7)	4 (6.9)	
Darkening of root	1 (0.8)	0 (0.0)	
No evidence	51 (42.1)	23 (39.7)	

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Table 1. (CONTINUED)

Variable	Sample Size: n_{index} = 100 Patients; k_{index} = 313 Teeth	Sample Size: n_{valid} = 50 Patients; k_{valid} = 137 Teeth	*P* Value*
Operative			
Teeth extracted (n) (n_{index} = 100, n_{valid} = 50)			.24
Mean	3.1 ± 1.1	2.8 ± 1.2	
Range	1-4	1-4	
Procedure type (k_{index} = 313, k_{valid} = 137)			.20
Erupted, nonsurgical	85 (27.2)	25 (18.2)	
Erupted, surgical	10 (3.2)	6 (4.4)	
Soft tissue, impacted	51 (16.3)	23 (16.8)	
Partial bony, impacted	70 (22.4)	28 (20.4)	
Full bony, impacted	97 (31.0)	55 (40.1)	
Anesthesia type (k_{index} = 313, k_{valid} = 137)			.36
Local	47 (15.0)	28 (20.4)	
Local + nitrous oxide	57 (18.2)	24 (17.5)	
General	209 (66.8)	85 (62.0)	
IAN visualized† (yes) (k_{index} = 166, k_{valid} = 75)	7 (4.2)	4 (5.3)	.70
Surgical experience (yr) (k_{index} = 313, k_{valid} = 137)			.81
Mean	8.4 ± 10.8	9.7 ± 11.0	
Range	−7-36	−6-30	
Outcome			
Observed extraction time (min) (k_{index} = 313, k_{valid} = 137)			.30
Mean	6.4 + 7.0	7.7 ± 7.6	
Range	0.08-44.3	0.23-41.1	

Abbreviations: M3, third molar; IAN, inferior alveolar nerve.

Data presented as mean ± standard deviation or numbers, with percentages in parentheses.

*Continuous variables were compared using an independent samples *t* test and categorical variables using a χ^2 test.

†For mandibular teeth only ($k_{mandibular}$ = 243 teeth).

‡For a detailed explanation of the computation of the mandibular position composite score, refer to Susarla and Dodson.[8]

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models were similar in direction, but not in magnitude. The β-coefficients for tooth morphology and surgical experience were similar in both magnitude and direction.

Application of the index linear regression model to the entire population (k = 450 teeth) calculated a mean predicted extraction time of 6.6 ± 5.4 minutes. Using a paired samples *t* test, the difference between this value and the mean extraction time for all teeth was −0.2 ± 5.0 minutes (P = .37).

MODEL FOR MAXILLARY M3s

Bivariate analyses for the index population of maxillary teeth are summarized in Table 2. For maxillary teeth (k_{index} = 145 teeth), ethnicity, body mass index, mouth opening, Winter's classification, tooth morphology, procedure type, and surgical experience were associated with the extraction time ($P \leq .15$). After iterative elimination, the multiple linear regression model for maxillary teeth (Table 4) included body mass index, tooth morphology, procedure type, and surgical experience (R^2 = .38).

Our multiple model for maxillary M3s (k_{index} = 145 teeth) predicted an extraction time of 3.9 minutes for a maxillary tooth (Table 4). The extraction time is increased by an increase in body mass (+0.10 minutes for each 1-kg/m^2 increase), Winter's classification (+0 minutes for vertical, +1.9 minutes for distoangular, +3.8 minutes for mesioangular, and +5.7 minutes for horizontal), and procedure type (+0 minutes for nonsurgical, erupted; +0.77 minutes for erupted, surgical; +1.5 minutes for soft tissue impacted; +2.3 minutes for partial bony impacted; and +3.1 minutes for full bony impacted). The extraction time decreased with increasing surgical experience (−0.05 minutes/year) and tooth morphology (−4.6 minutes for favorable morphology).

A comparison of the standardized β-coefficients for the model from the index population of maxillary teeth (k_{index} = 145 teeth) with that from the validation population (k_{valid} = 62 teeth) is summarized in Table 4. The body mass index, procedure type, and surgical experience were statistically significant in both models. Winter's classification and tooth morphology were not statistically significant in the model developed from the validation population. The β-coefficients for procedure type and surgical experience were similar in magnitude and direction for both models.

