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The Incidence and Risk Factors of Scaphoid Fracture Associated With Radial Head and Neck Fracture in Trauma Patients

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Abstract

Background: Scaphoid and radial head fractures are two injuries derived from the common fall on outstretched hand. How these injuries are related has not been fully investigated. The aim of this study was to evaluate risk factors for having concomitant proximal radius and scaphoid fractures. The goal was to identify at-risk patient populations and drive improvement in diagnosis and management of these injuries.

Methods: A retrospective review of the National Trauma Data Bank from 2007 through 2012 identified 11,309 patients with proximal radius fracture, and, as a proxy for low-energy injury, an injury severity score of less than 15. These patients were then categorized by presence of concomitant scaphoid injury. Presence of scaphoid fracture was then analyzed based on age, sex, race, trauma type, mechanism, and injury severity score.

Results: Three hundred seventy-eight (3%) scaphoid fractures among the 11,309 proximal radius fractures were identified. Both age and sex reached statistical significance as risk factors for concomitant scaphoid and radial head injury. There was an incremental increase in risk for concomitant injury with younger age. Subset analysis demonstrated a 10% incidence of concomitant fractures in men aged 18 to 30 years.

Discussion: This study provides a better understanding of how these two fractures are related. There is a markedly higher risk for concomitant injuries in male and young patients, especially those whose mechanism is a fall. Close examination of the wrist should be performed for any proximal radius fracture, and any pain should be a cause for further investigation of scaphoid injury.

Fractures of the radial head and neck have an overall incidence of 55.4 per 100,000 people and comprise 33% of all fractures of the elbow.[1,2] The most common mechanism of injury for this fracture is a fall on outstretched hand.[3] A number of other upper extremity fractures share this same mechanism. Of these injuries, fractures of the scaphoid are of

considerable interest. Scaphoid fractures have an estimated incidence of 1.47 fractures per 100,000 person-years and account for 2.4% of wrist fractures in the United States.[4] Not only is the overall incidence of this fracture notable, it is also a diagnosis that is missed at initial presentation up to 40% of the time.[5] Contributing to this high misdiagnosis rate is that initial radiographs of the scaphoid are falsely read negative up to 30% of the time.[5] Missed scaphoid fractures can have devastating consequences including nonunion and progressive carpal collapse Scaphoid Non-union Advanced Collapse [SNAC]).[6] Because of the common mechanism of injury of scaphoid and radial head and neck fractures, it is possible that a number of these fractures could occur concurrently. In addition, scaphoid injuries can be easily missed or diagnosed late in the face of distracting injuries, such as radial head and neck injuries.[7] Although previous small-scale, epidemiologic studies have provided data on the incidence of acute scaphoid fracture with ipsilateral radial head and neck fracture, there has been no large-scale study to elucidate a more representative incidence of this type of injury.[2,8,9] Moreover, there was a paucity of studies in our literature search that attempted to associate other upper extremity injuries with proximal radius fractures.[7,9] The purpose of this study was to investigate the incidence of scaphoid fracture with concurrent radial head or radial neck fracture, in the setting of low-energy trauma and falls. In addition, we planned to identify risk factors to identify at-risk patient populations in an attempt to drive improvement in diagnosis and clinical management of these concomitant upper extremity injuries.

Methods

Using the National Trauma Database (NTDB) data from 2007 to 2012, we extracted all encounter records with ICD-9 code 813.05 (closed radial head fracture), 813.15 (open radial head fracture), 813.06 (closed radial neck fracture), or 813.16 (open radial neck fracture). If there were multiple such codes associated with an encounter, we recoded the diagnosis as 813.99. Furthermore, if any of the injuries for a given encounter were open (813.15, 813.16), we set a variable indicating this fact.

Along with the encounter diagnoses of radial head injury, the variables extracted from NTDB were age, sex, race, trauma type, mechanism, and injury severity score (ISS). For each encounter, we additionally recorded all other ICD-9 codes associated with the encounter and noted specifically whether codes for closed fracture of the scaphoid or open fracture of the scaphoid (814.01 or 814.11, respectively) were in that list, for each encounter.

We removed all patients with ISS greater than 15, age younger than 18 years, or a trauma type other than blunt. Age was categorized as 18 to 30, 31 to 40, 41 to 50, 51 to 65, and greater than 65 years.

All variables in the resulting data set were summarized using the appropriate univariate statistics: means and SDs for continuous variables and frequencies and proportions for categorical variables. To understand what, if any, factors influenced the occurrence of scaphoid injuries, we examined the association of specific radius injury, presence of open radius injury, sex, and race with scaphoid injury using chi-squared tests.

