ORIGINAL ARTICLE

The usefulness of CT for patients with carpal bone fractures in the emergency department

Je Sung You, Sung Pil Chung, Hyun Soo Chung, In Cheol Park, Hahn Shick Lee, Seung Ho Kim

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See end of article for authors' affiliations

Correspondence to: Dr H S Lee, Department of Emergency Medicine, Yongdong Severance Hospital, Dogok-dong, Gangnam-gu, Seoul 135–720, Republic of Korea; emer6657@yumc.yonsei.ac.kr

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Objective: The wrist is the most commonly injured joint in the body. However, wrist injuries are often missed in the emergency department (ED). If the fracture is not diagnosed and remains untreated, the patient runs a considerable risk of chronic disability. The utility of CT as an aid in the diagnosis of carpal bone fracture was investigated.

Materials and methods: A retrospective analysis was performed of patients who underwent CT and plain radiography for wrist injury in the ED between March 2003 and February 2006. Plain radiograph interpretations were classified into three groups: (1) the definite fracture group, (2) the no fracture group, and (3) the ambiguous fracture group. The CT results were analysed in relation to the classification of the plain radiograph interpretation. The final diagnoses reviewed from the medical records were used as the reference standard.

Results: 36 carpal fractures in 33 patients were identified from 45 patients who underwent plain radiography and CT. The interpretations of plain radiographs were classified into definite fractures (n = 10), ambiguous fractures (n = 15) and no fractures (n = 20). When both the definite fracture and ambiguous fracture groups were considered positive, the sensitivity and specificity were 69.7% and 83.3%, respectively. The sensitivity and specificity of CT scans were both 100%.

Conclusion: Emergency physicians should consider CT of the wrist after plain radiography when patients with suspected carpal fracture show normal radiographic findings.

About 2.5% of patients present to the emergency department (ED) with wrist injury as their chief complaint.[1] The wrist consists of many bones and joints mixed in a complex form, making it difficult to diagnose fractures accurately with plain radiography. The misinterpretation rate of wrist radiography is about 9.3%.[2] The sprained wrist is the second most common initial diagnosis in patients with diagnostic error made in the ED.[3]

Suspected scaphoid injuries make up a significant percentage of litigation claims. The traditional method of management is to immobilise all suspected scaphoid fractures in a cast until further review. However, continued immobilisation without a definitive diagnosis may extend over several weeks, during which the patient is unable to work normally. Clinical signs are poor indicators of scaphoid fractures, and immobilisation based on anatomical snuff box tenderness alone has been shown to lead to overtreatment of 85% of patients with acute wrist injuries.[4]

Because plain radiography is unreliable, some authors proposed have skeletal scintigraphy, performed at least 72 h after injury, as a screening tool in suspected scaphoid fracture.[5] However, direct access to scintigraphy is not usually provided in the ED and it cannot differentiate among scapholunate injury, capsular injury, contusion, avascular necrosis and normal healing. Combining radiography with scintigraphy may result in 25% of patients being overtreated with cast immobilisation.[6]

Recently, CT has been used widely in most EDs, and is also commonly used in the diagnosis of complex fractures after radiography. The CT scan is also implemented to evaluate carpal injury.[7] The purpose of this study was to compare plain radiography findings with CT findings performed in the ED for patients with carpal injury.

MATERIALS AND METHODS

This was a retrospective study of patients undergoing CT scan after presenting to the ED with wrist injury. The study was reviewed and approved by the institutional review board, and was conducted in an urban teaching hospital ED with an annual load of 35 000 patients.

All ED requests of wrist or carpal CT processed from the installation of the CT apparatus from March 2003 to February 2006 were retrieved using the Picture Archiving and Communications System. All patients who ended up having CT after wrist injury in the same visit for treatment were included in the study.

Patients found to have fracture or dislocation on plain radiographs in the radius, ulnar and metacarpal bones were excluded. Dislocations of the carpal bones and paediatric patients (<15 years) were also excluded.