Table 2. BIVARIATE ANALYSES* OF STUDY VARIABLES VERSUS M3 EXTRACTION TIME FOR INDEX POPULATION

Variable	*P* Value		
	All M3s†	Maxillary M3s‡	Mandibular M3s§
Demographic			
Age	.77	.45	.59
Gender	.01‖	.99	.07‖
Ethnicity	.03‖	.06‖	.01‖
Snore	.30	.25	.35
Anatomic			
M3 location	<.01‖	NA	NA
Body mass index	.16	.03‖	.56
Mouth opening	.15‖	.15‖	.32
Cheek flexibility	.23	.29	.16
Winter's classification	<.01‖	<.01‖	NA
Tooth morphology	<.01‖	<.01‖	<.01‖
Angulation	NA	NA	.02‖
Mandibular position composite score	NA	NA	<.02‖
Root proximity to IAN canal	NA	NA	.03‖
Panoramic radiographic evidence	NA	NA	<.01‖
Operative			
Number of teeth extracted	<.01‖	.48	<.01‖
Procedure type	<.01‖	<.01‖	<.01‖
Anesthesia type	.13‖	.43	.16
Surgical experience	<.01‖	.06‖	<.01‖
Outcome			
Surgeon's postoperative difficulty estimate	<.01 (r = .72)	<.01 (r = .64)	<.01 (r = .69)

Abbreviations: NA, not applicable; IAN, inferior alveolar nerve.

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

†All M3s: n_{index} = 100 patients, k_{index} = 313 teeth.

‡Maxillary M3s: n_{index} = 83 patients, k_{index} = 145 teeth.

§Mandibular M3s: n_{index} = 92 patients, k_{index} = 168 teeth.

‖Variables that met the criteria for inclusion in the multiple model ($P \leq .15$).

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Applying the linear regression model for maxillary teeth to the entire population of maxillary teeth ($k_{maxillary}$ = 207 teeth), the mean predicted extraction time was 2.9 ± 1.9 minutes. Using a paired samples *t* test, the mean difference between this value and the mean extraction time for all maxillary teeth was 0.1 ± 2.5 minutes (P = .41).

MODELS FOR MANDIBULAR M3s

The bivariate relationships between the predictor variables and the extraction time for mandibular teeth (k_{index} = 168 teeth) are presented in Table 2. Gender, ethnicity, tooth morphology, tooth angulation, tooth position, root proximity to the IAN canal, panoramic radiographic evidence, number of teeth extracted, procedure type, instance of IAN visualization, and surgical experience all met the criterion for inclusion in the multiple model. The most parsimonious linear regression model for mandibular teeth (R^2 = .55) is presented in Table 5; tooth morphology, tooth angulation, number of teeth extracted, procedure type, and surgical experience were all statistically significant in this model ($P \leq .01$).

Our multiple model for mandibular M3s (k_{index} = 168) predicted an extraction time of 22.1 minutes for a mandibular tooth (Table 5). This baseline extraction time increased with procedure type (+0 minutes for nonsurgical, erupted; +1.6 minutes for erupted, surgical; +3.2 minutes for soft tissue impacted; +4.8 minutes for partial bony impacted; and +6.4 minutes for full bony impacted). The extraction time decreased with favorable tooth morphology (−4.7 minutes vs unfavorable morphology), increasing tooth angulation (−0.06 minutes/degree), and increasing surgical experience (−0.29 minutes/year).

