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ORIGINAL RESEARCH

Accuracy of the radiological protocols in detecting scaphoid fractures, a retrospective study

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Abstract

Early and accurate diagnosis of scaphoid fractures is vital for improving patient outcomes. However, there is no international agreement on the optimal imaging examination for diagnosing suspected scaphoid fractures. This study aimed to assess the different imaging examinations of scaphoid fractures at three major hospitals in Najran, Saudi Arabia. Radiological strategies for imaging suspected scaphoid fracture were determined using a short cross-sectional survey. The accuracy of the different imaging techniques was compared, and the number of patients with a scaphoid fracture who underwent examination at these hospitals in the past year preceding the start of this study was also investigated. The results showed that plain x-ray was the first line of imaging examination for suspected scaphoid fracture at the three hospitals. When the initial plain x-ray could not rule out scaphoid fracture, a repeated x-ray (10–14 days) was used as second-line imaging in two hospitals, while computed tomography (CT) was used as a third line of imaging. In the third hospital, CT scan was used as the second line of imaging, while magnetic resonance imaging (MRI) was used as the third line of imaging. A total of 112 patients sustained scaphoid fractures in the three hospitals. Initial plain x-ray was able to diagnose 72% of all cases as the first imaging line. Repeated x-ray identified 60% of the fractures that were not detected on the initial plain radiograph, while CT scans identified 88% of the fractures that were not detected on the first plain radiograph. Repeated plain x-rays maybe not be the ideal second-line imaging for scaphoid fracture. The ability of the CT scan to detect scaphoid fracture at an early stage was evident ($p = 0.001$). Altogether, these results indicate the important role of CT scan in diagnosing scaphoid fracture at an early stage. More studies are warranted to improve the national guidelines for the radiological investigation of scaphoid fractures.

Keywords

Trauma; Fracture; X-ray; Emergency radiology

1. Background

Acute scaphoid injury is one of the most common bone injuries in the upper extremities and by far the commonest carpal bone injury [1]. It is estimated that scaphoid fractures account for 50–80% of carpal bone fractures and around 5% of all bone fractures [2]. The early diagnosis of scaphoid fracture is crucial for improving the management of the fracture and minimizing the risks of complications, which might include avascular necrosis, nonunion or malunion, eventually leading to osteoarthritis and poor wrist motions [3]. Plain x-ray plays an important and central role in the differential diagnosis of suspected scaphoid fracture but might be limited as its sensitivity for scaphoid fracture is not ideal [4]. It has been reported that around a third of all scaphoid fractures are not detected in the initial radiographs [5].

In case of clinically suspected scaphoid fracture with negative radiographs, clinicians tend to immobilize the patient's hand in a cast to avoid undertreating the condition. However, true scaphoid fracture may only affect a small number of patients, indicating that most of these patients might be in fact over-treated [6]. Overtreatment is associated with lost working days, degrading the patient's quality of life, and may lead to inappropriate use of healthcare resources [7]. Thus, there has been a focus on using more advanced imaging modalities, such as bone scintigraphy, computed tomography (CT) and magnetic resonance imaging (MRI), to improve the diagnosis of suspected scaphoid fractures, as they were all reported to have superior diagnostic accuracy compared with x-ray, but were costlier [7].

Currently, as there is no international consensus on determining the most appropriate imaging modality for suspected scaphoid fractures, various imaging protocols are used to diagnose scaphoid fractures in clinics. Based on this gap in the literature, this study was performed to determine the ideal imaging protocol for suspected scaphoid fracture using the

imaging data of three major hospitals in Najran (Saudi Arabia). In addition, the current study also determined the number of patients with a suspected scaphoid fracture who underwent some forms of imaging procedures for the scaphoid fracture in the past year in these hospitals to further determine the value of the imaging protocols in diagnosing suspected scaphoid fracture.

2. Methods

This study was an observational retrospective study performed in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines for cohort studies. The data were collected in two stages. In the first stage, a short cross-sectional survey was conducted to collect data regarding the imaging modalities for scaphoid fracture in the three main hospitals in Najran, Saudi Arabia. In the second stage, the retrospective data regarding the number of patients with a confirmed scaphoid fracture in the past 12 months preceding the start of this study from these hospitals were assessed. These data included whether the fracture was diagnosed after the initial radiographs, later radiographs or with more advanced imaging examinations. Only cases with a confirmed diagnosis of having or not having scaphoid fracture were included. Patients with a suspected scaphoid fracture who were lost to follow-up were excluded. An emergency physician or orthopedic surgeon first reviewed the radiographs, and if the fractures could not be ruled out from the initial radiographs, the subsequent imaging examinations were reported by a radiologist. The data were recorded in a spreadsheet with the number of patients at each hospital and how the scaphoid fractures were diagnosed at each hospital. The data of hospitals A and B were combined to compare the repeated x-ray as the second line of imaging in these hospitals against the CT scan in hospital C as the second line of imaging using the chi-square test. The SPSS software for Windows, (version 25, IBM, Chicago, IL, USA) was used for statistical analysis. Institutional ethical approval was granted by the Ethics Committee of Najran University.

