PATTERNS OF MAXILLOFACIAL FRACTURES IN RELATION TO HELMET USAGE AND VELOCITY AMONG MOTORCYCLISTS

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Thank you.

Mior Faiq Bin Mior Abu Tahrin

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ABSTRAK

Pengenalan:

Sejumlah besar kemalangan jalan raya di Malaysia adalah melibatkan penunggang motosikal. Kecederaan di bahagian muka boleh menyebabkan masalah kepada para pesakit daripada segi fungsi, fisiologi dan nilai estetik. Salah satu faktor yang menyebabkan berlakunya kecederaan yang parah kepada penunggang adalah kelajuan motosikal semasa kemalangan dan kegagalan untuk memakai topi keledar. Kajian ini bertujuan untuk menentukan sama ada corak keretakan tulang di bahagian muka di kalangan penunggang motosikal mempunyai kaitan dengan penggunaan topi keledar, jenis topi keledar yang digunakan, dan kelajuan motosikal semasa berlakunya kemalangan.

Metodologi:

Ini merupakan sebuah kajian *cross-sectional* yang menganalisa corak keretakan tulang di bahagian muka di kalangan penunggang motorsikal. Sejumlah 163 orang pesakit telah mengambil bahagian di dalam penyelidikan ini dan mereka dibahagikan kepada 5 kumpulan (tidak memakai topi keledar, *full-faced, modular, open-faced,* dan *half-helmet).* Cara *convenience sampling* digunakan untuk merekrut pesakit-pesakit yang mengalami keretakan tulang di bahagian muka yang tiba di zon kecemasan di hospital ataupun yang dirujuk ke klinik. Kecederaan di bahagian muka kemudiannya ditentukan melalui pemeriksaan fizikal dan radiologi, seterusnya dibahagikan kepada zon atas, tengah dan bawah bahagian muka. *Proforma* khas digunakan untuk mencatat butiran mengenai kemalangan dan kecederaan pesakit.

Keputusan:

143 peserta lelaki dan 20 peserta perempuan telah mengambil bahagian di dalam penyelidikan ini. Daripada jumlah tersebut, pesakit berbangsa Melayu merupakan populasi tertinggi (85%), disusuli oleh bangsa India (7.4%), Cina (3.7%) dan lain-lain (3.7%). Tiga mekanisme tertinggi bagaimana berlakunya kemalangan tersebut adalah motorsikal *vs* kereta, motosikal tergelincir, dan motosikal *vs* motosikal. Secara amnya, keretakan tulang dimuka kerap terjadi di zon tengah muka (41.7%), disusuli kombinasi zon atas dan tengah muka (20.2%), kombinasi zon tengah dan bawah muka (16%), dan lain-lain (22.1%). Tiada hubungan dapat dikaitkan di antara penggunaan topi keledar dengan corak keretakan di bahagian muka ($p>0.05$), dan juga di antara corak keretakan di bahagian muka dengan kelajuan motosikal semasa kemalangan ($p>0.05$).

Kesimpulan:

Penggunaan topi keledar, jenis topi keledar yang dipakai dan kelajuan motosikal semasa berlaku kemalangan tidak mempengaruhi corak keretakan tulang di bahagian muka di kalangan penunggang motosikal yang mengalami kemalangan jalan raya. Walau bagaimanapun, topi keledar yang dipakai kemas dan kekal melekat di kepala setelah berlakunya kemalangan jalan raya masih akan memberikan perlindungan kepada penunggang daripada kecederaan di bahagian kepala dan muka.

ABSTRACT

Introduction

Significant number in road traffic accidents in Malaysia involve motorcyclists, and facial injuries poses serious functional, physiological and aesthetical problems. One of the contributing factors in sustaining debilitating injuries are speeding and non-compliance to the usage of safety helmets. The aim of this study is to determine the patterns of maxillofacial injury among motorcyclists according to helmet usage, different types of helmets used, and cruising velocity of the motorcycle.

Method

This was a cross sectional study that evaluates the patterns of maxillofacial injuries sustained following road traffic accidents among motorcyclists. A total of 163 patients were recruited into this study which were then grouped into five categories (unhelmeted, full-faced, modular, open-faced, and half-helmet). Convenience sampling was used in this study to recruit all the motorcyclists that presented to the Emergency Department, or those who was referred as an outpatient to the clinic. Maxillofacial injury was then determined based on clinical and radiological examination and then categorized into upper, midface and lower face fractures. Specific proforma was used for data collection.

Result

A total of 143 males and 20 females were involved in an accident in this study. Among all the races, Malay had the highest involvement (85.3%), followed by Indians (7.4%), Chinese (3.7%) and others (3.7%). The three most common mechanisms of injuries were motorcycle vs car, single-vehicle collision (skidded), and motorcycle vs motorcycle. In general, injuries were seen mainly on midface (41.7%), followed by a combination of upper and mid face (20.2%), combination of midface and lower face (16%) and others (22.1%). There was no association between helmet usage and pattern of maxillofacial fracture ($p>0.05$). There was also no association between pattern of maxillofacial fractures and velocity ($p> 0.05$).

Conclusion

Helmet usage, the types of helmet used, and velocity do not influence the pattern of maxillofacial injuries among motorcyclists following road traffic accidents. However, a helmet of any type that is correctly worn and remains secured on the head throughout a crash will provide some form of protection against head and facial injury.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Road traffic injuries have been identified as one of the leading causes of death globally. It was ranked as the ninth most frequent cause of mortality worldwide back in 2004, and the World Health Organization (WHO) predicted that by year 2030, the number of deaths secondary to road traffic injuries would rise to be the fifth most frequent cause of mortality worldwide [1]. Across the globe, there are at least 20 to 50 million of people who suffer from non-fatal injuries on the road, while over 1.35 million people ended up dead due to road traffic injuries in 2016 with the majority of them occurring in low-income countries based on a census by WHO [2].