Using our linear regression model for mandibular teeth, we calculated a mean extraction time of 9.5 ± 5.8 minutes ($k_{mandibular}$ = 243 teeth). Using a paired samples *t* test, the mean difference between this value and the mean extraction time for all mandibular teeth was 0.56 ± 6.0 minutes. This value, however, was not significantly different from 0 (P = .15), indicating that

Table 3. β-COEFFICIENT COMPARISON FOR THE INDEX AND VALIDATION SAMPLES FOR ALL M3s

Variable*	Index Sample†			Validation Sample†		
	B‡	β§	P Value	B	β§	P Value
M3 location	1.9	0.13	<.01	4.4	0.29	<.01
Winter's classification	1.4	0.20	<.01	0.58	0.08	.39
Tooth morphology	−5.4	−0.29	<.01	−5.4	−0.26	<.01
Number of teeth extracted	−1.6	−0.21	<.01	0.96	0.13	.06
Procedure type	1.4	0.31	<.01	1.3	0.25	<.01
Surgical experience	−0.20	−0.30	<.01	−0.21	−0.31	<.01
Constant	13.2	NA	<.01	4.9	NA	.02
R^2	0.58	NA	<.01	0.50	NA	<.01

Abbreviations: M3, third molar; NA, not applicable.

*Variables removed during maximum parsimony calculation were gender, age, ethnicity, mouth opening, and anesthesia type.

†n_{index} = 100 patients, k_{index} = 313 teeth; n_{valid} = 50 patients, k_{valid} = 137 teeth.

‡Nonstandardized coefficient for computational analyses.

§Standardized coefficient used for comparative analyses and measures of effect size ($\beta = B/\sigma_B$).

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this multiple linear regression model is an accurate predictor of the extraction times for mandibular M3s.

A comparison of the standardized β-coefficients for the model from the index population (k_{index} = 168 teeth) with that from the test population (k_{test} = 75 teeth) showed that tooth morphology, procedure type, and surgical experience were the only variables that were statistically significant in both populations (Table 5). In addition, the β-coefficients from the index and validation models for these variables are similar in magnitude and direction. These results indicate that our model for mandibular teeth is somewhat stable between the 2 populations, because 3 of 5 variables were comparable between the 2 models in statistical significance, magnitude, and direction of the β-coefficients.

We checked each computed linear regression model for violations of the assumptions of linearity, normality, and independence of variables. No gross violations of these assumptions were found in any of the models.

Discussion

Our aims in the present study were to use a defined set of predictor variables to develop multiple linear regression models to predict extraction time for M3s and subsequently validate those models. We hypothesized that a set of identifiable variables associated with extraction time could be identified and that multiple linear regression models developed using these factors would be both stable and accurate.

In brief, the mean extraction time for teeth included in the present study was 6.8 ± 7.2 minutes. We constructed multiple linear regression models for index samples of all teeth, maxillary teeth, and man-

Table 4. β-COEFFICIENT COMPARISON FOR INDEX AND TEST POPULATIONS FOR MAXILLARY TEETH

Variable*	Index Population†			Validation Population†		
	B‡	β§	P Value	B	β§	P Value
Body mass index	0.10	0.15	.03	0.19	0.29	.02
Winter's classification	1.9	0.20	<.01	−0.01	−0.001	.99
Tooth morphology	−4.6	−0.34	<.01	0.80	0.06	.62
Procedure type	0.77	0.41	<.01	0.91	0.45	<.01
Surgical experience	−0.05	−0.20	<.01	−0.07	−0.25	.03
Constant	3.9	NA	.01	−2.8	NA	.29
R^2	0.41	NA	<.01	0.29	NA	<.01

Abbreviation: NA, not applicable.

*Variables removed during maximum parsimony calculation were gender, age, ethnicity, and mouth opening.

†n_{index} = 83 patients, k_{index} = 145 teeth; n_{valid} = 40 patients, k_{valid} = 62 teeth.

‡Nonstandardized coefficient for computational analyses.

§Standardized coefficient used for comparative analyses and measures of effect size ($\beta = B/\sigma_B$).

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Table 5. β-COEFFICIENT COMPARISON FOR INDEX AND TEST POPULATIONS FOR MANDIBULAR TEETH

Variable*	Index Population†			Validation Population†		
	B‡	β§	*P* Value	B	β§	*P* Value
Tooth morphology	−4.7	−0.27	<.01	−6.6	−0.34	<.01
Angulation	−0.06	−0.26	<.01	−0.01	−0.03	.78
Number of teeth extracted	−2.2	−0.27	<.01	1.2	0.14	.13
Procedure type	1.6	0.28	<.01	2.2	0.32	<.01
Surgical experience	−0.29	−0.40	<.01	−0.31	−0.41	<.01
Constant	22.1	NA	<.01	9.0	NA	.02
R^2	0.55	NA	<.01	0.45	NA	<.01

Abbreviations: NA, not applicable; IAN, inferior alveolar nerve.

