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Research Article

A Comprehensive Study on Mid Face Fracture of Maxillofacial Trauma Patients: A Selected Case of Road Traffic Accident from Hospital USM from Year 2013 Till Year 2018

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Abstract

Objective: The aim of this study was to determine, proof and measurement of association among all the possible midface fracture bone in patients treated at the Hospital Universiti Sains Malaysia (HUSM), Kelantan, Malaysia.

Materials and Methods: The medical records of the patients with maxillofacial fractures treated were reviewed from 2013 to 2018. All the samples were the patients with maxillofacial fractures treated in Oral and Maxillofacial Surgery (OMFS) unit, Hospital USM. Data were collected in the categorical classification under the variables which were zygomatic complex, zygomatic arch, nasal, maxillary sinus, Le Fort I, Le Fort II, Le Fort III, orbital wall, alveolar palatal, naso-orbito-ethmoidal, maxillary bone, other-maxillary buttress. This is very important from the view of treatment modalities practiced for the correction of fractures.

Using IBM SPSS version 24 through the spearman correlation and chi-square analysis, all significant variables were listed, and these variables used for further analysis, through the SPSS modeler using the multilayer perceptron neural network procedure. Through this procedure, all the gained results from spearman correlation and chi-square analysis were validated for their real association of the maxillary fracture.

Results: The sample was selected from 263 patients with maxillofacial fractures treated in the OMFS unit, Hospital USM. It was found the maxillary fracture has strong correlation with concomitant zygomatic complex, Le Fort II, maxillary sinus, Le Fort I, Le Fort III, zygomatic arch, orbital wall, and nasal fracture. The obtained result from both analyses were validated through the procedure of Multilayer Perceptron Neural Network (MLPNN). The results were considered significant if the P-value is less than 0.05.

Conclusion: Correlation, chi-square and multilayer perceptron neural network show that maxillary fracture is the most common fracture and has strong association with concomitant zygomatic complex fracture. This finding is very important especially for the treatment modalities practiced for the correction of fractures.

Keywords: *Maxillofacial Fracture; Correlation; Chi-square; Multilayer Perceptron Neural Network (MLPNN)*

Introduction

Globally, maxillofacial trauma is one of the important surgical issues. Particular interest is established by the increasing incidence and diversification of the facial lesions [7,10,17]. The aetiology of maxillofacial fractures has altered over the time and extend to do so [5]. According to data from developing countries, road accident is one of the aetiologies of the maxillofacial fractures which is followed by falls and sports injuries [4,21]. While reports from developed nations have shown the violation being premeditated the iterated cause of suchlike fractures [2,15] with consideration to the anatomical location, zygomatic complex and mandible fractures version for the preponderance of all facial fractures and their occurrence differs according to the demographic factors, particularly the gender, age, and mechanism of injury [26]. The main causes of midface injuries as reported worldwide are road traffic accidents, interpersonal violence

falls and sports injuries [18]. Studies from Africa and Asia and some European countries have shown similar data which shown road traffic accidents are the main cause of midface fractures [1,14,16,23]. The incidence and epidemiological causes of maxillofacial trauma is varied widely in various parts of the world due to the social, economic, cultural and traffic regulation awareness.

Trauma to the midface is frequently complicated by the nearby anatomical structures so, early diagnosis and management of injuries are important for the prevention of the complications. Generally, zygomatic complex fractures and LeFort II fractures are the commonest in midface fractures [3]. Knowledge of correlations between midface fracture to other injuries provides appropriate strategies for patient care and avoidance of further complications. To evaluate the group of these patients, a study was carried out to determine the incidence, cause, patterns of midface fractures and correlation with other injuries from 2013 to 2018 in Hospital USM. A multidisciplinary approach is essential for the most favorable management in these patients. The midface fractures involve both hard and soft tissue areas, and in some cases, they are associated with other systemic pathologies and require multiple disciplinary management [8,12,22]. The midface fractures (maxilla and zygoma) form part of all skull fractures and their prevalence are varied by country, from 17% in Brazil to 26% in Austria and 60% in Turkey [6]. These differences may be due to the socio-economic, cultural, and environmental factors associated with changing patterns of trauma [18]. The study from Gassner., *et al.* [9] report that most fractures were midface fractures (72.5%), and mandibles (24.3%). The fracture of the orbit in 22.3% was on the floor of it and the usual Le Fort fracture was type 2 (45%). The maximum fractures of Hogg., *et al.* [13] studied in the maxilla (23%), and in orbit (22%). They stated that the type of midface fracture in the patient was 55.4% in orbit, 34.93% in zygoma, 32.53% in the maxilla, 31.32% in nasal bone and 9.63% Le Fort fracture was reported. The most common type of Le Fort fracture was type 2 (72.2%) [13].

