Bicycle-Related Shoulder Injuries: Etiology and the Need for Protective Gear

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ABSTRACT: **Background:** The popularity of bicycle riding for recreation, exercise and transportation has grown enormously in recent years, which has led to an increased incidence of bicycle-related injuries. While these injuries involve mainly the musculoskeletal system, data on shoulder-specific injuries incurred while bike riding are lacking. Classifying these shoulder injuries may provide insight and assistance in the creation and implementation of effective protective gear and measures.

Objectives: To investigate the types and mechanisms of shoulder injuries among cyclists.

Methods: This study retrospectively examined all cyclists who incurred shoulder injuries while riding and were admitted to the emergency department and shoulder clinic between January 2008 and November 2013. The study included 157 subjects with various bicycle-related shoulder injuries treated with either conservative or surgical measures.

Results: Eighty-four percent of injuries were caused by a direct blow to the shoulder, 7% by falling on an outstretched hand, 6% were traction injuries, and 3% were due to hyper-abduction. Nine different clinical types of injury were observed; the most common injuries were clavicle fractures (32%), followed by acromioclavicular joint dislocations (22%), rotator cuff tears (22%), and humeral fractures (8%). Fifty-one percent of subjects were managed with conservative care and the remaining patients required surgical interventions.

Conclusions: Shoulder injuries incurred while riding a bicycle span the entire spectrum of shoulder injuries and often result in debilitating conditions. Although the use of helmets is increasing, there is currently no effective protective gear or measures to prevent riders from suffering shoulder injuries.

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KEY WORDS: bicycle, shoulder injuries, clavicle fractures, protective gear

Bicycles were introduced in the 19th century in Europe and in 2003 numbered more than one billion worldwide, which is twice the number of automobiles [1]. The popularity of bicycle riding for recreation, transportation and exercise has risen immensely in recent years [1]. The United States Department of Transportation estimated that 57,000,000 people (27% of the general U.S. population) rode their bicycles at least once in the summer of 2002 [1]. In the urban setting, many people opt for bicycle transportation due to the lower operative costs and added benefit of physical fitness. Off-road bicycling has become a leading recreational activity that spans all ages and has experienced a noticeable increase of cyclists in their fifth and sixth decades.

The increased popularity of bicycles for recreation and transportation has resulted in an increased incidence of bicycle-related injuries, involving primarily the musculoskeletal system [2]. This is demonstrated clearly in South Korea where bike-related injuries increased by 44% between 2007 and 2009 [3].

It is unclear whether the presence or lack of transportation infrastructure protects riders from or contributes to bicycle accidents. Bicyclists are vulnerable because they must frequently share the same infrastructure with motorized vehicles, but bicycles offer their users no physical protection in the event of a crash [4]. As such, bicycle-related accidents often supersede motorcycle-related accidents in severity [5].

Bicycle-related injuries most commonly involve the upper and lower extremities followed by the head, face, abdomen, thorax and neck [6], with 86.7% of injuries above the waistline [7]. Furthermore, it has been reported that the shoulder is the most common site of traumatic musculoskeletal injury among cyclists [5].

Head injuries account for the most devastating of all bicycle-related injuries and the nature of their sequelae are especially severe. As such, the development and implementation of special protective gear, namely the helmet, has been widely adopted and even mandated by law in some countries. Helmets have the potential to dramatically reduce the risk of serious head and face injuries by up to 88% [2,8-11]. However, no data are available regarding the type of shoulder injuries incurred among cyclists and the availability or effectiveness of specific shoulder protection gear. The importance of shoulder protection is not neglected for motorcyclists, however, as many motorcycle jackets include shoulder armor, highlighting the importance of these protective measures.

To the best of our knowledge, no study has analyzed bicycle-related shoulder injuries. The purpose of this study was to

investigate types and mechanisms of shoulder injuries among cyclists. Additionally, the data collected will be analyzed to inform the design and implementation of future shoulder protection gear.

METHODS AND MATERIALS

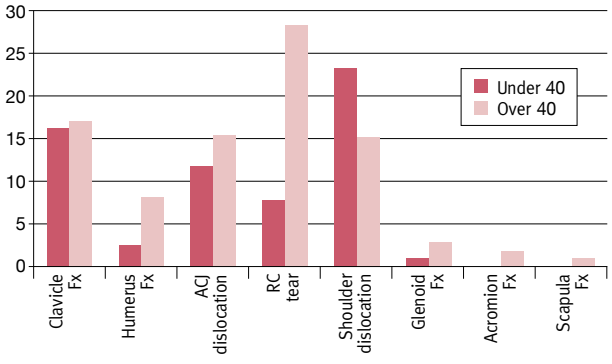
Local Institutional Review Board approval was obtained before commencement of the study. Tel Aviv Sourasky Medical Center is a designated level I trauma center and serves as a regional trauma center for the city of Tel Aviv and its surrounding communities. The medical center also functions as a tertiary referral center.

