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Original Article

A 10-year retrospective study on mandibular fractures in Northern Taiwan

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KEYWORDS
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Trauma;
Road traffic accident

Abstract *Background/purpose:* The mandible is an independent and protruding bone structure in the lower third portion of the human facial skeleton. Because of its prominent and unprotected position, the mandible is a primary site of facial trauma. Previous studies have not comprehensively discussed the association between the mandibular fractures and concomitant fractures of facial bones, the trunk, or limbs. This study analyzed the epidemiology of mandibular fractures and their correlation with concomitant fractures.
Materials and methods: The present study enrolled 118 patients with a total of 202 mandibular fracture sites during at any time from January 1, 2012, to December 31, 2021, in northern Taiwan.
Results: According to the study results, the patients between 21 and 30 years of age had the highest occurrence of trauma, and road traffic accidents (RTAs) constituted the primary cause of mandibular fractures. Fall-related injuries were significant in patients >30 years of age. By the analysis of Pearson's contingency coefficient, the number of mandibular fractures was not significantly associated with concomitant fractures of the extremities or the trunk. However, accompanying maxillary fractures can be regarded as an indication of concomitant extremity or trunk fractures in patients with mandibular fractures.

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Conclusion: Three-site mandibular fractures are not necessarily accompanied by extremity and trunk fractures; however, clinicians should implement multidisciplinary examination and management in patients with mandibular fractures accompanied by maxillary fractures. Maxillary fractures can be regarded as an indication of concomitant fractures of other facial bones, the extremities, or the trunk.

Introduction

The mandible, or lower jaw, is an independent bone structure in the lower third portion of the human facial skeleton. It determines facial appearance and supports the chewing function. The mandible is an unprotected and mobile bone that protrudes from the skull base. Due to its prominent and vulnerable position, traffic accidents and other physical injuries result in a high incidence of mandibular fracture. Research has revealed the mandible to be the most involved bone in maxillofacial fractures related to interpersonal violence.[1] A retrospective US study also reported that mandibular fractures were the most frequently fractured facial bone in emergency departments[2]; a retrospective Taiwanese study identified mandibular fractures to be the second most common fracture site.[3]

The epidemiology of mandibular fracture varies by geographic area, age, ethnicity, socioeconomic status, laws, and accident type. Although studies have described the epidemiology of mandibular fractures in central and southern Taiwan,[4–6] those studies have not comprehensively discussed the association between the mandibular fractures and concomitant fractures of facial bones, the trunk, or limbs. In addition, studies have not investigated the epidemiology of mandibular fractures in northern Taiwan. To examine the characteristics of mandibular fracture epidemiology in northern Taiwan, this study analyzed the mandibular fractures of an inpatient group in the Department of Oral and Maxillofacial Surgery at Wan Fang Hospital in Taipei, Taiwan, from January 1, 2012, to December 31, 2021, in accordance with the Dingman and Natvig classification of mandibular fractures. The incidence of concomitant fracture sites was also investigated.

Materials and methods

Patients and population

This study was conducted at Wan Fang Hospital in Wenshan District, Taipei, in northern Taiwan. Wenshan District is home to five universities, two high schools, a military base, a metro station, and several large communities. The population of Wenshan District was approximately 250,000 to 260,000 during the study period. This study was approved by the Institutional Review Board of Taipei Medical University Hospital (approval number TMU-JIRB No. N202203062). This retrospective study reviewed the data of patients who received treatment in the Department of Oral and Maxillofacial Surgery at Wan Fang Hospital between January 1, 2012, and December 31, 2021.

Data collection

The study included patients with mandibular fractures with or without other body fractures. The study excluded patients with incomplete registration data. Detailed patient information was retrieved, which included age, sex, cause of injury (i.e., assault, fall, motorcycle accident, motor vehicle accident, bicycle accident, ball game-related injury, pedestrian injury), and fractures of the extremities or the trunk. Mandibular fracture sites were recorded and labeled in accordance with the following Dingman and Natvig classifications: symphyseal, parasymphyseal, body, angle, ramus, coronoid process, subcondylar, and condylar. Other fracture sites were grouped into the following five categories: maxillary, other facial bone (excluding mandibular and maxillary), upper limb, lower limb, and pelvic. A total of 118 patients with 202 mandibular fracture sites were included.