In Malaysia, Maher., *et al.* [19] studied the Epidemiology of Maxillofacial Fractures (MFF) at Teaching Hospital in Malaysia which shown road traffic accidents were the most common cause of MFF (83.1%), with motorcycle accidents accounting for most injuries (73.6%). Orbit wall fractures were the most frequent with 51.2% of midface fractures. Patients of age over 20 years were at higher risk of sustaining orbital wall fractures but were at a lower risk of retaining mandibular fractures than patients who are 20 years and younger. The use of helmets among motorcyclists is significantly associated with the nasal wall, orbital wall, and maxillary sinus wall fractures. Motorcycle accidents were the most common cause of MFF in Kelantan, Malaysia [19]. Midface trauma management still remains a challenge for surgeons and clinicians. Permanent functional problems and the potential for scarring can definitely affect patients' "quality of life". The skeletal fracture of the midface is more frequent if compared to the mandibular ones [8,11].

Aim of the Study

The aim of this study was to determine, proof and measurement of association between all the possible midface fracture bone in patients treated at the Hospital Universiti Sains Malaysia (USM) Kelantan, Malaysia.

Materials and Methods

This study was conducted retrospectively by reviewing the medical record (Hospital Universiti Sains Malaysia) of patients with maxillofacial fractures from road traffic accident. Data was collected from 2013 - 2018 in OMFS Unit. Demographic characteristics, and types of maxillofacial fracture were recorded in the proforma. Mid face fracture was defined as zygomatic complex fracture, zygomatic arch fracture, nasal fracture, maxillary sinus fracture, Le fort I fracture, Le fort II fracture, Le fort III fracture, orbital wall fracture, alveolar palatal fracture, naso-orbito-ethmoidal fracture, other- maxillary buttress fracture, maxillary bone fracture and bone fracture. Statistical analysis was performed by using Statistical Package for the Social Sciences (IBM SPSS version 24). The descriptive analysis, as well as the chi-square and spearman correlation analysis, was done to assess the strength of correlation among the mid-face fractured bones as the data was categorical. At first, analysis was performed by spearman correlation. All the possible associations listed down and studied, further the significant association to maxillary bone fracture was selected and tested through chi-square analysis and MLP neural

network. This was to ensure that the selected variable from both analyses has a good quality of prediction to mid face fracture. Spearman correlation coefficients usually are the range between negative one to a positive one. A positive value of one showing the perfect positive correlation while the negative value of one showing the perfect negative correlation. A value of 0.00 represents no relationship between the two variables calculated. While, a weak correlation when the value was r_s = 0.10 to 0.29 or r_s = -0.10 to -0.29, moderate when the value was r_s = 0.30 to 0.49 or r_s = -0.30 to -0.49 and strong when the value was r_s = 0.50 to 1.00 or r_s = -0.50 to -1.00. Through the analysis that has been done, some relationship was evident in patients of the OMFS unit at Hospital USM, like concomitant zygomatic complex fracture of either side or Le fort II, maxillary sinus fracture, Le fort III fracture, Le fort I fracture, nasal bone fracture, zygomatic arch fracture and orbital wall fracture. According to the previous research finding, there about 9.9% of the cases of joint fractures in the middle with mandibular fractures was reported. While nasal fractures were common with maxillary and Le fort II fractures [20,24].

Multilayer Perceptron Neural Network (MLPNN) consists of an input layer, one hidden layer and one output layer. The neurons in the multilayer perceptron neural network are generally grouped into layers. Signals flow in one direction from the input layer to the next, but not within the same layer [Pham]. An essential factor of successes of the neural networks depends on the training network. Basically, the MLPNN algorithm with three-layer feed-forward architecture means that, the network has an input layer, one hidden layer and an output layer. In this research the output node was fixed at one since there is only eight independent variables.

Results

Data collection targeted patients within age range of 1 to 60 years old and the respondent in this study consists of 263 patients showed that 55 (20.9%) female and 208 (79.1%) male. Below is the summary of the mid face fracture which was recorded in Hospital Universiti Sains Malaysia for the past 5 years.