Recently, we could see a rising trend in the use of motorcycles for both transportation and recreational purpose, especially in developing countries, owing to its low cost of purchase price and its mobility. Motorized two-wheelers are the major contributor in the significant number of growths in the number of vehicles seen on the roads worldwide. Therefore, its sheer number led to the motorcyclists group comprising 1/3 of all road traffic deaths in the South-East Asia and Western Pacific region [1].

In several major Asian cities, there is approximately 196 motorcycles per 1000 people, which is about 7 times higher than the rest of the world [4]. In Malaysia, we can see similar trend as with other major Asian cities in which motorcycle make up 47% of the total vehicles that is registered with the Road and Transport Department of Malaysia [5].

In Malaysia, motorcyclists' fatalities have continued to outnumber other road users based on a statistic that spanned over 2 decades by MIROS. In the report, motorcyclist are 1.5 times more likely to be involved in a fatal accident when compared to the other road users [6]. Furthermore, it also states that the number of deaths involving motorcyclist is showing no

signs of abating, with an average annual increment of 2% being recorded since 2010 onwards. This is considered as a significant problem because most of the victims are young adults that make up a large portion of the nation's workforce and are breadwinners of their family, which can then have a huge social effect on their families and the country in general [7].

The main cause of severe injury, disability and death among motorcyclist have been attributed to head and neck injuries. It has been documented that the use of a standard motorcycle helmet confers protection to the rider by reducing the risk of fatality and serious injury by 40% and 70% respectively [3]. The impact of facial injuries to the victims can be generally divided into physiological, mechanical and aesthetic problems. Depending on the settings, nature of the studied populations, and case identification methods, the recorded incidence of facial trauma among motorcycle riders varies between 38% and 57% respectively [21-22].

As it is, there are an abundance of literatures discussing about the mortality and morbidity of head injuries among motorcyclists, and more studies are required that looks at facial injuries among helmeted and unhelmeted motorcyclists particularly in the Southeast Asia region.

The use of helmets has been shown to reduce injuries, death and hospital costs if they are fitted securely with a face shield and visor and is still within the period of validity of use [14]. On the contrary, motorcyclists who do not wear any helmets are exposing themselves to serious injuries which include facial skeletal deformities and soft tissue trauma. These injuries eventually lead to aesthetic and functional concerns to the patients which can be debilitating.

Even though helmets have been shown to offer some form of protection to its wearer, not all helmets are made equal and have the same safety profiles. In the market, there are various kinds of helmet that are available, namely full-face helmet, modular helmet (flip up), half helmet and the most popular among all which is the open face helmet.

Ramli et al (2008) reported that the most common site of fracture among helmeted patients at the lower and mid-facial regions are the mandible and zygoma respectively because both are considered to be the prominent bones in the facial skeleton. Therefore, they are more likely to be exposed to the force of impact upon collision [7]. In the same study, it was also reported that injuries to the upper third of facial region is also rare.

Speeding is known to be one of the potential risky behaviours that may lead to an accident. Elliot et al (2007) reported that speeding was a crash liability to riders and found that their desire to ride at a high velocity to be similar to their inclination to speed in cars, with motorcycles crashes to be the more fatal among those two [24].

Up until now, there is still insufficient data on the safety profiles of the different kinds of helmets on the market to shield its wearer from maxillofacial injuries and the relations between velocity and pattern of facial bone fractures following road accidents.

This study is aimed at determining the safety profiles of each helmets for motorcyclists and how effective it is in protecting its wearer and to outline the association of velocity upon crashing towards the pattern of facial bone fractures. Its finding may then be used to further strengthen our knowledge on helmet safety and become a steppingstone for further research to be done in reducing the rate of morbidity and mortality among motorcyclists and public road users.

CHAPTER 2

OBJECTIVES OF STUDY

2.1 GENERAL OBJECTIVE

To study the pattern of maxillofacial fractures in motorcyclists in relation to the usage of safety helmets and the velocity upon crashing.

2.2 SPECIFIC OBJECTIVE

- To determine the association between the pattern of maxillofacial fractures and the usage of helmets among motorcyclists in a motor-vehicle accident
- To determine the association between pattern of maxillofacial fractures with the type of helmet used by the rider
- To assess the association between the velocity of the motorcycle and pattern of maxillofacial fractures sustained

CHAPTER 3

MANUSCRIPT

(Archives of Plastic Surgery)

3.1 TITLE PAGE

PATTERNS OF MAXILLOFACIAL FRACTURES IN RELATION TO HELMET USAGE AND VELOCITY AMONG MOTORCYCLISTS

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Keywords: Maxillofacial fracture; helmet type; velocity; motorcyclists

Notes: No potential conflict of interest relevant to this article was reported. No grants or funding were received for this study.

3.2 ABSTRACT

Background

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Methods

This was a cross sectional study that evaluates the patterns of maxillofacial injuries sustained following road traffic accidents among motorcyclists. A total of 163 patients were recruited into this study which were then grouped into five categories (unhelmeted, full-faced, modular, open-faced and half-helmet). Convenience sampling was used in this study to recruit all the motorcyclists that presented to the Emergency Department, or those who was referred as an outpatient to the clinic. Maxillofacial injury was then determined based on clinical and radiological examination and then categorized into upper, midface and lower face fractures. Specific proforma was used for data collection.

