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Learning Curve in the Extraction of Impacted Lower Third Molars: A Prospective Cohort Study

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ABSTRACT

Introduction: Third molar removal is one of the most common surgical procedures in dentistry. Therefore, it is important to evaluate the learning curve of dentists undergoing surgical training. Thus, the aims of this study were to assess the performance of oral surgery residents in third molar extractions based on operative time and the occurrence of incidents/complications, and to determine which variables are associated with surgical difficulty.

Material and Methods: A prospective cohort study was carried out in adults requiring an impacted lower third molar extraction. All procedures were performed by residents of a master's degree in Oral Surgery and Implantology. The outcome variables were operative time and surgeon-reported difficulty. A descriptive, bivariate and multivariate analysis was performed.

Results: One hundred and 74 patients were operated on by six students. Similar performance was observed among the surgeons. Although a significant improvement in operative time was seen after 10 cases, a non-significant decreasing trend of incidents was also found. The multivariate analysis revealed an association between difficulty with crown/root sectioning and impaction against the second molar.

Conclusions: At least 10 lower impacted third molar extractions performed by postgraduate students with experience in tooth extractions are required to improve the operative time. Incidents seem to decrease slightly with the number of procedures performed. Surgical difficulty seems to be related to the need for crown/tooth sectioning and greater impaction against the second molar. Further studies are required to confirm these findings.

1 | Introduction

The learning curve is defined as the time and/or number of procedures required for a novice surgeon to be able to perform a given surgery autonomously and with a reasonable outcome. This is a process of skill improvement that was described by Wright in 1936 to evaluate the production line of aviation assemblies [1]. In recent decades, the term has been used in the medical field and specifically in studies evaluating minimally invasive surgical procedures [2]. Operative time and intra- and postoperative complication rates are some of the parameters used to quantify the learning curve [3]. In addition, some hospital-based studies on surgeon learning evolution have used other outcome variables such as days of hospital stay [4] or the volume of blood loss during surgery [5]. Indeed, a well-trained surgeon will not only result in a lower biological cost to the patient but also reduce the economic cost to the healthcare system [6].

Lower third molar (L3M) extraction is a common procedure associated with varying degrees of surgical difficulty and risk of complications [7, 8]. The estimation of surgical difficulty is of great importance to standardise surgeon opinions and to provide individualised information to patients [9, 10]. Besides, knowledge on the learning curve is of great interest, because it has implications in treatment outcomes. Indeed, Susarla et al. [11, 12] found that more experienced surgeons required less operative time.

A retrospective cohort study published by Sisk et al. [13] evaluated the effect of experience on the overall incidence of complications associated with impacted third molar extraction performed by professors and fellows of oral and maxillofacial surgery. Novice surgeons had a significantly higher incidence of complications, namely, alveolar osteitis. In contrast, Boer et al. [14] observed no relationship between experience and postoperative complications.

The study of surgical performance is usually made in terms of success or failure. In cardiac surgery, failure is usually the death of the patient. However, Leval et al. [15] underscore the importance of assessing events known as near misses (a concept used in aviation) to improve the discrimination of treatment outcomes and avoid unrealistically favourable results. Thus, incidents could be used to define a safety index for a given surgical procedure. More sensitive criteria would allow the surgeon to better self-assess his or her learning curve and the need for retraining to maintain good performance. Currently, there are no specific criteria for evaluating the degree of surgical experience in the removal of L3M. In fact, some studies use the number of operated cases [11, 16, 17], whereas others employ the years of practice in oral surgery [16, 18]. Data regarding the performance of dentists undergoing surgical training will provide information to prevent complications and improve postoperative quality of life for the patient. Moreover, the assessment of incidents will serve to better discriminate the improvement of skills.

Thus, the main objective of the present study was to assess the surgical performance of 2nd-year master's degree residents in impacted L3M removal in terms of operative time and the occurrence of incidents. Secondarily, the study aimed to analyse the relationship between clinical, surgical and radiological variables and surgical difficulty.

2 | Methods

A prospective cohort study was carried out in adults requiring the extraction of an impacted L3M. All procedures were performed by 2nd-year postgraduate students of the master's degree programme in Oral Surgery and Implantology of the University of (Barcelona) between December 2021 and December 2022. The residents were assisted by their fellows, mainly 1st- and 3rd-year postgraduate students, and were supervised by assistant professors.