All patients underwent a routine radiographic series of the wrist and hand. They consisted of wrist anteroposterior, lateral and both wrist and hand oblique radiographs, and hand posteroanterior and oblique views. When certain injuries were suspected on the basis of physical examination, additional views were obtained. For example, if scaphoid fracture was suspected, an ulnar-deviated posteroanterior view was obtained. If fracture of the pisiform or hook of the hamate was suspected, a supination oblique view was obtained, and if fracture of the hook of the hamate, pisiform, trapezium or scaphoid tubercle was suspected, a carpal tunnel view was obtained. Plain radiography was performed with a VD1508-10 (Shimaddzu, Kyoto, Japan).

Wrist or carpal CT was performed when carpal fractures were suspected clinically, even though fracture lines were not observed on the plain radiograph. Although plain radiographs showed fractures, patients underwent CT when clinical findings were not consistent or other carpal injuries were suspected. The decision to perform a CT scan was made by orthopaedic consultants.

CT scans were performed using a 16-channel multidetector scanner (Somatom Sensation 16; Siemen, Munich, Germany).

Abbreviations: AF, ambiguous fracture; DF, definite fracture; ED, emergency department; NF, no fracture

Routine multidetector row CT examinations were performed as follows: 3×0.75 mm collimation, interval 0.15 mm, gantry rotation time 0.75 s, pitch 1, table feed 13.5 mm, 120 kV, 90 mA and approximate total exposure time 6 s. Routine two-dimensional multiplanar reformattings were carried out in standard coronal and sagittal planes: slice thickness, 1.0 mm; reconstruction increment, 1.0 mm.

Medical records were reviewed by an emergency physician who was blinded to this study. The variables reviewed were age, sex, injury mechanism and accompanying injury, interpretations of both plain radiography and CT scan, and whether surgical treatment was received. Initial plain radiographs were compared with CT findings. Interpretations of the plain radiograph and CT scan were made by a consultant musculoskeletal radiologist with 14 years of experience, who was also blinded to this study.

Plain radiograph interpretation was classified into three groups: (1) the definite fracture (DF) group, (2) the no fracture (NF) group and (3) the ambiguous fracture (AF) group. The AF group was defined when the interpretation contained inconclusive terms such as ''rule out fracture'' or ''recommend clinical correlation''. The final diagnoses reviewed from medical records were the reference standard.

Data are shown as mean (SD). The DF and AF groups were considered positive and the NF group negative. Their sensitivity and specificity with 95% CI were also calculated.

RESULTS

Patient characteristics

A total of 45 patients underwent CT to evaluate suspected wrist injury in the ED during a 3-year period. They consisted of 34 men and 11 women with a mean (SD) age of 36 (12) years (range 17–75). Injury mechanisms were as follows: 19 (42%) slip down injuries, 10 (22%) pedestrian injuries, 4 (8.9%) fist blows, 4 (8.9%) motor vehicle injuries, 4 (8.9%) falls from a height, 2 (4.4%) blunt injuries, and 2 (4.4%) rotational injuries. In all, 36 (73.3%) fractures were found in 33 patients (table 1). In 17 (51.5%) patients' the fracture was right-sided. Seven additional injuries were detected: 1 traumatic subarachnoid haemorrhage, 1 facial bone fracture, 1 pelvic bone fracture, 2 ankle fractures and 2 lumbar spine fractures. Fourteen patients were hospitalised for surgical treatment.

Radiographic findings

Plain radiographic interpretations were classified into DFs (n = 10), AFs (n = 15) and NFs (n = 20). Figure 1 shows the CT results in relation to the interpretation of plain radiographs. CT showed carpal fractures in 9 of 10 patients in the DF group. Three of the nine patients had additional carpal fractures, which were not shown by plain radiography. CT also detected carpal fractures in 14 of 15 patients in the AF group and 10 of 20 patients in the NF group. Figure 1 shows the identified fractures among groups.

