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Systematic Review
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Patient, radiological, and operative factors associated with surgical difficulty in the extraction of third molars: a systematic review

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Abstract. The aim of this systematic review was to determine the patient, radiological, and operative variables associated with surgical difficulty in the extraction of third molars, according to a visual analogue scale completed by the surgeon, operative time, or surgical technique. Searches of the PubMed (MEDLINE), Scopus, and Cochrane Library databases were conducted by two independent reviewers. Randomized and non-randomized clinical trials and prospective cohort studies evaluating surgical difficulty in the extraction of impacted mandibular or maxillary third molars according to patient, radiological, and operative variables were included. The full texts of 21 of the 859 articles initially retrieved were analysed, and 15 articles were included in the final systematic review. All 15 reported prospective cohort studies. The following variables were found to be on the spectrum of highly difficult or complex cases: older patient age and being overweight (patient variables), surgeons with little experience and the use of complex surgical techniques requiring tooth sectioning linked to hard tissue impaction (operative variables), and adverse radiological factors such as deep impaction, unfavourable angulation and root morphology, and a close relationship with the second molar, maxillary sinus, or the inferior alveolar nerve canal (radiological variables).

Key words: third molar; surgical difficulty; surgical procedures; oral surgery.

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Removal of the impacted third molar is one of the most common procedures in oral and maxillofacial surgery[1,2]. Many studies have been conducted in order to predict surgical difficulty. In 1976, MacGregor[3] presented the first predictive model of surgical difficulty based on radiological variables. Although many classification systems, including those of Winter[4], Pell and Gregory[5], and Pederson[6], have scales for rating difficulty, none of them has been accepted worldwide and most are based on preoperative radiological variables[7]. In recent years, some studies have introduced demographic parameters and operative variables, such as surgeon experience and surgical technique, in order to predict surgical difficulty[2,8–15]. Surgeon experience remains a controversial issue. While some authors contend that this factor contributes directly to determining surgical difficulty[1,13,14], others have shown that there is little difference in terms of operative time between experienced and inexperienced surgeons[15–17].

A previously published systematic review on this topic by Akadiri and Obiechina[18] included studies that measured surgical difficulty only using operative time. The main conclusions drawn were that in addition to radiological variables, age (as a demographic variable) and surgeon experience and surgical technique (operative variables) were also important factors in determining surgical difficulty. Since some studies on this topic have evaluated surgical complexity using either surgical techniques[11,12] or the surgeon's subjective assessment on a visual analogue scale (VAS)[2,8,10], a new updated systematic review can be justified.

The ultimate goal of predicting surgical difficulty is to formulate an adequate treatment plan in order to reduce postoperative morbidity[1,19] and to inform the patient about the entire procedure they will be undergoing, as well as making them aware of the possible complications prior to the surgery, thereby improving patient satisfaction levels[1]. The identification of individuals at high risk of postoperative complications would also help in the management of pre- and postoperative preventive measures[20].

The main objective of this systematic review was to determine the patient, radiological, and operative variables associated with surgical difficulty in the removal of third molars, as determined by a VAS completed by the surgeon, operative time, or surgical technique.

Materials and methods

This systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[21]. A PICOS question was designed in order to answer the objective of the study: ''In patients with impacted third molars, which patient, radiological, and operative variables compared one to the other could increase surgical difficulty, as demonstrated by randomized or non-randomized clinical trials, as well as prospective cohort studies?''

Study selection criteria

The types of studies included were randomized and non-randomized clinical trials and prospective cohort studies evaluating surgical difficulty in the removal of impacted mandibular or maxillary third molars, taking into account patient, radiological, and operative variables. Retrospective cohort studies, cross-sectional studies, case series studies, and case reports were excluded. No restriction on language or publication date was applied.

