Frequency Estimates and Risk Factors for Postoperative Morbidity After Third Molar Removal: A Prospective Cohort Study

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Purpose: The aim of this study was to estimate the frequency of postoperative complications after mandibular third molar (M3) surgery and identify the risk indicators.

Patients and Methods: This was a prospective cohort study of a sample of subjects having at least 1 mandibular M3 surgically extracted at a teaching hospital in Jordan. The predictor variables were categorized as patient, anatomic, and operative specific. The outcome variables were postoperative complications recorded as present or absent. Bivariate analyses were computed, then a multivariate logistic regression model was used to identify independent predictors for the common postoperative complications.

Results: The study sample was comprised of 149 patients who had 245 extractions. The mean age was 21.6 ± 3.32 years; 64.9% were females. In the multivariate logistic regression model, age ($P = .033$, odds ratio [OR] = 1.178), M3 side in relation to the handedness of the operator ($P = .048$, OR = 4.078), and lingual retraction ($P = .001$, OR = 11.293) were the variables found as independent predictors for alveolar osteitis. The level of impaction had a significant association with trismus, and operation time acted as an independent predictor for pain ($P < .001$, OR = 1.085).

Conclusion: Postoperative morbidity increases with older age, deeper impaction, M3 side differing from the handedness of the operator, and longer procedures.

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Surgical removal of the third molar (M3) is one of the most common surgical procedures performed as a day case or as an inpatient,[1] and continues to be the most frequent surgical procedure performed in the specialty of oral and maxillofacial surgery.[2] The cost of this procedure to health care providers is substantial.[3,4] Third molars are removed for a variety of reasons, but pericoronitis is the main reason for extraction in most cases.[5] Postoperative complications after surgical removal of the M3 have been reported in different frequencies and extents, ranging from mild discomfort after the operation to major complications that require further treatment, hospitalization, and may result in permanent damage. Therefore, the routine extraction of the M3 when there is no clear indication is discouraged.[6-8] Patients should be given

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information regarding the risks of the procedure based on scientific evidence, and information gathered during the operation should be explained to them.[9] The literature reports several factors that have a significant effect on the occurrence of complications after the surgical procedure. There are patient-related factors, including age, gender, smoking, and the use of oral contraceptives.[10-12] Anatomic-related factors included the level of impaction, angulation, and preexisting inflammatory condition.[11,13] In addition, there are operation-related factors including reflection of flap, bone removal, operation time, and seniority of the operator.[2,13,14]

The aim of this prospective cohort study was to determine the frequency of minor complications after the surgical removal of the M3 at the University of Jordan Hospital (UJH) in Jordan, and to investigate the impact of patient-, anatomic-, and operative-specific indicators on postoperative complications, mainly pain, trismus, and alveolar osteitis.

Patients and Methods

STUDY DESIGN AND SAMPLE

To address the study purpose, the investigators designed and implemented a prospective cohort study. The sample was derived from the population of patients presenting to the oral and maxillofacial surgery (OMFS) department at the UJH for evaluation of impacted mandibular M3s between April 2006 and April 2007. Participants were healthy individuals with no systemic diseases, American Society of Anesthesiologists grade I, who needed extraction of at least 1 impacted mandibular M3. One inclusion criterion was that a mucoperiosteal flap was to be raised during the operation. Exclusion criteria included patients with systemic diseases, patients on medications, female patients who were pregnant or lactating, and those on oral contraceptives. Approval for the study was obtained from the local ethics committee, and informed consent was obtained from patients. Surgical procedures were performed in the day case unit by the OMFS specialists and residents, the latter under supervision by the former. Patients were scheduled for the operation with no correlation between the surgeon and patient, so that a random surgeon operated on the patient.

STUDY VARIABLES

The predictor variables for the study were sets of factors considered credibly related to complications. These were classified as patient variables, anatomic variables, and operative-specific variables. Patient variables included age, gender, and smoking. Age was analyzed as a continuous variable. Anatomic variables included level of impaction (soft tissue, partial bony, or total bony), angulation, and the presence or absence of an inflammatory condition associated with the impaction. The operative-specific variables included type of anesthesia (local anesthesia alone or local anesthesia and sedation), type of flap (envelop or triangular), bone removal, lingual flap retraction, suture type, noticeable inferior alveolar nerve after extraction, intraoperative bleeding, surgeon experience (junior resident, senior resident, and specialist), operation time analyzed as a continuous measure, the M3 side (R/L) in relation to the handedness of the operator (R/L).

