Shoulder Injuries in Single Bicycle Crashes

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ABSTRACT

Cyclist injuries leading to long-term consequences are common and therefore important to identify in order to design a more sustainable road transport system. Previous research has showed that almost 70% of all impairing injuries were to the upper and lower extremities. The most common injuries to the upper extremities were to the shoulder and the wrist (AIS 2).

The aim of this study was to investigate injury mechanisms leading to shoulder injuries in single-bicycle crashes in Sweden. In total 37 cyclists (8 females and 29 males) that sustained shoulder injuries and who seek medical care at University Hospital of Northern Sweden during the period 2010 to 2013 were included. While the injury data were obtained from hospital records, each patient was interviewed by telephone to obtain additional information regarding the subject's cycling habits, as well as details in the pre-crash and crash phases.

Most of the crashes (16/37) occurred on surfaces with low friction, such as ice or gravel, and 80% (30/37) reported not braking prior to the crash. Approximately 40% (15/37) of the cyclists sustained fractures of the clavicle.

In 90% of the cases (33/37) the injury to the shoulder was a result of a fall onto the shoulder or from a direct hit of the clavicle. Falling onto an outstretched hand only occurred in one case. 23 subjects reported falling to the side, which resulted in a straight hit on the shoulder, and further 7 hit the rear part of the shoulder, 5 of which fell over the handlebar.

Traditional prevention of cyclist injuries has been focused on helmet wearing. However, the findings in the present study indicate a need for other strategies to also prevent other injuries, especially to the upper extremities.

Keywords: bicycles, shoulder injury, long-term consequences, single-bicycle crashes.

1 INTRODUCTION

The popularity of cycling has increased and during the last years more attention has been paid from stakeholders to create a safer road environment for cyclists. Especially in big cities, cycling is an important complement to reduce vehicle congestion and CO_2 emissions, and to en-

courage health benefits. According to hospital reported crashes, cyclists account for a higher proportion than any other road user in Sweden in 2013 [1]: cyclists represented 45% of all severely injured (with medical impairment) and car occupants 33%. The injury consequences of bicycle crashes are primarily correlated to non-fatal injuries [2], as cyclists statistically represent around 6% of all road fatalities in Sweden [1].

In total almost 80% of all bicycle crashes in Sweden are single-bicycle crashes [3]. A similar figure could be seen in other studies based on hospital data from other countries [4]. The proportion of single-bicycle crash victims among the total number of hospitalised traffic casualties are in average 20%. It is clear that there are significant health and social care costs of cyclists injured in single-bicycle crashes. Previous studies have shown that there are different injury patterns in single-bicycle crashes and bicycle crashes involving a motor vehicle [5, 6]. Cyclists injured in a collision with a motor vehicle are generally more seriously injured [2], as head injuries are most common in those crashes. However, fractures to the upper extremities are more frequent in collisions with other cyclists or in single-bicycle crashes. Even if injuries to the upper extremities are more frequent in single-bicycle crashes (56%) than in collision with a motor vehicle these injuries stand for relatively large number of injuries 28% [7]. Fractures of the upper extremities are the most frequent AIS 2+ injury in bicycle crashes (50% of all AIS 2+ injuries) and these injuries often lead to long-term consequences [3].

Previous studies have showed that almost 70% of all impairing injuries were to the upper and lower extremities. The most common injuries to the upper extremities leading to medical impairment were to the shoulder and the wrist (AIS 2). Cyclist injuries leading to long-term consequences are common and therefore important to identify in order to design a more sustainable road transport system. However, little is known about how these injuries to the upper extremities occur. Such information is essential in order to understand the biomechanics behind these injuries and how to prevent them. Therefore the aim of this study was to investigate injury mechanisms leading to shoulder injuries in single-bicycle crashes.

2 METHODS

A retrospective review of the University Hospital of Northern Sweden trauma registry was conducted. All patients admitted between 2010 and 2013 with a bicycle-related trauma injury were identified (n=925). All cyclists above age 18 who were injured in a single-bicycle crash with an injury to the shoulder and treated at the hospital emergency department were selected. Cyclists who were under the influence of alcohol or cyclists who sustained a head injury were excluded. The nature of the cyclist's injuries (severity, types and body regions) were obtained from hospital records. Each patient was interviewed by telephone to obtain further information regarding the subject's cycling habits, as well as details in the pre-crash and crash phases. The interviews were conducted during the autumn 2013 by accredited hospital personal. Out of 51 cyclists that met the inclusion criteria, 37 participated in the interviews. Five did not want to participate and nine could not be reached for an interview.