Results

A total of 143 males and 20 females were involved in an accident in this study. Among all the races, Malay had the highest involvement (85.3%), followed by Indians (7.4%), Chinese (3.7%) and others (3.7%). The three most common mechanisms of injuries were motorcycle vs car, single-vehicle collision (skidded), and motorcycle vs motorcycle. In general, injuries were seen mainly on midface (41.7%), followed by a combination of upper and mid face (20.2%), combination of midface and lower face (16%) and others (22.1%). There was no association between helmet usage and pattern of maxillofacial fracture ($p>0.05$). There was also no association between pattern of maxillofacial fractures and velocity ($p> 0.05$).

Conclusions

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3.3 INTRODUCTION

Road traffic injuries have been identified as one of the leading causes of death globally. It was ranked as the ninth most frequent cause of mortality worldwide back in 2004, and the World Health Organization (WHO) predicted that by year 2030, the number of deaths secondary to road traffic injuries would rise to be the fifth most frequent cause of mortality worldwide [1]. Across the globe, there are at least 20 to 50 million of people who suffer from non-fatal injuries on the road, while over 1.35 million people ended up dead due to road traffic injuries in 2016 with the majority of them occurring in low-income countries based on a census by WHO [2].

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kinds of helmet that are available, namely full-face helmet, modular helmet (flip up), half helmet and the most popular among all which is the open face helmet.

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3.4 MATERIALS AND METHODS

This cross-sectional study was conducted in Hospital Universiti Sains Malaysia (HUSM), Hospital Kuala Lumpur and Hospital Sungai Buloh from February 2020 to September 2020.

Convenience sampling method was used throughout the course of this study due to the limited time constraints and difficulties to approach the subject in a trauma setting. In patients who met the inclusion criteria (patients involved in road traffic accidents (motorcycle) with maxillofacial fractures aged 12 years or older), they were given a brief explanation of the study and then asked if they were willing to participate.

In patients with severe facial trauma with unstable fractures, they were recruited in the emergency department upon arrival and referral to the plastic and reconstructive surgery team were made. However, in patients with mild and stable facial fractures, they were recruited in the outpatient plastic and reconstructive surgery clinic usually within 2 weeks post trauma.

When the subject was approached, an informed consent was obtained, and a brief explanation were given with regards to the nature of the study. Once agreed, the investigator will fill up the maxillofacial trauma proforma and obtain some demographic details from the patient before going on to examine the patient and finding out the result of radiographic examination that was done to the patient. Subsequently, the immediate management of the patient was then recorded in the final aspect of the proforma. The estimated time for data collection during each interview was approximately 5-10 minutes.

In order to standardize the data regarding velocity of motorcycle upon crashing, the cruising velocity of the motorbike prior to the accident were used. Bias were minimized by ensuring the participants that everything that was recorded from their statement (ie usage of

safety helmets, cruising speed prior to crashing) were kept strictly confidential and stored in a secure location that was only accessible by research team members and will not be shared with any regulatory bodies.

The subjects were not required to fill up the proforma themselves and they will not be informed of the study results.

Data analysis was done using the Statistical Package for Social Science software version 24. Continuous data were summarized using descriptive and inferential statistics. Univariate analysis was done using Chi Square test and statistical significance was cited at $P < 0.05$. Pattern of maxillofacial injuries in relation to type of helmet used and velocity were analysed.

3.5 RESULTS

A total of 163 patients participated in the study which comprises of 143 males and 20 females, and a male to female ratio of 7:1. Among these subjects, Malays constituted around 85.3% (n:139), followed by Indian at 7.4% (n:12), Chinese 3.7% (n:6) and others at 3.7% (n:6), respectively. The road traffic accidents involving the motorcyclists that were part of this study mostly took place in the evening, constituting 65.03% (n:106) of cases, whereas 10.4% (n:17) were unknown.

The mechanisms of injury were summarized based on the following pie chart (Figure 1). Motorbike versus car was found to be the most common cause of accident with an incident of 41% (n:67), followed by skidding at 28.8% (n:47), motorbike versus motorbike at 17.8% (n:29), motorbike versus animal at 4.9% (n:8), and motorbike versus pedestrian was the least common cause of accident at 3.1% (n:5). Among all of the subjects studied, 4.3% of them were unable to recall their mechanism of injury.