The outcome variables were postoperative complications that required further management outside planned treatment, including alveolar osteitis (dry socket), infection, inferior alveolar/lingual nerve paresthesia/anesthesia, unexpected/prolonged trismus (more than 10 mm 7 days postoperatively), and unexpected pain.

All patients were reviewed 7 days postoperatively to have their sutures removed and the surgical site inspected by a statistically blinded specialist examiner who had no access to the preoperative or operation data. Postoperative pain was recorded subjectively using a verbal analog scale (VAS) from 0 (absence of pain) to 10 (worst pain). However, other complications, like infection, alveolar osteitis, trismus, and paresthesia, were objectively recorded by the clinician.

OPERATION

All the surgical procedures were performed in the same theater, using the same surgical instruments, rotary and irrigation devices, and materials. An intravenous cannula was inserted into a vein in the dorsal side of the hand. For sedation, an initial dose of 0.03 mg/kg midazolam was injected; further doses were titred according to patient's need. All patients were given 8 mg dexamethasone and 1 g coamoxiclav i.v. at induction. Local anesthesia was applied using 2% Lidocaine with 1:100,000 adrenaline by local tissue infiltration and inferior alveolar nerve block. A surgical approach using a buccal mucoperiosteal flap was used in all cases. In some cases the decision was made to use lingual retraction intraoperatively if crown sectioning or distal bone removal was necessary. This had to be approved by the supervising specialist. Bone removal was done using a round bur in a straight handpiece under copious irrigation with sterile normal saline. If M3 sectioning was required, this was achieved using a fissure bur and a straight elevator. Lingual retraction and tooth sectioning were performed after consulting the supervising specialist. After the tooth was removed, the socket was inspected, curetted, and irrigated with normal saline. The flap

was then repositioned and sutured with 4-0 silk or Vicryl on a reverse cutting needle. The time from making the incision until finishing suturing was noted. A gauze pack was pressed against the surgical site for the patient to bite on. All patients were given written postoperative instructions and discharge medications: a nonsteroidal analgesic for 5 days and a mouth wash.

DATA MANAGEMENT AND ANALYSIS

Data were collected on a special form designed for this study then entered into a spreadsheet on a local PC over the course of the study. Statistical analysis was performed using SPSS for Windows release 15.0 (SPSS Inc, Chicago, IL). In subjects who had bilateral mandibular M3, random selection of 1 mandibular M3 per subject for analysis, obviating the issue of correlated observations. Bivariate analyses using chi-square tests, independent samples *t* test, 1-way ANOVA, and Spearman correlation were used to determine the associations between the different predictor variables and outcome variables (alveolar osteitis, trismus, and postoperative pain). Differences at the 5% level were accepted as significant. Some patients experienced other complications like postoperative paresthesia and infection; however, the numbers were too small to look for associated factors. Important relationships between the different significant predictors were tested using χ^2 tests, independent samples *t* test and, 1-way ANOVA. Forward stepwise multivariate logistic regression analysis was then used to control for potential confounding variables and to calculate the odds ratios (ORs) and confidence limits for potential independent predictors of the major complications. Biologically relevant variables (age and gender) and variables that had *P* values less than .20 in the initial analyses were entered into logistic regression model as independent variables. Regarding the stepwise analyses, .05 was the cutoff level for including, and .10 was the cutoff level for excluding, a variable in the analyses. The outcome variable postoperative pain (VAS score) was dichotomized before entering the logistic regression model; scores with a value of ≤1 (the median value) were recorded as 0; those of greater than 1 were recorded as 1.

Results

During the study interval, 149 patients were screened for study enrollment. One patient was excluded because she had oral antibiotics prescribed by their general medical practitioners in the postoperative period for reasons not related to her surgery. The final sample for data analyses was composed of 148 subjects having 245 mandibular M3s removed. The descriptive statistics for the sample are summarized in Table 1. The mean age of patients was 21.6 ± 3.32 years, and nearly two thirds of them were females. Most patients had partial bony impactions, and 93.2% were treated under local anesthesia and sedation. Teeth of nearly 79.1% of the patients were extracted after bone removal and tooth sectioning was required in 35.1% of the cases. The mean time to complete surgery was 14.3 ± 9.41 minutes, and ranged from 2 to 48 minutes. First- and second-year OMFS residents treated 17.6% of the patients, third- and fourth-year residents treated 48.6%, while specialists treated 33.8%.