A survey was developed to clarify different aspects and details related to the crash resulting in an injury to the shoulder. The first section included questions about the characteristics of the cyclist (gender, height and weight) as well as general description of the crash. The second section asked for more details in the pre-crash and crash phases (see Appendix).

Ethics approval was granted by the Ethical Review Board in Umeå, Sweden. Before being contacted, the participants were informed about the project with an explanatory statement sent to their home address. Those who were willing to participate were interviewed by telephone, which normally took about 20 minutes to complete.

3 RESULTS

In total 37 cyclists that sustained 42 shoulder injuries were included, Table 1. The participants were predominantly males (29 males and 8 females) and had a mean age of 46 (range 20-77 years). Injuries incurred included clavicle fractures, fractures of the humeral head, acromioclavicular joint dislocations, glenohumeral joint dislocation as well as haematoma, contusions and lacerations. Approximately 40% (16 of 42) of the cyclists sustained fractures of the clavicle and therefore was the most common injury type, Table 2.

Table 1. Characteristics of the data set, including mean age, height, weight and gender.

	Mean age (min-max)	Height (min-max)	Weight (min-max)	Gender (Female/male)
Injured cyclist	46 (20-77)	176 cm (163-193)	78 kg (55-110)	21.6/78.4

Table 2. Type of injuries by age groups

Injury type	**18-29**	**30-44**	**45-59**	**60+**	**Total**
Acromioclavicular joint dislocation/subluxation	1	3	3	1	8
Clavicle fracture	4	2	6	4	16
Glenohumeral joint dislocation				1	1
Haematoma/Contusions /Lacerations	3	2	6	3	14
Humerus fracture	1	1	1		3
Total (diagnoses)	9	8	16	9	42

In total 29 subjects reported falling sideways and in 8 crashes the subject fell over the handlebar. In 90% (33/37) of the cases the injury to the shoulder resulted from a fall onto the shoulder or from a direct hit of the clavicle. Falling onto an outstretched hand only occurred in one case. 23 of the 29 subjects reported that they were falling to the side resulting in a straight hit on the shoulder, and 7 hit the rear part of the shoulder of which 5 fell over the handlebar. Most of the injuries (29/42) were caused by a direct blow to the side of the shoulder,Table 3.

Approximately 46% of the crashes (17/37) occurred on surfaces with low friction, such as icy roads or gravel, see Table 4. Approximately 20% (7/37) reported braking prior to the crash.

Table 3. Type of injuries by direction of force

Injury type	**Rear**	**Front**	**Side**	**Total**
Acromioclavicular joint dislocation/Subluxation		2	6	8
Clavicle fracture		3	13	16
Glenohumeral dislocation	1			
Haematoma/Contusion/Laceration		6	8	14
Humerus fracture		1	2	3
Total (diagnoses)	1	12	29	42

Table 4. Direction of falling by road surface

Direction of falling	Ice/snow	Wet	Leafs	Gravel	Dry	Total
Sideways	9	2		3	15	29
Forward over the handlebar	2		1		5	8
Total (patients)	11	2	1	3	20	37

4 DISCUSSION

It was found that the vast majority of shoulder injuries occurred from direct hits on the shoulder or clavicle, and that falling onto an outstretched hand was very rare. Previous studies concentrating on clavicle fracture (regardless activity, i.e. not only in bicycle crashes) have shown that 94% of the injured persons had a fall onto the shoulder [8]. The mechanism of clavicle fractures is often the result of a fall onto the shoulder [9]. Similar mechanism causes injuries of the acromioclavicular joint. Injuries occur as a result of falling onto the shoulder with the arm adducted and the acromion, the bony process on the scapula, being forced under the clavicle. Anterior dislocation of the glenohumeral joint often occur as a results from a combination of abduction, extension and external rotation forces on the arm. This usually results from falling sideways onto the outstretched hand. Furthermore, the proximal humeral fractures usually occur to elderly people as a result of a fall onto the outstretched hand.

The most frequent scenario in the present study was falling sideways, which often resulted in a straight hit on the shoulder. It could be argued that falling from a bicycle often implies forces beyond the injury thresholds due to the height (around 1.3 meters) as well as the injury mechanisms mentioned above. These two combined factors increase the risk for injury to the shoulder, which are very common among injured cyclists, as reported in previous studies in Sweden[3, 10] and elsewhere [5, 7, 11]. Therefore the present study set out to investigate this issue, and found out that cyclist frequently sustained contusion and impact injuries to the shoulder region caused by direct impact. The most frequent injury type was clavicle fractures. These are known to cause long-term consequences: a follow-up study states that 46% of the patients still had problems ten years after the accident [12].