Table 1 Distribution of 36 carpal bone fractures identified in 33 patients on CT scan

Bone	n (%)
Scaphoid	12 (33.3)
Triquetrum	9 (25.0)
Hamate	8 (22.2)
Capitate	4 (11.1)
Pisiform	2 (5.5)
Trapezium	1 (2.7)
Total	36 (100)

When both DF and AF groups were considered positive, the sensitivity and specificity of plain radiograph were 69.7% (95% CI, 56.4 to 83.0) and 83.3% (95% CI, 72.5 to 94.1), respectively. Twelve patients with CT-negative findings (no fracture detectable) were followed up with no evidence of fracture, making both the sensitivity and specificity of the CT scan 100% (95% CI, 92.1 to 100).

DISCUSSION

In all, 33 patients of the 45 patients who underwent CT scan were diagnosed as having carpal fractures. The scaphoid and the triquetrum were the most commonly fractured carpal bones. This was consistent with other literature.[8] We discovered both false negative and false positive cases of plain wrist radiography. Among the 20 cases in the NF group, CT scan revealed carpal fractures in 10. An example of false negative cases described in fig 2. Five of them received surgical treatment. One patient in the DF group and one in the AF group were found to be false positive by CT (fig 3). Plain radiograph of both these patients were interpreted as scaphoid fracture. The radial articular surface of the scaphoid often ends with a slight bump that looks like cortical irregularity seen in a fracture. Similarly, foreshortening and overlap of the distal pole of the scaphoid can mimic the increased trabecular density of an impacted fracture.[8] Tei-Van Buul *et al*[9 10] also reported that the sensitivity and specificity of plain radiography were 35% and 92%, and that the interobserver reliability was low.

In an alternative diagnostic approach, MRI or ultrasonography has been proposed to diagnose scaphoid fracture.[11 12] However, MRI is expensive and not available in most EDs, and ultrasonography cannot evaluate other carpal bones other than scaphoid. In contrast, CT is available in most EDs, and all carpal bones can be evaluated.

Multidetector CT is faster and has better spatial resolution than conventional helical CT.[7] Moreover, technical breakthroughs such as two-dimensional multiplanar reconstruction and three-dimensional surface rendering provide images with even better quality. Through plain radiography, it is difficult to obtain a true lateral plain radiography because of the pain or the plaster cast, giving limitations to diagnosing dislocations or subluxations. This makes the sagittal view of the CT a useful diagnostic modality.[13] CT has disadvantages such as higher cost and more radiation exposure than plain radiography. However,

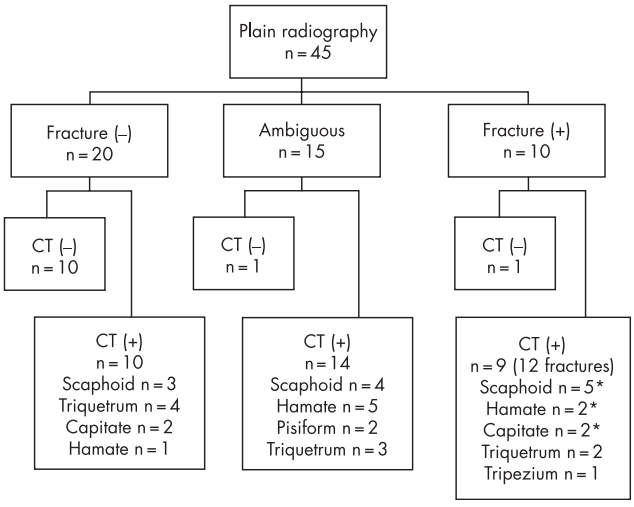

Figure 1 CT results in relation to the classification of the plain radiograph interpretation. *Additional fracture, which was discovered on a CT scan despite not being visible on plain radiograph.

