Radiographic Diagnosis of Scapholunate Dissociation Among Intra-articular Fractures of the Distal Radius: Interobserver Reliability

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Purpose To evaluate the reliability and accuracy of diagnosis of scapholunate dissociation (SLD) among AO type C (compression articular) fractures of the distal radius.

Methods A total of 217 surgeons evaluated 21 sets of radiographs with type C fractures of the distal radius for which the status of the scapholunate interosseous ligament was established by preoperative 3-compartment computed tomographic arthrography with direct operative visualization of diagnosed SLD (reference standard). Observers were asked whether SLD was present, and if yes, whether they would recommend operative treatment. Diagnostic performance characteristics were calculated with respect to the reference standard. We assessed interobserver reliability using the Fleiss generalized kappa.

Results The interobserver agreement for radiographic diagnosis of SLD was moderate (κ = 0.44). Correct diagnosis for a given set of radiographs ranged from 8% to 98% (average, 79%) of observers. Diagnostic performance characteristics were: 69% sensitivity, 84% specificity, 84% accuracy, 68% positive predictive value, and 84% negative predictive value. Based on a prevalence of 5%, Bayes adjusted positive and negative predictive values were 18% and 98%, respectively. Raters recommended operative treatment in 74% to 100% of patients diagnosed with SLD.

Conclusions Radiographs are moderately reliable and are better at ruling out than ruling in SLD associated with type C fracture of the distal radius. *(J Hand Surg 2013;38A:1685–1690.*

Type of study/level of evidence Diagnostic III.

Key words Interobserver reliability, distal radius intra-articular fracture, scapholunate injury.

The prevalence of ligamentous injury associated with fractures of the distal radius has been reported to be as high as 69% when partial injuries are included.[1] Intra-articular fractures are associated with a 2-fold increase in the risk of scapholunate ligament injury.[2] Complete scapholunate ligament disruption (SLD) may lead to alterations in carpal balance and subsequent arthrosis.[3–5]

Early diagnosis facilitates reduction and repair and may improve outcomes.[3] Diagnosis of acute SLD is difficult, especially when associated with a fracture of the distal radius. Fracture-associated pain precludes

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provocative wrist ligament testing,[3] and the presence of a displaced intra-articular distal radius fracture and the resulting carpal malalignment might obscure differences in intercarpal angles on radiographs.

This investigation evaluated the reliability and accuracy of radiographic diagnosis of SLD in patients with AO type C (compression articular) fractures of the distal radius.

MATERIALS AND METHODS

Study design

We asked members of the Science of Variation Group to evaluate 21 sets of radiographs of patients with AO type C intra-articular fractures of the distal radius in an Internet-based survey. For every patient, the status of the scapholunate ligament was established by preoperative 3-compartment computed tomographic (CT) arthrography followed by direct operative visualization of diagnosed lesions. Studies suggest that CT arthrography of the wrist can detect scapholunate ligament tears with a sensitivity of up to 94% and specificity of up to 95%.[6–8]

The Science of Variation Group is a collaborative of multiple fully trained surgeons from diverse countries and institutions. The objectives of the collaborative are to study variation in the definition, interpretation, and classification of injury and disease. The study was performed under a protocol approved by the institutional research board at the principal investigator's hospital.

Observers

A total of 681 independent board-certified orthopedic hand and trauma surgeons from several countries were invited via e-mail to join the Science of Variation Group. Other than an acknowledgment as part of the author collaborative in this report, no incentives were provided. A total of 308 surgeons were interested in participation and logged on to the Web site. Four weekly reminders to complete the online survey were e-mailed; 217 surgeons completed the study.

Radiographs

Radiographs of 7 patients were selected from a list of all cases of intra-articular fractures of the distal radius and operatively (fluoroscopy or open exposure) confirmed traumatic complete scapholunate ligament disruption (Geissler Grade IV) treated by the senior investigator from January 2006 to December 2010. These 7 patients were selected on the basis of availability of initial injury radiographs, adequate picture quality, and absence of additional fractures (eg, forearm or hand) or ligamentous injuries.

TABLE 1. Surgeons' Demographics

	Surgeons, n
All questions answered	217
Sex	
Male	202
Female	15
Area of practice	
United States	114
Europe	61
Other	42
Independent practice, y	
0–10	114
> 10	102
No information	1
Ligamentous lesions treated, n/y	
0–10	107
11–50	98
> 50	12
Specialty	
Trauma and orthopaedic	112
Hand and wrist	105

Radiographs of 14 patients with an intra-articular fracture of the distal radius and no ligament injury on CT arthrogram served as controls. An experienced board-certified radiologist performed preoperative triple-compartment arthrography to rule out SLD, and board-certified hand surgeons confirmed carpal stability after fracture reduction and fixation using fluoroscopy and PACS documentation (OEC 6800; General Electric Medical Systems, Salt Lake City, UT) by placing the wrist through a full radioulnar arc in a posteroanterior image and looking for asynchronous movement. Radiographs from 21 patients were de-identified by an independent research fellow and uploaded to the research group's Web site.