Results

In the 6-year period (2007 to 2012) surveyed through the NTDB, 11,309 radial head and neck fractures coded as occurring by any mechanism were identified. Men accounted for 56.8% of these fractures. Of the 11,309 fractures, falls accounted for 7,448 (65.9%), 2,443 (21.6%) were attributed to motor vehicle trauma, 457 (4%) were bicyclists, and the remainder were split between pedestrians, machine injuries, and other mechanisms. For all mechanisms, radial head fractures accounted for 9,694 (85.7%) of proximal radius fractures, radial neck fractures accounted for 1,199 (10.6%), with the remaining 416 (3.7%) being combinations of radial head and neck injuries. Incidence of proximal radius fracture by age is delineated in Table 1.

Of those with all-cause injury, 378 (3.3%) scaphoid injuries were identified among the 11,309 proximal radius injuries surveyed. Men accounted for 238 of the concomitant proximal radius and scaphoid injuries, with an odds ratio (OR) of 2.35 for scaphoid injury when compared with women ($P < 0.001$). In addition, age was noted to be an independent risk factor for having concomitant injuries (Table 2). Notably, the ORs for scaphoid injury relative to the youngest age group grew smaller with age; all were less than one (Table 3). Predictably, increased ISS was associated with combined injuries. The mean ISS with and scaphoid fracture was 8.06 and 7.66, respectively ($P = 0.021$). Moreover, higher ISS was significantly linked to younger age ($P < 0.00001$), as well as male sex ($P < 0.00001$). Race, open versus closed fracture, and type of proximal radial fracture were not associated with scaphoid fracture.

When limiting the data to those incidents with falls as the mechanism, 251 (3.4%) scaphoid injuries occurred among the 7,448 fall patients. Although the incidence of proximal radial fractures in the fall group occurred nearly equally, men were 3.2 times more likely to sustain an associated scaphoid fracture. In

Table 1

Demographics of Proximal Radius Fractures

	All Mechanisms		Falls	
	n	%	n	%
Injury				
Radial head only	9,694	85.7	6,381	85.7
Radial neck only	1,199	10.6	773	10.4
Combination radial head and neck	416	3.7	294	3.9
Concomitant injury				
Scaphoid injury	378	3.3	251	3.4
No scaphoid injury	10,931	96.7	7,197	96.6
Race				
American Indian	45	0.4	23	0.3
Asian	158	1.4	100	1.3
African American	814	7.2	447	6.0
Pacific Islander	17	0.2	8	0.1
Other	981	8.7	629	8.4
White	8,508	75.2	5,726	76.9
Unknown	786	7.0	515	6.9
Sex				
Male	6,385	56.5	3,785	50.8
Female	4,862	43.0	3,621	48.6
Unknown	62	0.5	42	0.6
Mechanism				
Fall	7,448	65.9	7,448	100.0
Machine injury	65	0.6		
MVT, motorcyclist	890	7.9		
MVT, occupant	1,134	10.0		
MVT, other	15	0.1		
MVT, pedalcyclist	120	1.1		
MVT, pedestrian	251	2.2		
MVT, unspecified	33	0.3		
Fall from bicycle	457	4.0		
Other pedestrian	30	0.3		
Struckby, against	256	2.3		
Transport, other	610	5.4		
Age				
18–30	2,192	19.4	975	13.1
31–40	1,669	14.8	949	12.7
41–50	1,940	17.2	1,134	15.2
51–65	3,084	27.3	2,254	30.3
65+	2,424	21.4	2,136	28.7
Open fracture				
Yes	669	5.9	331	4.4
No	10,640	94.1	7,117	95.6

Demographic breakdown of proximal radius injury based on all injury mechanisms compared with falls only.

