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Etiological factors for mandibular fractures in transoperative period of tooth extraction: systematic review

Fatores etiológicos para fraturas mandibulares no transoperatório de extração dentária: revisão sistemática

Factores etiológicos de las fracturas mandibulares en el período transoperatorio de extracción dental: revisión sistemática

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Abstract

Objectives: to analyze the possible etiological factors associated with mandibular fractures occurring during tooth extractions. Methods the following data were collected: sex, age, the extracted tooth, tooth classification, angulation, level of bone impaction, pathological association, recognized technical errors, instruments used at the time of the fracture, and the surgeon's experience and specialization, if applicable. An electronic search of the following databases was performed: PubMed/Medline, Lilacs, Embase, and Scopus. The data were tabulated and analyzed using the Chi-square test, a P-value less than 0.05 was considered significant. Results: a total of 80 cases were selected. Sex and age were not statistically significant (P>0.05). The teeth most associated with fractures were the mandibular third molars; however, the location was not significant. Pell & Gregory classes II, B, C, mesio-angular teeth, partial bone impaction, teeth related to pathological process, application of

excessive strength, extractions with elevators, and non-specialists showed greater association with mandibular fractures during transoperative time (P<0.05).

Keywords: Tooth extractions; Mandibular fractures; Molar; Molar, Third.

Resumo

Objetivos: analisar os possíveis fatores etiológicos associados às fraturas mandibulares ocorridas durante as exodontias. Métodos: foram coletados os seguintes dados: sexo, idade, dente extraído, classificação do dente, angulação, nível de impactação óssea, associação patológica, erros técnicos reconhecidos, instrumentos usados no momento da fratura e experiência e especialização do cirurgião, se aplicável . Uma busca eletrônica nas seguintes bases de dados foi realizada: PubMed / Medline, Lilacs, Embase e Scopus. Os dados foram tabulados e analisados por meio do teste Qui-quadrado, sendo considerado significativo um valor de P menor que 0,05. Resultados: foram selecionados 80 casos. Sexo e idade não foram estatisticamente significativos (P> 0,05). Conclusão: Os dentes mais associados às fraturas foram os terceiros molares inferiores; entretanto, a localização não era significativa. Pell & Gregory classes II, B, C, dentes mesioangulares, impactação óssea parcial, dentes relacionados ao processo patológico, aplicação de força excessiva, extrações com elevadores e não especialistas mostraram maior associação com fraturas mandibulares durante o tempo transoperatório (P < 0,05).

Palavras-chave: Extrações dentárias; Fraturas mandibulares; Dente molar; Dente Serotino.

Resumen

Objetivos: analizar los posibles factores etiológicos asociados a las fracturas mandibulares ocurridas durante las extracciones. Métodos: se recolectaron los siguientes datos: sexo, edad, diente extraído, clasificación dentaria, angulación, nivel de impactación ósea, asociación patológica, errores técnicos reconocidos, instrumentos utilizados en el momento de la fractura y experiencia y pericia del cirujano, en su caso. Se realizó una búsqueda electrónica en las siguientes bases de datos: PubMed / Medline, Lilacs, Embase y Scopus. Los datos se tabularon y analizaron mediante la prueba de Chi-cuadrado, considerándose significativo un valor de P inferior a 0,05. Resultados: se seleccionaron 80 casos. El sexo y la edad no fueron estadísticamente significativos (P> 0,05). Conclusión: Los dientes más asociados a fracturas fueron los terceros molares inferiores; sin embargo, la ubicación no fue significativa. Pell & Gregory clases II, B, C, dientes mesioangulares, impactación ósea parcial, dientes relacionados con el proceso patológico, aplicación de fuerza excesiva, extracciones con

elevadores y no especialistas mostraron una mayor asociación con fracturas mandibulares durante el período transoperatorio (P <0.05).

Palabras clave: Extracción dental; Fracturas mandibulares; Diente Molar; Tercer Molar.

