Assessment of Factors Associated With Surgical Difficulty During Removal of Impacted Lower Third Molars

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Purpose: The aim of the present study was to adjust a multivariate model to explain each of the response variables for the occurrence of surgical difficulty during the removal of impacted lower third molars.

Patients and Methods: A prospective cohort study was carried out involving patients submitted to at least one surgical removal of an impacted lower third molar. A total of 285 patients fulfilled the eligibility criteria and 473 surgeries were performed. Preoperative variables indicative of surgical difficulty were recorded. All surgical procedures were performed under the same conditions by two surgeons who were unaware of the data collected in the pre-selection phase. Either Pearson's chi-square test or Fisher's exact test was used for the data analysis (P<5.0%).

Results: Root number ($P^{(1)} < 0.004$*) and morphology ($P^{(1)} < 0.031$*), tooth position ($P^{(1)} = 0.001$*), periodontal space ($P^{(2)} < 0.004$*) and second molar relation ($P^{(1)} = 0.001$*) were significant predictors of surgical difficulty, whereas patient age ($P^{(1)} = 0.097$), gender ($P^{(1)} = 0.470$), body mass index ($P^{(1)} = 0.719$), associated pathologies ($P^{(1)} = 0.237$), relation with mandibular canal ($P^{(1)} = 0.384$) and width of 3rd molar crown ($P^{(1)} = 0.154$) were not significant predictors.

Conclusion: Many factors contribute to surgical difficulty, but considering these factors individually, some are only determinants of either difficulty or complications. Thus, not all significant predictors of surgical difficulty should be considered indicators of complications.

J Oral Maxillofac Surg 69:2714-2721, 2011

Third molar surgery corresponds to a significant portion of the surgical procedures carried out by oral and maxillofacial surgeons around the world and is an important activity at dental surgery training centers.[1,2] New surgical techniques, as well as extensive training, skill, and experience, have led to the evolution of dental surgery and allowed this procedure to be carried out in a less traumatic manner.[3] However, complications are inherent to any surgery, and oversights in the preoperative assessment may lead to difficulties and complications during surgery, constituting a permanent challenge to dental surgeons.[4]

A surgical complication is any unexpected event in a particular surgical situation that requires additional management beyond that originally planned.[5] The harm a surgical complication causes may lead to the loss of work days, loss of productivity, several postoperative sessions, as well as a possible lawsuit.[6,7] Thus, surgical procedures should be planned and executed according to scientific evidence.[8] Estimating possible difficulty in the removal of third molars is a constant challenge for dental surgeons.[9] Many studies that address this issue are based on opinions, retrospective studies (which are subject to selection bias), or poorly controlled variables, making an evidence-based approach a challenging task.[10-12]

A number of efforts have been made to establish a reliable assessment model for the surgical removal of impacted third molars. Although many such models have been proposed, none is considered universally applicable, and controversy remains.[2,4,10,13-15] An ap-

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This research was funded by FACEPE, Brazil.

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0278-2391/11/6911-0008$36.00/0
doi:10.1016/j.joms.2011.02.097

propriate paradigm is needed to determine factors associated with surgical difficulty to treat patients adequately and provide students and residents with the tools necessary to make the decision whether the procedure should be carried out, and to react appropriately when complications arise during surgery.[3,16]

Given the scarcity of scientific evidence on the proper conduct during the surgical removal of impacted third molars, studies are needed to confirm the main variables of an accurate model for the preoperative prediction of surgical difficulty. The aim of the this study was to adjust a multivariate model to explain each of the response variables for the occurrence of surgical difficulty during the removal of impacted lower third molars.

