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Accuracy of the common practice of doing X-rays after two weeks in detecting scaphoid fractures. A retrospective cohort study

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Abstract

Introduction: Although the NICE guidelines are clear in considering MRI as the gold standard for suspected scaphoid fracture, we noticed that there is a common practice of doing x-ray after two weeks. One of the reasons for that is the long waiting list till obtaining the MRI. The aim of our study is to illustrate the accuracy of this practice and to put an algorithm trying to make NICE guidelines more practical. Methods: In this retrospective study, we included135 acute trauma patients with suspected scaphoid fractures in St George's University Hospitals, London, UK, in the period between 01 /12 /2018 and 01/02/2019. Mechanism of injury, X-ray views and reports, CT and MRI reasons and results were recorded. All patients were followed by clinical examination and X-rays after six weeks from the injury. Results: Only 28 cases (20.7%) from the 135 cases included were proven to have scaphoid fractures (20 cases diagnosed from initial X-ray, two from X-rays after two weeks and 6 cases missed by both and diagnosed by CT and MRI). 69% of negative radiology initial reports recommend clinical reassessment and considering further imaging. Sensitivity, specificity, and accuracy of X-ray after two weeks were 25%, 78.5%, and 74.4%. Conclusion: MRI is the gold standard for diagnosing scaphoid fractures and excluding other wrist pathology. We should discourage the currently common practice of repeating X-rays after two weeks due to its low sensitivity. Clinical examination after two weeks and considering further imaging, other than repeat X-ray, is the best practice if MRI is delayed.

Keywords: Scaphoid fractures, X-rays at two weeks, Algorithm, Diagnosis, MRI.

INTRODUCTION

Scaphoid injuries are responsible for 1 in 10,000 attendances to emergency departments in the UK per year [1]. The scaphoid bone is one of the most commonly fractured bones in the body, responsible for 51-90% of whole carpal bone fractures and 2-7% of all fractures in body [1,2]. It is known in literature that the sensitivity of the initial radiograph for suspected scaphoid fracture varies from 60-80%, but fall with subsequent radiography to only 30% [3]. However, there is a common practice in our hospital for suspected scaphoid fractures with initially negative radiography. It is to immobilize the patient in case then to repeat the X-rays after two weeks. Graham and Smith [4] illustrated this by contacting 15 emergency departments in the south-west region of United Kingdom to determine how a patient with suspected scaphoid fracture will be managed. They found that repeat X-rays were performed by 92 % of the hospitals, Magnetic Resonance Imaging (MRI) by 54 % and Computed Tomography Scan (CT) by 38 %.

If a scaphoid fracture is missed, healing may be delayed due to the poor blood supply especially to the proximal pole. Avascular necrosis is proved to occur in 13-50 % of cases of scaphoid fracture, particularly in cases of involvement of the proximal one-fifth of the scaphoid [5]. Regarding the NICE (The National Institute for Health and Care Excellence) guidelines for suspected scaphoid fracture, they recommended considering MRI for first line imaging in people with suspected scaphoid fractures following a thorough clinical examination [6].

Although many doctors are aware of these guidelines for investigating a suspected scaphoid fracture, we noted that there is a common practice of repeating the X-rays after two weeks. There may be many reasons for that practice; the first is what was mentioned in literature that in scaphoid fractures, resorption of bone occurs around the fracture site after two weeks from the injury leading to more accurate diagnosis. Another reason is the long time that MRI takes to be done which force the treating clinicians to search other

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alternatives. We also noted that there is a common phrase mentioned in radiologists comments in the initially negative X-rays for suspected scaphoid fracture which is "If scaphoid fracture is suspected, the patient should be reassessed in 10-14 days with a view to further imaging if required, following appropriate clinical management".

Our aims from this study are:

1 - To focus some light on the common practice of repeating X-rays for suspected fractures of scaphoid in St George's University Hospital, as a major trauma centre, and to discuss the accuracy of the radiologists comments, mentioned above, for initially negative cases.

2 – Illustrate the advantages and disadvantages of clinical reassessment and repeat imaging after 14 days.

3 – Try to put an algorithm for investigating scaphoid fractures especially when following NICE guidelines becomes non-applicable due to scheduling issues of MRI.

PATIENTS AND METHODS

We conducted a retrospective study on acute trauma patients seen in emergency department (ED) in a United Kingdom inner city level 1 trauma centre, with injuries to the wrist suspicious of scaphoid fracture. We retrospectively studied 150 cases in the period between December 2018 to February 2019 with an age range (12-89 years, median 47 years). From these patients, 53 were females (39.25%) and 82 were males (60.7%). Inclusion criteria were patients aged more than 12 years, in acute trauma setting with injuries to wrist, and with repeat X-rays at two weeks. We excluded 15 cases from the 150 cases that had chronic presentation or ages less than 12 years; so the total number of cases included was 135 cases.