Table 2

Analysis of All Mechanisms of Injury

	Isolated Proximal Radius (n)	Concomitant Scaphoid Injury (n)	%	*P* Value
Race				0.355
American Indian	45	0	0.00	
Asian	155	3	1.90	
African American	791	23	2.83	
Pacific Islander	17	0	0.00	
Other	941	40	4.08	
White	8,227	281	3.30	
Sex				<0.00001
Male	6,102	283	4.43	
Female	4,768	94	1.93	
Age				<0.00001
18–30	2,037	155	7.07	
31–40	1,590	79	4.73	
41–50	1,875	65	3.35	
51–65	3,030	54	1.75	
65+	2,399	25	1.03	
Open fracture				0.456
Yes	359	19	5.03	
No	10,281	650	5.95	

Analysis of proximal radius fracture with concomitant scaphoid fracture for all recorded mechanisms of injury.

addition, there is also a significant association of scaphoid injury with younger age ($P < 0.00001$). Of those with proximal radial injures, 10.0% of the 18 to 30 age group, 5.6% of the 31 to 40 age group, 3.9% of the 41 to 50 age group, 1.6% of the 51 to 65 age group, and 1.0% of the 65+ age group had concurrent scaphoid injury (Table 4). ISS was also significantly in those with scaphoid fracture ($P = 0.00034$). Although the overall ISS was lower when controlled by sex and age, it was still notably higher in younger patients and men. Again, race, open versus closed fracture, and type of proximal radial fracture were not associated with scaphoid fracture when restricting attention to falls.

Table 3

Odds Ratios of Selected Variables: Falls and All Mechanisms

	All Mechanisms	Falls	*P* Value
Sex			<0.00001
Male	2.35 (1.82–2.89)	3.21 (2.39–4.31)	
Female	1	1	
Age			<0.00001
18–30	1	1	
31–40	0.65 (0.49–0.86)	0.54 (0.38–0.76)	
41–50	0.46 (0.34–0.61)	0.37 (0.25–0.53)	
51–65	0.23 (0.17–0.32)	0.14 (0.1–0.21)	
65+	0.14 (0.09–0.21)	0.09 (0.06–0.15)	

Odds ratios of having a concomitant scaphoid fracture when having a proximal radius fracture based on age and sex.

Discussion

The natural history of scaphoid injury makes it imperative to achieve early diagnosis and appropriate treatment. Proximal radius fractures and scaphoid fractures often have similar mechanisms of injury, and Wilden et al[7] showed that there was a trend toward late diagnosis when scaphoid fracture was associated with a proximal radius fracture. There have been multiple studies that characterize upper extremity fractures, but few studies that have explored the association of proximal radius fractures and scaphoid fractures. For example, Kaas et al found that radial head fractures had a concomitant scaphoid fracture 2.7% of the time, whereas Riet et al reported an incidence of 1.5% and Duckworth et al noted an incidence of 0.7%.[2,8,9] All of these studies were single-center, small-scale studies and none specifically identified risk factors for scaphoid fractures with concomitant proximal radius injury. This is the first large-scale study that examines proximal radius fracture and scaphoid fracture, restricting attention to injuries with a low-energy mechanism. Low-energy mechanisms are of particular importance because these are the traumas that are most commonly seen in the clinic setting. The incidence of concomitant proximal radius and scaphoid fracture from a low-energy

trauma was found to be 3.3%, among injuries caused by any mechanism. This is likely a more accurate representation of these injuries than previous studies.

If early diagnosis is not reached, clinical progression of scaphoid fracture can lead to serious disability. For example, osteonecrosis and nonunion are common complications associated with improperly treated scaphoid fracture. Osteonecrosis occurs at high frequency with scaphoid fracture because 70% to 80% of the blood supply is supplied in a retrograde fashion. Osteonecrosis is most common in proximal pole fractures and occurs up to 50% of the time. Moreover, nonunion will lead to pancarpal arthritis over the course of 20 to 30 years and can lead to carpal collapse.[10] This can cause notable disability and wrist pain.[11,12] Incidence of nonunion of nondisplaced fracture appropriately treated in cast has been as high as 12% in some studies, and as high as 50% when the fracture is displaced.[13,14] With such high risk of disability, there must be a high level of vigilance when dealing with any patient with proximal radius injury and any wrist pain.

Although close attention is warranted in any patient with radial head or neck fracture, certain patient characteristics seem to predispose to concomitant injury. Our study found a higher predilection for injuries in male and younger patients. These data are corroborated by previous studies, which have shown a similar trend when examining each injury in isolation.[2,15] When comparing between sexes among individuals with radial head or neck injuries, 4.4% of men also sustained a scaphoid fracture, whereas this occurred in only 1.9% of women (OR 2.35 [1.86 to 2.98]), among those with any type of injury mechanism. In those with fall as the mechanism, the difference was even more pronounced, with 5.1% incidence of concomitant scaphoid fracture in men, compared with 1.6% in women (OR 3.21 [2.39 to 4.31]). In addition, our data also show that the 18 to 30 age group has a markedly higher risk of having fractures of both the scaphoid and proximal radius than all older age groups. In fact, people in the 18 to 30 age group with a fall, had both scaphoid and proximal radius fractures 10.0% of the time, and were over 11 times more likely to have concomitant injuries than those in the 65+ age group. The risk for concomitant injury decreases from each age group to the next and is at its lowest in the 65+ age category. No study to date has shown this highly notable association between scaphoid and proximal radius fracture in both young and male patients.