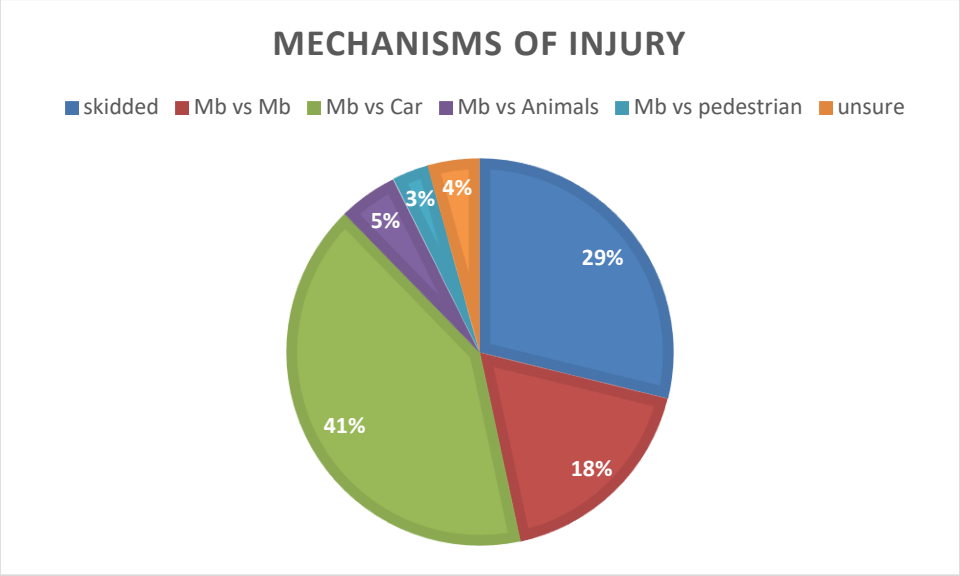

Figure 1: The mechanisms of injury among the motorcyclists

A total of 87.1% (n:142) of study participants were riding a motorbike with an engine displacement of <250cc, whereas 5.5% (n:9) of them rode motorbikes that were between 250 – 500cc. None of the study participants were riding a motorbike with engine displacement of more than 500cc, and 7.4% (n:12) of them were unsure of the engine displacement of their motorbikes.

In terms of cruising velocities of the motorcycles before getting into road traffic accident, almost half (49.1%) of the studied participants claimed they were riding below 70km/hour, while 33.7% (n:55) of them were riding between 70-90 km/hour. Only 4.9% (n:8) of the participants were cruising at more than 90km/hour and 12.3% (n:20) were unsure of the cruising velocity of their motorcycle before the accident happen (figure 2).

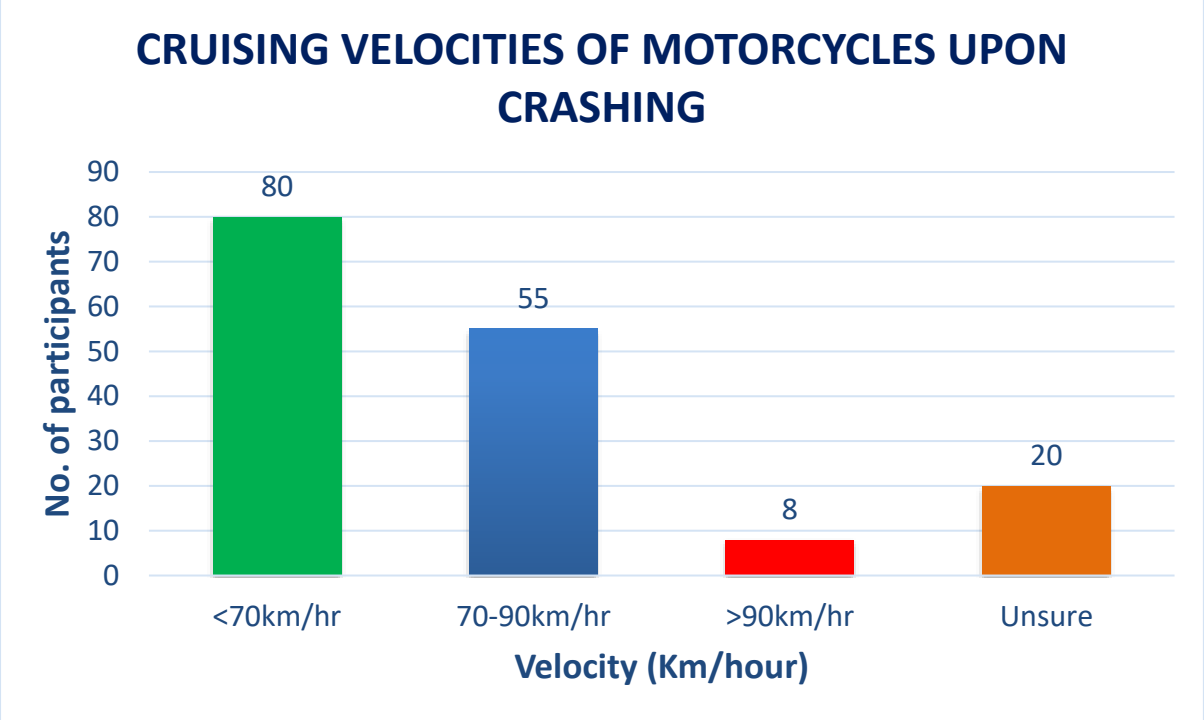

Figure 2: Cruising velocities of motorcycles

Out of 163 study participants, a total of 69.33% (n: 113) were wearing safety helmets when the accidents occurred. From those who wore helmets, the largest group were wearing open face helmets at 46.42% (n: 76), followed by half-helmets at 13.49% (n:22), modular helmets at 7.97% (n:13), and full-face helmets comprises the smallest group at 1.23% (n:2) (figure 3)