The study protocol was approved by the Ethical Review Board of the Dental Hospital of the University of (University of Barcelona), protocol number 51/2021. All patients agreed to participate in the study and signed the corresponding informed consent form. There was no financial compensation for participation in the study. The ethical principles of the Declaration of Helsinki were followed during the study [19], and the manuscript was written according to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology Statement) guidelines [20].

2.1 | Inclusion and Exclusion Criteria

Patients more than 18 years old requiring extraction of an impacted L3M with ostectomy and/or crown/root sectioning, without disease of the adjacent second molar and willing to attend the postoperative follow-up appointments were included in the study. Patients with significant systemic diseases (ASA score III or higher) contraindicating surgical procedures or who were under any pharmacological treatment interfering with wound healing were excluded. Patients with acute pericoronitis, severe periodontal disease or contraindications to the medication or local anaesthetic described in the study protocol were also excluded. If the patient required more that one extraction, only one tooth was selected by tossing a coin.

2.2 | Registered Variables

Variables were classified into several groups. The following surgeon-related variables were recorded: age, gender, dominant hand and experience of the surgical assistant. On the other hand, patient-related clinical variables such as age, gender, weight (kg), height (cm), ethnicity (Caucasian, African, Arabic, Afro-American, Indian-Pakistani, Chinese) and anxiety level according to the MDAS (Modified Dental Anxiety Scale) [21] and DFS (Dental Fear Survey) [22] scales were also recorded. Finally, surgical variables such as the operated side (left/right), the eruption status of the L3M (erupted/not erupted) and disposition of its roots (convergent, parallel or unfavourable, i.e., divergent, curved, separated, bulbous or dilacerated), the relationship with the second molar (erupted, impacted against the crown and/or root), the relationship with the inferior dental canal according to the signs described by Rood and Shehab [23], and the presence of a radiolucent lesion associated with the extracted tooth (absence, widened follicle < 3 mm, lesion $<$ or > 10 mm in diameter) were also assessed.

Operative time (defined as the duration of surgery in minutes from the beginning of the incision to the last suture stitch) and surgeon-reported surgical difficulty (using a visual analogue scale [VAS] from 0 to 10 cm) were selected as outcomes referring to L3M extraction difficulty.

As this study aimed to evaluate the student learning curve, success was defined as uneventful extraction of the third molar (absence of incidents or complications during both the procedure and follow-up period). In addition to intraoperative events (bleeding or displacement of the tooth into anatomical cavities) and postoperative complications (nerve injury, surgical wound infection, alveolar osteitis, mandibular fracture), variables called 'incidents' or near misses were also recorded. These are events that can lengthen or complicate surgery (root fracture, fracture/displacement of the buccal and/or lingual cortex, flap tear, ulceration of the lip/buccal mucosa, reaming of the lingual cortex and luxation of the adjacent second molar, among others).

These incidents were registered to identify successful procedures that could be improved upon.

2.3 | Surgical Procedure

The surgical procedure was performed by second-year postgraduate students of the master's degree programme in Oral Surgery and Implantology of the University of (Barcelona). Two researchers (E.S., X.A.-H.) collected the data.

All surgical procedures were performed under local anaesthesia with a 4% articaine solution with epinephrine 1:100000 (Artinibsa; Inibsa, Lliçà de Vall, Spain). An inferior alveolar nerve block (one 1.8 cc cartridge) and an additional buccal infiltration (one 1.8 cc cartridge) were performed (one 1.8 cc cartridge). A full-thickness triangular flap was raised with a mesial vertical releasing incision in the lower second molar. Ostectomy and/or tooth sectioning were performed with a number 8 tungsten carbide round bur for an electric straight hand piece (40 000 rpm) under sterile saline irrigation. The wound was closed with 4/0 polyglactin 910 sutures (Vicryl, Ethicon, Somerville, USA). The patients were scheduled 7 days after tooth extraction for postoperative follow-up assessment.

2.4 | Statistical Analysis

A convenience sample of at least 25 patients operated on by each of the six students during the academic year was included.

Two observers (E.S., X.A.-H.) were calibrated by assessing 10 panoramic radiographs from patients not included in the study. Inter-examiner calibration was optimal for the radiological variables of depth ($k = 0.8039$), available distal space ($k = 0.8361$) and angulation, according to Winter ($k = 1$).

Categorical outcomes were reported as absolute and relative frequencies. The groups were compared using simple binary logistic regression models. The odds ratio (OR) and 95% confidence interval (95% CI) were calculated.