Postoperative complications after the extraction of mandibular M3 are shown in Table 2. The most common complications were unexpected trismus (17.6%), alveolar osteitis (9.5%), infection (2%), transient paresthesia of the inferior alveolar nerve (3.4%) and lingual nerve (2.7%), and 37.2% of patients had a pain score of greater than 1 (the median) on the VAS 1 week postoperatively.

Table 3 summarizes the bivariate associations between the predictor variables and the main postoperative complications: trismus, alveolar osteitis, and pain.

RISK FACTORS FOR ALVEOLAR OSTEITIS

Alveolar osteitis was significantly affected by 7 factors: age of the patient ($P < .05$), the mean age of patients with alveolar osteitis was 23.4 years (±3.71) compared with 21.4 years (±3.24) of those who did not have it, the M3 side differing from the handedness of the operator ($P < .01$), bone removal ($P < .05$), tooth sectioning ($P < .05$), lingual retraction ($P < .001$), visibility of IAN ($P = .002$), and longer operation time ($P < .001$). Of these factors, older age, M3 side differing from the handedness of the operator, and lingual retraction were the only variables identified as independent predictors after controlling for other potential confounders, as shown in Table 4. In this model, the OR for age was 1.178 ($P = .033$), suggesting that for each 1-year increase in age there was an 18% increase in risk of developing alveolar osteitis. Patients who had their left mandibular M3 surgically removed by a right-handed operator were 4 times more likely to have alveolar osteitis (OR = 4.78, $P = .048$), and lingual tissue retraction brought with it an 11 times greater risk (OR = 11.293, $P = .001$). Lingual retraction was strongly associated with bone removal ($P < .001$), tooth sectioning ($P < .001$), and increase in operation time. The removal of left mandibular M3s by a right-handed operator was significantly associated with tooth sectioning ($P = .03$) and required more time (15.8 ± 9.57 minutes) compared with right M3s (13.0 ± 9.15 minutes); this difference was close to statistical significance ($P = .08$).

Table 1. PROFILE OF 148 TREATED CASES

Variable	Category	n	%
Patient variables			
Gender	Male	52	35.1
	Female	96	64.9
Age	Mean	21.6	
	Median	21.0	
	SD	3.32	
	Range	16-42	
Smoking	Yes	27	18.2
	No	121	81.8
Anatomic variables			
Angulation	Mesioangular	73	79.3
	Distoangular	24	16.2
	Vertical	32	21.6
	Horizontal	19	12.8
Level of impaction	Soft tissue impaction	37	25.0
	Partial bony impaction	98	66.2
	Total bony impaction	13	8.8
Inflammation	No	26	17.6
	Yes	122	82.4
Operative variables			
Anesthesia	Local	10	6.8
	Local + sedation	138	93.2
Type of flap	Triangular	126	85.1
	Envelope	22	14.9
Bone removal	No	31	20.9
	Yes	117	79.1
Tooth sectioning	No	96	64.9
	Yes	52	35.1
Lingual flap retraction	No	100	67.6
	Yes	48	32.4
Suture	None	4	2.7
	Silk	45	30.4
	Vicryl	99	66.9
Visibility IAN	No	93	62.8
	Yes	6	4.1
	Missing data	49	33.1
Intraoperative bleeding	No	145	98.0
	Yes	3	2.0
Operation time (min)	Mean	14.3	
	Median	14.0	
	SD	9.41	
	Range	2-48	
Surgeon	First- or second-year resident	26	17.6
	Third- or fourth-year Resident	72	48.6
	Specialist	50	33.8
M3 side	Right	81	54.7
	Left	67	45.3

Abbreviations: IAN, inferior alveolar nerve; SD, standard deviation.

Baqain et al. Risk Factors for Morbidity after Third Molar Removal. J Oral Maxillofac Surg 2008.

