Role of Multi-Detector CT in Evaluation of Carpal Bone Fracture in Wrist Injuries

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Abstract:

Multi-detector computed tomography imaging (MDCT) has become a standard imaging modality for the evaluation of patients with carpal bone fractures. Major advantages of MDCT are faster scanning time, increased volume coverage, and improved spatial and temporal resolution. These advantages also result in an increased number of slices obtained within a certain amount of time, which depends on the number of rows or channels. **Aim of study**: to evaluate the role of MDCT in assessment of carpal bones fractures in wrist injuries. **Subjects and methods**: The study was carried out in Radiology department of Benha university hospital, where 57 symptomatic patients with clinical suspicious of carpal bone fracture suffering from wrist joint disorders like pain, swelling and limitation of movement. **Results**: X-ray was able to detect fractures in 37 cases (64.9%), while 20 cases (35.1%) appeared negative from fractures. CT was able to detect fractures in 50 cases (87.7%) of cases, while only 7 cases (12.3%) were negative from fractures. There was a significant agreement between the two diagnostic techniques in all bony fractures, apart from lunate, pisiform, and distal ulnar fractures. CT was highly sensitive more than X-ray in these 3 fractures **Conclusion**: Radiography remains the primary imaging modality in wrist trauma, but in cases where there is doubt; MDCT can be used to rule out fractures. It also detects occult fractures and shows the exact fracture anatomy in wrist fractures, increasing diagnostic accuracy and eventually helping the attending physician.

Key words: Carpal bone, Fracture, Computed Tomography.

Introduction:

The wrist is composed of the anatomic region between the forearm and the hand. Its ability to place the hand in three-dimensional space is essential for normal daily function of the upper extremity [1]. Fractures and dislocations of carpal bones are more common in young active patients.

These injuries can lead to pain, dysfunction, and loss of productivity [1]. Conventional radiography remains the primary imaging modality. However, multi-detector computed tomography (MDCT) is playing an increasingly important role, especially in the following situations: (a) when results from initial radiographic findings are negative in patients with suspected carpal fractures, (b) when initial radiographic findings are indeterminate and (c) when knowledge of the extent of carpal fractures or dislocations is required before surgical treatment.

The advantages of multi-detector CT include quick and accurate diagnosis with availability in most emergency centers. Multi-detector CT can easily display the extent of carpal fractures and dislocations, often depicting fractures that are occult at radiography [1]. MR imaging can display carpal fractures well, but the examination is more difficult to arrange, needs longer examination time, and has a high cost. MDCT is more readily available, faster (6 – 12 seconds), and less costly. MDCT is highly accurate in depicting occult cortical scaphoid fractures but appears inferior to MR imaging in depicting solely trabecular injury. Thus, a positive multi-detector CT scan is diagnostic while a negative multi-detector CT scan may need further evaluation [2].

Aim of study

The aim of this work was to study the role of MDCT in assessment of carpal bones fractures in wrist injuries.

Subjects and methods

It was single center; that was conducted in Benha University hospital during the period from October 2018 to October 2019. All clinical information were collected from the patient's files. After approval from ethical committee, an informed consent was obtained from all patients in the research. All data of the patients had been confidential with secret codes and private files for each patient. All of patients were subjected to the following procedures:

I-Preparation of the study:

-The previous studies available with the patient.

-The procedure of the examination was explained to the patients.

-The patients were prepared for the MDCT study.

II- IMAGING (**MDCT protocol):**

Multi-detector high-resolution CT (8-detector row) scanning was performed in all patients with use of a sequence with a high-resolution 0.3 mm slice section thickness. The scan covered the wrist from the distal radioulnar joint to the carpometacarpal joints. Patients were positioned prone, with the affected arm above the body and with the palm down.

Statistical methods

IBM SPSS statistics (V. 23.0, IBM Corp., USA, 2015) was used for data analysis. Data were expressed as both percentage and number for categorized results.

Diagnostic validity test was used: It includes agreement and disagreement between 2 studied techniques. Chi-square test to study the association between each 2 variables or defined as comparison between 2 independent groups as regards the categorized data.The probability of error equal 0.05 was considered significant; while value at 0.01 and 0.001 are highly significant.

Results

This study was conducted during the period from October 2018 to October 2019 and included 57 cases with suspected carpal bone fractures. The mean age of the included cases was 31.3 years (range 18 – 57 years) (table 1).

A total of 45 males (78.9%) in addition to 12 females (21.1%) were included in the current study (table 2 & fig. 1). MDCT was able to detect fractures in 50 cases (87.7%) of cases, while only 7 cases (12.3%) were negative from fractures (table 3 & fig. 2).

Primary radiograph had sensitivity and specificity of 74 and 100% respectively, with a diagnostic accuracy of 77.2% (table 4 & fig. 3). There was a significant agreement between the two diagnostic techniques in all bony fractures, apart from lunate, pisiform, and distal ulnar fractures. CT was highly sensitive more than X ray in these 3 fractures (table 5).