1. Introduction

Tooth extraction is the most frequently performed oral surgical procedure, The following are the most common related complications; hemorrhage, pain, mandibular fracture, luxation of other teeth, nerve and soft tissue damages, emphysema, trismus, and infection.[1,2] Mandibular fracture is a rare complication that can be detected during extraction or in the immediate postoperative weeks with 0.0049% of incidence.[3]

Mandibular fractures during tooth extraction normally occur as a result of improper instrumentation with the application of excessive forces onto the bone.[3,4] Mandibular bone atrophy, osteoporosis, and other pathological processes, can reduce bone resistance.[4] Male patients of 35 years or older are at a higher risk for the occurrence of mandibular fractures after tooth extraction.[4,5] It is believed that bone elasticity is reduced with age; further, the use of certain medications can alter the bone density.[6,7] The type of tooth impaction and the surgeon's experience are related factors to the incidence of mandibular fractures during and after extraction.[1,2] The methods of treatment for the fractures range from soft diet, to open reduction and internal fixation under general anesthesia.[2,4,8]

The aim of this study was to perform a systematic review of literature to analyze the possible etiological factors for the occurrence of mandibular fractures during to identify the main risk factors and determine steps to minimize their occurrence.

2. Methodology

This review was performed following the guidelines of the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement and PICO was adapted for Population, Exposition and Outcome (PEO) format, which was developed to healthcare interventions without comparative groups.[9] The articles were selected based on the titles and abstracts by two authors (J.P.B. and G.A.C.M.), and there was no disagreement among them regarding the articles selected.

Eligibility criteria

The studies of this review fulfilled the following established PEO index criteria: (1) Population: Patients with necessity of tooth extraction; (2) Intervention: Patients who underwent tooth extraction; (3) Comparison: Patients who had mandibular fracture during the procedure; (4) Result: The main result of this study was based on the assessment of the etiological factors of the mandibular fractures during the tooth extractions and determination of the main factors that contributed to the fractures.

Information sources

An electronic search was performed in March of 2020, with no restrictions on the date or language, in the following databases: PubMed/Medline, Lilacs, Embase, and Scopus.

Search

The follow keywords “Molar, Third” and “Mandibular Fractures” available on "medical subject headings" (MeSH, PubMed) were selected. Subsequently, several combinations of these terms were used in the search.

Study selection

The inclusion criteria included randomized studies, prospective and retrospective studies, case reports, case series, letter to the editor, and opinion of expertise about the mandibular fractures during tooth extraction, with no restrictions on the date or language.

Exclusion criteria included as the following: articles or cases in the selected studies that generated doubt regarding the timing of the fracture (during extraction or postoperatively

Data collection process

For the selection of titles, abstracts, and full reading of the articles, a Kappa test was carried out resulting in the following concordance values: K = 1.1 for PubMed/MEDLINE; K = 1.1 for Lilacs; K = 1.1 for Embase; and K = 1.1 for Scopus.

After analyzing all the titles and abstracts, 36 articles were considered eligible for this systematic review.

Data items

From the studies included after the final analysis, the following data, when available, were extracted: year of the publication, number of cases, article type, sex, age, extracted tooth, classification of the impacted lower third molar (classification de Pell e Gregory)[10], angulation (classification de Winter), level of bone impaction, pathological association, Type of anesthesia, recognized technical errors, instrument used during the fracture, and the surgeon's experience and specialization, if applicable.

Risk of bias in individual studies

The selected manuscripts were analyzed regarding the clinical evidence (Table 1). The articles were classified according their evidence level, as proposed by the National Health and Medical Research Council (NHMRC).[11]

Table 1. Reports of mandibular fracture during the tooth extraction.