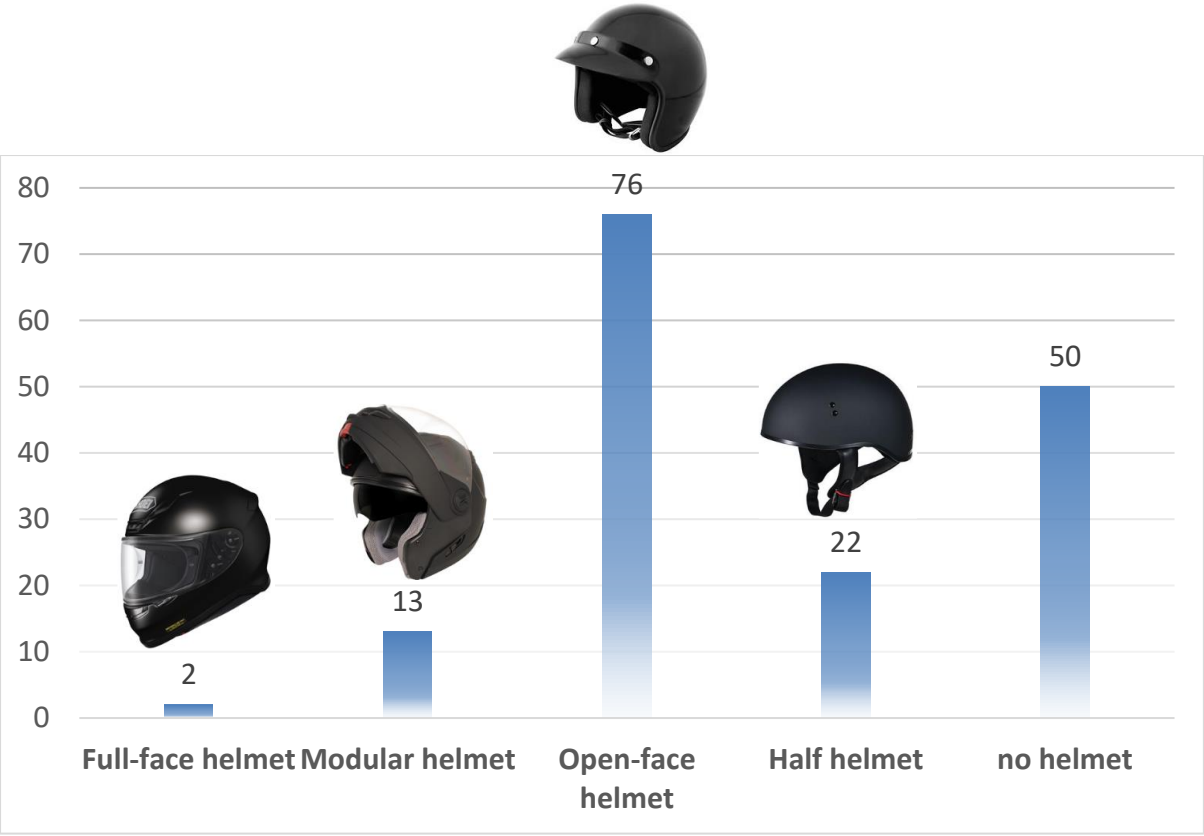

Figure 3: The types of helmets used by participants

Inferential statistics

Table 1 shows the association between pattern of maxillofacial fractures and usage of helmet among patients who was referred to Plastic and Reconstructive Surgery Department from the other disciplines following motor-vehicle accidents. From the table, there was no significant association between helmet wearing and upper face, midface and lower face fracture ($p>0.05$).

Table 1: The association between the pattern of maxillofacial fractures and usage of helmet

Pattern of maxillofacial fractures	**Helmet usage**		**Total n(%)**	**p-value[a]**
	Yes n(%)	No n(%)		
Upper facial				
Yes	29(25.7)	17(34.0)	46(28.2)	0.276
No	84(74.3)	33(66.0)	117(71.8)	
Mid facial				
Yes	91(80.5)	43(86.0)	134(82.2)	0.400
No	22(19.5)	7(14.0)	29(17.8)	
Lower facial				
Yes	41(36.3)	14(28.0)	55(33.7)	0.302
No	72(63.7)	36(72.0)	108(66.3)	

[a]Pearson chi-square test used; expected count <20%

Figure 4 shows the frequency of pattern of maxillofacial fractures based on helmet usage. From the figure, we can see that among the helmeted subjects, midfacial fracture was seen to be most predominant fractures at 28.83%, followed by combination of upper & midface fracture at 12.27%, combination of midface and lower face fracture at 11.66%, lower face fracture at 11.04%, combination of upper, middle and lower facial fracture at 3.07%, and finally upper face fracture at 2.50%. Similarly, the top 3 patterns of facial fractures in the unhelmeted group was midface fracture, followed by combination of upper and midface fracture and combination of midface and lower face fracture at 12.88%, 7.97%, and 4.29% respectively.