Table (1): Age distribution in the cases of the study:

Items	Study cases n=57
Age (years)	
Mean ± SD	31.3 ± 9.14
Median (range)	30 (18-57)

Table (2): Sex distribution in the cases of the study:

Items	Study cases n=57	
Sex	**Number**	**Percent**
Males	45	78.9%
Females	12	21.1%

Table (3): Detection of fractures according to MDCT:

Items	Study cases n=57	
MDCT	**Number**	**Percent**
Negative	7	12.3%
Positive	50	87.7%

Table (4): Correlation between 1ry radiographic findings and occurrence of fractures.

Fractures		**Fractures by 1ry radiographs**	
		Fractures (n=37)	**No fractures (n=20)**
	Fractures (n=50)	37 (true positive)	13 (false negative)
	No fractures (n=7)	0 (false positive)	7 (true negative)
Sensitivity	74%		
Specificity	100%		
Accuracy	77.2%		
PPV	100%		
NPV	35%		

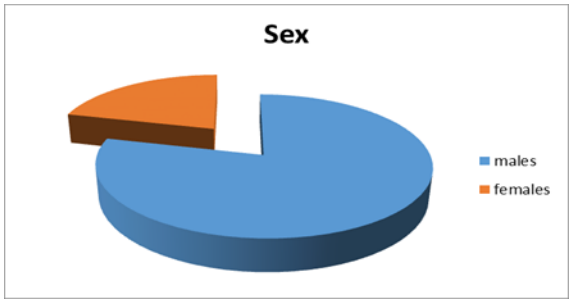

Fig (1): Sex distribution in the study cases.

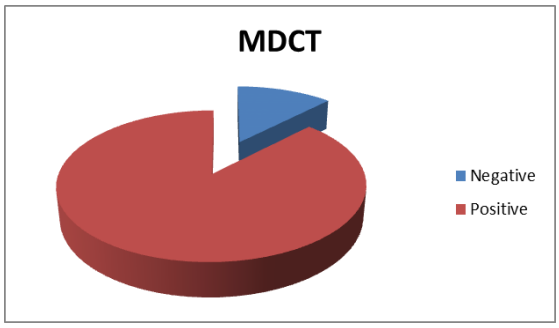

Fig (2): Detection of fractures by MDCT in the study cases

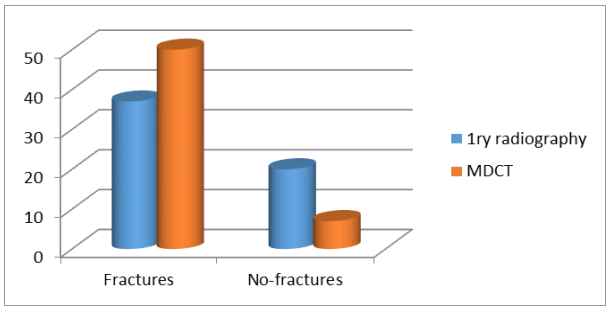

Figure (3): Correlation between 1ry radiographic findings and occurrence of fractures.

Table (5): Radiographic and CT Detection of Fractures:

	Number of fractures			
Type of fractures	**MDCT**	**1ry radiographs**	**Sensitivity**	**Agreement between the two techniques**
Scaphoid	33	24	72.7%	0.041*
Lunate	4	2	50%	0.70 (0.58- 1.27)
Triquetrum	6	6	100%	< 0.001*
Pisiform	2	1	50%	0.237
Trapezium	8	7	87.5%	0.005*
Trapezoid	2	2	100%	< 0.001
Capitate	3	3	100%	< 0.001
Hamate	2	2	100%	< 0.001
Distal radius	8	8	100%	< 0.001
Distal ulna	2	1	50%	0.237
Proximal metacarpals	3	3	100%	< 0.001
Total number	73	59	80.8%	0.011*

*: statistically significant (p< 0.001)

Discussion

After trauma to the wrist, radiographic examination often provides valuable diagnostic information for the treating physician. However, the previous clinical experience has shown that many carpal bone fractures are radiographically occult and detectable only on CT [3].

Conventional tomography and several different special radiographic views have been described to better image the scaphoid and other small carpal bones. Although these special views do increase diagnostic accuracy, MDCT with MPR in sagittal and coronal planes shows the wrist anatomy without superimposed structures, and occult fractures are therefore more easily revealed [4]. Carpal bone fractures are common in wrist injuries.

Early diagnosis and appropriate treatment of these fractures are important in preventing complications such as delayed healing, nonunion, pseudoarthrosis, avascular necrosis, and arthrosis [5]. Another study handled the same perspective and included a total number of 60 cases with wrist trauma. The mean age of the included cases was 37 years (range, 10 – 80 years) [6]. Other authors included 98 cases with wrist injuries. The participants had a median age

of 53 years (range, 18 – 87 years) [7]. In the current study, we included 45 males (78.9%) and 21 females (21.1%). Another study reported an increased prevalence of wrist trauma in males compared to females as authors included thirty-eight patients (24 males, 14 females) [8]. Conversely, another study reported more predominance of female cases. The study population included 27 men (45%) and 33 women (55%) [6].

In the current study, 27 cases had fractures on the left side (47.4%), while 23 cases had fractures on the right side (40.4%). The remaining cases had no fractures. In another study, thirty-three of 61 (54%) cases were of the right wrist compared with 28 of 61 (46%) of the left [6].