Authors	Year	Number of cases	Article type	Level of evidence	
Hammer [24]	1955	2	Case series	IV	Poor
Nyul [25]	1959	4	Case series	IV	Poor
Nęcek [26]	1965	2	Case series	IV	Poor
Ohm [27]	1966	1	Case series	IV	Poor
Harnisch [28]	1971	2	Case series	IV	Poor
Farish [12]	1972	1	Case report	IV	Poor
Haunfelder and Tetsch [29]	1972	3	Case series	IV	Poor
de Carvalho et al. [30]	1977	1	Case report	IV	Poor
Borea et al. [31]	1977	7	Systematic review/case series	I	Satisfactory
Berlin [32]	1977	2	Case series	IV	Poor
Schneider [33]	1980	1	Case series	IV	Poor
Barsekow [34]	1981	1	Case report	IV	Poor
Gusmán et al. [20]	1990	1	Case series	IV	Poor
Lizuka et al. [18]	1997	1	Case series	IV	Poor
Libersa et al. [3]	2002	17	Letter to professionals	IV	Poor
Tamashiro-Higa and Inclán [35]	2003	1	Case series	IV	Poor
Shinohara et al. [36]	2004	1	Case report	IV	Poor
Woldenberg et al. [15]	2007	1	Case report	IV	Poor
Valiati et al. [37]	2008	1	Case report	IV	Poor
Santos et al. [38]	2009	1	Case report	IV	Poor
Niedzielska et al. [39]	2009	5	Case series	IV	Poor
Lombardi et al. [19]	2010	2	Case series	IV	Poor
Chrcanovic et al. [14]	2010	1	Systematic review/case series	I	Satisfactory
Gallego et al. [42]	2010	1	Case report	IV	Poor
Grau-Manclús et al. [6]	2011	7	Case series	IV	Poor
Cankaya et al. [41]	2011	2	Case report	IV	Poor
Hiregoudar [42]	2012	1	Case report	IV	Poor
Ethunandan et al. [8]	2012	1	Systematic review/case series	I	Satisfactory
Özçakir-Tomruk and Arslan [43]	2012	2	Case series	IV	Poor
Duarte et al. [44]	2012	1	Case series	IV	Poor
Zhang et al. [45]	2012	1	Case report	IV	Poor
Msagati et al. [46]	2013	1	Descriptive studies	III-3	Satisfactory
Rodrigues et al. [47]	2013	1	Case report	IV	Poor
Oliveira et al. [48]	2013	1	Case report	IV	Poor
Xu et al. [2]	2014	1	Short report	IV	Poor
Bonardi et al. [16]	2015	1	Case report	IV	Poor
Total		80			

Source: Authors.

The relationship between the frequency of the fractures and the following parameters were analyzed: tooth to be extracted, inclusion type, pathological association, age, sex,

recognized technical errors, instrument used at the moment of the fracture, and experience of the surgeon with tooth extractions.

Additional analyses

Measurement data were organized in an Excel table (Microsoft Office Excel, Redmond, WA, USA). A Chi-square test was used to evaluate the differences between the analyzed parameters, comparing the observed group to the expected group.

3. Results and Discussion

Through the database searches, 476 articles were found, of which 36 were included in this review (Fig.1). They included 80 cases of mandibular fractures that occurred during the tooth extractions.