The main outcome variable was surgical difficulty as measured on a VAS by the surgeon (that included the surgeon's

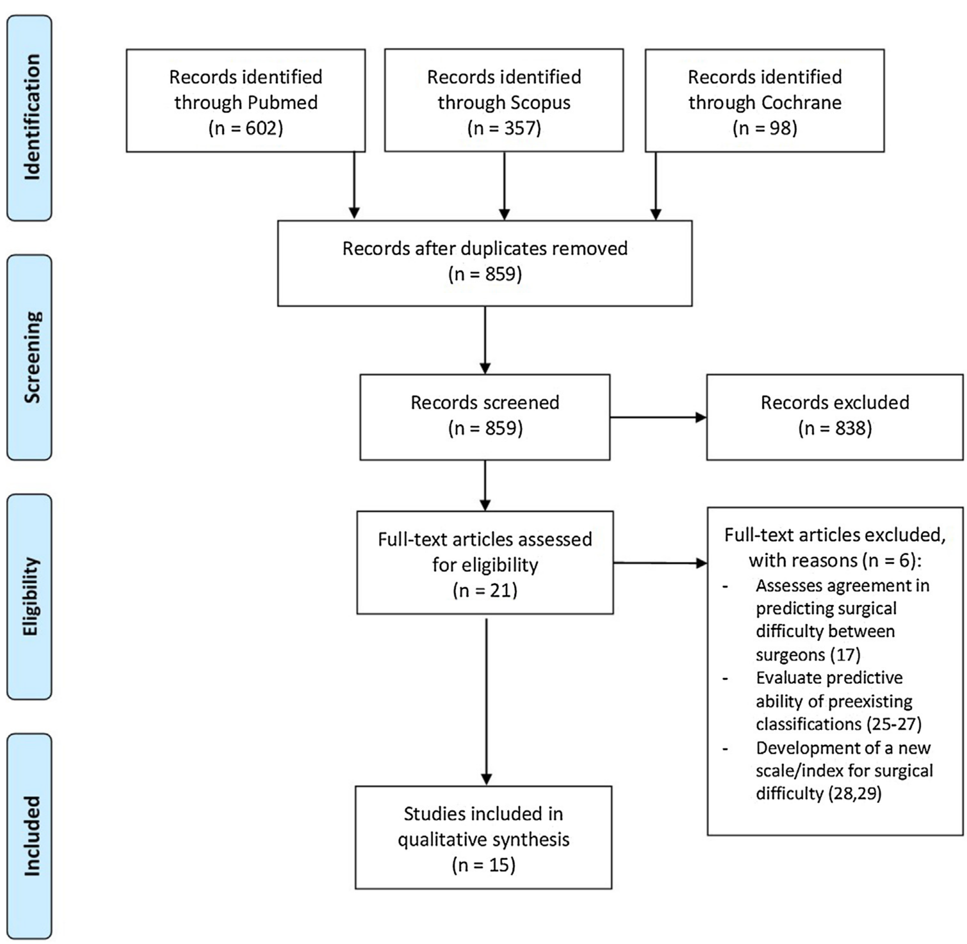

Fig. 1. Systematic review process. Flow chart of article selection through the systematic review process according to the PRISMA guidelines.

profile), operative time (in minutes), or surgical technique (the need for ostectomy, crown and/or root sectioning). Secondary variables were all characteristics assessed in the included studies that were closely associated with an increase in surgical difficulty. No follow-up time of the patients was registered, as the variables were collected preoperatively or during the surgical interventions performed in the selected studies; hence the length of follow-up was not considered in the eligibility criteria. Whenever possible, the significant factors were chosen from multivariate analyses performed in the studies.

Search strategy

An independent electronic search was conducted from December 15, 2018 to February 5, 2019 in the PubMed (MEDLINE), Scopus, and Cochrane Library databases. The search strategy used was (''Risk Factors''[MeSH] OR risk indicators OR surgical difficulty) AND (''Molar, Third''[MeSH] OR wisdom teeth OR third molar removal OR third molar extraction). A manual search was also done by examining the references of the selected articles.

Selection of studies

The articles were first screened by abstract and title in order for the two independent reviewers to decide on their eligibility (JSC, MUB). Next, a complete

Author	Number		Method for estimation of difficulty			SIGN score	NOS scale			
	Patients	Molars	Operative time	100 mm VAS	Surgical technique		Selection	Comparability	Outcome	TOTAL
MANDIBLE										
Akadiri et al. 2008 (9)	79	79				2++	**		***	5
Alvira-González et al. 2017 (2)	130	130				2++	***		***	6
Aznar-Arasa et al. 2014 (10)	102	102				2++	***		***	6
Benediktsdóttir et al. 2004 (32)	335	388				2++	***		***	6
Carvalho & Vasconcelos 2011 (11)	285	473				2++	***		***	6
Carvalho & Vasconcelos 2018 (12)	465	753				2++	****	*	***	8
Gbotolorun et al. 2007 (1)	87	90				2+	**		***	5
Renton et al. 2001 (13)	354	354				2++	***		***	6
Santamaria & Arteagoitia 1997 (34)	100	100				2++	***		***	6
Susarla & Dodson 2004 (8)	82	133				2++	***		***	6
Susarla & Dodson 2005 (35)	150	243				2++	***		***	6
Susarla & Dodson 2013 (30)	150	243				2++	***		***	6
Tenglikar et al. 2017 (33)	40	40				2+	**		***	5
Yuasa et al. 2002 (14)	44	44				2++	****	*	***	8
MAXILLA										
Carvalho et al. 2013 (31)	106	204				2++	***		***	6
Susarla & Dodson 2004 (8)	82	117				2++	***		***	6
Susarla & Dodson 2013 (30)	150	207				2++	***		***	6