Table 1 shows number of patients versus types of mid face fracture recorded from 2013 to 2018. The highest percentage mid face fracture was maxillary bone fracture (64.1%, n = 168) which mainly resulted from vehicles accident. The second highest percentage was zygomatic complex fracture (30.4%, n = 80) and followed by orbital wall fracture (25.9%, n = 68). Basically, patients may have facial disfigurement and pain after emergency treatment.

Mid Face Fracture	n (%)
Maxillary Bone Fracture	168 (64.1%)
Zygomatic Complex Fracture	80 (30.4%)
Orbital Wall Fracture	68 (25.9%)
Nasal Fracture	29 (11.0%)
Le Fort II Fracture	25 (9.5%)
Le Fort I Fracture	22 (8.4%)
Maxillary Sinus Fracture	20 (7.6%)
Zygomatic Arch Fracture	19 (7.2%)
Le Fort III Fracture	9 (3.4%)
Naso-orbito-ethmoidal Fracture	7 (2.7%)
Alveolar Palatal Fracture	4 (1.5%)
Other-Maxillary Buttress Fracture	1 (0.4%)
Nasal Bone Fracture	1 (0.4%)

Table 1: *Occurrence of Mid Face Fracture due to high velocity force.*

Table 2 shows the maxillary bone fracture (37.1%) is the most common fracture among all the studied fracture. The second highest fracture is zygomatic complex fracture (17.7%) and the third is orbital wall fracture (15%). Other contribution can be seen clearly from the table 3.

Mid face fracture	Percent
Zygomatic Complex Fracture	17.7%
Zygomatic Arch Fracture	4.2%
Nasal Fracture	6.4%
Maxillary Sinus Fracture	4.4%
Le Fort I Fracture	4.9%
Le Fort II Fracture	5.5%
Le Fort III Fracture	2.0%
Orbital Wall Fracture	15.0%
Alveolar Palatal Fracture	0.9%
Naso-orbito-ethmoidal Fracture	1.5%
Other- Maxillary Buttress Fracture	0.2%
Maxillary Bone Fracture	37.1%
Nasal Bone Fracture	0.2%
Total	100.0%

Table 2: *Mid face fracture analysis from multiple response perspective.*

Variable	Maxillary Bone Fracture, *n* (%)		χ^2 (df)	P-Value	Variable	Maxillary Bone Fracture, *n* (%)		χ^2 (df)	P-Value
	Yes	No				Yes	No		
1. Zygomatic complex fracture					5. Le Fort I fracture				
Yes	77 (29.4%)	3 (1.1%)	51.67 (1)	0.000*	Yes	22 (8.4%)	0 (0.0%)	13.43 (1)	0.000*
No	91 (34.7%)	91 (34.7%)			No	146 (55.7%)	94 (35.9%)		
2. Zygomatic arch fracture					6. Le Fort II fracture				
Yes	18 (6.9%)	1 (0.4%)	8.346 (1)	0.004*	Yes	25 (9.5%)	0 (0.0%)	15.464 (1)	0.000*
No	150 (57.3%)	93 (35.5%			No	143 (54.6%)	94 (35.9%)		
3. Nasal fracture					7. Le Fort III fracture				
Yes	25 (9.5%)	4 (1.5%)	6.913 (1)	0.009*	Yes	9 (3.4%)	0 (0.0%)	5.215 (1)	0.022*
No	143 (54.6%)	90 (34.4%)			No	159 (60.7%)	94 (35.9%)		
4. Maxillary sinus fracture					8 Orbital wall fracture				
Yes	20 (7.6%)	0 (0.0%)	12.115 (1)	0.001*	Yes	64 (24.4%)	4 (1.5%)	35.916 (1)	0.000*
No	148 (56.5%)	94 (35.9%)			No	104 (39.7%)	90 (34.4%)		

Table 3: *Chi-square analysis among the types of mid face of maxillofacial fractures.*
y Chi-square is significant at the 0.05 level (2-tailed).*

Data from unit of record (maxillofacial trauma case), Hospital Universiti Sains Malaysia, was screen and assigned to the partition which consist of training (70%) and testing (30%). In this case, the accuracy of MLP was 91.6%, which is can be considered at a very good level of accuracy (Figure 1). Through this process, the result of MLP neural network evaluated through the predictor important. Through this result, we can see clearly the variable which having association towards maxillary bone fracture. The result was arranging from the highest to the lowest important of predictors, using probability calculation.