Normality of the distribution of the scale variables was assessed using the Shapiro–Wilk test and from visual analysis of the P–P and box plots. Where normality was rejected, the interquartile range (IQR) and median were calculated. Where data distribution was consistent with normality, the mean and standard deviation (SD) were calculated. Differences with 95% CI between groups of scale variables were explored using simple linear regression models.

A funnel plot was performed to compare the performance of the different surgeons [24]. Lastly, multivariate analysis was performed using linear regression to determine the factors associated with increased surgical difficulty according to operative time and self-reported difficulty. The statistical analysis was carried out with the Stata 14.2 package (StataCorp LLC, Lakeway Drive, USA) using Bonferroni correction for multiplicity of contrasts. The assumptions underlying the statistical analysis were checked.

3 | Results

A total of 174 patients (174 L3M extractions), 74 males (42.5%) and 100 females (57.5%), mostly Caucasian ($n = 147$; 84.5%) and with a mean age of 26.8 ± 8.8 years (range 18–68 years), were included. Eighty-six left L3M (49.4%) and 88 right L3M (50.6%) were analysed.

3.1 | Surgeon Characteristics Related to Near Misses and Complications

Six right-handed postgraduate students (two men and four women) with a mean age of 24.5 years performed all the surgical extractions.

Table 1 shows the distribution of the number of L3M extractions, incidents and complications, as well as the description (mean and SD) of the outcome variables referred to surgical difficulty for each surgeon. During the study period, 19 incidents were observed in 17 patients, accounting for 9.8% of the surgeries. The most frequent incident was root fracture ($n = 13$; 7.5%), followed by bruising of the lower lip ($n = 5$; 2.9%) and a single case of displacement of the L3M into the submandibular space ($n = 1$; 0.6%). Moreover, no relationship was observed between the occurrence of intraoperative incidents and the experience of the surgical assistant (1st- or 3rd-year postgraduate student) ($p = 0.160$).

TABLE 1 | Distribution of the number of extractions, incidents and complications, operative time, surgeon-reported difficulty and surgical technique.

Surgeon	#1	#2	#3	#4	#5	#6
Incidents	6	2	1	2	4	4
Complications	4	4	2	4	4	4
Surgeries	25	31	25	28	31	34
Operative time (min)	36.2 (17.2)	32.6 (17)	35 (13.5)	43.4 (18.9)	34.9 (12.9)	36.9 (17.3)
Subjective difficulty (VAS)	3.8 (2.5)	3.6 (2.7)	4 (2.5)	3.8 (2)	2.9 (1.5)	3.3 (2.2)
Technique (Parant)	2.8 (1.2)	2.7 (1.3)	3 (1.1)	2.6 (1)	3 (0.9)	3 (1.2)

Note: Results reported as the mean (standard deviation).
Abbreviations: Min, minutes; VAS, visual analogue scale.

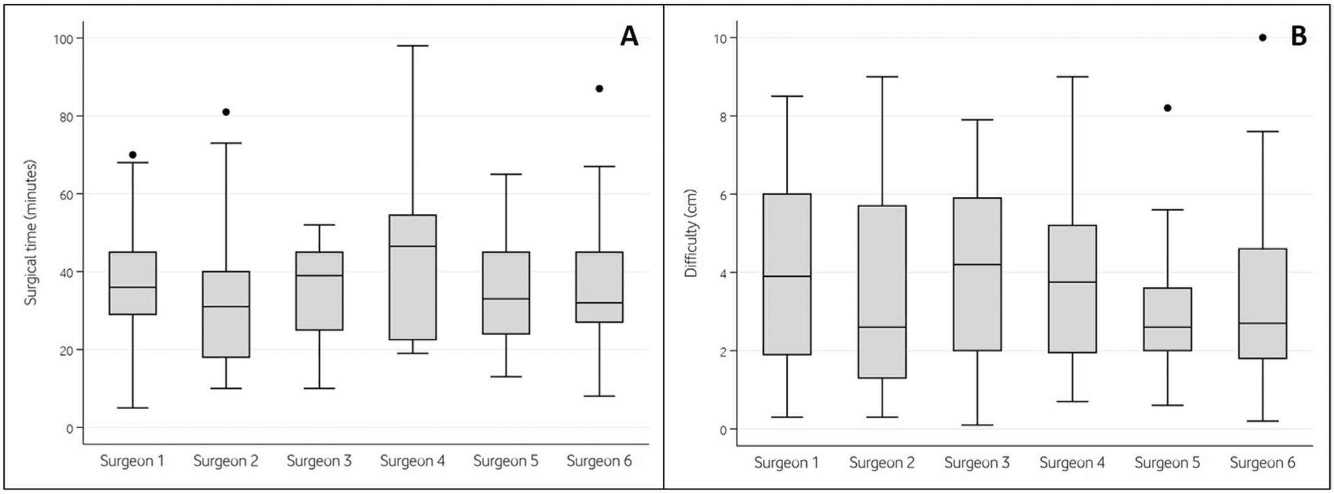

FIGURE 1 | Box plots representing (A) operative time and (B) surgical difficulty for each surgeon.