We conducted a retrospective examination of all shoulder-related injuries incurred by adult cyclists who were admitted to the emergency department or referred to the outpatient clinics between January 2008 and November 2013. A total of 157 patients with various shoulder injuries were included in this study. Data on gender, age, dominant side, site of injury, type and mechanism of injury, fracture classification where applicable, and type of management chosen (surgical/non-surgical) were recorded during history taking. Supplemental data were added as needed during a retrospective review of the medical records. Imaging modalities (X-rays, computed tomography or magnetic resonance imaging scans) were implemented to assess bone and soft tissue injuries. Patients were classified by age into the < 40 and > 40 year old group as the natural history of shoulder injuries varies greatly with respect to age. In patients younger than 40 who dislocate their shoulder, the recurrence of instability is relatively frequent, while in patients older than 40 dislocations are associated with injuries to the rotator cuff [12] [Figure 1].

STATISTICAL ANALYSES

Data were analyzed by calculating means and percentages for establishing trends. Data were summarized as means. The chi-square test was implemented when possible and Fisher exact tests were used when chi-square tests were not appropriate. A two-sided *P* value of 0.05 was considered statistically significant. Statistical analysis was performed using SPSS, version 21.0 (SPSS).

Figure 1. Type of injury categorized by age group



Fx = fracture, ACJ = acromioclavicular joint, RC = rotator cuff

RESULTS

The study population comprised 157 consecutive patients; 128 were male and 29 were female. The mean and median age of participants was 43 (range 14–79 years). After exclusion of bilateral injuries, 70 right-side and 70 left-side injuries were observed. Of 115 right-dominant patients, 63 (54%) incurred dominant (right) limb injuries, whereas 18 (72%) of 25 left-dominant patients incurred injuries on their dominant (left) limbs. The results show a significant ($P < 0.05$) predisposition for dominant limb injury resulting from traumatic bicycle accidents.

Four main types of injury mechanisms were identified. The most common was direct blow to the shoulder (84%), followed by fall on an outstretched hand (7%), traction injuries (6%) and hyper-abduction (3%) [Figure 2]. In the younger group (patients under 40), the most prevalent injury was glenohumeral joint (GHJ) dislocation (40%) while the older group experienced more injuries to the rotator cuff (34%) [Figure 1]. Clavicle fractures were the second most common injury in both groups, 30% and 19% in the younger and older groups respectively.

Clavicle fractures were divided according to their type using the Neer classification [13] [Figure 3]. Fifty-one percent of fractures were type 2 (distal third fractures), 29% were type 1 (middle-third fractures) and 20% were type 3 (medial-third fractures). Sixteen patients (41%) who presented with clavicle fractures required surgical intervention, of which five were type 1, six were type 2, and three were type 3 [Figure 3].

Figure 2. Main types of injury mechanisms

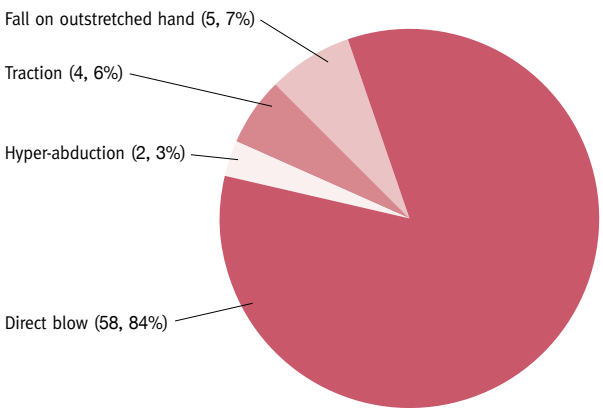
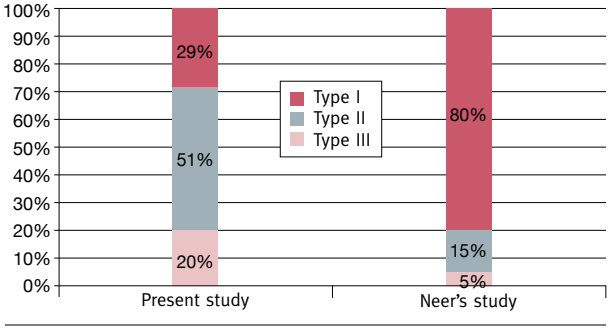


Figure 3. Clavicle fractures distribution in the current study vs. the study by Neer [13]



Fractures of the proximal humerus were classified using the Neer classification [14] commonly used in clinical settings. These fractures were not common and presented mainly in the older age group. Of the 10 patients who presented with proximal humerus fracture, 1 was 18 years old, 1 was 39 years old and the remaining 8 were in the above 40 age group (average 49, range 41–60).