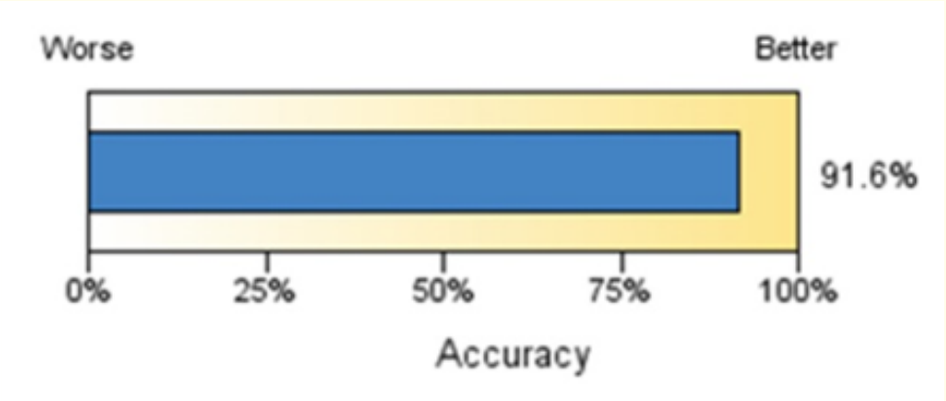

Figure 1: *The accuracy of multilayer perceptron neural network analysis.*

Figure 2 emphasised on the determination of the most associated predictor important toward maxillary bone fracture using a multilayer perceptron neural network. This method captures the most related factor which has a strong association with a maxillary bone fracture. Data was divided into two categories which are known as training and testing procedure, which means discovering the relationship between the target variable and the predictors. The architecture of the MLP is given in figure 3. There is three main layers, input, hidden and output layer. The suggested of the proposed MLP was fully evaluated through the testing and training results obtained from the running analysis.