Fig. 2. Characteristics of the studies selected for the systematic review. The number of participants and third molars extracted, the method/s used to estimate the surgical difficulty (highlighted in grey), the level of evidence (SIGN, Scottish Intercollegiate Guidelines Network), and the risk of bias (NOS, Newcastle–Ottawa scale) are shown.

evaluation of the full texts of the selected articles was performed. A third reviewer (CGE) resolved any discrepancies. Cohen's kappa coefficient was calculated to determine the level of agreement between the reviewers regarding the articles selected.

Data extraction and method of analysis

Data from the articles were extracted and entered into tables, and included the author names, year of publication, assessment criteria, and factors significantly associated with an increase in surgical difficulty (classified into patient, radiological, and operative variables). The level of evidence from the selected articles was assessed according to the Scottish Intercollegiate Guidelines Network (SIGN) grading system[22].

Risk of bias and heterogeneity assessment

The *Cochrane Handbook for Systematic Reviews of Interventions*, version 5.1.0, was used to assess the risk of bias in randomized clinical trials and the heterogeneity, distinguishing between three types: clinical diversity, methodological diversity, and statistical heterogeneity[23]. The Newcastle–Ottawa scale (NOS) for assessing the quality of non-randomized studies was used for the cohort studies[24].

Results

Study selection and description

Figure 1 shows the flow chart of the articles selected through the systematic review process. Of the 859 articles initially retrieved in the search, 838 were excluded by title and abstract. After full-text evaluation, the authors agreed to eliminate six articles, due to the reasons shown in the flow chart[17,25–29]. Fifteen articles were finally included in the systematic review and all of them were prospective cohort studies[1,2,8–14,30–35]. The level of agreement between reviewers was excellent for PubMed ($\kappa = 0.913$), Scopus ($\kappa = 0.803$), and the Cochrane Library ($\kappa = 1$).

A total of 2509 patients with 3700 third molars (528 upper and 3172 lower) were treated. Figure 2 shows the main characteristics of the included studies according to the number of participants and third molars, the method/s used for estimating surgical difficulty, the level of evidence (SIGN), and risk of bias (NOS).

Risk of bias and heterogeneity assessment

According to the NOS scale, three articles were classified as low quality[1,9,33], 10 articles as moderate quality[2,8,10,11,13,30–32,34,35], and two were deemed to be high quality[12,14]. The last two articles were the only ones that had a point of comparison, as these studies included preoperative surgical difficulty.