Evaluation

On logging in to the Web site, surgeons were asked to provide the following demographic and professional information: (1) sex, (2) location of practice, (3) years in independent practice, (4) training of surgical trainees, (5) number distal radius fractures and number of ligamentous lesions treated per year, and (6) clinical specialty.

Posteroanterior and lateral radiographs obtained immediately after injury were presented to the observers without clinical information (eg, age, sex, mechanism).

TABLE 2. Interobserver Analysis, Agreement on SLD

Multirater Agreement	Agreement	Kappa	PA, %
Overall	Moderate	0.44	75
Practice, y			
0–10	Moderate	0.47	76
> 10	Fair	0.40	70
Ligamentous lesions treated, n/y			
0–10	Moderate	0.45	75
> 10	Moderate	0.42	74
Specialty			
Trauma and orthopedic	Moderate	0.45	75
Hand and wrist	Moderate	0.43	76

PA, proportion of agreement.

FIGURE 1: A Anteroposterior and **B** lateral radiographs show type C fracture and associated complete scapholunate ligament disruption. Scapholunate dissociation was diagnosed by 8% of raters.

Observers were asked to decide whether SLD was present or absent. In addition, observers were asked whether additional imaging (eg, magnetic resonance imaging, radiographs of the contralateral wrist) was required. When observers diagnosed SLD, they were asked whether they would treat it operatively.

All questions had to be completed to continue with the next case, and observers could comment on each case. The observers completed the study at their own pace.

Statistical analysis

The multirater agreement of the dichotomous variable (SLD present/absent) was calculated with the Fleiss generalized kappa.[9,10] This is a statistical chance-corrected measure for assessing multirater agreement with binary ratings. It calculates the kappa values between 0 and 1 that which were interpreted in accordance to the guidelines by Landis and Koch[11]: 0.01 through 0.20 represent slight agreement, 0.21 to 0.40 fair agreement,

FIGURE 2: A Anteroposterior and **B** lateral radiographs show type C fracture and associated complete scapholunate ligament disruption. Scapholunate dissociation was diagnosed by 98% of raters.

0.41 to 0.60 moderate agreement, 0.61 to 0.80 substantial agreement, and above 0.80 almost perfect agreement.

The proportion of correctly diagnosed SLD (present or absent; in percentage; rated by 217 surgeons) for each fracture was calculated. Sensitivity, specificity, accuracy, and positive and negative predictive values were calculated with respect to the reference standard.

RESULTS

Surgeons

There were 202 male and 15 female surgeon observers (Table 1). Most surgeons reside in the United States or Europe. Approximately half of the observers had been in independent practice for more than 10 years. The majority of surgeons (84%) were in academic practice (in terms of supervising trainees). A total of 107 surgeons operated on 0 to 10 ligamentous lesions per year, 98 on 11 to 50, and 12 on more than 50 per year. Eighteen observers were general orthopedic surgeons, 27 were orthopedic trauma surgeons, 67 were trauma surgeons, and 105 were hand and wrist surgeons.

Interobserver reliability of diagnosis of SLD

The interobserver reliability of radiographic diagnosis of SLD was moderate (κ = 0.44) and the proportion of agreement (PA) was 75%. General orthopedic and trauma surgeons (κ = 0.45; PA, 75%) and hand and wrist surgeons (κ = 0.43; PA, 76%) had comparable reliability. More years of practice (> 10 y) and a higher number of ligamentous lesions treated per year (> 10 lesions) did not improve the agreement (Table 2).

TABLE 3. Diagnostic Performance

Fracture No.	SLD	Correctly Diagnosed, %
1	No	88
2	No	91
3	Present	98
4	No	96
5	Present	78
6	No	68
7	No	91
8	No	71
9	No	88
10	Present	71
11	No	77
12	No	70
13	No	96
14	No	94
15	No	63
16	No	93
17	No	90
18	Present	8
19	Present	56
20	Present	77
21	Present	96

Sensitivity was 0.69 (95% CI, 0.67–0.71); specificity was 0.84 (95% CI, 0.83–0.85); and accuracy was 0.79.
SLD, scapholunate dissociation (operatively confirmed).

