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ORIGINAL ARTICLE

Soft Tissue Injuries of the Maxillofacial Region Occurring from Motorcycle Accidents

Md. Zeeshan Arif[1] · B. R. Rajanikanth[1] · Kavitha Prasad[1]

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Abstract
Introduction Soft tissue injuries are the most common type of injury occurring from a motorcycle accident. Not many studies have been conducted to determine the incidence and pattern of soft tissue injuries and the effectiveness of helmet to prevent them.
Methods In this prospective cross-sectional study, all the patients attending three centres in North Bangalore, with facial injuries occurring from a motorcycle accident, were included. The subjects were analysed for the type of collision, helmet use, type of helmet use and incidence and pattern of extra-oral and intra-oral soft tissue injuries.
Results A total number of 311 motorcyclists were included in this study for a period of 18 months (December 2015–June 2017). The most prominent age group was 21–30 years. Abrasions were the most common type of injury followed by the lacerations, contusions and communication. Injuries to the middle third and lower third of the face were significantly higher in non-helmeted and open-face-helmeted patients. Middle third injuries were most common in the full-face helmet group.
Conclusion Abrasions are the most common type of soft tissue injury, and most common site was the nose, followed by the forehead, orbit and chin. Full-face helmets are more effective and protective as compared to open-face helmets. Open-face helmets offer minimal protection against facial injuries occurring from road traffic accidents.

Keywords Maxillofacial injuries · Soft tissue injuries · Helmet · Road traffic accident

Introduction

Road traffic injuries are a major public health problem and a leading cause of death and injury around the world. Each year nearly 1.2 million people die as a result of road crashes, and millions more are injured or disabled [1]. In low-income and middle-income countries, car ownership and use rates are generally much lower than those in high-income countries. However, the ownership and use of motorcycles and other two wheelers are generally relatively high—for example, in India 69% of the total number of motor vehicles are motorised two wheelers [2]. Globally, there is an upward trend in the number and use of motorcycles and bicycles, for both transport and recreational purposes. Indeed, most of the growth in the number of vehicles on the world's roads comes from an increasing use of motorised two wheelers. Asian countries, in particular, are expected to experience a considerable rise in the number of motorised two-wheeler vehicles on their roads. This rapid growth in the use of motorcycles in many low-income and middle-income countries is already being accompanied by a considerable increase in the number of head injuries and fatalities that will only continue to increase if present trends continue unchecked [3].

The use of crash helmets has been the subject of many studies, pointing out their efficiency in decreasing mortality

✉ Md. Zeeshan Arif
zarif1991@gmail.com

B. R. Rajanikanth
rajanikanthbr@gmail.com

Kavitha Prasad
iamkps@rediffmail.com

[1] Department of Oral and Maxillofacial Surgery, Faculty of Dental Sciences, M.S. Ramaiah University of Applied Sciences, New Bel Road, Bangalore, Karnataka 560054, India

and morbidity compared with motorcyclists who did not use this protective measure [4]. Soft tissue injuries are the most common type of injuries occurring from a road traffic accident. Most studies on maxillofacial trauma have concentrated on facial fractures and their distribution in relation to aetiology [5]. Several studies, particularly in developed countries, have exclusively reported on soft tissue injury, looking at the distribution, type and mechanism of injury in relation to the aetiology [6]. There have been very few studies of maxillofacial trauma that include soft tissue injury from developing countries, particularly from Southeast Asia. The present study aims to look at the distribution, pattern and type of soft tissue injury occurring from motorcycle road traffic accidents in helmeted and non-helmeted patients attending three centres in Bengaluru, India.

Aim

The purpose of this study was to determine the types of soft tissue injuries occurring from motorcycle accidents and the role of helmet in the prevention of the same.

Objectives

The objective of the study was to compare and contrast the type of helmet used, prevalence of soft tissue injuries and the distribution of the injuries based on demographic characteristics.

Materials and Methods

This study was approved by the institutional review board and ethics committee according to the Declaration of Helsinki. A written informed consent was obtained from the participants agreeing to be a part of the study.

Study Setting

1. The Department of Accident and Emergency—Ramaiah Medical College and Teaching Hospital
2. The Department of Accident and Emergency—Ramaiah Memorial Hospital
3. The Department of Oral and Maxillofacial Surgery—Faculty of Dental Sciences, Ramaiah University of Applied Sciences

Source of Data

All motorcycle crash victim patients (rider/pillion) involved in a motorcycle crash accident attending the above-mentioned centres.

Study Period

A prospective clinical study was conducted for a period of 18 months extending from December 2015 till June 2017.