Level of evidence

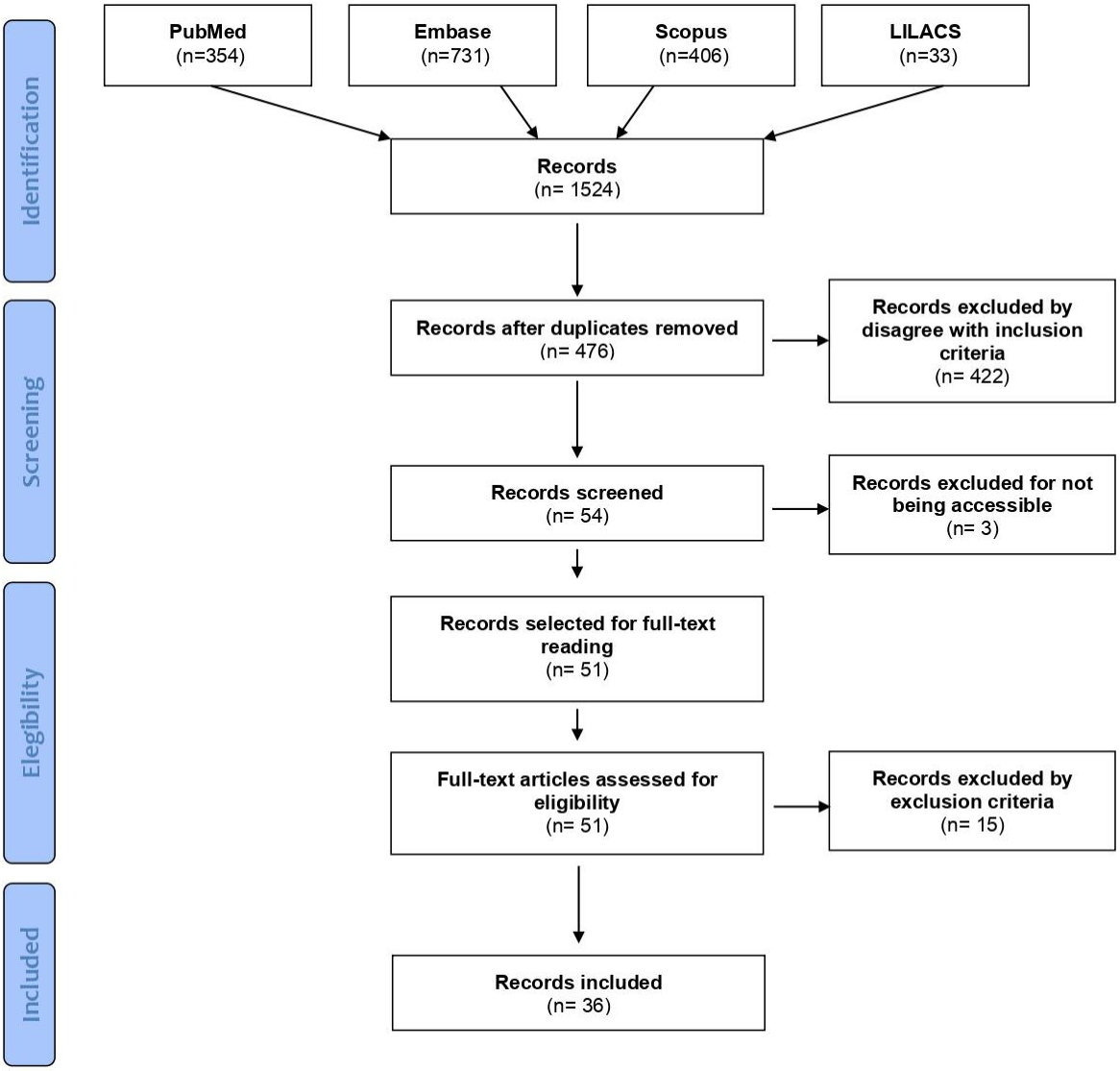
Of the 36 selected articles, 32 had a poor evidence level and 4 had a satisfactory evidence level.

Sex and age

Sex was reported in 65 cases, age in 63 cases, and ethnical group in only 7 cases.

53.8% were female patients and 46.2% were male patients ($P > 0.05$). The highest incidence of fractures was found in the age range 26 to 35 years (18 cases), followed by 36 to 45 years (17 cases) ($P > 0.05$), which represents 55.5% of cases (Table 2).

Figure 1. Flow diagram of the study selection for the systematic review.



Source: Authors.

Table 2. Gender and age associated to mandibular fractures during tooth extractions.

Variable	Number of cases		%
Gender	Male	30	46.1
	Female	35	55.8
Age (Years)	<25	14	22.2
	26-35	18	28.6
	36-45	17	30.0
	46-60	9	14.3
	>60	5	7.9

Source: Authors.

The tooth to be removed at the time of the fracture was reported in 62 cases. The highest incidence of mandibular fractures occurred during the extraction of inferior third molars, which comprised 79.0% of the cases. Of these, the right inferior third molar was associated with the most associated mandibular fractures (26 cases; 41.9%); however, this was not significant when compared to the contra lateral side (37.1%; P = 0.06) (Table 3).

Table 3. Local factors that could be associated to the risk of mandibular fracture.