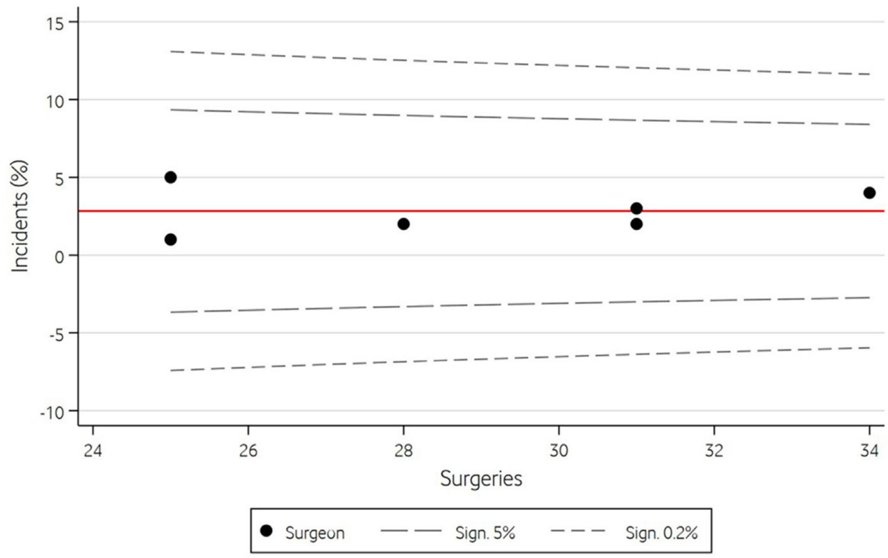

FIGURE 2 | Funnel plot detailing the surgical performance of the six surgeons included in the study.

On the other hand, 22 postoperative complications were recorded in 18 patients (10.3%). The most frequent complication was alveolar osteitis ($n=7$; 4%), followed by surgical site infection ($n=6$; 3.5%), inferior alveolar nerve injury ($n=5$; 2.8%) and bleeding ($n=4$; 2.3%).

Figure 1 shows box plots with the distribution of operative time and surgical difficulty for each surgeon. There were no differences in surgical performance between surgeons regarding operative time ($p=0.204$), number of incidents ($p=0.457$) or complications ($p=0.952$).

3.2 | Learning Curve

Figure 2 shows a funnel plot detailing the surgical performance of the six surgeons included in the study. All were within the expected range, although surgeon 1, who

TABLE 2 | Mean difference in operative time and incidents by clusters of surgical interventions.

	Operative time		Incident	
Interval	**MD (95% CI)**	***p***	**OR (95% CI)**	***p***
1–10 (reference)	0		1	
11–20	−7.82 (−15.61 to −0.02)	0.049*	0.72 (0.16–3.28)	1.000
21–30	−9.83 (−18.10 to −1.57)	0.011*	0.43 (0.07–2.80)	1.000
> 30	−11.42 (−29.69 to 6.86)	0.583	NA	

Abbrevations: MD, mean difference; *p*-value with Bonferroni correction; NA, not applicable.
*Value denote Statistically significant.

performed fewer surgical procedures, showed slightly inferior surgical performance. The occurrence of incidents was associated with greater perceived difficulty ($p = 0.001$) and operating time ($p = 0.015$).

The surgical procedures were grouped into clusters of 10 to analyse the surgeon improvement trend in terms of incidents and operative time (intervals of 1–10, 11–20, 21–30 and > 30) (Table 2).

Operative time was seen to be influenced by surgical experience ($p = 0.007$). Specifically, the first 10 operations lasted significantly longer than those in the following two intervals ($p = 0.049$ and $p = 0.011$, respectively). With regard to the incidents, a decreasing trend was also observed after 10 cases, though statistical significance was not reached ($p = 0.466$). Figure 3 shows the operative time and incidents for each of the three intervals of surgeries.

