The Value of Spiral CT in the Diagnosis of Traumatic Carpal Dislocation or Fracture-Dislocation: Postprint

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Abstract

Objective: To investigate the diagnostic value of spiral CT multiplanar reconstruction in traumatic carpal bone dislocation and fracture-dislocation.

Methods: A retrospective analysis was performed on the clinical and imaging data of 48 patients with carpal bone dislocation or carpal bone fracture-dislocation confirmed by clinical data, to analyze the value of X-ray examination and CT (including axial, MPR, and VR reconstruction) in the diagnosis of carpal dislocation.

Results: Among the 48 patients confirmed by clinical follow-up, the diagnostic accuracy of multi-detector spiral CT was 100%, while that of X-ray was 70.83%, with a significant difference between CT and X-ray in the detection of carpal dislocation (2=4.5, P<0.05). Among the cases missed on X-ray, 10 were due to failure to detect small fractures of the scaphoid and triquetrum. In this group, there were 4 cases of misdiagnosis on X-ray, among which pisiform dislocation had a higher misdiagnosis rate.

Conclusion: X-ray has a relatively high detection rate for carpal dislocation, but insufficient capability for detecting small carpal bone fractures. MPR and VR reconstruction of spiral CT can clearly display carpal bone displacement, fractures, etc., providing imaging support for clinical treatment planning. Additionally, misdiagnosis of dislocation on X-ray is mostly related to patients being in a passive position after injury.

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Full Text

Value of Spiral CT in Diagnosing Traumatic Carpal Dislocation or Fracture-Dislocation

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Abstract

Objective: To evaluate the diagnostic value of spiral CT multiplanar reconstruction in traumatic carpal dislocation and fracture-dislocation. **Methods:** The clinical and imaging data of 48 patients with confirmed carpal dislocation or fracture-dislocation were retrospectively analyzed. The diagnostic accuracy of plain film radiography and CT (including axial, MPR, and VR reconstructions) for wrist dislocation was compared. **Results:** Among 48 patients confirmed by clinical follow-up, the diagnostic accuracy of multidetector spiral CT was 100%, while that of plain radiography was 70.83%. There was a significant difference in detection of carpal dislocation between CT and X-ray (^{2}=4.5, P<0.05). Of the cases missed on X-ray, 10 were due to failure to detect small fractures of the scaphoid and triquetrum. Four cases were misdiagnosed on plain film, with pisiform dislocation having the highest misdiagnosis rate. **Conclusion:** While X-ray demonstrates relatively high detection rates for carpal dislocation, its ability to identify small carpal fractures is insufficient. MPR and VR reconstructions of spiral CT can clearly display carpal displacement and fractures, providing imaging support for clinical treatment planning. Additionally, misdiagnosis of dislocation on X-ray is often related to patients' passive positioning after injury.

Keywords: spiral CT; X-ray; carpal; dislocation

Introduction

Wrist injuries are common following trauma, with approximately 2.5% of emergency department visits attributed to wrist injuries according to literature reports [?]. The wrist is surrounded by numerous tendons and muscles, making it susceptible to dislocation and fracture from external forces. The wrist joint has a delicate and complex structure, and prompt identification of fracture and dislocation sites and types is crucial for determining treatment plans. While X-ray remains the preferred initial examination for bone and joint injuries due to its excellent density resolution [?], the overlapping bone structures of the wrist and patients' passive positioning after injury result in a misdiagnosis rate as high as 25% [?]. In clinical practice, we frequently encounter patients with negative X-ray findings who are subsequently found to have fractures or dislocations on CT.

Although some scholars recommend MRI as the optimal imaging modality for wrist injuries [?], its high cost and long examination time limit its use in emergency settings. Conventional axial CT can overcome some of these limitations but still struggles to comprehensively and objectively evaluate intra-articular fractures and displacement [?]. Multidetector spiral CT offers fast scanning speed, high resolution, and robust post-processing capabilities, enabling rapid assessment of wrist injuries [?]. Therefore, this study retrospectively analyzed patients with post-traumatic wrist dislocation or fracture-dislocation using conventional X-ray, CT multiplanar reconstruction (MPR), and volume rendering (VR) to compare different imaging modalities and identify a more suitable imaging approach for carpal fractures.