Variable	Number of cases		%
Tooth	Left mandibular third molar	23	37.1
	Right mandibular third molar	26	41.9
	Left mandibular second molar	1	1.6
	Right mandibular second molar	3	4.8
	Left mandibular first molar	3	4.8
	Right mandibular first molar	2	3.2
	Left mandibular second premolar	2	3.2
	Right mandibular second premolar	1	1.6
	Right maxillary third molar	1	1.6
Tooth classification	Antero-posterior to third molars		
	I	6	22.2
	II	17	63.0
	III	4	14.8
	Vertical to third molar		
	A	5	18.51
	B	11	40.7
	C	11	40.7
Angulation	D	4	13.3
	H	4	13.3
	M	14	46.7
	V	7	23.3
	Angular vestibule	1	3.3
Level of bone impaction	Complete	6	27.3
	Partial	15	68.2
	With no bone recovery	1	4.5
Pathological association	None	2	11.1
	Follicular cyst or increased follicle	12	66.7
	Osteogenesis imperfecta	1	5.5
	Odontoma follicular	1	5.5
	Radicular granuloma	1	5.5
	Radicular cyst	1	5.5

D: Disto-angular; H: Horizontal; M: Mesio-angular; V: Vertical. Source: Authors.

Classification of the tooth

Pell & Gregory classification was reported in 27 cases. The most frequent classes were II, B, and C (Table 3).

The angulation of the tooth was reported in 30 of the reported cases of mandibular fractures. Mesio-angulation impaction was related to 14 cases of associated mandibular fracture (46.7%) followed by 7 (23.3%) related to vertical angulation ($P < 0.05$) (Table 3).

The level of bone impaction was reported in 22 cases. Partial impaction was most frequent type of impaction that was related to mandibular fracture (15 cases; 68.2%), followed by full impaction (6 cases; 27.3%), and 1 (4.5%) case of no impaction ($P < 0.05$) (Table 3).

There were 18 cases mandibular fracture was associated with periapical pathology. A follicular cyst or simply an increase of the follicle was associated with 12 cases of mandibular fracture (75.0%; $P < 0.05$) cases (Table 3).

Type of anesthesia

The type of anesthesia was reported in 24 cases of mandibular fracture associated with dental extraction and the surgery was performed under general anesthesia only in three cases (Table 4).

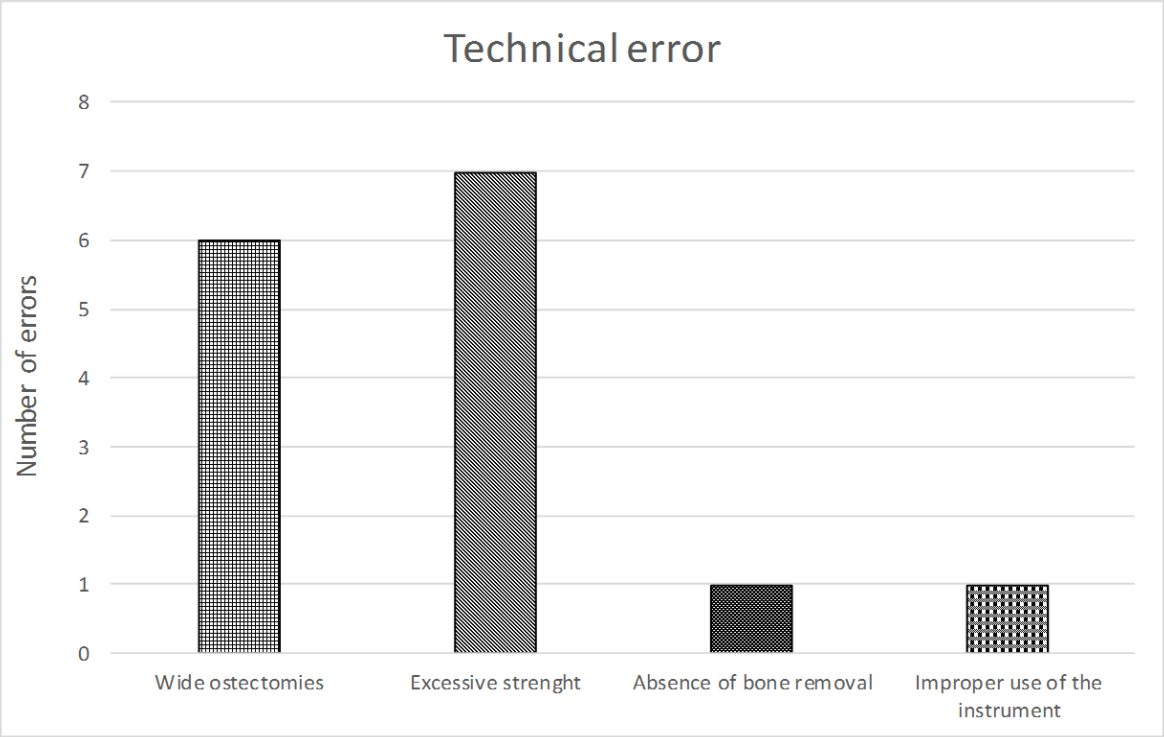
Table 4. Factors associated to the technique and professional formation.