3.3 | Bivariate Analysis

Table 3 shows the distribution of patients according to their clinical, radiological and surgical characteristics, and the bivariate analysis in relation to operative time, surgeon-perceived difficulty and the surgical technique.

Males had more difficult L3M according to the Parant classification ($p = 0.018$). In addition, African and Afro-American individuals presented a slightly greater degree of subjective difficulty, although without reaching statistical significance ($p = 0.070$), and required a more complex surgical technique ($p = 0.020$). Additionally, a greater degree of anxiety according to the DFS scale was significantly related to a more complex surgical technique ($p = 0.042$). The radiological variables more strongly associated with increased surgical difficulty were the available distal space, angulation, number and adverse root morphology, as well as the degree of impaction against the second molar. Furthermore, the presence of an associated radiolucent lesion increased the complexity of the surgical technique ($p = 0.001$), and radiological signs of inferior alveolar nerve proximity, such as canal narrowing and white line interruption, significantly increased surgeon-perceived difficulty ($p = 0.001$ and $p = 0.044$, respectively). Lastly, all recorded surgical variables (soft tissue impaction, bone impaction, ostectomy, crown sectioning and root sectioning) were significantly associated with increased difficulty.

3.4 | Multivariate Analysis

The need for crown and root sectioning was associated with greater difficulty, as assessed by operative time and surgeon-perceived difficulty. Also, a greater degree of impaction against the second molar was correlated with greater subjective difficulty (Table 4).

4 | Discussion

The main objective of the present study was to assess the evolution of the surgical performance of novice surgeons in performing L3M extractions. The results show a similar performance pattern among the different surgeons, with significant improvement in operative time after 10 cases, followed by slower improvement. Although a greater number of extractions were correlated with fewer incidents, the association was not significant. This may be due to the fact that there were fewer surgeries in the last two groups (21–30, and > 30). According to our results, the most relevant variables associated with increased surgical difficulty are the complexity of the surgical technique (need for ostectomy and/or tooth sectioning), the degree of impaction against the second molar and the number of L3M roots.

The learning curve of surgeons has also been assessed in other specialties. Qu et al. [25] reported a reduction in operative time and complication rates after 20 endoscopic thyroidectomy procedures. Likewise, Cao et al. [26] reported that novice surgeons should operate on 25 cases of endoscopic thyroidectomy to achieve a shorter operative time and a lower complication rate. On the other hand, Liu et al. [27] stated that 60 cases are advisable to master this surgical procedure. The learning curve

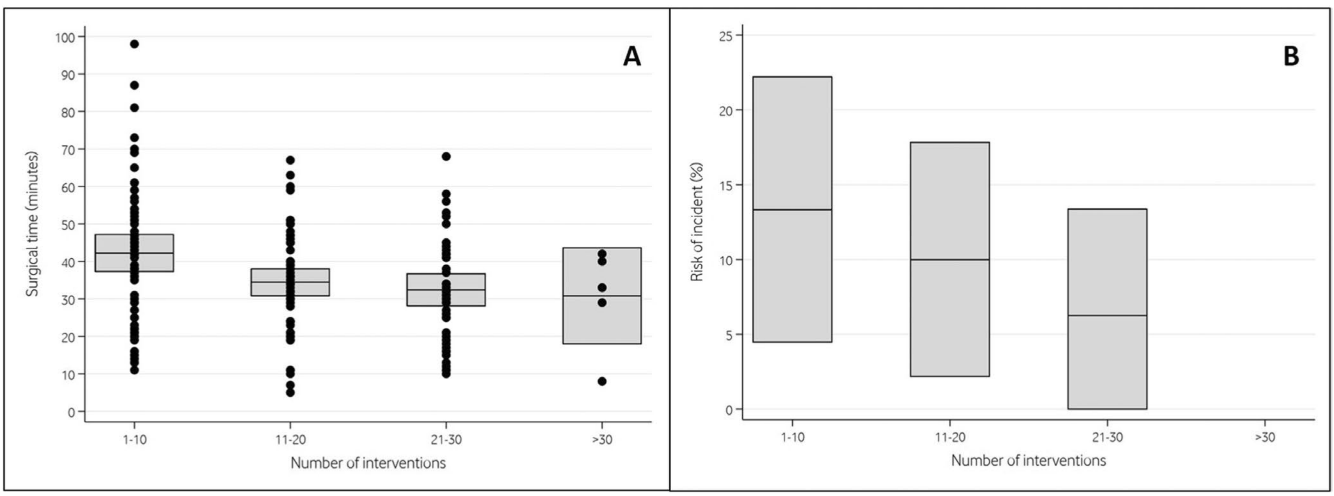

FIGURE 3 | (A) Box and scatter plot for operative time in three surgery intervals. (B) Box plot for incidents in the three surgery intervals. For each box, the interior line in bold shows the mean, and the edges of the box are estimates of the lower and upper 95% confidence intervals.