3. Results

All three main hospitals in Najran have three lines of radiological investigation protocols for suspected scaphoid fractures. The three hospitals used plain x-ray as the first line of investigation. For the second line of radiological investigation, two hospitals used repeated x-ray (10–14 days) after the first x-ray to diagnose the scaphoid fracture. The third hospital performed CT as the second line of investigation. For the third line of investigation, two hospitals (hospitals A and B) used the CT scan as the third line of investigation, while the third hospital (hospital C) used MRI as a third radiological imaging line (Table 1).

The three hospitals had a total of 112 patients who underwent radiological investigations and were diagnosed with a scaphoid fracture in the past 12 months prior to this study. Among them, 81 (72%) were diagnosed with scaphoid fracture after the first imaging line (initial x-ray), 21 (19%) were diagnosed with scaphoid fracture after the second line of investigation, and 10 (9%) were diagnosed after performing the third line of imaging (Table 2).

Among the 112 patients, 21 were diagnosed after undergoing second-line imaging. In the two hospitals where the imaging protocols comprised of repeated x-ray, only 14 fractures out of the remaining 23 fractures that were not detected in the initial x-ray were detected by this stage. The remaining 9 patients were referred to third-line imaging, namely CT scan, and by this stage, all the remaining fractures were visible on the CT scans.

However, in the hospital where the CT scan was used as a second-line investigation, 7 fractures were detected out of the 8 fractures that were not detected in the initial x-ray. Only one patient was referred to the third line of imaging (MRI) based on the hospital's imaging protocol, following which the fracture was detected (Table 3). Statistical analysis was conducted to determine the value of the CT scan against repeated x-ray as a second line of investigation, and statistically significant differences were observed between CT scans and repeated x-ray as a second line of imaging ($p = 0.001$).

4. Discussion

The diagnosis of scaphoid fracture remains challenging in many cases due to the anatomical nature of the scaphoid bone and the complexity of the mechanism of injury in the wrist. The early and accurate diagnosis of a scaphoid fracture can significantly impact several healthcare quality parameters, such as the time taken to diagnosis, enhancement of treatment quality, and efficient use of healthcare resources. This study aimed to assess the efficiency of the imaging protocols in the three main hospitals in Najran (Saudi Arabia). It was not surprising that the three hospitals had different imaging protocols for diagnosing scaphoid fractures due to the absence of regional or national agreement on the optimal imaging examination for scaphoid fractures. However, this occurrence was not exclusive to this study as well-documented literature has highlighted these differences in radiological protocols in different parts of the world or even the complete absence of such imaging protocols whereby the choice of imaging modality was mostly decided by the treating physician's experience [8, 9]. However, it was reported that even in places where a national guideline for scaphoid fracture imaging was instilled, it is not always followed, making the diagnostic process for scaphoid fracture complicated and frustrating for both the patient and the healthcare provider. For instance, it was reported that the UK National Institute for Health and Care Excellence (NICE) guidelines for imaging scaphoid fracture is not followed by around half of the hospitals in the UK [10, 11]. It is believed this might be due to the limited access to advanced imaging modalities, unavailability of advanced imaging facilities, and long waiting time to have imaging, especially for MRI scans [12–14].

The three hospitals in this study used plain x-ray as the first line of imaging for suspected scaphoid fracture, consistent with many other studies that showed that plain x-ray is the first-line imaging technique in many hospitals around the world [15, 16]. However, the sensitivity of plain x-ray for scaphoid fracture is not ideal as it is well known that plain x-ray is not

TABLE 1. Imaging protocols for suspected scaphoid fracture in the three participating hospitals.

Hospital	Protocol
Hospital A	1^{st} line: x-ray 2^{nd} line: second x-ray 3^{rd} line: CT
Hospital B	1^{st} line: x-ray 2^{nd} line: second x-ray 3^{rd} line: CT
Hospital C	1^{st} line: x-ray 2^{nd} line: CT 3^{rd} line: MRI

CT: computed tomography; MRI: magnetic resonance imaging.

TABLE 2. Number of patients with a scaphoid fracture in each hospital and at what stage they were diagnosed.