Variable	Number of cases		%
Type of anesthesia	General anesthesia	3	12.5
	Local anesthesia	21	87.5
Recognized technical errors	Wide ostectomies	6	40
	Excessive strength	7	46.7
	Absence of bone removal	1	6.7
	Improper use of the instrument	1	6.7
Instrument	Elevator	21	70
	Forceps	2	6.7
	Chisel + elevator	2	6.7
	Chisel	2	6.7
	Elevator + Forceps	2	6.7
	Chisel + Forceps	1	3.3
Surgeon's experience	Yes	5	33.3
	No	10	66.7
Specialist Surgeon	Yes	5	22.7
	No	17	77.3

Source: Authors.

Regarding the technical errors, a significant difference was found between excessive force and absence of bone removal (P = 0.04), as well as excessive force and use of improper instruments (P = 0.04). There was no significant difference between extensive bone removal and excessive force (P = 0.78) and between extensive bone removal and absence of ostectomies or utilization of improper instruments (P = 0.06) (Fig. 2).

Figure 2. Representative chart of the different technical errors, in which excessive strength is more prevalent.



Source: Authors.

The type of instrument used during the procedure that resulted in the mandibular fracture was reported in 30 cases. The elevator was used in 21 (70.0%) cases, followed by the forceps (2 cases), chisel plus elevator (2 cases), chisel (2 cases), elevator plus forceps (2 cases), and chisel plus forceps (1 case) ($P<0.05$) (Table 4).

The surgeon's experience was reported in 15 cases. In 10 (66.7%) cases the surgeon had limited surgical experience ($P = 0.19$) (Table 4).

Only 22 articles reported whether the surgeon was a specialist, 77.3% of the cases of the reported mandibular fractures occurred when the operator was a not a specialist ($P = 0.01$) (Table 4).

Bodner et al.[1] reported that mandibular fractures are related to tooth extractions during the trans- and postoperative periods with a male to female ratio of 2.2:1, the highest incidence was in the age range of 40 to 49 years. In a similar study, Ethunandan *et al*.[8] presented a male to female ratio of 1:1.3, with the highest incidence in the age group of 36- to 45-years, for fractures that occurred during the transoperative period; and a 3.9:1 ratio, with biggest incidence in the age group of 36- to 60-year for fractures that occurred during the postoperative period. In a review of mandibular fractures after third molar extractions by Pires

et al.[9] it was observed that 73.7% of the cases occurred in male patients, aged between 46 to 60 years. Thus, the authors concluded that the risk of mandibular fracture increases with the age. These authors attributed these results to the major force of the mandible during chewing generated by the male patient in conjunction with a decrease of bone elasticity, osteoporosis, periodontal ligament narrowing, and ankylosis in the elderly.[9] In this review, the sex distribution was similar to that found by Ethunandan *et al*.,[8] with regard to fractures that occurred during the transoperative period, with a male:female patient ratio of 1:1.2 ($P > 0.05$). This showed there was no difference between the sexes. however, an analysis of the data in Table 2 showed a balanced distribution between the age groups. Therefore, the literature reviewed in this study showed no evidence for age significance to the occurrence of mandibular fractures during dental extraction.