TABLE 3 | Descriptive and bivariate analysis according to clinical, radiological and surgical characteristics and outcome variables that assess difficulty.

		Operative time		Surgeon-reported difficulty	
	***N* (%)**	**Mean (SD)**	***p***	**Mean (SD)**	***p***
Clinical variables					
Age	26.8 (8.8)[a]	—	0.803	—	0.467
Gender					
Female	100 (57.5)	34.8 (±1.7)	0.129	3.4 (±2.2)	0.211
Male	74 (42.5)	38.6 (±1.9)		3.8 (±2.3)	
BMI	24 (4.7)[a]	—	0.598	—	0.295
Ethnic background					
Caucasian	147 (84.5)	36 (±16.5)	0.096	3.4 (±2,3)	0.044*
African	6 (3.5)	42.5 (±19.7)		3.2 (±2.5)	
Afro-American	15 (8.6)	43.7 (±13.5)		5 (±2)	
Indian-Pakistani	4 (2.3)	20.8 (±11.6)		2.4 (±1.6)	
Chinese	2 (1.2)	29.5 (±0.7)		5.6 (±0.1)	
MDAS	9.8 (6.1)	—	0.237	—	0.204
DFS	35.2 (10.9)	—	0.945	—	0.150
Radiological variables					
Depth					
A	99 (56.9)	35.6 (±17.2)	0.736	3.5 (±2.4)	0.715
B	60 (34.5)	37.6 (±14.9)		3.6 (±2.2)	
C	15 (8.6)	37.4 (±17.5)		3.1 (±2,1)	
Available distal space					
1	49 (28.2)	31.8 (±16.7)	0.017*	2.9 (±2.3)	0.000*
2	104 (59.8)	37.2 (±16)		3.5 (±2.2)	
3	21 (12)	43.5 (±15.7)		5.3 (±1.9)	
Angulation					
Mesial	52 (29.9)	37.3 (±14.9)	0.083*	3.5 (±2.1)	0.349
Distal	17 (9.8)	39.2 (±21.7)		3.8 (±2.8)	
Vertical	57 (32.7)	32 (±16.3)		3.2 (±2.5)	
Horizontal	48 (27.6)	39.8 (±15.4)		3.9 (±1.9)	
Number of roots					
0	2 (1.1)	27.5 (3.5)	0.006*	2.1 (0.1)	0.023*
1	3 (1.7)	22.3 (8.1)		2.7 (2.5)	
2	156 (89.7)	35.6 (15.6)		3.4 (2.1)	
3	10 (5.8)	53.2 (22.9)		5.7 (3.4)	
4	3 (1.7)	44 (10.4)		4.1 (3.7)	

(Continues)