Patients and Methods

A prospective cohort study was carried out involving patients submitted to at least 1 surgical intervention for the removal of an impacted lower third molar between January and September 2009. Three hundred patients who voluntarily sought treatment for the removal of impacted lower third molars were preselected. All patients were examined by a single practitioner. Two hundred eighty-five fulfilled the eligibility criteria (indication for the surgery under local anesthesia and categories I and II of the American Society of Anesthesiology, ie, ASA I and II), and 15 patients were excluded based on the exclusion criteria (absence of lower second molar, systemic and/or behavior disorder that rendered local anesthesia unviable, pregnant or lactating women, recent irradiation, cognitive impairment that rendered the comprehension of the study objectives impossible, and nonacceptance of the methodology). Among the 285 patients included in the study, 473 surgical interventions were performed. All patients signed terms of informed consent, and the study received approval from the ethics committee of the University of Pernambuco, Brazil (Project No. 212/08).

In the preoperative phase, predictive variables of surgical difficulty were recorded by a single examiner (Table 1). Further data were obtained from panoramic radiographs. Bilateral extractions were necessary in 188 patients, but all interventions were carried out on different occasions. After the initial examination, the patients were randomly allocated to 2 previously calibrated senior residents who had no contact with the patients in the preselection phase and were unaware of the previously collected data.

SURGICAL TECHNIQUE

All procedures were carried out in the same surgery unit with the same instruments, high-speed drills (80,000-150,000 rpm, conical bit no. 702) and materials. Local anesthesia was administered (3% lidocaine with noradrenalin at 1:50,000) for the regional blocking of the lower alveolar, lingual, and buccal nerves after aspiration. No sedation method was employed in the study. All 473 interventions were carried out with the standardized general method for the surgical removal of impacted lower third molars described by Farish and Bouloux.[3] For the record of surgical difficulty, an examiner who was unaware of the data collected in the preselection period observed the actions employed for the extraction and recorded the surgery time in minutes with the aid of a chronometer (Table 2).

DATA INTERPRETATION AND STATISTICAL METHODS

For interpretation purposes, surgical difficulty was determined by the surgical technique employed and the length of surgery time, which are believed to be the aspects that most accurately reflect surgical difficulty. Either Pearson χ^2 test or Fisher exact test (when the χ^2 test was not appropriate) was used for the statistical calculations. A model was first adjusted for each response variable considering all independent variables with a level of significance up to 15% ($P < .15$). The adjustment of the final model was performed using the backward stepwise procedure, maintaining only those variables with a level of significance up to 5.0% ($P < .05$). The backward stepwise procedure adjusts the final model involving all variables selected. With each step, a nonsignificant variable is removed, and a new model is adjusted until all variables remaining in the model have a significant contribution to a previously selected level of significance for explaining the probability or percentage of a category of the response variable. This process always uses the same criterion for determining significance (the same P value) and, at each step, the variable with the least contribution to the model (that with the largest P value) is removed and a new model is adjusted with the remaining variables. This procedure is repeated until no further variables can be removed. Odds ratios are estimated using the independent variables included in the model. The Statistical Package for the Social Sciences (SPSS, version 15.0) was used for the statistical calculations.

Results

Mean patient age was 21.8 $\pm$ 2.4 years. The proportion of females to males was 3 to 1 (75.1% and 24.9%, respectively). Approximately 1 in every 5 patients was overweight (body mass index >25 kg/m^2). Most patients had lower third molars with 2 or more roots (71.5%), were nondilacerated (79.7%), had a radiolucent periodontal space (79.5%), and had no associated pathologies (76.3%). The root apex was