Diagnostic performance characteristics

The presence or absence of SLD was diagnosed correctly by an average of 79% of the raters per set of radiographs [range, 8% (Fig. 1) to 98% (Fig. 2)] (Table 3). The sensitivity to diagnose a SLD was 0.69, the specificity was 0.84, the accuracy was 0.84, the positive predictive value was 0.68, and the negative predictive value was 0.84. Based on a 5% prevalence of SLD in a recent retrospective cohort of type C fractures of the distal radius at 1 of our institutions, the Bayes prevalence adjusted positive and negative predictive values were 0.18 and 0.98, respectively.

TABLE 4. Diagnostic and Treatment Recommendations for Scapholunate Ligament Dissociation

Fracture No. With SLD	Further Tests	Treatment
3 (213 raters)	Additional views (35%)	Operative (96%)
5 (169 raters)	MRI (31%)	Operative (98%)
10 (154 raters)	Radiograph of contralateral wrist (27%)	Operative (94%)
18 (17 raters)	MRI (41%)	Operative (100%)
19 (121 raters)	Arthrogram (27%)	Operative (74%)
20 (168 raters)	MRI (43%)	Operative (95%)
21 (208 raters)	None (34%)	Operative (92%)

SLD, scapholunate dissociation (operatively confirmed); MRI, magnetic resonance imaging.

Treatment of SLD

In case of correctly diagnosed SLD, the raters recommended operative treatment in 93% (range, 74% to 100%). The need for further tests was less clear (Table 4). No further tests were requested in 25% (range, 13% to 34%), magnetic resonance imaging in 23% (range, 9% to 43%), arthrogram in 17% (range, 14% to 27%), and radiograph of the contralateral wrist in 16% (range, 0% to 27%).

DISCUSSION

Scapholunate ligament tears represent a spectrum of injuries rather than an all-or-nothing phenomenon, and even complete tears might not lead to carpal malalignment because of secondary stabilizers.[3,12] Accurate and reliable radiographic diagnosis of SLD associated with distal radius fractures might reduce the number of additional tests and unnecessary arthroscopic examinations. Radiographic signs of SLD include widening of the scapholunate gap, a scapholunate angle greater than 70°, discontinuity in the Gilula lines, and the presence of a scaphoid ring sign.[13–15] The scaphoid ring sign is visible on posteroanterior radiographs when the distal pole of the scaphoid is superimposed on the waist of the flexed, foreshortened scaphoid.[3] All of these signs are indicative but not diagnostic of SLD, and differences in positioning of the wrist and radiographic and measurement techniques account for a high degree of variability.[16]

We do not know the percentage of SLD associated with type C fracture of the distal radius with no radiographic signs as in Figure 1, but this example is certainly unsettling. In line with other studies,[14,15] radiographs are only 69% sensitive for diagnosing SLD; but given the low prevalence of SLD, the Bayes adjusted negative predictive value is 98%. That means that when there are no radiographic signs of SLD, the probability of missing an SLD is less than 2%, which seems acceptably low.

Given that greater experience did not improve agreement as it often does,[17–19] we speculate that disagreement may result more from a lack of clear definitions of radiographic signs of SLD as well as inadequacies of radiographs taken at the time of injury (which are difficult to standardize). Several observers commented on the need for postreduction radiographs to reevaluate carpal alignment or the need for dynamic imaging to analyze scapholunate motion.

Raters recommended operative treatment of SLD in 93% (range, 74% to 100%) of cases. Observers who opted for nonoperative treatment argued that decision making is based on patient factors as opposed to radiographic or injury characteristics, and commented on the need to know patient age, level of activity, and associated demands.

There are several limitations to this study. First, for practical reasons, the Science of Variation Group studies do not measure intra-observer reliability. Second, 85% of the participating observers were in academic practice, which could create bias by overestimating agreement because surgeons in academic referral clinics might be more familiar with these complex injuries. Third, we used the initial injury radiographs as opposed to standardized radiographs. We believe that using radiographs of varying quality better reflects routine clinical conditions, which facilitates the application of our findings to current practice. Fourth, the observers were specifically asked to look for SLD, so our results might be different from standard practice. Fifth, there is no consensus reference standard for the diagnosis of SLD, although routine arthrography confirming positive tests with direct operative

visualization is good. Finally, these results are subject to spectrum bias because there was a greater prevalence of SLD in these sets of radiographs than occurs among AO type C fractures of the distal radius in general.

The diagnosis of SLD associated with fracture of the distal radius is moderately reliable. Given the low prevalence of SLD, the negative radiographs are easier to interpret than positive radiographs. Radiographs interpreted as no SLD are unlikely to miss SLD, but positive radiographs need confirmation with arthrography, arthroscopy, or open exposure.

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