We found no clinical trials or systematic reviews that exclusively analyzed the relationship between the extraction of a specific tooth and mandibular fractures. The review that provides results closest to this issue was described by Bodner *et al*.,[1] which combined the incidence of fractures during the trans- and postoperative periods. The results were like those found in this review, in which the third molars had the highest association with mandibular fractures during the transoperative period. Regarding the fractures of the mandibular angle, the result of this review also resembles those described in the literature,[1,8,9] in which the difference between the sides is not significant. An interesting finding reported by Farish,[12] was the fracture of the coronoid process during the extraction of the maxillary third molar (Table 3).

The literature describes the Pell and Gregory classes II/III and B/C as having the highest association with mandibular fractures during tooth extractions.[8,9,13] The disto-angular position is considered as more difficult to execute and often requires extensive bone removal.[14] Teeth that were totally impacted in bone have the highest incidence of mandibular fracture during extraction.[1,8,9] In this review, classes I/II and B/C were the most prevalent. Although reports state that the most difficult position for extraction is the disto-angular,[15] the results of this review are consistent with other studies that show that the extraction of the mesio-angular and vertical teeth are more frequently associated with mandibular fractures.[1,8,9,16] This result can be justified by the fact these angulations occur more frequently in the general population.[17] Among the different results found in the literature, partial bone impaction had the highest association with fractures during a procedure (Table 3).

Teeth with a pathological lesion occupy bone space, leading to weakness at the region, which favors the occurrence of a fracture during extraction[5,18] (Table 3).

Furthermore, the use of general anesthesia was reported in three cases. According to Xu et al.,[2] the patient underwent to general anesthesia due a previously angle osteoctectomy planned. However, during procedure it was opted to remove the third molar tooth and, probably due the bone weakening, occurred the mandible fracture. Study by Lombardi et al.[19] did not report the reason to perform the surgery under general anesthesia. Only one author[20] reported that the patient had the procedure carried out under general anesthesia due the high risk of mandible fracture which could be immediately fixed if it occurred during the removal of the tooth. The literature suggests that mandibular fractures during the transoperative period occur due to improper surgical technique.[8] Grau-Manclús *et al*.[5] report in a case series in which the elevator of Winter was used for the luxation of the tooth, which allows for the application of significant strength and requires a reasonable level of experience before Bodner *et al*.[1] reported in their review that there was no statistical difference in the surgeon's experience, however the highest number of the fractures was associated with inexperienced surgeons. The authors agree that the transoperative mandibular fracture is associated with improper technique and the risk of occurrence is inversely related to the experience of the surgeons; however, their results did not prove this fact. In our review, technical error was recognized and reported in 15 cases, of them only two cases reported that surgeon was experienced and a specialist. In these two cases, the technical error was excessive bone removal and the most frequent error was excessive application of force (46.7% of the cases). The association of fractures with the use of elevators was also clear, in which 70.0% of the cases was related to the use of the instrument. Only 15 cases reported whether the operator was experienced, and 22 cases reported whether the surgeon was a specialist. Despite the low number of reports, the results regarding the level of specialization were significant ($P = 0.01$), but insignificant in relation to the level of experience ($P = 0.19$).

Despite the low number of cases reporting experience of the surgeon, it was noted that Pell & Gregory class I, mesio-angular teeth, and vertical impaction which are relatively easier to remove surgically are associated with the highest incidence of mandibular fractures which suggest that the etiological factor was a technical error related to the limited experience of the operator . In addition, the largest number of technical errors were due to inexperienced professionals. The large number of inexperienced or non-specialist professionals and the use of elevators were associated with most of the fractures. These results strongly suggest that the inexperience of the surgeon is one of the main factors contributing to the occurrence of mandibular fractures during the transoperative period. With these findings, the steps to be taken in order to reduce transoperative mandibular fractures would be related to the training

of the inexperienced professionals on the surgical procedure during their graduate period or even restricting to the complex extractions to the specialists.

4. Final Considerations

Thus, it can be concluded that etiological factors of transoperative mandibular fractures during tooth extractions are related to the surgical difficulty and professional inexperience. However, regarding inexperience, the data in the literature is still scarce. Therefore, more studies are necessary, or this information should be reported more often in case reports or case series.

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