Sampling Frame

Motorcycle rider or a pillion who is involved in a road traffic accident, within the study region, during the study period was selected. The sample size was calculated using the Open Source Epidemiologic Statistics for Public Health or OpenEpi Version 2.3.1.

Inclusion Criteria

All motorcyclists (rider or pillion)
All ethnic groups
All age groups and gender
All types and severity of maxillofacial injuries, involved in a motorcycle crash.

Exclusion Criteria

Motorcyclists who discharged themselves from hospital care without a definitive diagnosis.
Patients who could not answer the questions, in case of loss of consciousness or death.

Resources Used

Data were collected with the help of a questionnaire, injury proforma and crash information datasheet. The demographic data, crash characteristics and the type of helmet were evaluated and recorded with the help of the proforma questionnaire. The type of soft tissue injuries was accessed as laceration, abrasion, contusion and communication. Site of the soft tissue injury was assessed as extra-oral and intra-oral injuries. Extra-oral injuries were recorded by MCFONTZL system developed by Lee et al and Hussaini et al [5, 7]. Intra-oral wounds were classified into six types—labial mucosa, sulcular mucosa, buccal mucosa, tongue, gingiva and palatal mucosa (Figs. 1, 2, 3, 4).

Statistical Analysis

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., was used to perform statistical analyses. Descriptive analysis of all the explanatory and outcome parameters was done using frequency and proportions for categorical variables. Chi-square test was used to compare demographic, helmet type, collision types and soft tissue injuries

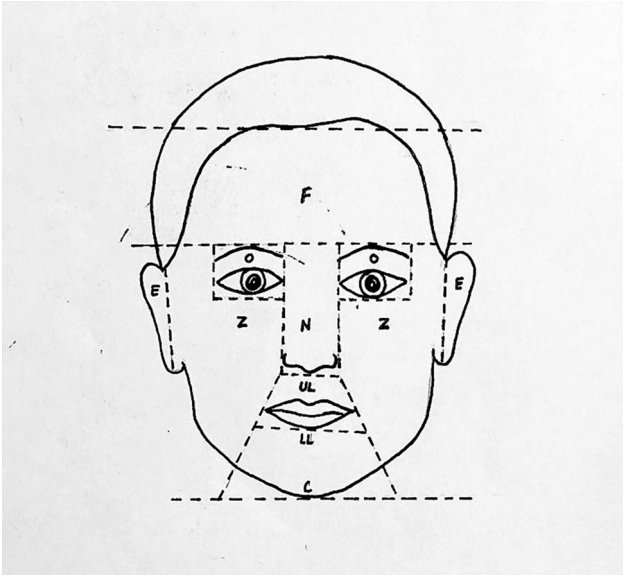

Fig. 1 Modified MCFONTZL classification of soft tissue injury. *F* forehead, *O* orbit, *C* chin, *N* nose, *L* lip (upper and lower), *E* ear, *Z* zygoma [5, 7]

Fig. 2 Extra-oral injuries: abrasions over the left zygoma, bridge of the nose and the ala of the nose involving a part of the upper lip. Laceration of the forehead

with helmet-related characteristics. It is statistically significant if $P < 0.05$.

Fig. 3 Laceration of the lower labial mucosa

Fig. 4 Contusion over the upper labial mucosa

Results

See Tables 1, 2 and 3.

Discussion

Demographic Data

Road traffic accident is the most common cause of maxillofacial injuries in developing countries, whereas assault is the most common cause of maxillofacial injuries in developed countries. In our study a total number of 311 patients were evaluated, who sustained facial injuries after the motorised two-wheeler accident, in which 248 were male and 63 were female. A total of 234 patients were wearing a helmet at the time of the accident, out of which 137 were open-face helmets (58.5%) and 97 were full-face helmets (41. 5%). The subjects' age ranged from 18 to 63 years. Most common age group to sustain maxillofacial injuries was 21–30, which accounted for 44.7%. The percentage of male and female was 79.7% and 20.3%,

Table 1 Comparison of helmet use based on demographic characteristics

Variables	Categories	Helmet (n = 234)		No helmet [n = 77]		χ^2 value	P value
		n	%	n	%		
Age group	≤ 20 years	17	7.30	5	6.50	0.925	0.92
	21–30 years	107	45.70	32	41.60		
	31–40 years	75	32.10	29	37.70		
	41–50 years	27	11.50	8	10.40		
	> 50 years	8	3.40	3	3.90		
Sex	Males	188	80.30	60	77.90	0.21	0.65
	Females	46	19.70	17	22.10		
Personnel	Rider	168	70.90	69	29.10	10.141	0.001*
	Pillion	66	89.20	8	10.80		
Type of collision	Head-end	104	82.50	22	17.50	6.073	0.04*
	Rear-end	25	69.40	11	30.60		
	Fall	105	70.50	44	29.50		