DISCUSSION

The findings of this study revealed that the predominant mechanism of injury in bicycle accidents involving the shoulder was direct blow to the shoulder (84%). Overall, nine specific types of injuries were recorded, including soft tissue injuries and fractures. Due to the nature of the study population (e.g., the variance of ages), the impact of injuries on baseline soft tissue status could not be concluded.

The most common injury was clavicle fracture (32%). The distribution of clavicle fractures in this study differed from that reported in the literature. There were substantial discrepancies in the percentage of distal clavicle fractures (15% in current literature and 51% in this study) and of the medial third of the clavicle (5% in the literature and 20% in this study) [15-18]. The mechanism of injury common to cyclists may help explain these discrepancies as a direct blow to a cyclist, as it combines an injury sustained while moving with falling and the direct impact to the apex of the shoulder. This could possibly explain the higher overall rates of clavicle fractures and the shifts in the distribution of clavicle fracture location. Forty-one percent of the clavicle fractures in our cohort were treated surgically. The high rate of surgical intervention may be explained by the predominance of distal clavicle fracture (type 2) observed in our population. According to Brin et al. [19], the treatment approach for a displaced middle-third clavicular fracture seems to be evenly split between conservative and operative approaches. However, it should be mentioned that the study population included patients referred by other institutions or clinics. Depending on the specialization of the referring institution or clinic, bias may have been introduced impacting the severity and types of fractures encountered. This rate of surgical treatment is high compared to the rate of surgical fixation of fractures incurred due to explosion or gunshot injuries involving the upper limb, as reported by Luria and colleagues [20], which would presumably require surgical management.

Proximal humerus fractures, which are commonly osteoporotic in nature, were not common in this setting and were predominantly seen in the older patient group. In this group however, proximal humerus fractures occurred in patients with a mean age of 49 (18-60). The mean age of patients who suffered from proximal humerus fractures was lower than expected. This result may be explained by the fact that one patient was 18 years old and the sample size was relatively small, contributing to an outlier effect.

The discrepancy between the percentages of right-dominant and left-dominant injuries, although unexpected, may be explained by societal factors. Considering the high prevalence of right-hand dominance in the general population, the relationship between dominant side injuries in right-handed vs. left-handed patients may pertain to societal infrastructure. This relationship cannot be easily quantified considering that the design of products and the infrastructure favor right-dominant individuals. Some countries have begun to modify and create infrastructure specifically designed for recreational and transportation cyclists. Reynolds et al. [4] postulate that cyclist-specific infrastructure may decrease the severity and rate of bicycle-related accidents.

We are not aware of any existing effective protective shoulder gear for bicycle riders. Head injuries account for the most devastating of all bike accident injuries. As such, helmets have been widely adopted as specialized head protection. After the introduction and improvement of the helmet, studies have concluded that the impact of this protective gear on bicycle accidents is substantial. Helmet use has been estimated to reduce the risk for serious head and face injury by up to 88% [11]. Furthermore, helmets have been implemented as a necessary and, in many cases, mandatory protective gear. The same concern has been shown with regard to other sports and recreation activities [21]. Since the vast majority of shoulder injuries were due to a direct blow, we recommend that the protective gear provide protection specific to the apex of the shoulder. Educational programs on how to avoid a bicycle accident and how to correctly fall during an accident may lead to decreased incidence and severity of shoulder injuries as well. Although specialized shoulder protection gear is available, cyclists do not typically wear this gear as they do not feel it is necessary.

LIMITATIONS

The limitations of this study include those common to all observational cohort studies. Additionally, baseline characteristics could not be stringently controlled for and may dif-

fer between groups. Some patients were referred to Tel Aviv Sourasky Medical Center by other clinics, and this may have contributed to the high incidence of distal clavicle fractures. Additionally, no information was recorded on the type of bicycle riding (i.e., mountain, city, racing) which may have impacted the observed patterns of injury.

CONCLUSIONS

This study documented the predisposition for dominant limb injury in bicycle accidents as well as the most common mechanism of injury (direct blow). Regardless of the tremendous popularity of cycling, to the best of our knowledge no studies have classified the types of shoulder injuries incurred while riding. Further research is warranted to clarify the epidemiology, mechanisms and management of shoulder injuries among bicycle riders.

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"The most perfect technique is that which is not noticed at all"

Pablo Casals (1876-1973), Spanish cellist, conductor and composer, considered the greatest cellist of all time