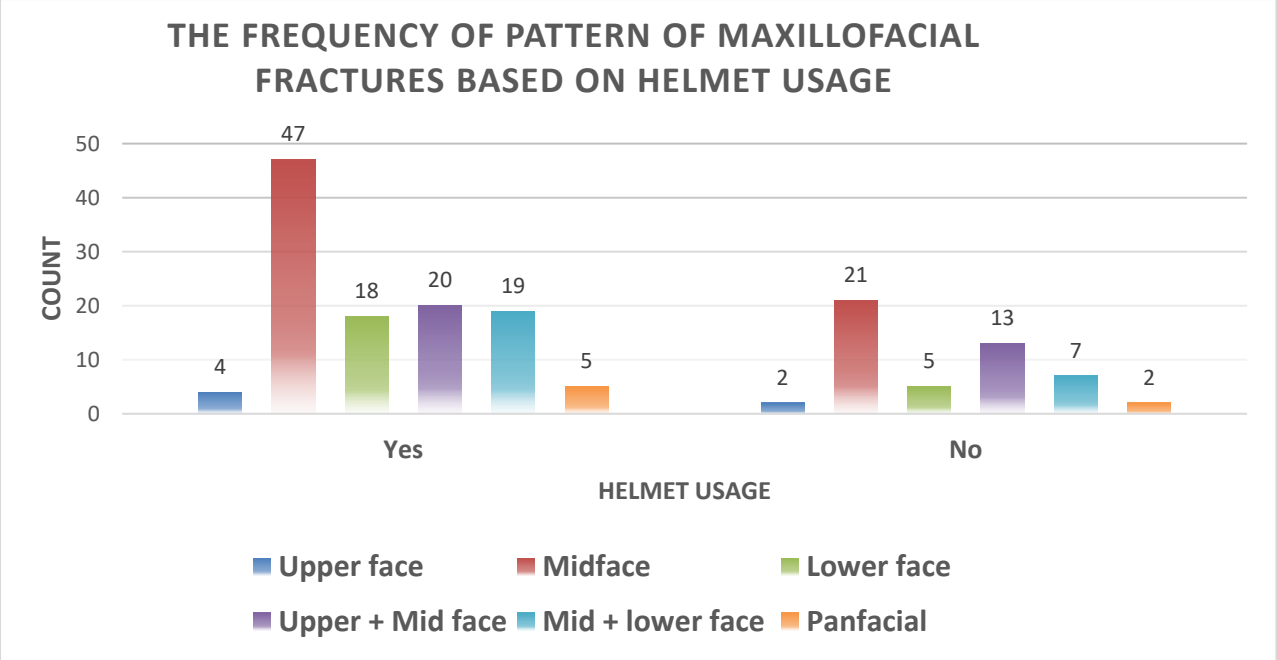

Figure 4: The frequency of pattern of maxillofacial fractures based on helmet usage

From the table below (table 2), there was no association between the pattern of fractures and the type of helmets used ($p>0.05$). However, we can see based on the frequency that patients that wore full face helmet had no upper facial fracture and only 2 patients and 1 patient had mid and lower facial fracture respectively. A total of 61 patients out of 76 patients who wore open face helmet had mid facial fracture.

Table 2: The association between the pattern of maxillofacial fractures and type of helmet

Pattern of maxillofacial fractures	**Type of helmet**					**Total n(%)**	**p-value[b]**
	Full face n(%)	Modular n (%)	Open face n(%)	Half n(%)	Not applicable n(%)		
Upper facial							
Yes	0(0.0)	6(46.2)	18(23.7)	5(22.7)	17(34.0)	46(28.2)	0.345
No	2(100.0)	7(53.8)	58(76.3)	17(77.3)	33(66.0)	117(71.8)	
Mid facial							
Yes	2(100.0)	11(84.6)	61(80.3)	17(77.3)	43(86.0)	134(82.2)	0.842
No	0(0.0)	2(15.4)	15(19.7)	5(22.7)	7(14.0)	29(17.8)	
Lower facial							
Yes	1(50.0)	2(15.4)	30(39.5)	8(36.4)	14(28.0)	55(33.7)	0.347
No	1(50.0)	11(84.6)	46(60.5)	14(63.6)	36(72.0)	108(66.3)	

[b]Fisher exact test used; expected count >20%

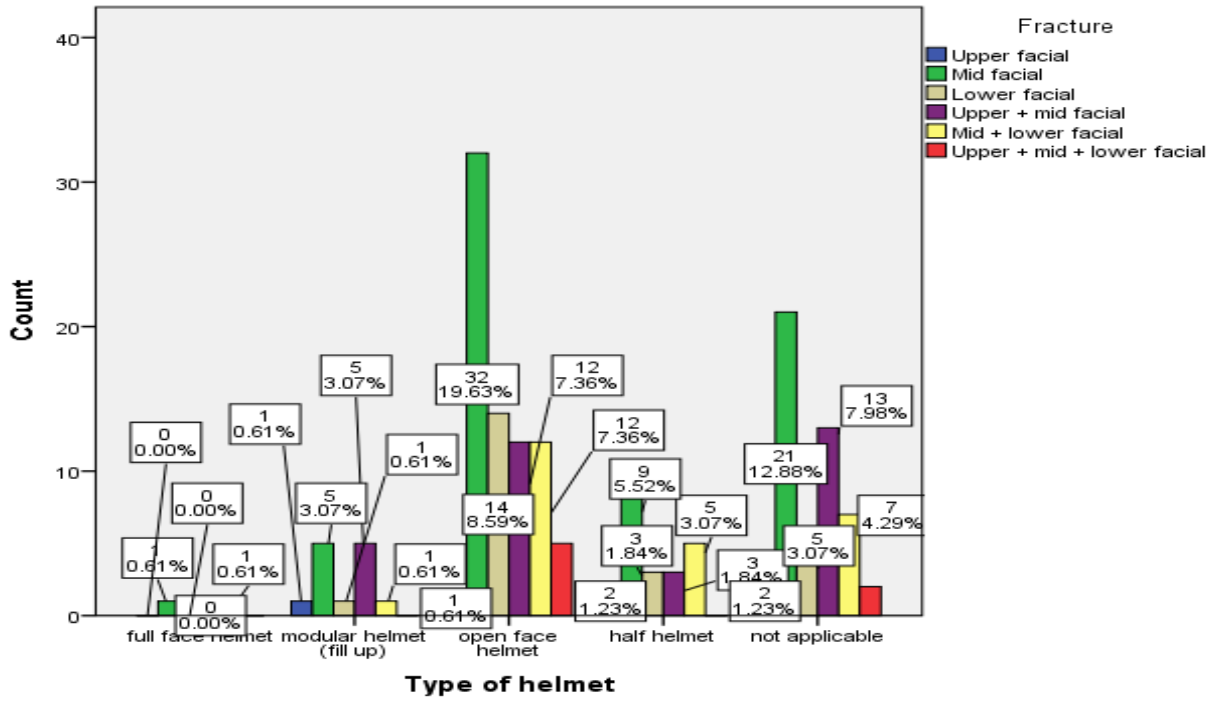

Figure 5: The frequency of pattern of maxillofacial fractures based on type of helmet

There was no association between the pattern of fractures and the cruising velocity (p>0.05). In the velocity of more than 90 km/hour group, 7(87.5%) patients had mid facial fracture and 5 (62.5%) patients had upper facial fracture.