Statistical analyses

The chi-square test was employed to compare categorical variables (e.g., sex and age) between injury causes for the corresponding P value (Table 1). Statistical significance was indicated at $P < 0.05$. Pearson's contingency coefficient was implemented to compare mandibular and maxillary fracture counts between body fractures (Fig. 6, Table 2), in addition to condylar or subcondylar fractures between different mandibular fracture sites (Table 3). All results are presented as correlation coefficients.

Results

Our study included 75 male and 43 female patients (male: female = 1.74:1). The mean age was 32.08 (range: 6–86) years. The 118 patients had a total of 202 mandibular fractures recorded from medical records and radiography. Five patients whose injury causes could not be identified from their medical charts were excluded from the analysis of fracture causes.

The patients between 21 and 30 years of age had the highest occurrence of trauma (35 of 113 patients), followed by those between 11 and 20 years of age (Fig. 1). Among the study participants, 63.71% (72 of 113 patients) were under 30 years of age. Road traffic accidents (RTAs) were the primary cause of mandibular fracture and accounted for

Table 1 Descriptive statistics for sex and age.

N	Fighting	Fall	Motorcycle	Car	Bicycle	Relating to ball game
	7	28	52	17	6	3
Sex						
male (%)	4 (5.3)	14 (18.7)	37 (49.3)	12 (16.0)	3 (4.0)	3 (4.0)
female (%)	3 (7.0)	14 (32.6)	15 (34.9)	5 (11.6)	3 (7.0)	0 (0.0)
P-value[a]	1.000	0.138	0.184	0.705	0.785	0.471
Age						
> 30 (%)	4 (8.5)	17 (36.2)	17 (36.2)	4 (5.6)	2 (4.3)	1 (2.1)
<30 (%)	3 (4.2)	11 (15.5)	35 (49.3)	13 (18.3)	4 (5.6)	2 (2.8)
P-value[a]	0.571	**0.018**	0.224	0.224	1.000	1.000

[a] Chi-square test.

injuries in 75 of 113 patients (66.10% of patients; motorcycle accidents 46.0%, motor vehicle accidents 15.0%, bicycle accidents 5.3%). The second most common cause was fall-related injuries (28 of 113 patients, 24.7%); other causes included assault (7 of 113 patients, 6.1%) and ball game-related injuries (3 of 113 patients, 2.6%) (Fig. 2). The results of the chi-square test indicated no significant association between patient sex and cause of injury. When analyzing the etiology of injuries by age, the results indicated a significant association between patients over 30 years of age and falls. In addition, motorcycle accidents were the primary cause of mandibular injuries, regardless of sex or age, but the association was not statistically significant (Figs. 3 and 4).

With respect to the severity of mandibular fracture, 51 of 118 patients (43.22%) had a single mandibular fracture, 50 of 118 (42.37%) had two mandibular fractures, and 17 of 118 (14.40%) had three mandibular fractures. No patient in this study had a mandibular fracture in more than four sites. Out of the total 202 mandibular fracture sites, the parasymphyseal area (47 of 202, 23.26%) was the most common location, followed by the condyle (39 of 202, 19.30%) and the subcondyle (38 of 202, 18.81%; Fig. 5). In an analysis with all fractures from the entire body falling into a single category, single mandibular fractures were the most common type (83 of 118, 70.3%), followed by co-occurring maxillary fractures (11 of 118, 9.30%) and upper limbs with maxillary fractures (5 of 118, 4.20%). In addition, the results indicated no significant difference between mandibular fracture site numbers and fractures of the extremities and the trunk (Fig. 6).

Furthermore, the results indicated that single versus double mandibular fracture status was not associated with the severity of mandibular fracture or with the presence of fractures of other bones in the face, extremities, or trunk (Table 2). A weak but significant correlation was noted for the following fracture types: (1) three-site mandibular fractures without other fractures ($r = 0.184$, $P = 0.042$), (2) single mandibular fractures accompanied with single maxillary fractures, which were correlated with facial bone fractures accompanied with upper limb fractures ($r = 0.161$, $P = 0.076$), and (3) in bimaxillary fractures affecting five sites. Moderate correlations were found between lower limb fractures ($r = 0.218$, $P = 0.015$) and other facial bone fractures accompanied with upper limb fracture ($r = 0.218$, $P = 0.015$).