1.1 General Materials

We selected 60 patients who presented to our hospital between 2013 and 2017 with suspected wrist dislocation due to trauma. All patients underwent both wrist X-ray and multidetector spiral CT (MSCT) examinations. After excluding distal radioulnar joint dislocation, radiocarpal dislocation, and carpometacarpal dislocation, 48 patients with clinically confirmed carpal dislocation remained for analysis. The cohort included 32 males and 16 females, aged 9-72 years (mean 36.4 years). Clinical manifestations included pain, wrist swelling, limited mobility, and joint deformity.

1.2 Examination Methods

Radiography: Kodak CR950 system was used to obtain anteroposterior and lateral wrist radiographs. The wrist was positioned at the center of the examination table whenever possible. Technical parameters: focus-film distance 90 cm, tube voltage 52-60 kV, tube current 100 mA, exposure time 0.05 s.

CT Scanning: GE LightSpeed 64-slice spiral CT was employed with the following parameters: tube voltage 100-120 kV, tube current 300-500 mA, slice thickness 5 mm, scanning range extending 10 cm proximal and distal to the wrist joint. After scanning, image post-processing was performed on a workstation. The raw data were first reconstructed into thin-section soft tissue and bone window images, upon which MPR and VR reconstructions were performed. For some patients, reconstruction angles were adjusted to achieve optimal diagnostic visualization.

1.3 Image Analysis

All X-ray and CT images (including axial, MPR, and VR) were independently reviewed by two radiologists. Evaluation included presence of carpal dislocation, dislocation type, and associated fractures. Disagreements were resolved through discussion to reach consensus.

1.4 Statistical Analysis

SPSS 20.0 software was used for statistical analysis. Categorical data were analyzed using paired chi-square test, with $P<0.05$ considered statistically significant.

2. Results

Conventional X-ray detected carpal dislocation in 34 cases, while spiral CT identified dislocation in all 48 cases. X-ray produced four misdiagnoses. All CT-confirmed wrist injuries were verified through follow-up and matched clinical discharge diagnoses. Specific dislocation types are shown in .

CT identified 13 cases of lunate dislocation. Among these, X-ray suggested concurrent lunate fracture in two cases, but CT showed no clear fracture lines [Figure 1: see original paper]. Additionally, three scaphoid fractures were not visible on X-ray but were confirmed by CT. Lunate dislocation with concurrent dislocation of other carpal bones is rare; one case of translunate triquetral dislocation was confirmed by both X-ray and CT [Figure 2: see original paper].

There were 23 cases of perilunate dislocation, including six scaphoid occult fractures and one triquetral fracture that were not visible on X-ray. Isolated dislocation of other carpal bones is uncommon. Due to complex anatomical relationships, one scaphoid dislocation and two pisiform dislocations were poorly visualized on X-ray. Conversely, two cases suspected as pisiform dislocation on X-ray showed no definitive evidence on CT. Both modalities confirmed pisiform dislocation in one case [Figure 3: see original paper].

Overall, among 48 patients with clinically confirmed wrist injuries, X-ray diagnostic accuracy was 70.83%. There was a significant difference in detection of wrist dislocation between CT and X-ray ($^2=4.5$, $P<0.05$).

3. Discussion

The wrist joint comprises carpal bones of varying sizes and shapes, including the radiocarpal, intercarpal, and carpometacarpal joints. Except for the thumb carpometacarpal joint, these joints communicate with each other and are collectively referred to as the wrist joint [**?**]. On anteroposterior radiographs and MPR coronal images, the anterior and posterior margins of the proximal and distal carpal rows form smooth arcs known as Gilula' s lines: the proximal and distal cortical edges of the scaphoid, lunate, and triquetrum form smooth arcs (Gilula I and II lines), while Gilula III line represents the proximal cortex of the capitate and hamate. Interruption or altered curvature of any arc indicates abnormal carpal alignment [**?**]. Additionally, attention should be paid to carpal bone morphology and intercarpal joint space changes on anteroposterior views [**?**]. Normal intercarpal joint spaces are generally <2 mm, with the radiocarpal joint slightly wider and the carpometacarpal joint slightly narrower. On lateral radiographs or MPR sagittal images, the radial longitudinal axis should pass through the lunate, capitate, and third metacarpal [?].