All patients in our study were initially examined in ED and were proven to have at least one positive clinical sign of scaphoid fracture (tenderness at the anatomical snuff box, at the scaphoid tubercle, on palpation of scaphoid tubercle, or on axial compression of the thumb). All were initially investigated by X-rays, then repeat X-rays at two weeks and six weeks with four standard views (antero-posterior (AP), lateral, scaphoid, and oblique views) then referred to an orthopaedic clinician in a course of one week.

We recorded the true positive, true negative, false positive and false negative cases in the initial X-ray and in the X-ray done after two weeks. From that we calculated the sensitivity, specificity, accuracy, positive and negative predictive values of the test. A final diagnosis was put by the treating clinician in all cases. We recorded the date and mechanism of injury and whether the X-rays after two weeks were commented on by a registrar, consultant or 'unknown level' radiologist. CT and MRI dates, reasons, and results were also recorded for all patients in whom they are requested. We also recorded the method of treatment whether operatively or non-operatively.

We recorded our data from two sources; the first was the picture archiving and communication system (PACS), from which we had a look at the radiological investigations requested, the dates, and the comments made by the radiologist for the reason of the radiography, the results, and his recommendations if applicable. The second source was the medical records of patients on the Electronic Patient Record system (*EPR)* from which we reached the dictation letters made by the treating clinicians about the results of clinical assessment, the reasons of requesting his investigations, the final diagnosis and treatment plan.

After analyzing our data, we calculated five quality measurements for both initial and repeat X-rays after two weeks. The first was the sensitivity which is the percentage of sick people who are correctly identified as having the condition. It is calculated as the number of true positive cases divided by true positive cases added to false negative cases [7]. The second is the specificity which is the percentage of healthy people who are correctly identified as not having the condition. It is calculated as the number of true negative cases divided by true negative cases added to false positive cases [7]. The third was the accuracy which is the degree of closeness of measurements of a quantity to that quantity's true value and is calculated as the number of true positive and true negative cases divided by the total number of cases included in the test. An accuracy of 99% of times the test result is accurate, regardless positive or negative [8]. The last two values are the positive and negative predictive values which are the proportions of positive and negative results in statistics and diagnostic tests that are true positive and true negative results, respectively. The positive predictive value is the true negatives divided by true positives and false positives, while the negative predictive value is the true negatives divided by the true negatives and false negatives [9].

We carried on this study in St George's Hospital, a level 1 trauma centre which serves a population of 1.3 million across southwest London and is one of the UK's largest teaching hospitals. St George's Hospital receives and treats approximately 120 patients every month as a result of trauma. As a major acute hospital, St George's Hospital also offers very specialist care for the most complex of injuries and illnesses, including trauma, neurology, cardiac care, renal transplantation, cancer care and stroke.

RESULTS

Demographics

We retrospectively included 135 patients with suspected scaphoid fracture in acute trauma setting in the period between 1 /12 /2018 and 1/2/2019; 82 males (60.7%) and 53 females (39.25%) aged 12-89 (median 47) years. A total of 44 cases (32.5%) were complaining of injuries in the right side, while 90 cases (66.6%) have suspected lesions on the left side. The most common mechanism of injury was falling on outstretched hand (FOOSH) in 127 cases (94%), followed by hyperflexion injury to wrist in three cases (2.2%), and knocking the door with force in two cases (1.4%).

Initial X-ray results

All the 135 cases were initially examined in ED for suspected scaphoid fracture and were proved to have at least one positive clinical sign of possible scaphoid fracture (tenderness at the anatomical snuff box, at the scaphoid tubercle, on palpation of scaphoid tubercle, or on axial compression of the thumb).

From the initial X-ray done, 20 cases (14.5%) were reported as confirmed scaphoid fractures, 34 cases (25%) were reported as negative, and 81 cases (60%) as having suspicious scaphoid changes (i.e. radiolucent changes in the scaphoid). Reviewing the radiologists' comments, they advised to do radiography after two weeks in 12 cases of these initially negative 34 cases and in all the 81 suspicious cases combined with thorough clinical examination.

X-rays after two weeks

X-rays were repeated after two weeks for all cases except these cases with proven fracture from first X-rays. Eight of these cases were treated by operative fixation by mini screw.

A - Regarding the 34 radiologically negative cases in initial X-rays

From *Figure 1*; following the 34 cases with initially negative X-ray by X-rays after two weeks, two cases were proven to have fractures of scaphoid (*Figure 2*), and the rest of them (32 cases) were still negative not showing any pathology. One of these two cases was treated surgically due to fracture of proximal pole. Clinical assessment of these 32 cases revealed no pain in the wrist in 22 of them who have been

followed up after six weeks by X-ray and reassessment which showed normal findings; so they were discharged. Regarding the remaining 10 cases of the 32 negative cases, clinical assessment revealed persistent wrist pain in them. Five of them have been investigated by CT scan which revealed scaphoid fracture in three cases and normal CT findings in two of them. From these three cases with new fractures, one case was treated operatively (*Figure 3*), while the other two were treated by cast. The last five cases did MRI scan which showed three fractures, one normal study, and one scapho-lunate ligament injury case (SLI). From these three scaphoid fractures proven from MRI, only one case (*Figure 4*) was treated operatively with mini screw, and the other two treated in a cast (*Figure 5*).