Table 1. PREOPERATIVE PREDICTIVE VARIABLES OF SURGICAL DIFFICULTY

Variable/Definition	Classification
Gender	1: Female 2: Male
Age	1: <25 yrs 2: ≥25 yrs
Body mass index (weight [Kg] divided by height squared [m^2])	1: <18.5 2: 18.5–24.9 3: ≥25
Associated pathologies (condition associated with third molar)	1: None 2: Pericoronitis 3: Caries 4: Bone resorption
Level of occlusal plane—Pell and Gregory (occlusal plane of third molar in relation to second molar)	1: High—larger part of crown of third molar above or on same level as second molar 2: Medium—larger part of crown of third molar between occlusal plane and cementoenamel junction of second molar 3: Low—crown of third molar completely below cementoenamel junction of second molar
Available retromolar space—Pell and Gregory (distance between distal-most point of second molar crown and anterior-most point of ascending ramus)	1: Sufficient—space greater than or equal to mesiodistal distance of third molar 2: Reduced—space greater than half and less than mesiodistal distance of third molar 3: Insufficient—space less than half the mesiodistal distance of third molar
Impaction angle (winter), measured in degrees (angle between the crossing of the long axis of third molar and occlusal plane)	1: Horizontal 0° to 30° 2: Mesioangular 31° to 60° 3: Vertical 61° to 90° 4: Distoangular >90°
Number of roots	1: One fused root 2: ≥2 roots 3: Tooth germ
Root curvature (angle between long axis of crown and root of third molar)	1: Nondilacerated <10° 2: Dilacerated >10°
Tooth relation with mandibular canal (distance [mm] from root apex to upper cortex of mandibular canal)	1: Negative—apex above upper cortex of mandibular canal 2: Positive—apex level with or crossing upper cortex of mandibular canal
Relation to second molar (relation of third molar crown with second molar)	1: No contact 2: Contact with crown alone 3: Contact with crown and root 4: Contact with root alone
Crown width (mesiodistal distance of third molar crown compared to second molar)	1: Nonbulbous (equal to or less than that of second molar) 2: Bulbous (greater than that of second molar)
Periodontal space (status of space between root of third molar and alveolar cortex)	1: Radiolucent 2: Mixed (radiolucent and radiopaque) 3: Radiopaque

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related to the mandibular canal in approximately half of the cases (49.3%). Table 3 displays the descriptive statistics of the sample.

According to the Pell-Gregory and Winter classifications, the most frequent tooth positioning was A (48.4%), 1 (59.4%), and vertical (49.5%). Crown morphology was nonbulbous in 73.8%. There was no contact between the second and third molars in 42.9% (Table 3). The surgical technique most often used for the removal of lower third molars was ostectomy (57.9%). Mean surgery time was 22 ± 3.5 minutes (Table 4).

Root number ($P^{(1)} < .004^*$) and morphology ($P^{(1)} < .031^*$), tooth position ($P^{(1)} = .001^*$), periodontal space ($P^{(2)} < .004^*$), and second molar relation ($P^{(1)} = .001^*$) were significant predictors of surgical difficulty, whereas patient age ($P^{(1)} = .097$), gender ($P^{(1)} = .470$), body mass index ($P^{(1)} = .719$), associ-

Table 2. CLASSIFICATION ACCORDING TO SURGICAL DIFFICULTY

Definition	Classification	Difficulty
Surgical technique (technical actions employed for extraction)	1: Use of elevator alone	Low
	2: Ostectomy	Moderate
	3: Ostectomy and tooth sectioning	High
Surgery (time elapsed between incision and suturing of tissues)	1: <15 min	Low
	2: 15–30 min	Moderate
	3: >30 min	High

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ated pathologies ($P^{(1)}$ = .237), relation with mandibular canal ($P^{(1)}$ = .384), and width of third molar crown ($P^{(1)}$ = .154) were not significant predictors. Table 5 displays the bivariate associations between the predictive variables and surgical difficulty.

The odds ratios revealed that the likelihood of difficulty during the surgical removal of an impacted lower third molar is greater *1*) if classified by Winter as horizontal in comparison with those classified as mesioangular by Pell and Gregory or classified as C3 in comparison with those classified as A1; *2*) if it has 2 roots or a germ in comparison with those with a fused root; *3*) if the root is bent; *4*) if the periodontal space is completely radiopaque in comparison with those with a mixed or completely radiolucent image; and *5*) if there is a close relation with the crown and root of the second molar in comparison with those only in contact with the root of the second molar.