The results showed no correlation for the following fracture types. The first was bimaxillary fractures affecting three sites; no correlation was indicated with other fractures ($r = 0.255$, $P = 0.004$), other facial bone fractures ($r = 0.220$, $P = 0.014$), or other facial bone fractures accompanied with upper limb ($r = 0.307$, $P < 0.001$) and pelvic fractures ($r = 0.324$, $P < 0.001$). The second was bimaxillary fracture affecting four sites; no correlation was indicated with other fractures ($r = 0.287$, $P = 0.001$), upper limb fractures ($r = 0.234$, $P = 0.009$), other facial bone fractures ($r = 0.238$, $P = 0.008$), upper and lower limb fractures ($r = 0.184$, $P = 0.042$), or other facial bone fractures accompanied with lower limb fractures ($r = 0.184$, $P = 0.042$). The third was bimaxillary fractures affecting six sites.

The correlation between condylar or subcondylar fractures and other mandibular fracture sites (Table 3) were analyzed. The results indicated a weak but significant correlation between left mandibular fractures and right subcondylar fractures ($r = 0.241$, $P = 0.007$), bilateral condylar or subcondylar fractures and symphyseal fractures ($r = 0.192$, $P = 0.033$), and left condylar fractures and no mandibular fracture ($r = 0.195$, $P = 0.031$). Regarding of the relation between injury cause and the severity of mandibular fracture, the only significant correlation was found between the falling the three-site fracture (Table 4).

Discussion

According to previous studies, the epidemiology of mandibular fractures may be affected by geographic and population characteristics, such as demographic composition, laws, and types of transportation.[3–17] Wan Fang Hospital is located in a densely populated area with a diverse population in terms of age, career, and socioeconomic status. This district also contains many metro stations, highway exits, and motorcyclists. These geographic and population characteristics create a valuable dataset to study the epidemiology of mandibular fractures.

The results of this study revealed that patients between 21 and 30 years of age had the highest incidence of mandibular fractures; our results are similar to those of a previous retrospective study conducted in central Taiwan whose results indicated that the highest incidence of mandibular fractures was among individuals between 21

Table 2 Correlation between mandibular fracture severity, bimaxillary fracture, and fractures of other parts of body.

	Mandible = 1	Mandible = 2	Mandible = 3	Maxilla + Mandible = 2	Maxilla + Mandible = 3	Maxilla + Mandible = 4	Maxilla + Mandible = 5	Maxilla + Mandible = 6
Nil	0.096	0.121	**0.184***	0.044	**0.255***	**0.287***	0.125	0.049
Lower limb	0.041	0.064	0.066	0.030	0.050	0.047	**0.218***	0.017
Upper limb	0.038	0.028	0.088	0.041	0.068	**0.234***	0.047	0.023
Other facial bone	0.097	0.094	0.046	0.021	**0.220***	**0.238***	0.025	0.012
Pelvis	0.039	0.045	0.046	0.021	0.035	0.033	0.025	0.012
Upper limb + Lower limb	0.008	0.115	0.057	0.026	0.168	**0.184***	0.030	0.015
Lower limb + other facial bone	0.008	0.002	0.057	0.026	0.044	**0.184***	0.030	0.015
Upper limb + other facial bone	0.138	0.133	0.066	**0.258***	**0.307***	0.047	**0.218***	0.017
pelvis + other facial bone	0.069	0.066	0.033	0.015	**0.324***	0.023	0.017	0.009

**P*-value <0.05.
Correlation coefficient was calculated by Pearson's contingency coefficient.

and 30 years of age.[4] However, a study in India reported the greatest occurrence of fractures in young adults, with a mean age of 36 years.[7] Another study in the United Kingdom found that the majority of patients with fractures were between the ages of 10 and 40 years.[8] According to that study, the highest incidence of fractures occurred in the 20s for men and in the 30s for women.[8]

The causes of mandibular fractures vary by region but primarily comprise motor vehicle accidents, falls, and assault.[2,4,9–12,14] Our study results revealed that 66.10% of mandibular fractures were caused by RTAs, followed by falls and assault; RTAs resulting in mandibular fracture were most commonly caused by motorcycles. Our study findings agreed with those of previous studies conducted in Taiwan.[3–6] This finding may be explained by the fact that motorcycles are the primary mode of private transportation in Taiwan.[5] Furthermore, the second major fracture cause was fall-related injuries. The results did not indicate a significant difference in all-cause fracture with respect to sex. However, the results indicated a significant difference in fall-related fractures with respect to age when evaluating individuals younger and older than 30 years of age; a particularly significant difference was noted for individuals in their 50s.