Regarding heterogeneity, the studies only differed in clinical diversity because

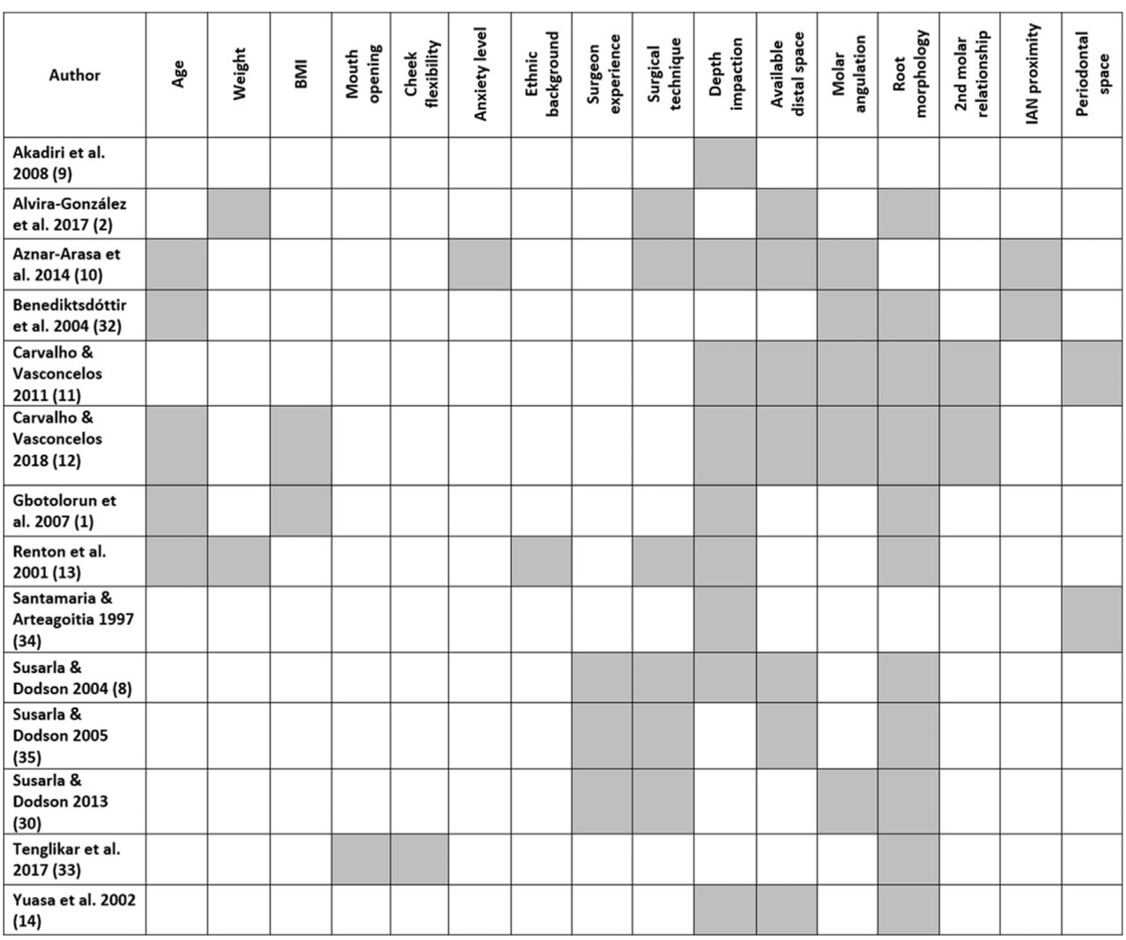

Fig. 3. Mandibular third molars: variables significantly related to surgical difficulty. (BMI, body mass index; IAN, inferior alveolar nerve.).

they studied distinct outcome variables. Overall, there was a low methodological diversity and the great majority of them used multivariate statistical analysis.

Qualitative assessment

The information extracted from the articles with regard to variables significantly related to surgical difficulty in mandibular third molar removal is displayed in Fig. 3 and given in more detail in Tables 1–3 [1,2,8–14,30,32–35]. The results of the study by Susarla and Dodson[35] included in this review, only relate to mandibular third molars, as no separate analysis for maxillary third molars is included in the article. The majority of variables studied and significantly related to surgical difficulty were radiological. Overall, Pell and Gregory type 3C, horizontal or distoangular angulation, and the presence of divergent or bulbous roots and tooth germ increased the surgical difficulty. With regard to demographic variables, the results showed that increased patient age and being overweight were also relevant factors. Patient anxiety rated on validated scales directly influenced the difficulty as rated by the surgeon on a 100-mm VAS and increased the operative time. Finally, one study, conducted by Renton et al.[13], found that difficulty was increased for people of black ethnicity, since the operative time was longer. Operative variables like the need for an ostectomy, tooth sectioning, and full bony impaction increased surgical difficulty. Furthermore, the experience of the surgeon was shown to be a major factor affecting difficulty[8,30,35].

The information regarding maxillary third molars is shown in Fig. 4 and given in more detail in Table 4. Only three studies were included[8,30,31]. Some characteristics found to influence surgical difficulty in the extraction of mandibular third molars were the same for this anatomical location. Being overweight (as measured by the body mass index) and operative variables such as full bony impaction and surgeon experience also influenced difficulty in terms of operative time and the score on a 100-mm VAS. Carvalho et al.[31] found that deep impaction near the maxillary sinus and impaction towards the distal aspect of the second molar were factors associated with increased surgical difficulty.