	N (%)	Operative time		Surgeon-reported difficulty	
		Mean (SD)	p	Mean (SD)	p
Root morphology					
Convergent	71 (41.3)	32.8 (±13.5)	0.014*	3.1 (±2.2)	0.040*
Parallel	38 (22.1)	39.4 (±15.7)		3.9 (2.3)	
Divergent	6 (3.5)	39.2 (±10.4)		3.3 (±1.3)	
Curved	27 (15.7)	39.2 (±21.3)		4.1 (±2.4)	
Separated	8 (4.6)	30.4 (±11.6)		3 (±1.6)	
Bulbous	17 (9.9)	46.1 (±20.2)		4.6 (±2.4)	
Dilacerated	5 (2.9)	23.8 (±10)		1.7 (±0.9)	
Lesion					
Absent	95 (54.6)	34.6 (±16.8)	0.402	3.3 (±2.2)	0.433
Follicle (< 3 mm)	62 (35.6)	38.2 (±14.8)		3.7 (±2.3)	
Size < 10 mm	16 (9.2)	40.6 (±19.7)		4.1 (±2.8)	
Size > 10 mm	1 (0.6)	33 (±0)		2.1 (±0)	
Second molar impaction					
Non-impacted	63 (36.2)	32.9 (±20.4)	0.017*	3.3 (±2.7)	0.116
Crown impacted	31 (17.8)	34.3 (±12.5)		3.6 (±1.9)	
Crown and root impacted	47 (27)	42.6 (±12.1)		4.2 (±2.1)	
Root impacted	33 (19)	36.5 (±14.4)		3.1 (±1.8)	
Radiological signs of proximity with IAN (27)					
Darkening	59 (33.9)	33.8 (±14.6)	0.125	3.4 (±2.3)	0.649
Deflection	18 (10.3)	36.3 (±16.1)	0.975	3.5 (±2.3)	0.992
Narrowing of the canal	65 (37.4)	39.4 (±17.2)	0.067	4 (±2.4)	0.044*
Bifid apex	10 (5.7)	38.9 (±19.9)	0.628	4.7 (±3.1)	0.092
White line interruption	99 (56.9)	38.2 (±16.8)	0.114	3.9 (±2.5)	0.021*
Canal deviation	14 (8.1)	40 (±16.2)	0.401	4.6 (±2.1)	0.057
Narrowing of the apex	51 (29.3)	34.7 (±15.9)	0.359	3.7 (±2.2)	0.586
Surgical variables					
Soft tissue impaction					
Yes	153 (87.9)	38.4 (±15.7)	0.000*	3.8 (±2.2)	0.000*
No	21 (12.1)	22.4 (±14.7)		1.8 (± 1.7)	
Bony impaction					
Erupted	28 (16.1)	22 (±13.1)	0.000*	1.8 (±1.7)	0.000*
Semierupted	142 (81.6)	38.9 (±15.6)		3.9 (±2.2)	
Included	4 (2.3)	51 (±5.7)		3.3 (±1.8)	
Ostectomy					
Yes	136 (78.2)	40.5 (±14.9)	0.000*	4.1 (±2.2)	0.000*
No	38 (21.8)	21.9 (±13.2)		1.5 (±1.2)	

(Continues)

TABLE 3 | (Continued)

	N (%)	Operative time		Surgeon-reported difficulty	
		Mean (SD)	p	Mean (SD)	p
Crown sectioning					
Yes	109 (62.6)	44.1 (±13.4)	0.000*	4.5 (±2.1)	0.000*
No	65 (37.4)	23.6 (±12.7)		1.9 (±1.5)	
Root sectioning					
Yes	67 (38.5)	46.6 (±14.9)	0.000*	5 (±2.3)	0.000*
No	107 (61.5)	30.1 (± 14)		2.6 (±1.7)	

Abbreviations: BMI, body mass index; DFS, Dental Fear Survey; IAN, inferior alveolar nerve; N, number of cases; MDAS, Modified Dental Anxiety Scale.
[a]Mean (standard deviation).
*Value denote Statistically significant.

TABLE 4 | Multivariate linear regression analysis of operative time and surgeon-reported difficulty.

	Coefficient	Standard error	p	95% CI
Operative time				
Age	0.04	0.12	0.748	−0.19 to 0.27
Gender	−0.42	2.10	0.844	−4.57 to 3.74
MDAS	0.18	0.18	0.327	−0.18 to 0.54
DFS	−0.01	0.11	0.903	−0.22 to 0.19
Crown sectioning	17.19	2.78	0.000*	11.70–22.68
Root sectioning	6.01	2.69	0.027*	0.71–11.31
Depth	2.64	1.91	0.167	−1.12 to 6.41
Angulation	−0.04	0.90	0.961	−1.82 to 1.73
Number of roots	4.20	2.58	0.105	−0.89 to 9.29
Root morphology	0.33	0.56	0.554	−0.77 to 1.43
Second molar impaction	−1.33	1.13	0.241	−3.56 to 0.90
Constant	9.78	7.75	0.209	−5.53 to 25.09
Surgeon-reported difficulty				
Age	0.02	0.02	0.203	−0.01 to 0.05
Gender	−0.01	0.30	0.987	−0.59 to 0.58
MDAS	−0.01	0.03	0.988	−0.05 to 0.05
DFS	0.02	0.01	0.128	−0.01 to 0.05
Crown sectioning	2.31	0.39	0.000*	1.54–3.09
Root sectioning	0.98	0.38	0.010*	0.23–1.73
Depth	0.36	0.27	0.182	−0.17 to 0.89
Angulation	−0.03	0.13	0.809	−0.28 to 0.22
Number of roots	0.34	0.36	0.353	0.38–1.06
Root morphology	0.02	0.08	0.784	−0.13–0.18
Second molar impaction	−0.35	0.16	0.028*	−0.67 to −0.04
Constant	−0.42	1.09	0.705	−2.58–1.75