The results of this study identified single fracture as the primary mandibular fracture pattern, followed by two-site mandibular fracture and three-site fracture. However, a study in central Taiwan reported that 57.1% patients had multiple mandibular fractures.[5] Among those patients with a single fracture, parasymphyseal mandibular fractures were the most common, followed by mandibular condylar fractures. After reviewing relevant studies, we concluded that the most common mandibular fracture site in the US was the angle, whereas the most common site in Turkey was the body.[13] In Italy, the condyle was the most commonly affected region,[14] followed by the parasymphyseal area and the angle. Another retrospective study in southern Taiwan revealed that the condylar neck and head were the most common areas of mandibular fractures, followed by the parasymphyseal area and the symphyseal area.[3] Regardless of etiology, research has established that the most prevalent mandibular fracture sites include the symphyseal and parasymphyseal areas and the condyle and subcondyle.[3,4,6,9,14,15] Some authors have reported that fracture site is related to impact type, which can be categorized as low-velocity blunt force trauma or high-velocity blunt force trauma. Mandibular angle fractures were the most common injury site caused by low-velocity blunt force trauma, which includes assault and falls. High-velocity blunt force trauma, such as that caused by RTAs, can result in a greater number of condylar fractures and subsequent symphyseal fractures.[15] Our study results identified motorcycle accidents as the primary cause of mandibular fractures, a finding that was consistent with the most common fracture site of the parasymphyseal area, followed by condylar fractures. Studies have reported a correlation between mandibular angle fractures and assault.[15–17] Seven patients in our study had undergone assault with six mandibular angle fractures in twenty mandibular angle fractures; these results revealed a strong association between assault and mandibular angle fracture.

Table 3 Correlative mandibular fracture pattern.

	left mandible	left mandible & symphysis	right mandible	right mandible & symphysis	symphysis	left and right mandible	left and right mandible & symphysis	no mandbile fracture
left condyle	0.168	0.054	0.003	0.054	0.156	0.127	0.044	**0.195***
left subcondyle	0.129	0.062	0.127	0.062	0.040	0.144	0.050	0.142
right condyle	0.055	0.052	0.119	0.052	0.139	0.121	0.042	**0.347***
right subcondyle	**0.241***	0.054	0.131	0.054	0.071	0.127	0.044	0.126
no condyle/ subcondyle	0.125	0.173	0.127	0.173	0.124	**0.384***	0.142	**0.403***
left and right condyle/subcondyle	0.201	0.059	0.081	0.059	**0.192***	0.139	0.048	0.108

*P-value <0.05.
Correlation coefficient was analyzed with Pearson's contingency coefficient.

Moreover, mandibular fractures can have multiple accompanying anatomic subsites. Understanding the varying patterns of concomitant fractures is of crucial importance for clinicians. A retrospective Italian study revealed that 10.5% of patients had combined maxillofacial fractures.[14] In addition, the most frequent accompanying maxillofacial fractures were those of the zygomatic complex.[3] The most common patterns in our study were mandibular fracture only, followed by accompanying maxillary fracture and mandibular fracture combined with maxillary and upper limb fracture.

To analyze the association between mandibular fracture severity and fractures of the extremities and the trunk, we divided the patients based on the number of mandibular fractures; we then recorded the number of patients with accompanying fractures of the extremities and the trunk. Although the results indicated no significant difference between the number of mandibular fracture sites and fractures of the extremities and the trunk, they did indicate that patients with three mandibular fracture sites had a lower rate of accompanying fractures of the extremities and the trunk. This finding may result from the fact that the mandible directly absorbed the force of the impact during injury. To further investigate concomitant mandibular fractures, we analyzed the correlation of various combinations of bimaxillary fractures between the facial bones, the extremities and the trunk. The analyses of Pearson's contingency coefficient (Table 2) revealed a correlation between mandibular fractures and other facial bone fractures, such as zygomatic fractures and accompanying upper limb fractures, even with single maxillary and mandibular fractures. The results also revealed many moderate or significant correlations between bimaxillary fractures and extremity and trunk fractures. Our data demonstrated that maxillary fractures play a crucial role in the investigation of extremity and trunk fractures in patients with mandibular fractures. This may be due to the partial protection of the maxilla by the mandible and zygoma.

