Diagnostic modalities for the occult scaphoid fracture

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Chapter 4

Interobserver variability among radiologists for diagnosis of scaphoid fractures by computed tomography

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J Hand Surg Am. 2012 Nov;37(11):2252-6.

Abstract

Objectives To determine the interobserver variability among radiologists for Computed Tomography (CT) diagnosis of scaphoid fractures.

Methods Four specialized musculoskeletal radiologists evaluated the CT scans of 150 consecutive patients who were clinically suspected of having sustained a scaphoid fracture but whose scaphoid-specific radiographs were normal. The radiologists were asked to determine the presence or absence of a scaphoid fracture and to localize the fracture. Interobserver agreement was calculated using the kappa statistic.

Results The radiologists diagnosed between 11 (7%) and 22 (15%) scaphoid fractures; the kappa value was 0.51.

Conclusion Agreement on the presence of a scaphoid fracture and its location on a CT scan was moderate among the 4 radiologists. This finding raises the question as to whether scaphoid fractures could be under- or overdiagnosed in daily practice when CT is used to exclude or confirm a fracture. This should be kept in mind when interpreting clinical and radiological results in patients with suspected scaphoid fractures.

Introduction

Twenty percent of all scaphoid fractures are not evident on initial radiographs.(1-3) An untreated or mistreated scaphoid fracture may give rise to osteonecrosis, nonunion, carpal instability with subsequent pain, or functional impairment.(4-9) To initiate appropriate treatment as soon as possible, the diagnostic method chosen must be accurate and allow for the accurate identification of scaphoid fractures among suspected fractures.CT is often advocated for the diagnosis of scaphoid fractures in patients who are clinically suspected of having a fracture but whose radiographs are negative. The primary aim of this study was to determine the interobserver variability in the use of CT for the diagnosis of true scaphoid fractures among suspected fractures. Interobserver variation in fracture localization was additionally evaluated because the location of a fracture could have distinct consequences on the choice of treatment.(10,11)

Methods and materials

Patients

This cross-sectional study was approved by the regional medical ethics committee. Between November 2007and March 2010, all eligible patients who had consecutively presented at the emergency department of our facility were included in the study after both oral and written informed consent had been obtained. The eligibility criteria were a suspected scaphoid fracture (a tender anatomic snuffbox and pain in the snuffbox when applying axial pressure on the thumb or index finger), recent trauma (within 48 h) and no evidence of a fracture on scaphoid radiographs. The scaphoid radiographs were taken on three planes: a posteroanterior view with the hand in a neutral position, an oblique view with the wrist in 10° of supination and maximal ulnar deviation and a true lateral view with the wrist resting in the ulnar position on the x-ray plate. Patients who had sustained multiple injuries, who were younger than 18 years of age, or in whom CT was contraindicated were excluded from the study.

CT protocol

The CT scans were obtained with a General Electric Lightspeed Qx/I CT Scanner (Pewaukee, WI). The technique used was described by Sanders.(12) A patient lay prone on the scanning table with the hand extended forward, palm down, over the head, with the wrist in neutral flexion and neutral radial-ulnar deviation. Scout images were obtained to ensure that the scanning plane corresponded with the scans that provided a lateral view of the scaphoid, as defined by the central longitudinal axis of the scaphoid. Coronal plane images, defined as images that provided a posteroanterior view of the scaphoid in the anatomic plane and in line with the axis of the scaphoid, were obtained by supinating the forearm 90° while keeping the wrist in a neutral position. Slice thickness was 0.625 mm with reconstructions every 0.4 mm (120 per kilovoltage, 80 mA, noise index 34). For multiplanar reformatted images, the parameters were a 2-mm slice thickness at a 2-mm interval. All scans were reconstructed in high kernel bone algorithms (high spatial resolution/low contrast resolution).

Observers

We asked four of our facility radiologists, experienced in musculoskeletal trauma radiology, to evaluate the CT scans of the patients included in the study for the presence or absence of a scaphoid fracture. If a fracture was diagnosed, we also asked for its exact location. The four radiologists had 36, 18, 16 and 12 years of clinical experience, respectively.