Statistically significant if $P < 0.05$

Table 2 Comparison of prevalence of soft tissue injury among helmeted and non-helmeted subjects as well as type of helmet using Chi-square test

Area	Soft tissue injury	Helmet [n = 39]		No helmet [n = 96]		χ^2 value	P value	Open type		Closed type		χ^2 value	P value
		n	%	n	%			n	%	n	%		
Extra-oral	Abrasion	158	67.50	77	100.00	33.096	< 0.001*	122	89.10	36	37.10	69.856	< 0.001*
	Laceration	113	48.30	75	97.40	58.449	< 0.001*	52	38.00	61	62.90	14.135	< 0.001*
	Contusion	62	26.50	75	97.40	118.188	< 0.001*	38	27.70	24	24.70	0.262	0.61
	Communication	17	7.30	72	93.50	210.939	< 0.001*	15	10.90	2	2.10	6.658	0.01*
Intra-oral	Abrasion	58	24.80	40	51.90	19.805	< 0.001*	35	25.50	23	23.70	0.103	0.75
	Laceration	40	17.10	33	42.90	21.407	< 0.001*	33	24.10	7	7.20	11.406	0.001*
	Contusion	18	7.70	20	26.00	18.053	< 0.001*	12	8.80	6	6.20	0.53	0.47
	Communication	11	4.70	13	16.90	12.073	0.001*	9	6.60	2	2.10	2.576	0.11

Statistically significant if $P < 0.05$

respectively. 21–30-year age group was considered as the most common age group for the incidence of maxillofacial injuries [5, 8].

Rider/Pillion Variable

In a study conducted by Mallikarjun et al, 75.5% were riders and 24.3% were pillions [8]. The incidence of injury increased if there was more than one pillion in a motorcycle [9]. Non-helmeted pillions, both male and female, had significantly lower Glasgow Coma Scale scores than helmeted pillions [10].

Type of Collision

In the present study the maximum number of collisions was head-end collisions 82.5%, followed by self-fall 70.5%. Yu et al and Oginni et al also described similar results where the head-end collisions were more than the rear-end collisions [9, 11].

Helmet Characteristics

There were two types of helmets described in this study: an open-face helmet and a full-face helmet. An open-face helmet is a half-helmet which has no protection of the face, whereas a full-face helmet has the protection of the face including the chin. Full-face helmets were more effective

Table 3 Extra-oral and intra-oral distribution of soft tissue injuries

	Total number cases				Helmet wearing subjects				Non-helmeted subjects				Open-face helmet cases				Full-face helmet cases			
	Ab.	Lac.	Cont.	Com.	Ab.	Lac.	Cont.	Com.	Ab.	Lac.	Cont.	Com	Ab.	Lac.	Cont.	Com	Ab.	Lac.	Cont.	Com.
Forehead	183	112	87	12	72	40	21	1	111	72	66	11	65	31	17	1	7	9	4	0
Orbit	173	95	83	7	68	22	23	0	105	63	60	7	59	18	20	0	9	4	3	0
Chin	151	126	57	32	69	56	25	11	82	70	32	22	60	36	20	10	9	20	5	1
Nose	193	134	43	19	89	47	17	7	104	87	26	12	56	36	12	6	33	11	5	1
Upper lip	119	115	38	45	42	40	19	15	77	75	39	30	40	33	11	12	2	7	8	3
Lower lip	127	109	45	56	49	49	25	21	78	60	36	35	55	35	17	18	4	14	8	3
Ear	52	23	2	0	10	7	0	0	42	16	2	0	10	6	2	0	0	1	0	0
Zygoma	110	60	7	5	40	20	2	0	70	40	9	5	30	15	2	0	10	5	0	0
Labial mucosa	85	79	43	31	36	29	11	11	49	50	32	20	22	20	8	6	14	9	3	1
Sulcular mucosa	64	53	21	2	29	20	10	0	35	33	11	2	22	12	8	0	7	8	2	0
Buccal mucosa	79	43	24	4	36	18	8	1	43	25	16	3	29	11	6	1	7	7	2	1
Tongue	52	32	5	9	22	10	1	1	30	22	4	18	18	8	1	1	4	2	0	1
Gingiva	42	35	25	13	17	14	11	3	25	11	14	10	15	10	9	3	2	4	2	2
Palatal mucosa	9	6	3	0	3	2	0	0	6	4	3	0	3	2	0	0	0	0	0	0

Ab. abrasion, *Lac.* laceration, *Cont.* contusion, *Com.* communication

than the open-face helmets in terms of protection of the face and reducing head injuries [12–14] (Fig. 5).