Table 1. Patient variables related to surgical difficulty in the extraction of mandibular third molars. The subcategories that were found to increase difficulty significantly are shown in bold.

Authors	Age (years)	Weight	BMI (kg/m2)	Mouth opening	Cheek flexibility	Anxiety level	Ethnic background
Alvira-González et al. 2017[2]	–	F: <57 kg/**≥57 kg** M: <77 kg/**≥77 kg**	–	–	–	–	–
Aznar-Arasa et al. 2014[10]	Scale variable	–	–	–	–	MDAS: Anxious: ≥19 Non-anxious: <18 DFS: Anxious: ≥63 Non-anxious: <62	–
Benediktsdóttir et al. 2004[32]	>23	–	–	–	–	–	–
Carvalho and Vasconcelos 2018[12]	<25 ≥25	–	Ideal weight: 18.5–24.9 Overweight: ≥25	–	–	–	–
Gbotolorun et al. 2007[1]	16–24 / 25–35 / >**35**	–	<18 / 18–25 / 25–30 / >**30**	–	–	–	–
Renton et al. 2001[13]	**≥30**	**≥85 kg**	–	–	–	–	White, **Black African**, **Black Caribbean**, Indian, Pakistani, Chinese
Tenglikar et al. 2017[33]	–	–	–	Restricted mouth opening	Minimum cheek flexibility	–	–

BMI, body mass index; DFS, Dental Fear Survey; F, female; M, male; MDAS, Modified Dental Anxiety Scale.

Table 2. Operative variables related to surgical difficulty in the extraction of mandibular third molars. The subcategories that were found to increase difficulty significantly are shown in bold.

Author	Surgeon experience	Complexity of surgical technique
Alvira-González et al. 2017[2]	–	Ostectomy Crown odontosection **Crown and root odontosection**
Aznar-Arasa et al. 2014[10]	–	Ostectomy **Crown and/or root odontosection** Soft tissue coverage (**total**/partial/no) Bone coverage (**total**/partial/no)
Renton et al. 2001[13]	–	Non-impacted Soft tissue impaction **Hard tissue impaction**
Susarla and Dodson 2004[8]	Number of years since completion of residency	Erupted, non-surgical/surgical Soft tissue impacted Partial bony impacted Full bony impacted
Susarla and Dodson 2005[35]	Number of years since completion of residency	Erupted, non-surgical/surgical Soft tissue impacted Partial bony impacted Full bony impacted
Susarla and Dodson 2013[30]	Number of years since completion of residency	Erupted, non-surgical/surgical Soft tissue impacted Partial bony impacted **Full bony impacted**

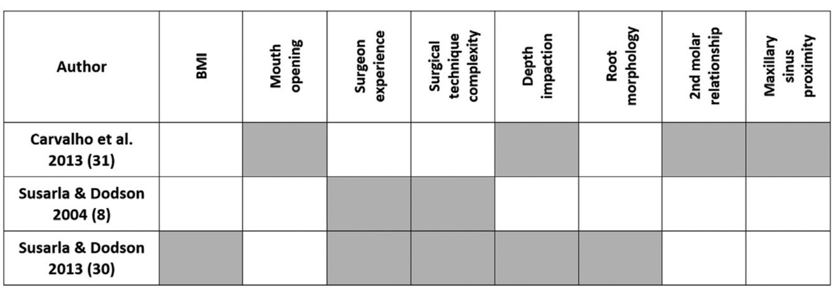

Fig. 4. Maxillary third molars: variables significantly related to surgical difficulty. (BMI, body mass index.).

Discussion

Almost all of the articles included in this systematic review used the operative time as the method for estimating surgical difficulty. Moreover, some of them used a 100-mm VAS or the surgical technique in order to rate surgical difficulty. This review aimed to determine the patient, radiological, and operative variables associated with surgical difficulty in the removal of impacted third molars. The results showed that there are characteristics within each type of variable that influence operative complexity. One drawback of this report is that the majority of studies addressed the complexity of mandibular third molar removal, but only a few did so for maxillary third molars. This hinders the direct comparison of factors between these two anatomical areas. In fact, some authors stated that the degree of difficulty of maxillary third molar extraction tends to be low, which is probably due to low bone density in this region[8,30]; therefore the complexity of this surgery is not often valued, although there are reports of complications requiring complex management[31].