Table 3: The association between the pattern of maxillofacial fractures and velocity

Variable	Velocity				Total n(%)	p-value[a]
	<70 km/hour n(%)	70-90 km/hour n(%)	>90 km/hour n(%)	No data		
Upper facial						
Yes	25(31.3)	13(23.6)	5(62.5)	3(15.0)	46(28.2)	0.059
No	55(68.8)	42(76.4)	3(37.5)	17(85.0)	117(71.8)	
Mid facial						
Yes	60(75.0)	48(87.3)	7(87.5)	19(95.0)	134(82.2)	0.112[b]
No	20(25.0)	7(12.7)	1(12.5)	1(5.0)	29(17.8)	
Lower facial						
Yes	26(32.5)	22(40.0)	2(25.0)	5(25.0)	55(33.7)	0.589
No	54(67.5)	33(60.0)	6(75.0)	15(75.0)	108(66.3)	

[a]Pearson chi-square test used; expected count <20%

[b]Fisher exact test used; expected count >20%

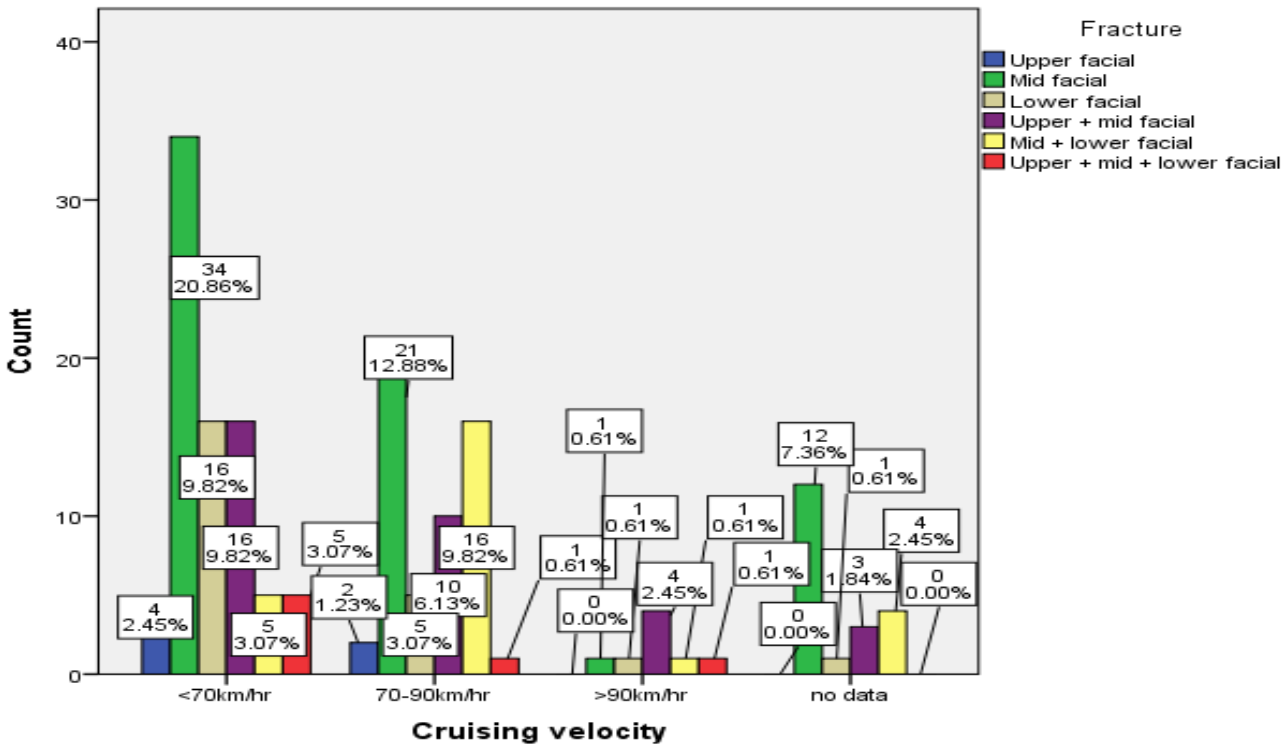

Figure 6: The frequency of pattern of maxillofacial fractures based on velocity

3.6 DISCUSSION

Approximately 80% of motorcycle accidents in Malaysia result in injury, and the mortality among this group of road users can be as high as 60% for both the motorcyclists and their pillion riders. The overall relative risk of motorcyclists' fatality is roughly 17-20 times greater than the occupant of a car according to Radin et. al (1995). This can pose a significant problem in Malaysia mainly due to the increasing number of motorcycle users. It was estimated in 2006 that as high as 49% of registered vehicles in Malaysia are motorcycles. A few factors may contribute to the high level of ownership in this country which are low purchase price of the vehicle, cheap insurance coverage rate, and relatively low age limit to apply for a riding license as compared to getting a car driving license. Based on another study by Radin Umar et. al, it was reported that Malaysians in general prefer to ride their

motorcycle to work for as long as 52 minutes than spending an average cost of Ringgit Malaysia 18 on a public transport [27].