Soft Tissue Injuries: Helmet Versus No Helmet

Abrasions were the most common type of injury followed by lacerations, contusions and communications. Soft tissue injuries were divided into extra-oral injuries and intra-oral injuries. The soft tissue injuries were significantly more in non-helmeted subjects. (P value < 0.001).

Non-helmet subjects sustained more injuries as compared to helmeted subjects. The injuries were significantly more in non-helmet motorcyclists.

A study conducted by Hussaini et al determined that road traffic accidents were the main cause of maxillofacial trauma (73%). Of the RTA victims, 75% sustained soft tissue injuries and they were mainly motorcyclists (40% of all RTA casualties), and 69% were laceration or laceration with other wounds followed by abrasion and contusion, which accounted for 31% [5]. On the contrary in our study abrasions were the most common type of injury.

Soft Tissue Injuries: Open-Face Helmet Versus Full-Face Helmets

Open-face helmet subjects sustained more injuries as compared to full-face helmets. The extra-oral lacerations, abrasions and through-and-through communications were more in case of open-face helmet motorcyclists as compared to full-face-helmeted motorcyclists. And this value was statistically significant (P value < 0.001, < 0.001 and 0.01 respectively).

Interestingly, the intra-oral injuries (abrasions, contusions and communications) had a high incidence in the open-face helmet group but the values were not statistically significant. The extra-oral contusion injuries were also more in the open-face helmet group, but the difference was statistically nonsignificant.

Soft Tissue Injuries: Abrasion

Abrasions were the most common type of injuries seen among the subjects. The most common site for extra-oral abrasions was the nose, followed by the forehead, orbit and chin. The most common site for abrasions in the helmeted group subjects was the nose. This can be explained by the fact that helmets protect the upper face and full-face helmets protect the full face except that the mid-face, which is mostly exposed, leading to injuries in the mid-face. More number of abrasions were seen in the open-face helmet subjects.

Intra-oral abrasions were most common type of intra-oral injury observed in our study. The most common site for intra-oral abrasions was the labial mucosa followed by the buccal mucosa and sulcular mucosa. The most common site for intra-oral abrasion in helmeted group was buccal mucosa and labial mucosa in case of non-helmeted group. Open-face helmet subjects sustained more intra-oral injuries as compared to full-face helmets.

There were no forehead abrasions in case of full-face fastened group of motorcycle riders. The full-face helmet group had less number of abrasions as compared to open-face helmets. This can be attributed to the fact that full-face helmets provide better facial protection as compared to open-face helmets.