Although this study was designed to find injuries constrained to lower energy mechanisms, each individual injury will have a different degree of associated force. This likely explains why younger and male patients are more likely to have simultaneous injuries. Indeed, the individual ISS scores for each injury were compared between sexes and age groups for the entire population. Women had an ISS of 7.17 versus 8.05 for men for any injury mechanisms ($P < 0.00001$), and 6.78 among women versus 7.82 among men in those with fall as injury mechanism ($P < 0.00001$). In addition, there is a statistically significant trend toward decreased ISS with increased age. The average ISS for all groups was still consistent with that of lower energy, but markedly higher ISS scores were seen in male and younger patients within our dataset. Using ISS as a surrogate for mechanism energy, it appears

Table 4

Analysis of Injury With Falls as Mechanism

	Isolated Proximal Radius (n)	Concomitant Scaphoid Injury (n)	%	*P* Value
Race				0.276
American Indian	23	0	0.00	
Asian	98	2	2.00	
African American	432	15	3.36	
Pacific Islander	8	0	0.00	
Other	599	30	4.77	
White	5,546	180	3.14	
Sex				<0.00001
Male	3,594	191	5.05	
Female	3,562	59	1.63	
Age				<0.00001
18–30	878	97	9.95	
31–40	896	53	5.58	
41–50	1,090	44	3.88	
51–65	2,219	35	1.55	
65+	2,114	22	1.03	
Open fracture				0.565
Yes	238	13	5.18	
No	6,879	318	4.42	

Analysis of proximal radius fracture with concomitant scaphoid fracture with falling as the mechanism of injury.

that male and younger patients are more likely to be on the higher end of the low-energy mechanism spectrum; thus, leading to a higher risk for concurrent proximal radius and scaphoid injury.

The substantial association between radial head or neck fractures and scaphoid fractures demands consistent vigilance, especially in the young and male patient populations. Careful history should be taken into account when interviewing a patient with likely upper extremity injury. This study shows that falls are associated with a higher rate of scaphoid injury compared with all other mechanisms. Physical examination is also an extremely important tool in patients with a diagnosis of radial head or neck injury. The entire extremity should be palpated and any tenderness in the wrist should be met with plain radiographs. If radiographs are negative and suspicion for scaphoid fracture continues to be high, then proceeding with advanced imaging due to possible aforementioned consequences of missed diagnosis is prudent.

The main limitation of this study is the use of the NTDB and the fact that it is somewhat difficult to control for low-energy mechanisms.[13] ISS < 15 was used as a surrogate for low energy, but this is subject to the coding of each traumatic episode at each center. In addition, our database search was based on ICD-9 codes that do not take laterality into account. This makes it uncertain if scaphoid injuries and radius injuries are occurring on the same extremity. Moreover, 0.6% of data points for sex were missing, as were 7.0% of data points for race. This likely does not introduce bias into the study because the percent missing from each category is small. The nature of searching ICD-9 codes also limits understanding of more complex injuries to the wrist and elbow. Longitudinal radioulnar disassociation (Essex-Lopresti injury) occurs with an injury to the radial head and concomitant disruption to the longitudinal stabilizers of the forearm and wrist.[16] Force transmission through the forearm is at its greatest when the elbow is extended and the forearm is pronated; so this will share a common mechanism of injury with both scaphoid and radial head injuries.[17] Essex-Lopresti injuries are also often missed and can vary, from subtle injuries with 2-mm changes in ulnar variance to full dislocation of the distal radial ulnar joint (DRUJ).[16] Our analysis does not include this injury because no single ICD-9 code exists for it. It is possible that in the future NTDB data can better assess the associations between wrist and elbow injuries through more specific and evolving ICD-10 codes.

The primary strength of this study is the large sample size of the database. The NTDB is currently the largest trauma registry in the United States and contains data on >5 million cases for >900 registered trauma centers, making it highly generalizable to centers across the United States.[13] It also shows previously undefined relationships of two injuries with similar mechanisms. This study also stratifies and analyzes multiple demographic variables in an attempt to further characterize these upper extremity injuries.

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