The most frequent two-fracture combination in this study consisted of left mandibular body and right mandibular condylar fractures, followed by right parasymphyseal and left condylar fractures. The most frequent three-fracture combination in this current study included mandibular symphyseal, right mandibular condylar, and left

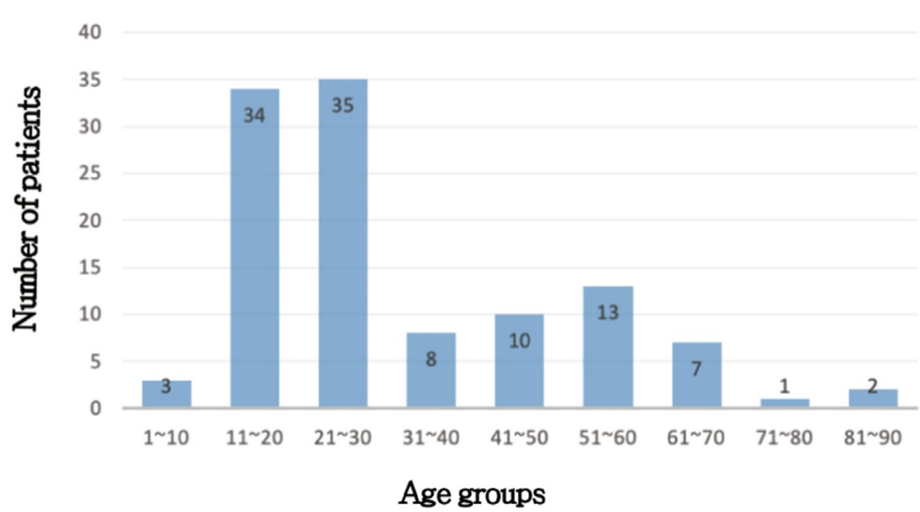

Figure 1 Distribution of patients ($n = 113$) with mandibular fractures stratified by age group.

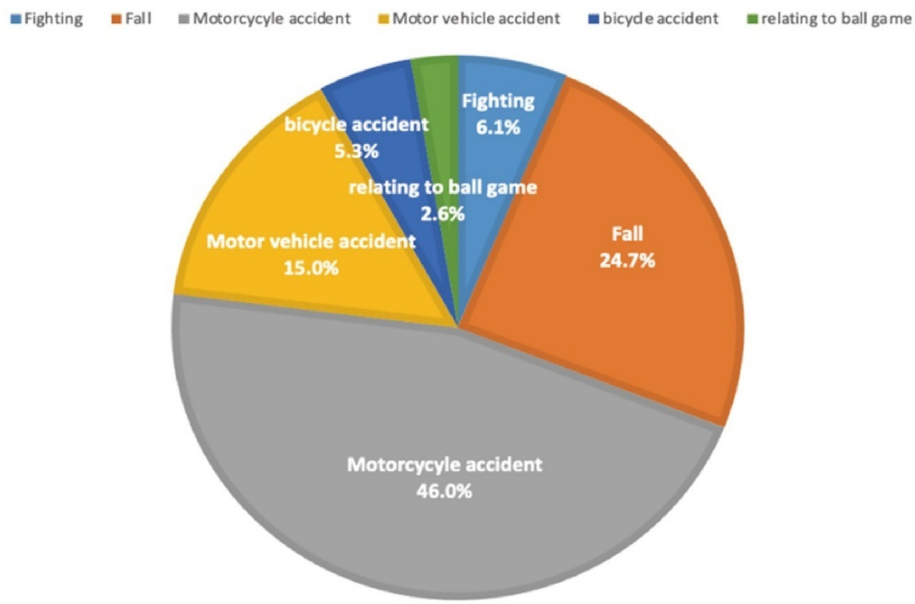

Figure 2 Distribution of mandibular fracture causes (113 patients) including motorcycle accidents (52 of 113, 46.0%), falls (28 of 113, 24.7%), motor vehicle accidents (17 of 113, 15.0%), assault or fighting (7 of 113, 6.1%), bicycle accidents (6 of 113, 5.3%), and ball game-related accidents (3 of 113, 2.6%).

mandibular condylar fractures. One study indicated that mandibular fractures caused by high-velocity blunt force trauma resulted in a greater number of condylar fractures, followed by symphyseal fractures; that study also revealed that mandibular symphyseal fractures were most often associated with concomitant angle fractures and complex condylar fractures.[15]