Table 3. DISTRIBUTION OF PATIENTS ACCORDING TO PREOPERATIVE VARIABLES

Preoperative Variables	Classification	n	%
Gender	Male	118	24.9
	Female	355	75.1
Age	<25	349	73.8
	≥25	124	26.2
Body mass index	<18.5	46	9.7
	18.5-24.9	356	75.3
	≥25	71	15.0
Pell and Gregory	A	229	48.4
	B	194	41.0
	C	50	10.6
	1	281	59.4
	2	164	34.7
	3	28	5.9
Winter	Vertical	234	49.5
	Horizontal	71	15.0
	Mesioangular	163	34.5
	Distoangular	5	1.1
Associated pathologies	None	361	76.3
	Pericoronitis	63	13.3
	Caries	22	4.7
	Bone resorption	27	5.7
No. of roots	1 root	116	24.5
	≥2 roots	338	71.5
	Germ	19	4.0
Root dilaceration	Yes	96	20.3
	No	377	79.7
Relation with mandibular canal	Yes	233	49.3
	No	240	50.7
Contact with second molar	None	203	42.9
	Crown alone	177	37.4
	Crown/root	54	11.4
	Root alone	39	8.2
Periodontal space	Radiolucent	376	79.5
	Mixed	91	19.2
	Radiopaque	6	1.3
Width of third molar crown	Bulbous	124	26.2
	Nonbulbous	349	73.8
TOTAL		473	100

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Discussion

In a recent literature review, Akadiri et al[13] reported that demographic, radiographic, and surgical variables are strongly associated with surgical difficulty. However, no previous study has analyzed the multivariate associations among preoperative factors, surgical difficulty, and complications. The difficulty of the assessment is perhaps the most important factor. MacGregor (1979) made the first attempt to establish a model for assessing surgical difficulty.[14] This model served as the basis for subsequent studies.[4,12,16] The Pell and Gregory classification is a classic method.[17] However, this method has recently been found to be inadequate for the determination of surgical difficulty.[11] Thus, a classification system based on clinical and radiographic results would be a useful tool.[3]

The female-to-male gender proportion in this study was 3:1, demonstrating that women seek third-molar surgery more frequently than men. According to Nakagawa et al,[18] the female gender is a risk factor because of the mandible's lesser bone thickness. In the present study, however, gender was not a determinant of surgical difficulty.

According to a number of authors, age is the most consistent factor in the determination of surgical difficulty, considering the differences in bone density associated with age.[3,13] In the present study, age was not a determinant of surgical difficulty, but it is commonly reported to be significant to the occurrence of complications. The positive correlation may be related to the increase in bone density, which may require more handling during the operation. Moreover, the increase in age is associated with complete root formation, which may be related to the higher

Table 4. DISTRIBUTION OF PATIENTS ACCORDING TO SURGICAL DIFFICULTY

	Difficulty	Definition	n	%
Surgical technique	Low	Use of elevator alone	149	31.5
	Moderate	Ostectomy	274	57.9
	High	Ostectomy and tooth sectioning	50	10.6
Surgical time	Low	<15 min	161	34.0
	Moderate	15 to 30 min	235	49.7
	High	>30 min	77	16.3
TOTAL			473	100

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rate of complications among patients over 25 years of age in this study compared with younger patients (29.0% vs 18.3%).

Fifteen percent of the sample was overweight (body mass index >25 kg/m^2). Surgical difficulty in such cases is attributed to the projection of the cheek tissue. However, there was no significant increase in surgery time.

Complications are justified and accepted by most dental surgeons when tooth status is associated with pathological processes.[19] In the present study, bone resorption reduced the degree of difficulty, because only the use of an elevator was needed, which was the most often employed surgical procedure. Complications occur in nearly half of the cases with associated pericoronitis. This may be explained by the fact that pericoronitis is commonly associated with distally angled teeth, which frequently require sectioning.[20] However, this resource was used little in the cases analyzed here.

Bone density of the tooth has been described as the most important indicator for the prediction of surgical difficulty.[4,21] In the present study, deviation from the vertical alignment of the tooth increased surgical difficulty because of the difficult access to the rotation axis of the tooth. Moreover, greater difficulty occurred in cases classified in the >C3 category (Pell & Gregory classification). However, tooth position appears not to be significantly associated to the occurrence of complications. This result may be a reflection of the teaching of surgical tooth sectioning based on angle.