Many studies have found that radiological factors are related to surgical difficulty for both upper and lower third molars, with the depth of impaction, distal space available, molar angulation, and root morphology being the main variables contributing to the difficulty. Moreover, the proximity of the roots to the maxillary sinus[31] and also to the mandibular canal[11] are factors associated with increased difficulty, probably because the operative time is longer since more accurate techniques are required in order to prevent complications such as oroantral communication or nerve damage, respectively. The fact that previous scales of difficulty have mainly been based on radiological factors may have led to an underestimation of other variables such as patient characteristics[2,11,13] and surgeon experience[2,11]. In fact some studies, like the one published by Alvira-González et al.[2], state that radiographic factors may be insufficient for predicting surgical difficulty. A recently validated difficulty index for mandibular third molars introduced by Carvalho and Vasconcelos[12] includes clinical, demographic, and radiographic factors and has obtained high performance values, indicating it to be a reliable tool. This was developed by using the operative time and surgical technique as outcome variables for difficulty, and one of the main advantages seems to be including patient factors.

With regard to demographic variables, some articles found that increased patient age and being overweight are associated with more difficult procedures and a longer operative time[1,13,32], which is in contrast to the results of Susarla and Dodson[8]. Older patients may have higher bone density and a greater likelihood of having ankylosis, with both factors contributing to more complex procedures[2]. In contrast, no relationship between age or being overweight and surgical difficulty was found for maxillary third molars[31]. Being overweight may reduce visibility of the surgical area[2], probably due to the thickness of the cheek tissue[11,13,31]. Only one study on maxillary third molars, published by Carvalho et al.[31],

Table 3. Radiological variables related to surgical difficulty in the extraction of mandibular third molars. The subcategories that were found to increase difficulty significantly are shown in bold.

Author	Depth of impactiona	Available distal space[a]	Molar angulation[b]	Root morphology	Second molar relationship	IAN proximity	Periodontal space
Akadiri et al. 2008[9]	A / B / C	–	–	–	–	–	–
Alvira-González et al. 2017[2]	–	1 / 2 / 3	–	**Bulbous Divergent** Merged Parallel Separated Curved Convergent	–	–	–
Aznar-Arasa et al. 2014[10]	A / B / **C**	1 / 2 / **3**	Mesioangular Vertical **Distoangular** **Horizontal**	–	–	Signs of proximity to mandibular canal (Rood and Shehab 1990)	–
Benediktsdóttir et al. 2004[32]	–	–	Mesioangular Vertical Distoangular **Horizontal**	Number of roots: $\geq$**2 roots**	–	'Close' proximity	–
Carvalho and Vasconcelos 2011[11]	A / B / **C**	1 / 2 / **3**	Mesioangular Vertical Distoangular **Horizontal**	Root curvature: Non-dilacerated **Dilacerated** Number of roots: One fused root **2 roots** **Tooth germ**	No contact Contact with crown alone **Contact with crown and root** Contact with root alone	–	Radiolucent Mixed **Radiopaque**
Carvalho and Vasconcelos 2018[12]	A / B / **C**	1 / 2 / **3**	Mesioangular Vertical **Distoangular** **Horizontal**	Root curvature Non-dilacerated **Dilacerated** Number of roots One fused root **2 roots** **Tooth germ**	No contact Contact with crown alone **Contact with root**	–	–
Gbotolorun et al. 2007[1]	>6 mm[c]	–	–	Curvature of roots Incomplete roots Straight roots Favourable roots	–	–	–

Table 3 (*Continued*)

Author	Depth of impaction[a]	Available distal space[a]	Molar angulation[b]	Root morphology	Second molar relationship	IAN proximity	Periodontal space
				Curved in opposite direction or against path of elevation			
Renton et al. 2001[13]	>8 mm[c]	–	–	Favourable	–	–	–
				Unfavourable: divergent, bulbous			
Santamaria and Arteagoitia 1997[34]	0–4 mm	–	–	–	–	–	≥1 mm
	4.1–8 mm						0.9–0.1 mm
	>8 mm						0 mm
Susarla and Dodson 2004[8]	A / B / C	1 / 2 / 3	–	Favourable	–	–	–
				Unfavourable			
Susarla and Dodson 2005[35]	–	1 / 2 / 3	–	Favourable	–	–	–
				Unfavourable			
Susarla and Dodson 2013[30]	–	–	Mesioangular	Favourable	–	–	–
			Vertical Distoangular Horizontal	**Unfavourable**			
Tenglikar et al. 2017[33]	–	–	–	Favourable	–	–	–
				Unfavourable			
Yuasa et al. 2002[14]	A / B / **C**	1 / 2 / **3**	–	Width of root	–	–	–
				Thin and thick **Bulbous**			

IAN, inferior alveolar nerve.