RISK FACTORS FOR TRISMUS

Two factors significantly affected the development of trismus in the bivariate analysis (Table 3): level of impaction ($P < .001$) and lingual tissue retraction ($P = .01$). Angulation of the M3 and operation time were close to statistical significance. When multivariate regression analysis was used (Table 5) only the level of impaction maintained significant association with trismus and acted as an independent predictor. When compared with soft tissue impactions, the risk of unexpected trismus for partial bony impactions was around 4 times (OR = 3.669, $P = .093$), and for total bony impactions around 20 times (OR = 20.396, $P = .001$). The level of impaction was significantly associated with retraction of the lingual tissues ($P < .001$); only 10.8% of soft tissue impactions required lingual retraction compared with 35.7% for partial bony and 69.2% for total bony impactions.

RISK FACTORS FOR PAIN

Five factors were found to be significantly associated with postoperative pain in the bivariate analysis: angulation ($P = .001$), bone removal ($P = .01$), tooth sectioning ($P = .004$), lingual flap retraction ($P = .001$), and operation time ($P < .001$). With multivariate regression analysis (Table 6) only operation time acted as an independent predictor. For every minute increase in operating time there was a 9% increase in

Table 2. POSTOPERATIVE COMPLICATIONS

Complication	n	%
Alveolar osteitis		
No	134	90.5
Yes	14	9.5
Trismus		
No	122	82.4
Yes	26	17.6
Infection		
No	145	98.0
Yes	3	2.0
Paresthesia LN		
No	144	97.3
Yes	4	2.7
Paresthesia IAN		
No	143	96.6
Yes	5	3.4
Pain (VAS)		
Mean	2.25	
Median	1.0	
SD	2.50	
Range	0-9	
≤1	62	41.9
>1	55	37.2
Missing cases	31	20.9

Abbreviation: LN, lingual nerve.

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Table 3. ASSOCIATION BETWEEN THE VARIOUS VARIABLES AND POSTOPERATIVE COMPLICATIONS

Variable	Alveolar Osteitis			Trismus			Pain (VAS)		
	n	%	*P**	n	%	*P*	Mean	SD	*P*†
Age			**.039**†			.85†			.12‡
Gender			.22			.16			.96
Male	7	13.5		6	11.5		2.26	2.61	
Female	7	7.3		20	20.8		2.24	2.46	
Smoking			.99			.13			.74
No	11	9.1		24	19.8		2.21	2.62	
Yes	3	11.1		2	7.4		2.41	1.94	
Anesthesia			.29			.83			.87
LA	0	0.0		2	20.0		2.11	2.15	
LA + sedation	14	10.1		24	17.4		2.26	2.53	
Angulation			.46			.052			**.001**
Mesioangular	8	11.0		18	24.7		2.55	2.53	
Distoangular	2	8.3		3	12.5		1.33	1.97	
Vertical	1	3.1		1	3.1		1.04	1.69	
Horizontal	3	15.8		4	21.1		3.72	2.85	
Level of impaction			.07			**<.001**			.08
Soft tissue	0	0.0		2	5.4		1.48	2.05	
Partial bony	12	12.2		17	17.3		2.35	2.52	
Total bony	2	15.4		7	53.8		3.33	2.96	
Inflammation			.74			.81			.80
Absent	2	7.7		5	19.2		2.38	2.25	
Present	12	9.8		21	17.2		2.22	2.57	
Type of flap			.95			.60			.52
Triangular	12	9.5		23	18.3		2.31	2.44	
Envelope	2	9.1		3	13.6		1.88	2.85	
Bone removal			**.04**			.19			**.01**
No	0	0.0		3	9.7		1.05	1.60	
Yes	14	12.0		23	19.7		2.51	2.59	
Tooth sectioning			**.02**			.40			**.004**
No	5	5.2		15	15.6		1.76	2.14	
Yes	9	17.3		11	21.2		3.15	2.87	
Lingual flap retraction			**<.001**			**.01**			**.001**
No	3	3.0		12	12.0		1.68	2.05	
Yes	11	22.9		14	29.2		3.18	2.89	
Suture			.79			.64			.20
None	0	0.0		1	25		0.00	0.00	
Silk	4	8.9		6	13.3		1.97	2.41	
Vicryl	10	10.1		19	19.2		2.43	2.54	
Visible IAN			**.002**			.59			.23
No	8	8.6		22	23.7		2.37	2.57	
Yes	3	50.0		2	33.3		3.67	2.34	
Intraoperative bleeding			.15			.47			.22
No	13	9.0		25	17.2		2.20	2.47	
Yes	1	33.3		1	33.3		4.00	3.61	
Operation time			**.001**†			.09†			**<.001**‡
Surgeon			.19			.14			.91
First- or second-year resident	0	0.0		8	30.8		2.05	2.58	
Third- or fourth-year resident	8	11.1		10	13.9		2.26	2.50	
Specialist	6	12.0		8	16.0		2.33	2.51	
M3 side			**.009**			.10			.29
Right	3	3.7		18	22.2		2.03	2.27	
Left	11	16.4		8	11.9		2.53	2.76	