We used Pearson's contingency coefficient to analyze the correlation between condylar or subcondylar fractures and the side of mandibular fractures (Table 3). Our results demonstrated a correlation between left mandibular body fractures and right condylar fractures; however, no correlation was indicated between right mandibular body fractures and left condylar or subcondylar fractures. This finding may be explained by the fact that most Taiwanese are right-handed and thus instinctually protect the right side of their body when accidents occur. In addition, we discovered that symphyseal fractures correlated with bilateral condylar or subcondylar fractures; when bilateral mandibular body fractures occurred with mandibular symphyseal fractures, the frequency of condylar or subcondylar fractures decreased. This finding had a moderate correlation.

In summary, the high correlation between maxillary fractures and fractures of the extremities and the trunk in patients with mandibular fracture is of crucial importance

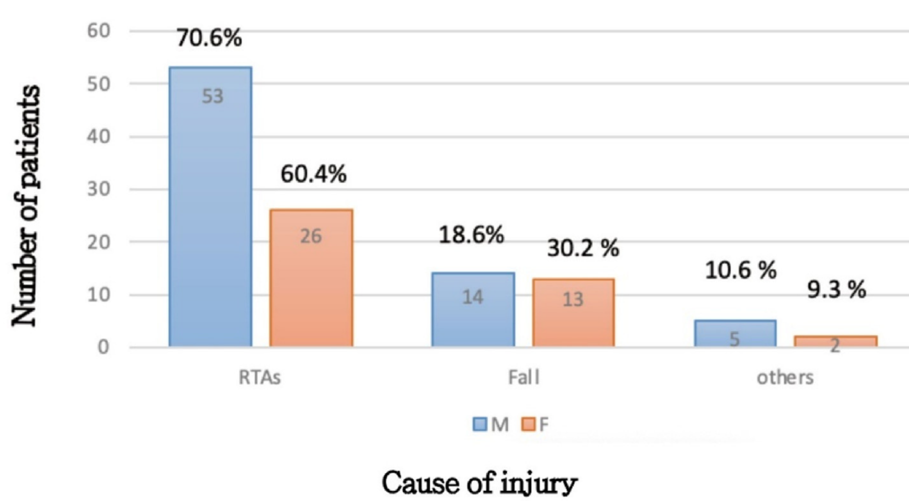

Figure 3 Distribution of major etiologies of mandibular fractures stratified by the patient ($n = 113$) and the sex. RTAs: Road traffic accidents.

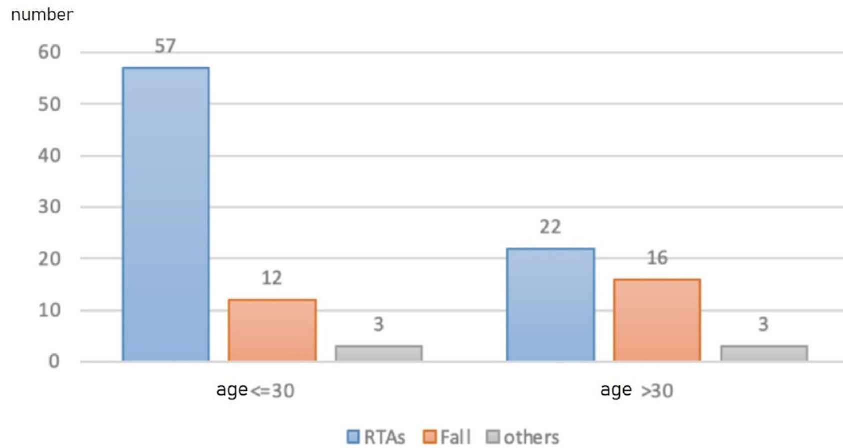

Figure 4 Stratified number of mandibular fractures ($n = 113$) by major cause and age subgroup ($\geq$30 vs < 30). RTAs: Road traffic accidents.