It is clear that there are health benefits of cycling. However, a full understanding of the influence on the public health requires attention to be paid not only to the benefits, but also to the factors that influence the risk of injury. Most of the cyclist injuries are caused by a single-bicycle crash event. The present study suggests that, to prevent shoulder injuries, both strategies to prevent crashes from occurring in the first place, but also body protections to other part of the body than the head are needed. Furthermore, the broad injury panorama of different body regions shows that prevention of bicycle injuries cannot be accomplished through helmet wearing alone; further preventive strategies are necessary in order to reduce the injury outcome.

During the last years, many stakeholders in Sweden have acknowledged the legitimacy of bicycles as a healthy and effective mean of transportation in urban areas [10]. These discussions also highlighted the responsibility that different stakeholders may have to encourage the use of bicycles, but also to prevent the injuries that may occur by using them. For instance, the recent Swedish strategy toward safer bicycling stressed that the urban infrastructure needs to be further developed to meet the safety needs of bicyclists. Approximately 60% of the single-bicycle crashes in Sweden are related to shortcomings or defects in the road infrastructure and most of these occurred due to low friction (70%) [13]. An additional figure could be seen when studying single-bicycle crashes resulting in shoulder injuries. Good maintenance of the bicycle network can improve friction, for instance by de-icing during the winter and by removing sand and gravel during the rest of the year. Furthermore, removing or posting of obstacles can help reduce the risk of crashes.

Bicycles are intrinsically unstable vehicles, which means that cyclists may fall off their bicycles even if effective infrastructure measures are introduced. One possible countermeasure could be to include energy-absorbing material in clothes. This approach has been extensively used to reduce injuries among motorcyclists, and studies based on real-life crashes have showed great benefits [14]. While the injury patterns among bicyclists and motorcyclists may not differ too much from each other, it is also evident that motorcycle protective gear is not suitable for bicycling. The user requirements in terms of ergonomics and heat comfort are clearly different, and so is probably user acceptance.

The present study was based on only 37 single-bicycle crashes but may give important insights into the injury types and mechanisms that occur in single bicycle crashes with shoulder injuries. However, a more comprehensive study should be performed to obtain further knowledge and confirm the present results.

As in all surveys, there are a few limitations that need to be discussed. The injured cyclists were interviewed by telephone up to three years after the accident. In retrospective surveys like the present study, underreporting due to memory distortion and over-reporting due to exaggeration may bias the analyses [15, 16] . Other studies have shown acceptable reliability in self-administered reports of specific injury details, such as the body part injured, but self-administered reports have been found to not correspond sufficiently to medical records [17]. Therefore, all data concerning diagnoses were taken from medical records.

A further limitation of the present study is that records from only one hospital in Northern Sweden were used. It could be argued that different weather conditions may lead to different bicycling habits; also, the distributions of road conditions may differ across different regions, and that this aspect may lead to different injury mechanisms. While it was not possible to obtain injury data from other hospitals, the distributions of road surface in the present study was very similar to the national statistics for bicycle crashes in all Sweden [10].

4 CONCLUSIONS

Most of the crashes resulting in shoulder injuries occurred on surfaces with low friction, such as ice or gravel.

In 90% of the crashes the injury to the shoulder was result from a fall onto the shoulder or from a direct hit of the clavicle. Falling onto an outstretched hand only occurred in one case.

Most frequent scenario was falling sideways resulting in a straight hit to the shoulder followed by direct hit to the rear part of the shoulder.

The findings indicate a need for strategies to prevent injuries to the upper extremities.

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APPENDIX

The following questions were asked to the survey participants.

- General description of the crash
- Where did the crash occur?
    - Place type
    - Road surface
    - Road conditions
- What do you think caused the crash?
- Were you braking before the crash?
- Did any sort of skidding occur before the crash?
- How did you fall?
- Describe the direction of force during the impact to the shoulder
- What speed range did you have right before the impact?
- What body region did you initially hit the ground with?
- What body region did you hit the ground with later, if any?
- How far from the bicycle did you stop after you fell?
- Did you slide on the ground or did you stop approximately in the same spot where you crashed?
- Describe the sitting position on your bicycle
- What kind of bicycle do you have?
- Did you wear any clothes with sleeves?
- Did you wear a bicycle helmet?
- Was the traffic dense?