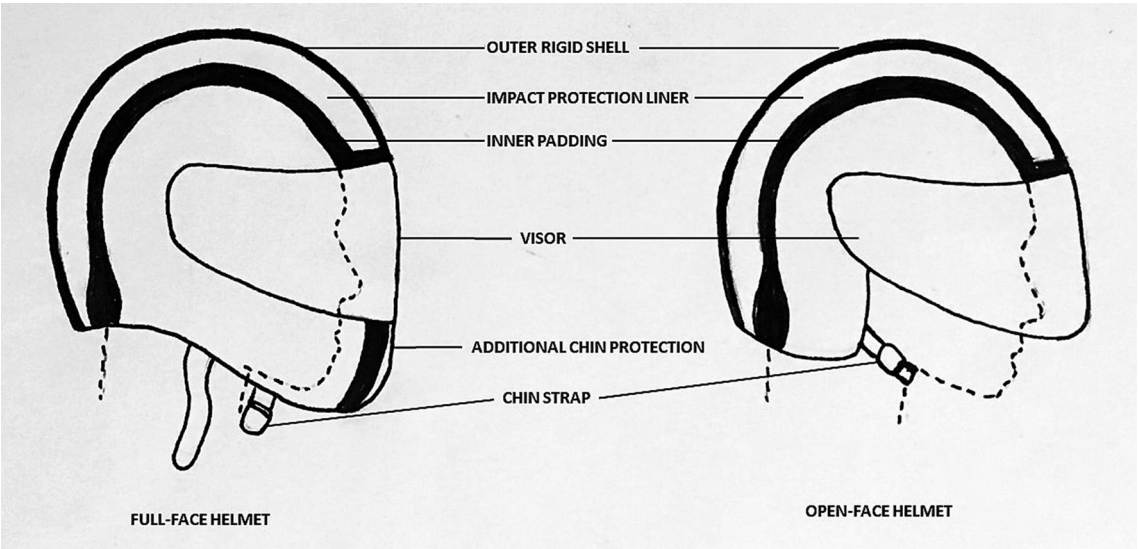

Fig. 5 Parts of a motorcycle helmet

Soft Tissue Injuries: Laceration

The number of lacerations was less as compared to abrasions in our study. In a study by Hussaini et al lacerations were the most prominent type of soft tissue injury observed after a motorcycle accident [5]. The most common site for extra-oral injury was the nose, followed by chin, upper lip, forehead and orbit. The least number of cases was seen in the ear, indicating the fact that both the type of helmets was effective for the protection of the head and the ear. The maximum number of intra-oral injuries was seen in labial mucosa, followed by sulcular mucosa, buccal mucosa, gingiva, tongue and palatal mucosa. All the extra-oral sites as well as the intra-oral sites sustained more injuries in case of non-helmeted group as compared to helmeted group. More number of lacerations were seen extra-orally in non-helmeted group as compared to helmeted group.

Soft Tissue Injuries: Contusion

The maximum number of contusions was seen in the forehead, followed by the orbit, chin, lower lip, nose, upper lip, zygoma, ear. The most common site for intra-oral contusions was labial mucosa, followed by gingiva, buccal mucosa, sulcular mucosa, tongue, palatal mucosa. The least number of contusions was seen in the palate. There were more contusions seen in the open-face-helmeted group as compared to full-face helmet group. Full-face helmets were more effective than open-face helmets.

Soft Tissue Injuries: Communication

A through-and-through communication was the least number of soft tissue injuries observed in our study. The maximum number of soft tissue communications extra-orally was seen in the lower lip followed by the upper lip. Most number of communications intra-orally were seen in the labial mucosa followed by the gingiva, tongue, buccal mucosa and sulcular mucosa. Non-helmeted motorcyclists sustained more extra-oral and intra-oral injuries as compared to non-helmeted motorcyclists. Open-face helmets were found to be less effective in preventing facial injuries, than full-face helmets.

Effect of Visor

In most of the helmets there is a visor, which is usually made of plastic or polycarbonate which tends to break at the time of the impact. This might result in soft tissue injuries of the face, especially the mid-third and the lower third of the face. In the present study, the maximum number of soft tissue injuries in the open-face helmet group was in the mid-third and lower third of the face. Open-face helmets offer minimal to no protection of the mid-third and lower third of the face. A visor attached to the open-face helmet has no support or lock in the lower helmet. This might also contribute to the injuries of the face.

In our study, an increased incidence in the mid-face injuries in the full-face helmets (zygoma, nose, upper lip) was observed. That is the only open part in a full-face helmet and is usually covered by a visor. The increased incidence of mid-face injuries in full-face helmets is suggestive of visor breaking during the point of impact.

Conclusions

The results of our study are consistent in suggesting a protective effect of motor cycle helmets on serious injuries of the facial region. Soft tissue injuries are the most common type of injury occurring in helmeted and non-helmeted motorcyclists. The incidence of facial injuries was significantly less in helmeted subjects as compared to non-helmeted subjects. The incidence of maxillofacial injuries in full-face helmets was significantly less as compared to open-face helmet.

There is minimal protection offered by the open-face helmets as compared to the full-face helmets. The use of open-face helmets should be discouraged. Vaughan et al. [15] in their study, about 35 years ago, had suggested that the use of full-face helmets should be encouraged and consideration given to the revision of helmet standards to require the provision of facial protection. Mandatory use of helmet for bicycle riders will also help to reduce the maxillofacial injuries and morbidity related to it [16].

The incidence of soft tissue injuries was the most in non-helmeted motorcyclists. The motorcycle helmet rules which are not effective in some regions can be the defining cause of the same. There is a significant negative impact of relaxed motorcycle helmet laws leading to an increase in craniomaxillofacial injuries [17]. After the application of the compulsory helmet law, which states mandatory helmet use for the rider as well as the pillion, the incidence of maxillofacial injuries as well as traumatic brain injuries has reduced considerably [18]. Lack of adequate training coupled with poor law enforcement among motorcyclists may be the reason of the accidents [19].

Future Directions

The effect of visor on the incidence of maxillofacial trauma should be assessed in future studies. Many helmets used by the motorcyclists are substandard which are not certified according to international helmet standards, which leads to more head and maxillofacial trauma. The motorcyclists

should be educated about a good helmet selection in relation to quality, size and fitting. The use of substandard, non-certified helmets and open-face helmets should be discouraged, and a generalised standardisation of the helmet type should be put into effect by the governing committee.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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