Evaluation

All CT images were blinded and uploaded into a workstation (GE Medical Systems IT, Zeist, The Netherlands, software Centricity Radiology RA 600 Standard v6.1 Build 1588 patch 05, 04, 02, 01). Both before and during evaluation of the CT scans, the radiologists had been aware of the fact that all patients were clinically suspected of having scaphoid fractures but whose radiographs had been negative. They did not have access to the radiographs or any other clinical data. Each radiologist independently rated each CT scan using a standardized scoring sheet containing the following items:

1. Scaphoid fracture (yes/no) and, if yes, its location (distal/waist/proximal)
2. Distal radius fracture (yes/no)
3. Other carpal fracture (yes/no)
4. No injury

Statistical analysis

Interobserver agreement among the four observers was calculated. For the presence or absence of a scaphoid fracture, the simple kappa coefficient was calculated. For the location of a scaphoid fracture, the weighted kappa coefficient was calculated because these data had been scored on an ordinal scale. For the interobserver variations, an overall kappa statistic along with the pairwise kappa statistics was provided. For the overall weighted kappa, an intraclass correlation coefficient was calculated. The kappa statistic is a chance-corrected measurement of agreement in data. A kappa value can range from +1 (perfect agreement) to -1 (absolute disagreement). A value of 0 indicates no more agreement than could be expected by chance alone. The interpretation of the kappa value was based on the guidelines of Landis and Koch,(13) which suggest that values between 0 and 0.2 represent slight agreement; between 0.21 and 0.40, fair agreement; between 0.41 and 0.60, moderate agreement; and between 0.61 and 0.80, substantial agreement. A value above 0.80 is considered to be an almost perfect agreement.

Results

A total of 162 patients with a clinically suspected scaphoid fracture were eligible for inclusion. Two patients who had not undergone CT scanning were excluded from the analyses, as well as 10 patients whose CT scans had not been carried out according to the protocol. There were 150 (93%) patients included with a mean age of 41 years (range, 18 – 89 y); 77 (51%) were male.

Interobserver agreement for the presence of scaphoid fracture

The four radiologists diagnosed 22, 16, 15 and 11 scaphoid fractures, respectively. Overall, kappa for presence of a scaphoid fracture was 0.51; the kappa between observers ranged from 0.36 to 0.68 (Table 1). Figure 1 contains a slice of the CT of the scaphoid upon which the radiologists agreed a scaphoid fracture was present. In this patient, a fracture line in the scaphoid became visible on the x-ray that was repeated six weeks after trauma. Figure 2 is an example of a CT scan on which the radiologists had not agreed. Two radiologists had scored “scaphoid fracture” and two radiologists had scored “no injury.” Interobserver agreement for the location of the scaphoid fracture Three radiologists reported “waist” most often as the location of the scaphoid fracture (Table 2). Overall, kappa for scaphoid fracture location among four observers was 0.48 and kappa ranged from 0.26 to 0.84 among observers (Table 3). Figure 3 gives examples of a CT scan in which the radiologists had not agreed on the location of the scaphoid fracture.

Other fractures

The four radiologists collectively diagnosed a total of 48 distal radius fractures and 97 other carpal fractures in the absence of any scaphoid fracture.

Table 1. Interobserver variation for 150 Computed Tomography Scans relating to the Presence or Absence of a Scaphoid Fracture. 95% confidence intervals in parentheses.

Observer	1	2	3	4
1	X	0.52 (0.36-0.68)	0.48 (0.32-0.64)	0.36 (0.21-0.51)
2		X	0.68 (0.52-0.84)	0.55 (0.39-0.71)
3			X	0.50 (0.34-0.66)
4				X

Table 2. Overview of the Location of the Scaphoid Fractures for the four Radiologists Independently

	Observer 1	Observer 2	Observer 3	Observer 4
Location				
proximal	1 (1%)	1 (1%)	6 (4%)	1 (1%)
waist	11 (7%)	9 (6%)	3 2%)	6 (5%)
distal	9 (6%)	6 (4%)	6 (4%)	4 (3%)
not reported	1 (0.7%)	0	0	0
no scaphoid fracture	128 (85%)	134 (89%)	135 (90%)	139 (93%)

Table 3. Interobserver Variation for 150 Computed Tomography Scans Relating to Localization of a Scaphoid Fracture. 95% confidence intervals in parentheses.

Observer	1	2	3	4
1	X	0.84 (0.34-1.0)	0.5 (0.12-0.88)	0.53 (0-1)
2		X	0.52 (0.15-0.89)	0.4 (0-0.88)
3			X	0.26 (0-0.77)
4				X

Figure 1. Coronal reformatted CT section of a patient with a suspected scaphoid fracture (arrow). Two radiologists diagnosed a scaphoid fracture and two radiologists did not.

Figure 2. Coronal reformatted CT section of a patient with a suspected scaphoid fracture (arrow). All four radiologists scored a scaphoid fracture as being present.