Other authors reported that the fracture was right-sided in 12 patients (41%) and in 17 (59%) it was left sided [8]. When it comes to the fracture number in our study, single fractures were the commonest (34 cases), followed by 2 fractures (11 cases), 3 fractures (4 cases), and 5 fractures (1 case). No fractures were detected in 7 cases. Welling and his associates reported that CT showed a total of 69 fractures in 45 of 61 (74%) wrists; 27 wrists had one fracture, 13 had two fractures, four had three fractures, and one had four fractures [6]. Carpal fractures account for 18% of hand and wrist fractures and 6% of all fractures overall [9]. The scaphoid is the most common carpal fracture, accounting for 10% of all hand fractures and 60–70% of all carpal fractures [10]. Although our study confirmed that the scaphoid is the most commonly fractured carpal bone, the incidence was not as high (45.2%).

The incidence of fractures of the capitate, lunate, and hamate bones in the literature accounts for only 1–3% of all carpal fractures [11], but our study showed an incidence of 12.3%. Another study reported an incidence of 15% regarding these fractures, and this is slightly higher than our findings [6]. Fractures of the pisiform, triquetral, trapezium, and trapezoid bones are reportedly much less common [12].

However, another study showed an incidence of 17% (12/69) collectively for these four bones [6]. In our study, the incidence of these fractures was higher (24.6%). The differences between the incidences of various fractures in this study and those reported in the literature may be explained by selection bias, more symptomatic or significant injuries are more likely to have further diagnostic evaluation with CT. In the current study, there was a

significant agreement between the two diagnostic techniques in all bony fractures, apart from lunate, pisiform, and distal ulnar fractures.

CT was highly sensitive more than X ray in these 3 fracture types. Fractures were detected at the following bones by CT; 33 scaphoid fractures (24 by X ray – 72.7%), 4 fractures at lunate (2 by X ray – 50%), 6 fractures at triquetrium (6 by X ray – 100%), 2 pisiform fractures (1 by X ray – 50%), 8 trapezium fractures (7 by X ray – 87.5%), 2 trapezoid fractures (2 by X ray – 100%), 3 capitate fractures (3 by X ray – 100%), 2 hamate fractures (2 by X ray – 100%), 8 distal radial fractures (8 by X ray – 100%), 2 distal ulnar fractures (1 by X ray – 50%), and finally, 3 proximal metacarpal fractures (3 by X ray – 100%).

In the study conducted by Welling and his associates, there was a significant agreement between X ray and CT in all fracture types ($p < 0.005$), except for lunate ($p = 1$), triquetrum (0.23), trapezoid ($p = 1$), and capitate ($p = 1$).

There was a fracture of the scaphoid in 16 wrists at CT (with 13/16 or 81% diagnosed at prospective radiography), lunate in three (0/3 or 0% seen at radiography), triquetrum in five (1/5 or 20% seen at radiography), pisiform in one (1/1 or 100% seen at radiography), trapezium in three (2/3 or 67% at radiography), trapezoid in three (0/3 or 0% at radiography), capitate in two (0/2 or 0% at radiography), hamate in five (2/5 or 40% at radiography), distal radius in 17 (17/17 or 100% at radiography), distal ulna in six (6/6 or 100% at radiography), and proximal metacarpal in eight (6/8 or 75% at radiography) [6].

In another study, conventional radiography showed high sensitivity (100%) for detecting capitate and hamate fractures, while that sensitivity vanished when it came to lunate, trapezium, and trapezoid fractures. However, the specificity of the same modality was higher than 85% in all fracture types [7].

In our study, CT X ray was able to detect fractures in 37 cases (64.9%), while 20 cases (35.1%) appeared negative from fractures. On the other hand, CT was able to detect fractures in 50 cases (87.7%) of cases, while only 7 cases (12.3%) were negative from fractures. X ray had sensitivity and specificity of 74 and 100% respectively, with a diagnostic accuracy of 77.2%.

In another study, radiography reports indicated a total of 48 fractures in 39 of 61 (64%) examined wrists; 32 patients had one

fracture, and eight patients had two fractures.

Overall, 30% of the fractures seen on CT were not prospectively diagnosed at radiography [6]. In another report, in four cases (14%), MDCT revealed nine occult fractures in the wrist compared to primary radiography: two trapezoid and capitate fractures, one hamate fracture, one trapezium, one metacarpal V, and one case of fracture–subluxation of metacarpals III and IV.

Furthermore, 14 patients of the 38 (37%), wrist fracture initially was suspected on the basis of the primary radiograph and proved by MDCT not to be present (false-positive): in the scaphoid in seven cases, in the trapezoid and triquetrum in two, in metacarpals I and V in one case, and a carpometacarpal joint subluxation in one [8].

Conclusion:

Radiography remains the primary imaging modality in wrist trauma, but in cases where there is doubt; MDCT can be used to rule out fractures. It also detects occult fractures and shows the exact fracture anatomy in wrist fractures, increasing diagnostic accuracy and eventually helping the attending physician.

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