NOTE. **Bold** text indicates values that are statistically significant.
Abbreviations: SD, standard deviation.
*P value of χ^2 test.
†P value of t test or ANOVA.
‡P value of Spearman's rho.

Baqain et al. Risk Factors for Morbidity after Third Molar Removal. J Oral Maxillofac Surg 2008.

Table 4. STEPWISE LOGISTIC REGRESSION MODEL FOR ALVEOLAR OSTEITIS

Variable	Regression Coefficient	*P* Value	Odds Ratio	Confidence Limits for Odds Ratio
Age	0.164	.033	1.178	1.013-1.370
Lingual flap retraction	2.424	.001	11.293	2.546-50.092
Left third molar	1.406	.048	4.078	1.015-16.389

Baqain et al. Risk Factors for Morbidity after Third Molar Removal. J Oral Maxillofac Surg 2008.

chance (OR = 1.085, $P < .001$) of experiencing pain (VAS > 1). The operation time was found to be significantly associated with angulation ($P < .001$); vertical impactions took in average 9.09 minutes (±6.83) to be removed compared with 11.88 minutes (±9.51) for distoangular, 14.53 minutes (±8.43) for mesioangular, and 24.84 minutes (±8.36) for horizontal impactions. Teeth that required bone removal were extracted within 16.70 minutes (±8.98) compared with 5.0 minutes (±3.19) for those extracted without bone removal ($P < .001$). Teeth that required sectioning were extracted within 22.77 minutes (±8.06) compared with 9.64 minutes (±6.40) for those extracted without sectioning ($P < .001$). In addition, teeth that required lingual retraction were extracted within 20.77 minutes (±9.45) compared with 11.12 minutes (±7.66) for those extracted without lingual retraction ($P < .001$). There was no correlation between operation time and the seniority of the operator.

Discussion

Several studies looked at the relationship between postoperative morbidity after the surgical removal of mandibular M3 and individual risk factors without adjusting for other potential risk indicators.[2,9,15,16] The purpose of this study was to estimate the frequency of postoperative complications after mandibular M3 removal and to identify the risk factors using a multiple logistic regression model to control for potential confounding variables. Our results showed that 37.2% of patients reported pain, 17.6% had trismus, and 9.5% were diagnosed with alveolar osteitis in the follow-up appointment. Several risk factors were associated with the complications. Older age, lingual retraction, and an opposing M3 to the handedness of the operator were associated with an increased risk of alveolar osteitis. Deeper impactions were associated with a higher risk of trismus, and longer operations were associated with prolonged discomfort.

Alveolar osteitis, a well-known and a common complication of surgical extraction of mandibular M3, has a significant morbidity including loss of working days, loss of productivity, and multiple postoperative visits to the clinic.[17] There is a great variation in its reported incidence: 1% to 45%.[9,18-22] This variation is attributed to the differences in diagnostic criteria and the methods of assessment.[17] This study, and in accordance with previous studies, showed a greater risk of developing alveolar osteitis with traumatic and difficult surgery.[2,11,14,22,23] Trauma is known to result in delayed wound healing by compressing bony lining of the socket, thus compromising vascular penetration and the perfusion of the surgical site.[24] Multiple regression model identified lingual retraction as an independent operative variable. Although it is accepted that extractions involving flap reflection are more traumatic,[14] no previous study implicated lingual flap retraction as an etiological factor in this pathology. However, this study showed a significant association between deeper impactions that require more bone removal and/or tooth sectioning and lingual flap reflection. The side of M3 impaction with respect to the handedness of the operator was also identified as a significant risk indicator. The authors are not aware of published literature explaining this, but it is expected that a right-handed operator finds a left M3 more difficult to remove, and vice versa. All the operators in