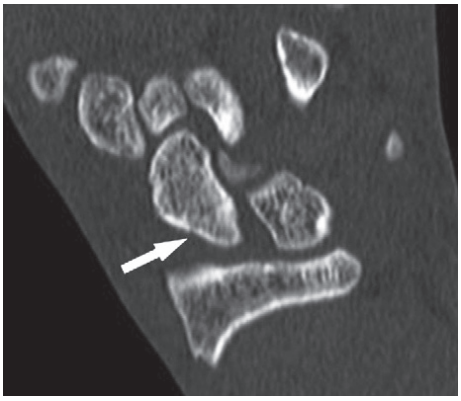
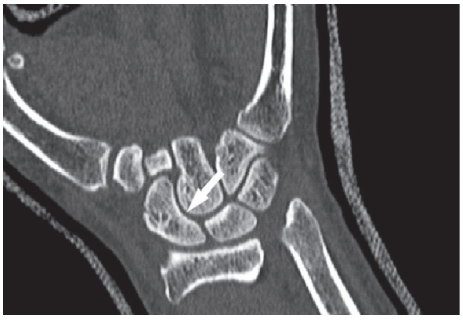
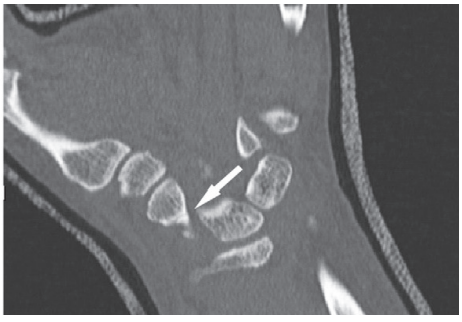


Figure 3. (a) Coronal reformatted CT section of a patient with a suspected scaphoid fracture (arrow) in which there was a discrepancy in the location of the fracture as judged by the radiologists. (b) Another coronal section of the same patient. The fracture line (arrow) in this image is still present, indicating there was a fracture.



(a)



(b)

Discussion

The primary aim of this study was to determine interobserver variability in the interpretation of CT scans in clinically suspected scaphoid fractures. Our study showed that agreement among the four radiologists for the presence of a true scaphoid fracture among clinically suspected patients was moderate, with a kappa value of 0.51. Agreement on the location of a scaphoid fracture on a CT scan was also moderate (kappa value, 0.48). Together, the four radiologists diagnosed a total of 48 distal radius fractures and 97 other types of carpal fractures in the absence of any scaphoid fracture. The presence of these injuries likely explained the clinical symptoms and initial suspicion of a scaphoid fracture. The literature reveals that an initial clinical suspicion of scaphoid fracture with no fracture seen on an initial radiograph results in the diagnosis of a different adjacent injury in 30% of cases.(14) The standard protocol for CT used in our clinic may present a limitation to this study. A different protocol with thinner slice reformations and higher resolution might increase the observer agreement. The current results, therefore, apply primarily to the CT protocol used in this study. Another limitation of this study is that the CT scans and their reviews were conducted in a single institution. Another study has investigated the interobserver variation of the use of CT for suspected scaphoid fractures. (15) They used eight observers who reviewed 30 CT scans of patients with suspected scaphoid fractures. That study revealed substantial interobserver agreement (average kappa value, 0.66 [95% confidence interval (CI), 0.58–0.72]).The different kappa value in comparison with our results may be due to a different CT protocol used in the two studies. Generally speaking, CT is advantageous for diagnosing scaphoid fractures in patients with suspected scaphoid fractures in several ways: it is readily available, is fast and costs less than Magnetic Resonance Imaging (MRI) or bone scintigraphy. (15-19) One disadvantage of CT is radiation exposure. If the diagnosis of a scaphoid fracture is missed and treatment is delayed or inadequate, it could lead to severe impairment; therefore, the examination method chosen should be highly sensitive. A meta-analysis by Yin et al. concerning the diagnostic performance of CT showed a sensitivity of 93% and a specificity of 96%.(20) Alternative diagnostic modalities that could be used for triaging suspected scaphoid fractures are MRI and bone scintigraphy. Sensitivity and specificity for these tools have been reported as being 96% and 99% for MRI, respectively and 97% and 89% for bone scintigraphy.(20) Observer agreement scores for MRI and bone scintigraphy are substantial.(21,22) Both MRI and bone scintigraphy, therefore, appear to result in better diagnostic performance than CT. Although interobserver agreement is just one aspect of diagnostic performance and does not indicate whether fractures are missed or overdiagnosed, the quest for a true reference standard for scaphoid fractures continues. The previously published results on sensitivity and specificity should, therefore, be interpreted with care. Clinicians who use CT to triage suspected scaphoid fractures should be aware of these results and should carefully deliberate before excluding a scaphoid fracture. If clinical doubt arises based on discrepancies between the CT results and the physical examination, additional imaging modalities such as MRI or bone scintigraphy may be helpful.

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