Variables	No. of cases	Diagnosed after first line of imaging	Diagnosed after second line of imaging	Diagnosed after third line of imaging
Hospital A	51	36 (70%)	9 (18%)	6 (12%)
Hospital B	28	20 (71%)	5 (18%)	3 (11%)
Hospital C	33	25 (76%)	7 (21%)	1 (3%)
Total	112	81 (72%)	21 (19%)	10 (9%)

TABLE 3. Accuracy (as %) of the imaging modalities to detect scaphoid fracture.

Imaging modality	Number of patients with the positive diagnosis	The total number of patients who underwent this imaging modality	Accuracy (%)
Plain initial x-ray	81	112 (All patients)	72%
Repeated x-ray 10 to 14 days after the initial x-ray	14	23	60%
CT scan (as a second line of investigation)	7	8	88%
CT scan (as a third-line investigation)	9	9	100%
MRI as a third line of investigation	1	1	100%

CT: computed tomography; MRI: magnetic resonance imaging.

accurate in determining scaphoid fracture in the early stage [17]. The initial x-ray only detected 72% of the scaphoid fractures in our cohort, which was concordant with previous literature, which showed a detection range of 70% to 85% in the early stage [16]. However, the availability and convenience of x-ray make it a preferred and fast imaging option [17]. The evolution of artificial intelligence (AI) and its potential role in radiology may improve the diagnostic accuracy of x-ray in the future. A recent study showed promising results of using AI and convolutional neural networks (CNN) for detecting scaphoid fractures on anteroposterior wrist radiographs, with a sensitivity of 76% and specificity of 92% [18]. With the continuous advancement of AI in radiology, it is expected that these figures will improve in the future.

Repeated x-ray (10–14 days after the initial x-ray) was used as second-line imaging in two hospitals and was able to show only 14 fractures out of 23 fractures. Although the accuracy of the x-ray did not improve after the repeated x-ray, its convenience and availability might attract physicians to continue using it as a second line of investigation. It was even reported that 68% of hospitals in the UK use repeated x-ray before requesting more advanced imaging technologies such as CT or MRI [13]. However, repeated x-ray has limited value in ruling out scaphoid fracture, and alternative imaging approaches should be considered if the initial plain radiographs are negative while a fracture is still clinically suspected.

The value of CT in the diagnosis of scaphoid fracture was evident in this study. Statistical analysis indicated a significant difference between CT and repeated x-ray in identifying suspected scaphoid fractures ($p = 0.001$). CT was able to detect 7 out of 8 fractures as second-line imaging in one hospital and all 9 fractures as third-line imaging in two hospitals (Table 3). Although CT has very good but not perfect sensitivity and specificity for scaphoid fractures, its accessibility makes it a good choice for imaging scaphoid fractures. In a national survey comprising UK hospitals, Brookes et al. reported that 26% of UK hospitals use CT scans as second-line imaging for suspected scaphoid fracture and that its value was superior to repeated plain x-ray [12]. It has also been suggested that CT is adequate to rule out scaphoid fracture in the absence of

MRI [19]. Therefore, the role of the CT scan in our healthcare settings should be re-evaluated in larger prospective studies, especially when considering the relative availability of the CT scan.

MRI has been suggested as an alternative to x-ray as an early imaging technique for scaphoid fracture [20]. Only one patient underwent an MRI scan in our cohort, which was performed as the third line of imaging. MRI is considered the best imaging modality for diagnosing scaphoid fracture by both The American College of Radiology and the UK's NICE guidelines, with a sensitivity and specificity close to 100% [10]. In fact, the NICE guidelines suggest that MRI should be used as the first-line imaging, and cost-effective analyses showed that the overall cost of early imaging of scaphoids with MRI was lower despite the initial high cost of MRI [13]. However, the limited access and the long-waiting time to have an MRI scan may hinder its applicability as a first-line investigation. Nevertheless, it is still one of the most accurate imaging modalities for scaphoid fracture and should be used whenever possible, especially in complex cases.

5. Conclusions

In conclusion, plain x-ray remains the most convenient and pragmatic examination used for early diagnosis of suspected scaphoid fracture despite its several limitations. AI may play a significant role in improving the diagnostic accuracy of plain radiographs in the future. Presently, a better alternative imaging technique instead of a repeated x-ray should be recommended for occult scaphoid fracture. CT scan might be a promising alternative, either as a first- or second-line imaging due to its increasing availability, fast time to diagnosis, cheaper cost than MRI, and greater accuracy than X-ray. However, multicenter studies are still needed to establish a national guideline to improve the diagnosis of scaphoid fractures.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

HAA—designed the research, performed the research, analyzed the data and wrote the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The ethical approval has been granted by the Scientific Research Ethical Committee at Najran University (Reference No.: 443-32-57070-DS). The need for informed consent has been waived owing to the retrospective nature of the study.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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