Crown morphology was not significantly associated with surgical difficulty, which corroborates the findings of a previous study.[13] In contrast, root morphology and number of roots were significantly associated with difficulty. Limited root development conducts the rotation of the tooth around its axis, commonly requiring sectioning and a surgery time of more than 30 minutes.[3] Teeth with complete and divergent roots also prove more difficult to remove.[3] Such teeth are often treated with sectioning before any mobility is attained because the fragmentation reduces the retention areas and facilitates removal with greater preservation of the adjacent bone and anatomical structures.[22]

Although no significant associations with surgical difficulty were found in the present study, the relation between the mandibular canal and tooth roots should be considered during extractions.[3,23] However, radiographic images do not provide the necessary reliability.[24] The hypothesis is that when the white line of the mandibular canal is absent or indistinct from the tooth root, surgery time is lengthened because of the fear of reaching the mandibular canal.[20] Along with importance of recognizing this, knowledge on the arrangement of the structures within the mandibular canal is fundamental, for the partial sectioning of the canal could affect the nerve bundle, which may not be perceived as a complication during the operation.[23]

A greater proximity between the second and third molars makes surgery more difficult and therefore represents an additional risk.[3] The space between the distal surface of the second molar and mesial surface of the third molar and the periodontal ligament space was significantly associated with surgical difficulty. Contact with the root alone or with the crown and root and tooth ankylosis often require sectioning and greater surgery time.

A number of studies have used surgery time and surgical technique as determinants of difficulty.[2,13,16,25] In one study, the authors found both these factors to be reliable, statistically significant measures and the best way to predict surgical difficulty.[25]

More than half of the procedures analyzed in the present study were categorized as having a moderate degree of difficulty. The surgical technique most often used for the removal of lower third molars was ostectomy. Mean surgery time was 22 ± 3.5 minutes.

Many factors contribute to surgical difficulty, but considering these factors individually, some are only determinants of either difficulty or complications. Thus, not all significant predictors of surgical difficulty should be considered indicators of complica-