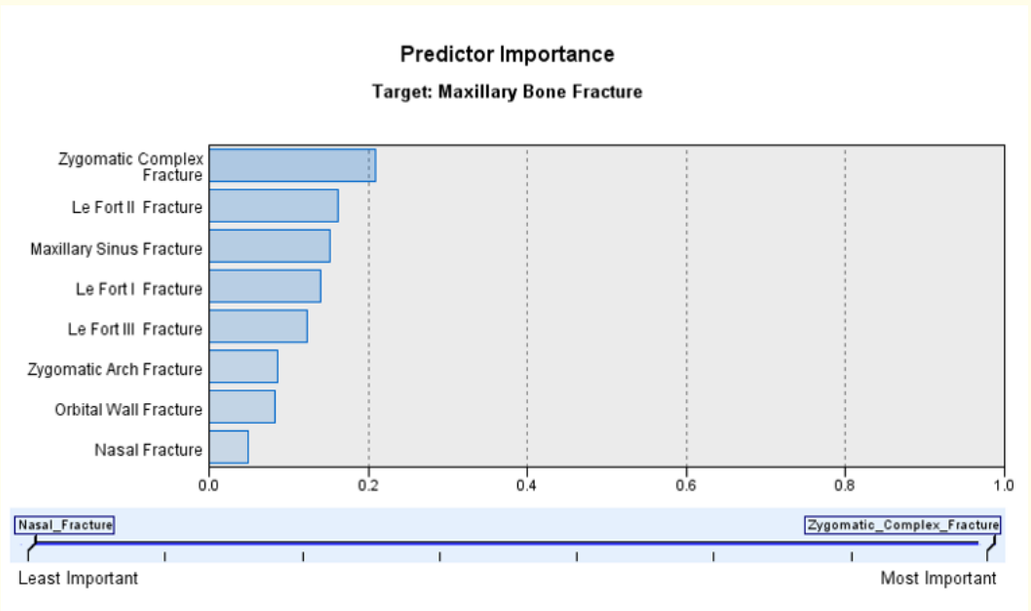

Figure 2: *The accuracy of multilayer perceptron neural network analysis.*

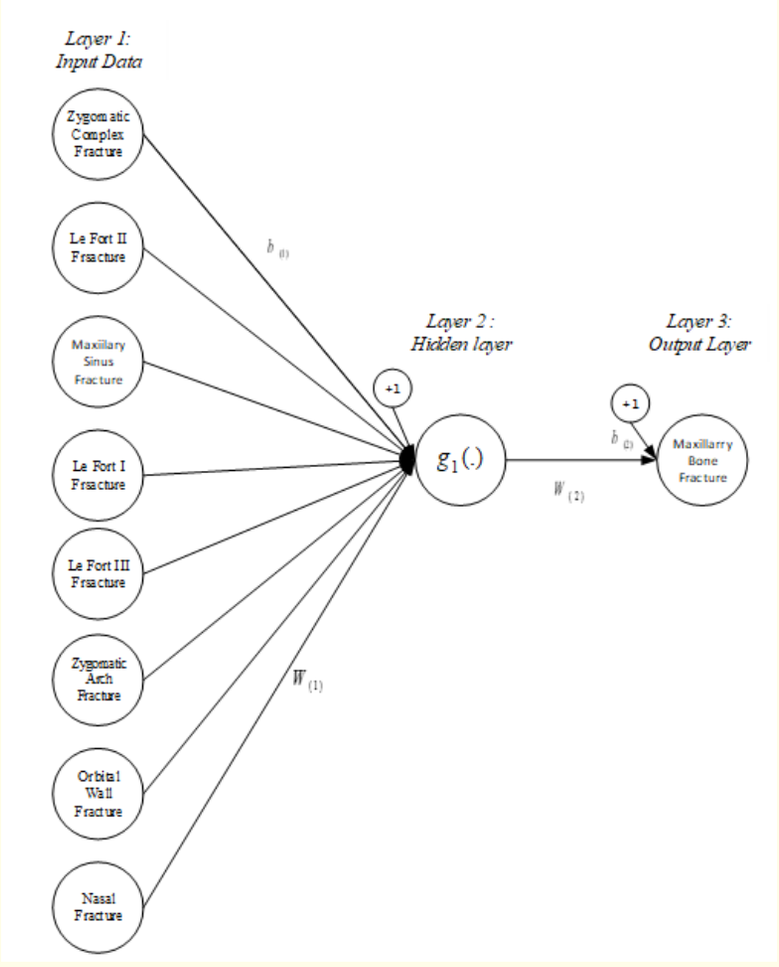

Figure 3: *The architecture of the best (MLP) model with eight input variables, one hidden layer and one output node.*

Table 4 shows the performances of the proposed multilayer perceptron neural network model with eight input variables, one hidden layer, and one output node. Training (91.62%) and testing (95.24%) result of the correct classification is very high. This indicates that the proposed model has a high accuracy. All the predictors which given by figure 2 are being validated through the training and testing process. The detailed result is given in table 4.

Output Variables: Maxillary bone fracture. **Input Variables:** Zygomatic complex fracture (21%), Le Fort II fFracture (16%), Maxillary sinus fracture (15%), Le Fort I fracture (14%), Le Fort III fracture (12%), Zygomatic arch fracture(9%), Orbital wall fracture(8%) and Nasal fracture (5%).		
	Training	**Testing**
Correct	91.62%	95.24%
Wrong	8.38%	4.76%
Accuracy	91.62	96.39%
2.Fold Correct Above	96.7%	100%

Table 4: *The summary of training and testing for multilayer perceptron neural network.*

Discussion

The aim of this paper was to study the mid face fracture in maxillofacial trauma from the road traffic accident point of view. Data was collected based on the road traffic accident which involving the mid face fracture. At first, the selected data was screening from the outlier, this was to make sure there is no outlier in the studied data, this will increase the reliability of the analyze data. There were few articles published on the association of mid face fracture among the patient who involved in traffic road accident. Here, male is predominantly suffered midface fracture compared to female. This could be related to more male as motor vehicle drivers compared to female.

In this study, we found that maxillary bone fracture was the most common fracture (from the correlation analysis point of view). It was important to determine the association of maxillary bone fracture toward others potential mid face bone fracture. According to the multilayer perceptron neural network analysis, concomitant zygomatic complex fracture having the strongest association with maxillary bone fracture ($r_s = 0.444$). MLP also predict that 21% of the concomitant zygomatic complex fracture was strongly correlated with maxillary bone fracture. Hence, concomitant Le Fort II fracture (16% with $p < 0.05$), maxillary sinus fracture (15% with $p < 0.05$), Le Fort I fracture (14% with $p < 0.05$), Le Fort III fracture (12% with $p < 0.05$), zygomatic arch fracture (9% with $p < 0.05$), orbital wall fracture (8%, with $p < 0.05$) and nasal fracture (5%, with $p < 0.05$) were found the next common affected site of maxillary bone fracture in Hospital USM.