Abbreviations: BMI, body mass index; CI, confidence interval; DFS: Dental Fear Survey; MDAS, Modified Dental Anxiety Scale.
*Value denote Statistically significant.

exhibits a non-linear pattern, as errors or incidents may occur during its course [28]. According to Leval et al. [15], the curve should describe a decrease in risk with accumulated experience. As there is no universal measure to quantify surgeon experience, different authors thus far refer to the total number of surgeries performed or the number of years of practice [29]. In the present study, a significant decrease in operative time was observed from 10 cases onwards, which might reflect the minimum number of operated cases necessary to achieve some autonomy. It is important to stress that the surgeons included in the present study were 2nd-year postgraduate students enrolled in a full-time master's degree programme, so previous experience in conventional and simple surgical tooth extractions had already been gained in the 1st year of training. Determining the minimum number of procedures required to acquire surgical skill can be very useful for establishing guidelines in specialist training programmes.

Darzi and Mackay [30] suggest that three basic components are required to achieve adequate surgical performance: intraoperative judgement, prior knowledge on the part of the surgeon and manual dexterity. According to these authors, technical skills alone are not sufficient to ensure patient safety. In this sense, when incidents or complications occur, sound theoretical knowledge is required to understand the aetiology and to find the most adequate solution for the problem. Indeed, in the present study, the occurrence of incidents such as a root fracture significantly increased the operative time and surgeon-perceived difficulty (VAS score), probably because it required rapid intraoperative judgement, increased surgical skills, knowledge of the main anatomical landmarks and visual-spatial intelligence.

Recording all events, and not only complications, allows the surgeon to become aware of his/her learning process. Indeed, this is an excellent tool for further improvement and better prediction of difficulty. In addition, the evaluation of incidents makes it possible to discriminate which procedures or steps have room for improvement. In the present study, the recording of this variable probably promoted reflective learning, because surgeons were able to analyse why the event took place, thus likely leading them to consider this information in future cases and to modify or adapt the technique in order to prevent such incidents. In fact, when surgical difficulty increases (longer operative time or high difficulty perceived by the surgeon), complication rates seem to be higher [31]. Thus, it is important to consider variables like the position of the third molar or the degree of impaction against the second molar when assessing the difficulty of the procedure and the likelihood of complications [31, 32].

Some studies have demonstrated the correlation between surgical experience and postoperative morbidity and patient's quality of life. Evans et al. [33] showed that patients treated by experienced surgeons had better quality of life in the 1st week than those treated by novice clinicians. Similarly, Sisk et al. [13] reported a fourfold greater risk of complications in patients treated by oral and maxillofacial surgery residents than by experienced professors. In contrast, Vranckx et al. [34] analysed 8672 third molar extractions in 2560 patients and found only minor differences between experienced and novice surgeons—although persistent pain (> 10 days) proved more common with less experienced clinicians. Again, these results underscore the importance of studying the learning curve of surgeons due to its direct impact on the quality of care and treatment outcomes.

We believe this information to be clinically relevant, because it might help to improve oral surgery training and stress the need for lifelong learning. Nevertheless, our study has some limitations. First, each resident performed about 25 extractions, which is a small sample of the surgeries performed throughout their postgraduate studies and professional life. Moreover, the study was performed in a few months, so the learning curve was limited to this period of time. Besides, although the participating students already had basic surgical skills, this gained experience was not taken into account. Lastly, the university context involved could reduce external validity, because these were students who had other students as assistants, with similar surgical knowledge, and who were supervised by assistant professors—thus restricting the surgeons' autonomy.

Nevertheless, evaluation of the learning curve in the field of oral surgery and implantology can foster research aimed at improving the training of students. In this regard, it would be of interest to evaluate the surgeon's intraoperative stress and how it affects the quality of care and patient safety.

5 | Conclusions

A minimum of 10 lower impacted third molar surgical extractions performed by postgraduate students with experience in tooth extractions is required to significantly improve surgical performance in terms of operative time. Incidents seem to slightly decrease with the number of procedures performed.

Surgical difficulty appears to be related to the complexity of the surgical technique (need for ostectomy and/or tooth sectioning) and to the degree of impaction against the second molar. Further studies are required to analyse the evolution of the learning curve in impacted L3M extractions.

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Conflicts of Interest

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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