Table 5. CORRELATION OF PREOPERATIVE FACTORS AND SURGICAL DIFFICULTY

Preoperative Variables	Surgical Technique						Surgical Time (Minutes)			
Difficulty	Low (Use of Elevator Alone) %		Moderate (Ostectomy)		High (Ostectomy and Tooth Sectioning) %		Low (<15) %	Moderate (15–30) %	High (>30) %	
Gender										
Male	31.3	$P^{(1)} = .850$	68.7	$P^{(1)} = .850$	41.1	$P^{(1)} = .470$	33.5	51.0	15.5	$P^{(1)} = .566$
Female	32.2		67.8		44.9		35.6	45.8	18.6	
Age										
<25	30.1	$P^{(1)} = .266$	69.9	$P^{(1)} = .266$	39.8	$P^{(1)} = .097$	36.1	48.4	15.5	$P^{(1)} = .269$
≥25	35.5		64.5		48.4		28.2	53.2	18.5	
Body mass index										
<18.5	47.8	$P^{(1)} = .001^*$	52.2	$P^{(1)} = .001^*$	30.4	$P^{(1)} = .017^*$	41.3	43.5	15.2	$P^{(1)} = .719$
18.5–24.9	26.1		73.9		45.8		32.9	50.0	17.1	
≥25	47.9		52.1		31.0		35.2	52.1	12.7	
Pell and Gregory										
A	54.6	$P^{(1)} = .001^*$	45.4	$P^{(1)} = .001^*$	19.7	$P^{(1)} = .001^*$	49.8	40.6	9.6	$P^{(1)} = .001^*$
B	10.8		89.2		61.3		17.5	62.9	19.6	
C	6.0		94.0		70.0		26.0	40.0	34.0	
1	42.7	$P^{(1)} = .001^*$	57.3	$P^{(1)} = .001^*$	29.5	$P^{(1)} = .001^*$	43.8	44.8	11.4	$P^{(1)} = .001^*$
2	15.9		84.1		59.1		20.1	58.5	21.3	
3	10.7		89.3		67.9		17.9	46.4	35.7	
Winter										
Vertical	49.1	$P^{(1)} = .001^*$	50.9	$P^{(1)} = .001^*$	20.5	$P^{(1)} = .001^*$	46.6	43.2	10.3	$P^{(1)} = .001^*$
Horizontal	2.8		97.2		93.0		11.3	62.0	26.8	
Mesioangular	19.0		81.0		50.9		25.2	54.0	20.9	
Distoangular	**		**		**		**	**	**	
Associated pathologies										
None	28.5	$P^{(1)} = .016^*$	71.5	$P^{(1)} = .016^*$	46.0	$P^{(1)} = .002^*$	32.1	51.5	16.3	$P^{(1)} = .237$
Pericoronitis	47.6		52.4		22.2		39.7	49.2	11.1	
Caries	40.9		59.1		27.3		45.5	40.9	13.6	
Bone resorp.	74.1		25.9		14.8		37.0	33.3	29.6	
N° of roots										
1 root	43.1	$P^{(1)} = .004^*$	56.9	$P^{(1)} = .004^*$	34.5	$P^{(1)} = .016^*$	49.1	36.2	14.7	$P^{(1)} = .001^*$
≥2 roots	28.4		71.6		43.2		29.6	54.1	16.3	
Germ	15.8		84.0		68.4		21.1	52.6	26.3	
Root dilacerations										
Yes	18.8	$P^{(1)} = .003^*$	81.3	$P^{(1)} = .003^*$	62.5	$P^{(1)} = .001^*$	18.8	61.5	19.8	$P^{(1)} = .002^*$
No	34.7		65.3		36.9		37.9	46.7	15.4	
Relation with mandibular canal										
Yes	29.6	$P^{(1)} = .384$	70.4	$P^{(1)} = .384$	41.6	$P^{(1)} = .848$	36.5	42.5	21.0	$P^{(1)} = .003^*$
No	33.3		66.7		42.5		31.7	56.7	11.7	

Table 5. (Cont'd)

Preoperative Variables	Surgical Technique						Surgical Time (Minutes)			
Difficulty	Low (Use of Elevator Alone) %		Moderate (Ostectomy)		High (Ostectomy and Tooth Sectioning) %		Low (<15) %	Moderate (15-30) %	High (>30) %	
Contact with second molar										
None	41.9	$P^{(1)} = .001$*	58.1	$P^{(1)} = .001$*	33.5	$P^{(1)} = .001$*	39.4	47.3	13.3	$P^{(1)} = .001$*
Crown alone	32.2		67.8		40.1		41.2	44.6	14.1	
Crown/root	11.1		88.9		66.7		7.4	63.0	29.6	
Root alone	2.6		97.4		61.5		10.3	66.7	23.1	
Periodontal space										
Radiolucent	31.1	$P^{(2)} = .031$*	68.9	$P^{(2)} = .031$*	41.0	$P^{(2)} = .030$*	36.4	48.9	14.6	$P^{(2)} = .004$*
Mixed	29.7		70.3		49.5		22.0	54.9	23.1	
Radiopaque	0.0		100.0		83.3		16.7	16.7	66.7	
Width of third molar crown										
Bulbous	28.2	$P^{(1)} = .361$	71.8	$P^{(1)} = .361$	44.4	$P^{(1)} = .549$	32.3	46.0	21.8	$P^{(1)} = .154$
Nonbulbous	32.7		67.3		41.3		34.7	51.0	14.3	

*Significant association at 5.0%.

**Undetermined because of sample size.

(1)Pearson χ^2 test.

(2)Fisher exact test.

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tions. Further studies will be conducted to assess specific types of surgical complications and establish correlations between preoperative factors and occurrences during surgery.

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