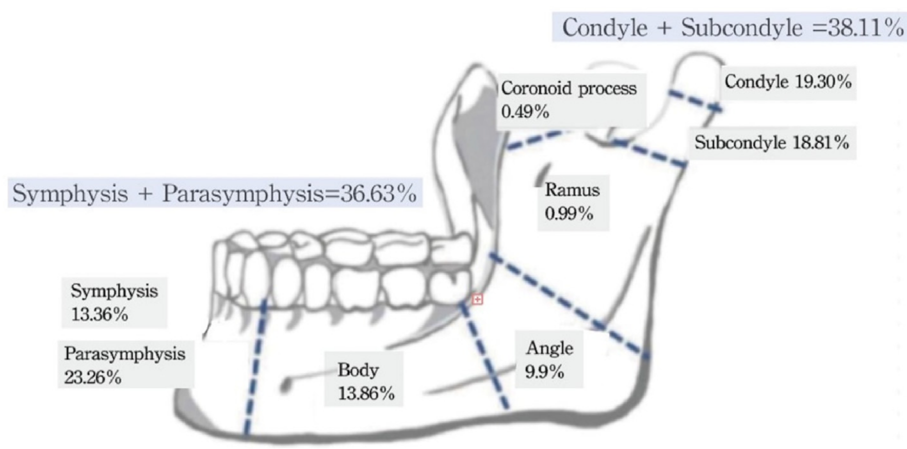

Figure 5 Distribution of mandibular fracture stratified by Dingman and Natvig classification. Distribution of mandibular fracture locations ($n = 202$) in patients ($n = 118$). Parasymphysis (47 of 202, 23.26%), condyle (39 of 202, 19.3%), and subcondyle (38 of 202, 18.81%) are the most common fracture sites. They are followed by fractures of the body (28 of 202, 13.86%), symphysis (27 of 202, 13.36%), angle (20 of 202, 9.9%), ramus (2 of 202, 9.9%), and coronoid process (1 of 202, 0.49%).

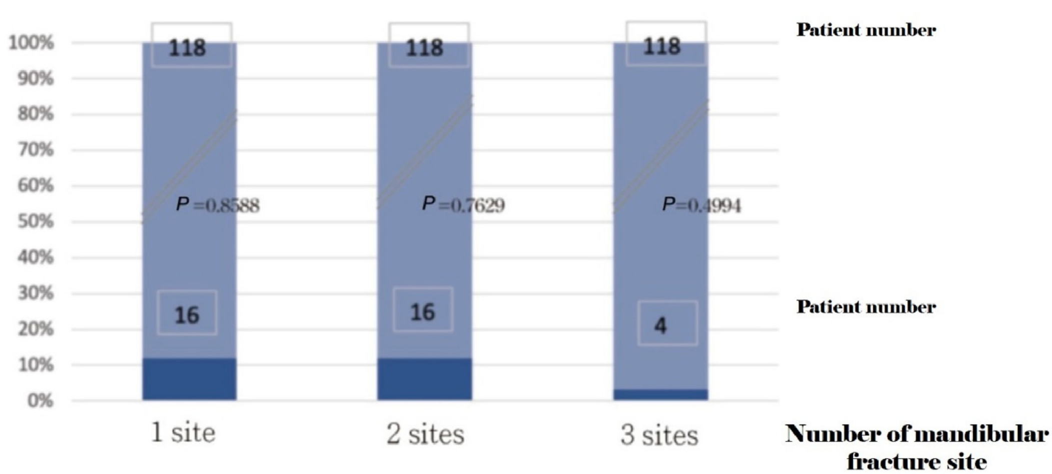

Figure 6 Percentage of patients with concomitant fractures stratified by number of mandibular fracture sites. Variables were analyzed using Pearson's correlation coefficient.

Table 4 Correlation between the cause and mandibular fracture severity.

	fracture = 1	fracture = 2	fracture = 3
fighting	0.071	0.007	0.108
falling	0.006	0.150	**0.212***
motorcycle	0.087	0.013	0.139
car	0.166	0.146	0.031
bicycle	0.048	0.040	0.011
relating to ball game	0.077	0.028	0.069

*P-value <0.05.
*Correlation coefficient was analyzed with Pearson's contingency coefficient.

to clinicians. Maxillary fractures can be regarded as an indication of concomitant fractures of other facial bones, the extremities, and the trunk. Therefore, when a maxillary fracture is accompanied by a mandibular fracture, clinicians must carefully examine the extremities and trunk for concomitant fractures. The limitation of this retrospective study is that the data is extracted from a single department in a single institutional database. Certain deficiencies can therefore not be accounted for. The RATs patient whose age under 18 could be unauthorized drivers/riders, passengers or bicycle riders. Because these details could not be recognized from the charts, the relevant issues could not be discussed.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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