Table 5. STEPWISE LOGISTIC REGRESSION MODEL FOR TRISMUS

Variable	Regression Coefficient	*P* Value	Odds Ratio	Confidence Limits for Odds Ratio
Level of impaction		.002		
Soft tissue impaction	Reference category		1.000	
Partial bony impaction	1.300	.093	3.669	0.805-16.730
Total bony impaction	3.015	.001	20.396	3.392-122.626

Baqain et al. Risk Factors for Morbidity after Third Molar Removal. J Oral Maxillofac Surg 2008.

Table 6. STEPWISE LOGISTIC REGRESSION MODEL FOR PAIN (VAS)*

Variable	Regression Coefficient	*P* Value	Odds Ratio	Confidence Limits for Odds Ratio
Operation time (min)	0.082	<.001	1.085	1.036-1.1365

Abbreviation: VAS, verbal analog scale.
*Pain used as dichotomized dependent variable ≤1 versus >1 point.

Baqain et al. Risk Factors for Morbidity after Third Molar Removal. J Oral Maxillofac Surg 2008.

this study were right handed. Age was found to be an independent predictor. This is in agreement with previous studies that related postoperative complications to older age.[9,15,22,25,26] A recent study by Chuang et al[22] as part of the American Association of Oral and Maxillofacial Surgeons' Age-Related Third Molar Study showed that patients over the age of 25 years were 46% more likely to develop complications, most commonly alveolar osteitis, than those under the age of 25. It is accepted that increased age is associated with alteration in bone properties including bone density.[15] Earlier studies showed that females, especially those on oral contraceptives, are more likely to get alveolar osteitis after dental extraction, because of the estrogenic effect on coagulation with early fibrinolysis.[9,27,28] However, because females on oral contraceptives were excluded from this study, this could explain the finding that gender had no relation to the incidence of alveolar osteitis. The seniority of the operator had no correlation with the rate of alveolar osteitis, unlike the findings of a previous study, when patients treated by junior surgeons were 3 times more likely to develop alveolar osteitis compared with those treated by specialists.[2] Contrary to previously published research, there was no significant difference between smokers and nonsmokers in the etiology of alveolar osteitis[10,16]; a possible explanation is that smokers constituted a relatively small percentage of cases: 18.2% in this study.

The current study, and in accordance with previous data, showed that deeper impactions had a greater risk of developing trismus. As bony impactions require lengthy procedures involving bone removal and a wider flap reflection, there was a greater chance for damaging adjacent muscles.[11,17,29-31] In this study the mean operation time for the surgical removal of a mandibular M3 (14.3 ± 9.41 minutes) compared favorably with previous studies.[15,29,32] Our results indicate that delayed postoperative pain was more likely with longer operations. This is in line with the findings of previous studies.[29,32] Operation time can be used as a reliable measure of surgical difficulty in mandibular M3 surgery.[15] This was confirmed here. There was a significant association between operation time and difficult angulation (horizontal impactions required the longest operation time), tooth sectioning, and lingual retraction, all signs of a difficult impaction.

It is important to take into consideration the strengths and weaknesses of this study when drawing conclusions. The prospective design minimizes selection and recall bias of subjects and blinding the examiner to operative and preoperative variables ensures absence of bias in reporting outcome variables. However, the results cannot be generalized, as subjects with less complicated conditions are not routinely referred to a university hospital to be treated by OMFSs. To minimize the effect of correlated observations with bilateral extractions random selections of 1 M3 per subject for analysis was performed. Our results suggest that few patients experienced serious or long-term complications. Older age, lingual retraction, deeper impaction, M3 side differing from the handedness of the operator, and longer procedures are important risk factors for postoperative morbidity in the surgical removal of mandibular M3. The relevant patient and anatomic variables have to be discussed with patients preoperatively as they are predetermined factors; however, operation variables, mainly lingual retraction, should be discouraged. Future research will focus on studying less common and more serious complications like infections and neurosensory deficits.

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