In terms of demographic, our results were somewhat similar to the other previous studies where there's a significant male preponderance, with a male to female ratio of 7:1 seen in our data [7,17]. This is possible due to the higher number of young men who opt to ride their motorcycle to go to work in order to avoid traffic jams and to save on their transportation costs while they run errands as part of their job in this country. This is in stark contrast with most of the western and developed countries where motorcycles are more associated with recreation and leisure.

In Malaysia, a typical motorcycle crash victim profile is a male rider aged between 16-25 years, with less than 3 years valid riding license, riding a motorcycle with an engine displacement of more than 150cc [28]. In our study, close to 90% of subjects rode a motorcycle that has an engine displacement of less than 250cc and only 12% of them were riding a motorcycle with engine displacement of more than 250cc.

Pang et al reported in their study that a motorcyclist that crashed onto a light or heavy commercial vehicle is 4 times as likely to result in fatality as compared to other motorcycle and passenger cars [28]. In our study, the commonest mechanisms of accidents were collision of the motorcycle with another car 41.1% (n:67), be it moving or stationary. That was followed by single vehicle collision (skidded) at 28.8%, and collision between 2 motorcycles at 17.8%.

The sheer number of accidents among these motorcyclists can be attributed to the increasing number of vehicles on Malaysian roads combined with various other factors such as visibility of the motorcycle riders on the road, erratic attitude among young riders, dangerous road environments, and lack of consideration by other road users towards the

safety of the motorcyclists. As a significant portion of motorcyclists come from middle to low-income groups, they usually reside in the sub-urban area and commute into the city centre daily to go to work. The long distance and velocity of riding on the major highway further increase their risk of getting into an accident.

In Malaysia, the use of safety helmet for both riders and pillion riders are mandatory and its strict enforcement has been enforced as far back as 1973. From our data, as high as 30.7% (n:50) of the study participants did not wear helmet at the time of the accident. Reason cited for non-compliance include the notion that the risk of getting involved in an accident is low if they are travelling within short distances, lack of fear of getting reprimanded from the law officer, or just simply indifference towards their own safety. However, Tham KY et al have found from their study that the usage of helmets do not ensure complete head and facial protection [29].

The data from our study revealed that most of the injury in the maxillofacial area occurs in the midface region (28.83%, n:47) even when the rider is wearing a helmet. This is in contrast with Ramli et al which showed that the commonest region in the maxillofacial area to sustain fracture following trauma in helmeted riders are in the lower face [7]. When the combination of both midface and lower face fractures are added to the lower face injury group among the helmeted subjects, the number increases to 40.49%. The high incidence of fracture occurring in this region is probably due to the prominence of its bony architecture which exposes it to direct impact and enhances the force of the trauma.

On the other hand, our study showed that maxilla was the most common bone to sustain fracture in the midface region among helmeted riders (52.21%, n: 59) which is then closely followed by the zygoma (46.9%, n: 53). This finding agrees with the findings of Kraus et al in their study [30]. However, Ramli et al had a contrasting outcome in which they found that

zygoma was the commonest bone to fracture in the midfacial region which they postulated is due to the nature of the bone being prominent like the mandible and thus are subjected to impact upon collision with objects or surfaces [7].

As for the upper facial injury, our study demonstrated that it is the least common zone of injury as compared to other zones among the helmeted subjects which is in agreement with the previous studies done [7,30].

In this study, the helmets were categorized mainly into 4 groups namely, half-face, open-face, modular, and full-face helmets. Each kinds of helmet have differing area of coverage in the head and face region which means they offer different form of protection to its wearer. It was discovered from our data that majority of the participants that wore a helmet used an open-face helmet (67.26%, n:76) and full-face helmet was the least worn (1.77%, n:2). Similar finding was found in the previous study "Patterns of Facial Injury in Relation to the Usage of Motorcycle Helmets and the Velocity in Hospital Universiti Sains Malaysia and Hospital Kuala Lumpur". The popularity of open-face helmet might be contributed to its low price when compared to other helmets while still providing a significant amount of coverage of the head and neck area. Our data showed that there was no association between the pattern of fractures and the types of helmet used which agrees with the findings of Ramli et al [7].

To answer our third objective, we analysed the effect of velocity on sustaining maxillofacial fractures. To facilitate data collection, the cruising velocity of the motorcycles was divided into 3 main groups: less than 70km/h, between 70-90 km/h, and more than 90km/h. In all three velocity groups, the data consistently showed that midface injury was the commonest zone of fracture site. On the other hand, upper facial zone was the least likely site of fracture in all speed categories except for in the more than 90km/h group. Our statistical

analysis concludes that there was no association between the pattern of fractures and the velocity of the motorcycles ($p>0.05$).

The results from our studies showed that there were no associations between pattern of maxillofacial fractures and types of helmet used and velocity ($p>0.05$). This is probably due to a relatively small number of participants particularly in the non-helmet wearing group.

3.7 CONCLUSION

Midface fractures were the commonest type of facial injuries sustained by motorcyclists following an accident on the road. Although our study showed there was no association between pattern of maxillofacial fractures and helmet usage and velocity, various literatures have demonstrated that helmet use do play a role in reducing the risk of death and risk of serious head injury.

3.8 LIMITATION AND RECOMMENDATIONS

The main limitation of this study is the small number of participants from the non-helmeted group and the relatively short study duration. If the duration had been longer, more efforts can be spent on recruiting more non-helmeted participants so that it will be somewhat equal to the helmeted group.