The percentage of midfacial fractures (Table 1) shows mainly maxillary region towards the orbit of the skull indicative of the impact of the accidents. Less injury towards the frontal of the head could be due to helmet wearing which prevents the upper head impact but injured the middle and the lower part of the face. In addition, the correlation of maxillary bone fracture with zygomatic arch fracture, nasal fracture, maxillary sinus fracture, LeFort I and II fracture, orbital wall fracture (Table 5) further explains the percentage relations of the midface fractures. This is very importance in predicting the soft tissues injury associated with these fractures such as sinus area, nasal areas and the eyes. The examination of the soft tissues injury also is crucial during the post-accident hospitalisation. Interestingly the maxillary bone fracture is not correlated with nasal bone fractures which indicate the impact could be due to hemifacial side.

Type of Mid Face Fracture	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Zygomatic Complex Fracture	1.000	-0.121	0.005	-0.003	0.129*	-0.073	-0.034	0.063	-0.082	-0.058	-0.041	0.444**	-0.041
2. Zygomatic Arch Fracture	-0.121	1.000	-0.098	0.142*	-0.031	-0.040	-0.053	0.137*	-0.035	-0.046	-0.017	0.178**	-0.017
3. Nasal Fracture	0.005	-0.098	1.000	0.036	0.025	0.134*	0.067	0.014	-0.044	0.168**	-0.022	0.162**	0.175**
4. Maxillary Sinus Fracture	-0.003	0.142*	0.036	1.000	-0.035	-0.093	-0.054	0.191**	-0.036	-0.047	-0.018	0.215**	-0.018
5. Le Fort I Fracture	0.129*	-0.031	0.025	-0.035	1.000	0.183**	-0.057	-0.022	0.075	0.035	-0.019	0.226**	-0.019
6. Le Fort II Fracture	-0.073	-0.040	0.134*	-0.093	0.183**	1.000	0.153*	-0.103	0.066	0.107	-0.020	0.243**	-0.020
7. Le Fort III Fracture	-0.034	-0.053	0.067	-0.054	-0.057	0.153*	1.000	-0.063	-0.023	-0.031	-0.012	0.141*	-0.012
8. Orbital Wall Fracture	0.063	0.137*	0.014	0.191**	-0.022	-0.103	-0.063	1.000	-0.002	0.010	-0.036	0.370**	-0.037
9. Alveolar Palatal Fracture	-0.082	-0.035	-0.044	-0.036	0.075	0.066	-0.023	-0.002	1.000	-0.021	-0.008	0.028	-0.008
10. Naso-orbito-ethmoidal Fracture	-0.058	-0.046	0.168**	-0.047	0.035	0.107	-0.031	0.010	-0.021	1.000	-0.010	0.025	-0.010
11.Other-Maxillary Buttress Fracture	-0.041	-0.017	-0.022	-0.018	-0.019	-0.020	-0.012	-0.036	-0.008	-0.010	1.000	0.046	-0.004
12. Maxillary Bone Fracture	0.444**	0.178**	0.162**	0.215**	0.226**	0.243**	0.141*	0.370**	0.028	0.025	0.046	1.000	-0.083
13. Nasal Bone Fracture	-0.041	-0.017	0.175**	-0.018	-0.019	-0.020	-0.012	-0.037	-0.008	-0.010	-0.004	-0.083	1.000

Table 5: *Spearman correlation among the types of mid face of maxillofacial fractures.*

**: Correlation is significant at the 0.05 level (2-tailed). **: Correlation is significant at the 0.01 level (2-tailed).*

Conclusion

This study was designed to explore the relationship between maxillary bone fracture with all possible mid face fracture. A maxilla bone fracture happens when the maxilla becomes cracked or broken due to injury such as a car accident and many more. These injuries can be significant. It is very important to predict the most common maxillary bone fracture fractured with the impact of high velocity force due to traffic road accident. It was found that another eight fractures significantly ($p < 0.05$) having association to the maxillary bone fracture. Table 4 summary the association according to the ranking priority. This information would be a very useful to those who handling the case of maxillary bone fracture. It is hope that, this study would provide important information and higher deep understanding about the maxillary bone fracture and their all possible relationship.

Ethical Approval

Patient's medical records were reviewed after getting permission from Human Research Ethics Committee, Universiti Sains Malaysia with the registered number of USM/JEPeM/19010030.

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Conflict of Interest

There is no conflict of interest.

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