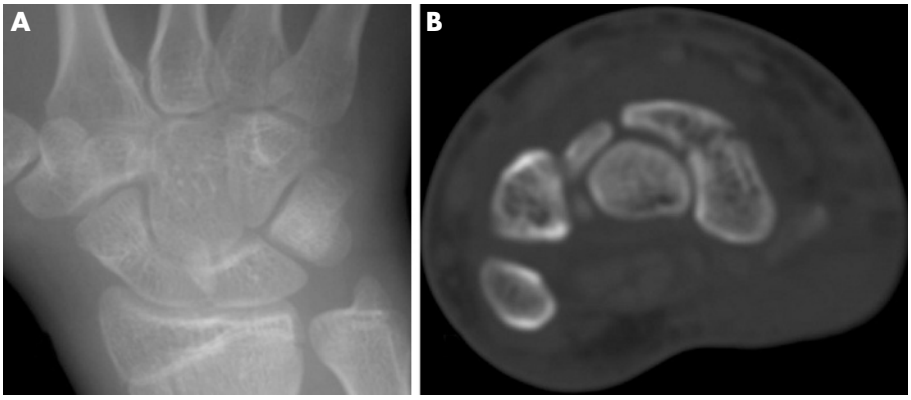

Figure 2 A 20-year-old man with an injury from a fist blow. (A) Posteroanterior view of the wrist shows no fracture line. (B) Axial CT image showing scaphoid fracture.

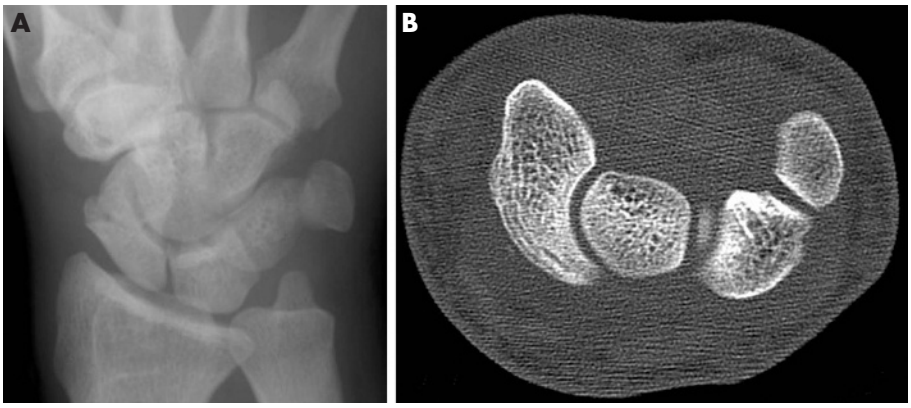

Figure 3 A 35-year-old man with a motor vehicle injury. (A) Posteroanterior radiograph of the wrist shows definite fracture line in the scaphoid. (B) Axial CT image showing normal scaphoid.

it can diagnose undetected fractures that may require surgical treatment, and can reduce unnecessary plaster casts in the AF or the false positive group.

This study has several limitations. Firstly, the nature of the retrospective study results in selection bias. The patients who underwent wrist CT scan might have had inconsistent clinical findings on plain radiography. However, the severity is difficult to detect from the initial physical examination. Secondly, this study has no false negative or false positive results for CT scan. However, both multidetector CT-negative and scintigraphy-positive cases were reported.[14] Hence, follow-up evaluation is required for clinically suspected cases. Finally, the cost effectiveness of CT should be studied. In this study comparing the cost effectiveness of immediate MRI with traditional follow-up for radiographically occult scaphoid fractures results suggest a nearly equivalent financial expenditure. In the future, a prospective study with a larger number of patients will be needed to compare the diagnostic utility and cost effectiveness of CT for screening of wrist injury.

Conclusion

Plain radiography of the wrist may produce false positive and false negative results for detecting carpal fractures. Emergency physicians should consider CT of the wrist after plain radiography when patients with suspected carpal fracture show normal radiographic findings.

Authors' affiliations

Je Sung You, Sung Pil Chung, Hyun Soo Chung, In Cheol Park, Hahn Shick Lee, Seung Ho Kim, Department of Emergency Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea

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