*Variables removed during maximum parsimony calculation were gender, age, ethnicity, mandibular position composite score (and individual component variables: Winter's classification, Pell-Gregory ramus classification, and Pell-Gregory occlusal classification), panoramic radiographic evidence, root proximity to IAN canal, and instance of visualization of IAN.

†n_{index} = 92 patients, k_{index} = 168 teeth; n_{valid} = 44 patients, k_{valid} = 75 teeth.

‡Nonstandardized coefficient for computational analyses.

§Standardized coefficient used for comparative analyses and measures of effect size ($\beta = B/\sigma_B$).

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dibular teeth and subsequently used these models to predict extraction times. The variables included in the model for all M3s were location, Winter's classification, tooth morphology, number of teeth extracted, procedure type, and surgical experience. The specific factors associated with extraction time for maxillary M3s were body mass index, tooth morphology, procedure type, and surgical experience. For mandibular M3s, the multiple linear regression model included tooth morphology, tooth angulation, number of teeth extracted, procedure type, and surgical experience.

We validated our models by examining the accuracy of the models and model stability. All 3 models were accurate predictors of extraction time, as evidenced by the statistically insignificant differences between the predicted and observed extraction times.

The value of accurate models in predicting the extraction time is of vital importance to the practicing oral and maxillofacial surgeon. Using these models could allow the practitioner to plan procedures accordingly, by examining the variables for each patient and estimating the required extraction time. Although our models can be used for this purpose, the large value of the standard deviations for the differences between the predicted and observed times indicate that a number of extrinsic variables might influence the extraction time. These variables might include, but are not limited to, the experience of the surgical assistant, the patient's need to be reanesthetized, and the time of day (surgeons might experience fatigue later in the day). In addition, the nature of scheduling within the practice could be of consideration in determining the extraction time. If a surgeon has a large number of cases during the day and is behind schedule, the surgeon might move more quickly in subsequent cases.

None of our models had appreciable stability, as evidenced by the deviations in the magnitude, direction, and statistical significance between β-coefficient values for the index and validation models for each set of teeth. This effect could certainly have resulted from sample size limitations, because our validation samples for the maxillary and mandibular teeth were quite small (62 and 75 teeth, respectively). The aptness of the comparison between the models for stability might not be as important a predictor of model validity as accuracy, owing to the nature of the "optimal" sample size. For larger sample sizes, the index and validation populations would be larger, but there is a diminishing marginal utility for increasing the sample size in this context.

In addition to quantifying the accuracy of our models and qualitatively describing the stability, we also identified several predictors of extraction time common to all models of teeth. These variables were surgical experience, tooth morphology, and procedure type. In addition to being present in all 3 models, these variables displayed significant influence over the extraction time within each model. On examining the β-coefficient values as estimates of effect size for each model, tooth morphology, procedure type, and surgical experience exerted the greatest influence over the extraction time in all 3 models. These results indicate that the operative variables influence a large amount of influence on the extraction times and that the nature of the procedure, experience of the operating surgeon, and local anatomy of the M3 are the most important factors in determining the extraction time. The goal of future works will be to compare the importance of specific variables as perceived by surgeons with various levels of surgical experience to the effect size of the variable in the multiple linear regression model, as measured by β-coefficient comparisons.

In the present study, we constructed multiple linear regression models to predict the extraction times for M3s. We created multiple linear regression models for all teeth, maxillary teeth, and mandibular teeth, using a subset of the total population of applicable teeth (the index population). We subsequently compared the times predicted by the models to the observed extraction times and found that all 3 models were remarkably accurate at predicting extraction times. In addition, we assessed the stability of our models by comparing the β-coefficients for variables in our multiple linear regression model with those from a model developed in a test population. Our models did not demonstrate stability across populations (ie, with significant variance between the β-coefficient values).

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