[a] Depth of impaction and available distal space according to the Pell and Gregory classification[5].

[b] Molar angulation refers to the Winter classification[4].

[c] Distance from the top of the alveolar crest vertically to the point of application of the elevator.

Table 4. Patient, operative, and radiological variables related to surgical difficulty in the extraction of maxillary third molars. The subcategories that were found to increase difficulty significantly are shown in bold.

Author	BMI (kg/m2)	Mouth opening	Surgeon experience	Complexity of surgical technique	Depth of impaction	Root morphology	Second molar relationship	Maxillary sinus proximity
Carvalho et al. 2013[31]	–	**<45 mm**	–	–	Mesioangular	–	No contact	Apex with no contact with cortex of MS
					Vertical		Contact with crown alone	**Apex in contact with cortex of MS**
					Distoangular		**Contact with crown and root**	
					Horizontal		**Contact with root alone**	
Susarla and Dodson 2004[8]	–	–	Number of years since completion of residency	Erupted, non-surgical	–	–	–	–
				Erupted, surgical Soft tissue impacted Partial bony impacted Full bony impacted				
Susarla and Dodson 2013[30]	Scale variable	–	Number of years since completion of residency	Erupted, non-surgical	Mesioangular	Favourable	–	–
				Erupted, surgical Soft tissue impacted Partial bony impacted **Full bony impacted**	Vertical Distoangular Horizontal	**Unfavourable**		

BMI, body mass index; MS, maxillary sinus.

demonstrated greater difficulty in patients with a maximum mouth opening of less than 45 mm. The authors recommended not exceeding this limit in order to ensure an easier procedure, since contraction of the muscle may press the cheek tissue against the surgical area thereby impairing visibility and manipulation of the area. The influence of patient ethnic background on surgical difficulty was demonstrated in only one study, published by Renton et al.[13], in which it was found that procedures performed on people of black ethnicity were more difficult. However, the authors stressed that these individuals had a significantly higher incidence of bone impaction, horizontal angulation, crown width, and unfavourable root morphology, thus making them characteristic features for this ethnic group.

In addition, variables related to the surgical procedure and surgeon experience seem to have a clear connection with difficulty. The studies list the experience of the surgeon in years. However, there is no threshold that classifies the practitioner as having little experience, or being moderately or highly experienced. Arbitrarily, it may seem that 10 years of practice or more constitutes a high level of experience and thus a senior surgeon. Carvalho et al.[31] found that 55.9% of maxillary third molar extraction procedures were considered to be low difficulty. This means that a thorough diagnosis, particularly for inexperienced clinicians, is imperative in order to detect very complex cases and thus be able to prevent complications that may require advanced knowledge and management. Likewise, Susarla and Dodson[8] also found that maxillary third molars were easier to extract than mandibular molars, probably due to bone density, since the *a* coefficient (constant value) obtained in the multivariate linear regression model had an extraction time of 1.5 minutes for maxillary third molars and 7.8 minutes for mandibular third molars in the absence of other factors. Interestingly, an article published by Komerik et al.[17] on mandibular third molar removal, comparing the estimated preoperative operation time based on clinical and radiographic factors between resident surgeons and senior surgeons, showed similar results for the two levels of surgical experience. Specifically, only 109 of 200 surgeries were correctly categorized, thus showing that preoperative assessment may be unreliable.

Preoperative assessment for surgical difficulty may help the practitioner refer the case to a specialist when necessary and may also predict possible complications so that the patient can be properly informed before consenting to the procedure[1,13,17].

In accordance with the available scientific literature, this review has highlighted the main characteristics of complex mandibular and maxillary third molar extractions. To conclude, the following variables were found to be on the spectrum of highly difficult or complex cases: increased patient age and being overweight (patient variables), surgeons with little experience and the use of complex surgical techniques requiring tooth sectioning linked to hard tissue impaction (operative variables), and adverse radiological factors like deep impaction, unfavourable angulation and root morphology, and a close relationship with the second molar, maxillary sinus, or IAN canal.

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Competing interests

None of the authors of the manuscript has any conflict of interest related to this study.

Ethical approval

Not applicable.

Patient consent

Not required.

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