Carpal dislocation types are numerous and complex, and no classification system can encompass all types [?]. Wang Yunzhao et al. [?] categorized carpal dislocation and fracture-dislocation into six types, though various authors report different classifications. Based on Gilula' s classification, perilunate dislocation is most common, where the anatomical relationship between the lunate and radius remains unchanged while other carpal bones dislocate with the capitate, most commonly dorsally. On lateral radiographs and CT sagittal reconstructions, the main finding is that the central axis passes through the lunate but not through the capitate and third metacarpal [?]. Additionally, attention should be paid to the capitolunate joint space and associated fractures of surrounding carpal bones and radial/ulnar styloid processes [?]. When such injuries are accompanied by fractures, they are termed translunate perilunate dislocations, most commonly involving scaphoid and triquetral fractures. In our study, six scaphoid fractures and one triquetral fracture associated with perilunate dislocation were not visible on X-ray, likely due to severe overlapping on radiographs and patient immobilization after injury.

The primary observation points are whether the three arcs formed by proximal and distal carpal rows remain continuous and whether the radius, capitate, and scaphoid share the same central axis [?]. Lunate dislocations can be further classified based on associated carpal fractures, such as transscaphoid lunate dislocation or transradial styloid and scaphoid lunate dislocation. Lunate dislocation is not difficult to recognize clinically, but accompanying injuries must be carefully identified. In our study, three scaphoid fractures were not clearly visualized on X-ray. Lunate and perilunate dislocations account for the majority of carpal dislocations, with other types being relatively rare. Our study encountered certain misdiagnoses with the pisiform. Normally, on anteroposterior wrist radiographs, the pisiform mostly overlaps with the triquetrum, with only a small portion projecting ulnar to the triquetrum. If most of the pisiform projects medial to the triquetrum, pisiform dislocation should be suspected. On lateral radiographs, the pisiform appears as an overlapping image among the scaphoid, capitate, and trapezium. Disappearance of this circular overlapping image or significant projection anterior to the scaphoid or separation indicates pisiform dislocation. In our series, two misdiagnoses on X-ray were likely caused by passive patient positioning resulting in external rotation of the pisiform and creating a false dislocation appearance.

The wrist joint has a complex anatomical structure, and most clinical injuries are compound. Untimely treatment may lead to chronic pain or functional impairment. Therefore, prompt assessment of injury extent and involved structures facilitates early intervention [?]. Our results show that limited wrist mobility after trauma makes it difficult to achieve standard radiographic positioning, affecting evaluation of wrist instability type and injury severity [?]. Axial CT clearly displays fracture sites and excels at identifying associated injuries such as soft tissue contusion and hematoma. However, due to partial volume effects and reading habits, it is sometimes difficult to confirm structural changes in joint spaces or articular surfaces. Furthermore, axial CT cannot completely display the full picture of fracture fragments or assess spatial displacement of fracture ends. Spiral CT' s powerful post-processing capabilities enable multi-planar observation of injuries. MPR reconstruction eliminates overlap seen on conventional radiographs, clearly displaying fracture location, type, and fracture line orientation [?]. However, MPR sometimes fails to demonstrate spatial relationships between carpal bones and lacks three-dimensional perspective. Additionally, since proximal and distal carpal rows are not on the same plane, individual carpal bones cannot be completely displayed on a single MPR image.

VR images can display three-dimensional structural relationships of injured sites, helping to clarify the spatial orientation of fractures or dislocations and providing important guidance for clinical surgery and reduction. Our results demonstrate that spiral CT combined with MPR and VR reconstruction achieves 100% diagnostic efficacy for lunate and perilunate dislocations. Some scholars believe that individual 2D CT, MPR, or VR reconstruction can each improve diagnostic accuracy [?]. However, since our institution routinely performs MPR and VR reconstruction for trauma patients, we cannot accurately evaluate the diagnostic efficacy of each technique alone. We believe that VR imaging alone may lose normal smooth sharpness, reduce layering, and obscure boundaries between carpal bones due to tissue overlay, inhomogeneous density, or inconsistent reconstruction thresholds, affecting observation. Therefore, we recommend comprehensive evaluation combining axial CT, MPR, and VR images to ensure improved diagnostic accuracy.

In summary, X-ray remains the most fundamental and preferred imaging modality for carpal injuries. However, due to significant carpal bone overlap and complex anatomical structures, spiral CT is recommended for patients with suspected dislocation requiring further clarification of dislocation type or direction, or for surgical planning. Spiral CT with MPR and VR reconstruction provides multi-angle, comprehensive evaluation of dislocations and associated injuries, better assisting clinical management.

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Note: Figure translations are in progress. See original paper for figures.