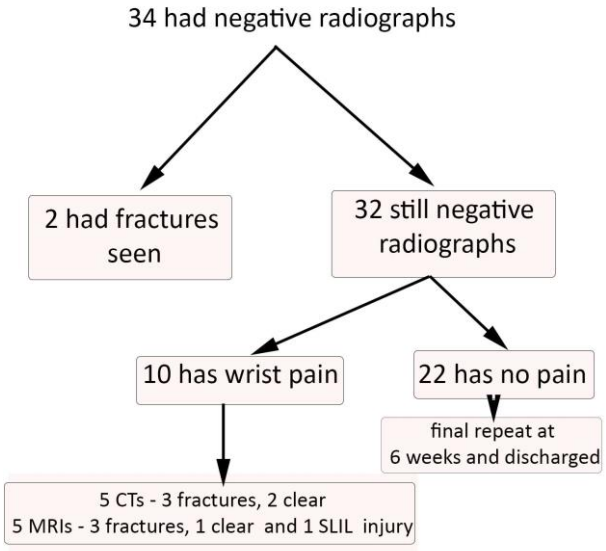

Figure 1: The follow up of the initial radiologically negative cases

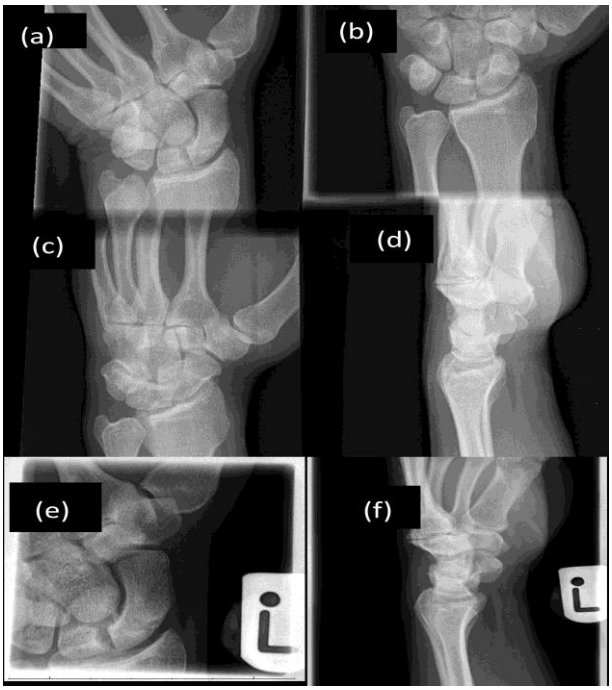

Figure 2: Missed scaphoid fracture from initial X-ray, then diagnosed after 2 weeks repeat X-ray. (a-d) initial X-ray of the wrist shows normal views. (e-f) are radiographs taken after two weeks and revealed proximal pole of scaphoid fracture

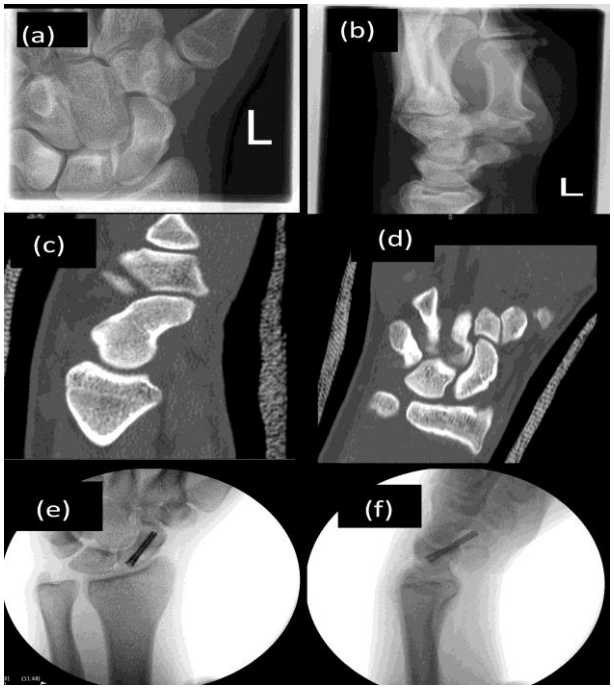

Figure 3: Missed scaphoid fracture from initial and repeat X-ray then diagnosed by CT scan. (a) anteroposterior (AP) and (b) lateral view of the wrist after two weeks of injury showing no scaphoid fracture. (c-d) CT scan was done and revealed subtle fracture at the proximal scaphoid. (e-f) the fracture was treated operatively by a mini screw

Figure 4: Missed scaphoid fracture from initial and repeat X-ray then diagnosed by MRI and treated operatively. (a) AP and (b) lateral view of the wrist two weeks after injury showed no scaphoid fracture. (c) MRI was done and showed a proximal scaphoid fracture which was treated operatively (d-e).

Figure 5: Missed scaphoid fracture from initial and repeat X-ray then diagnosed by MRI and treated by cast. (A-b) AP and oblique views of left wrist in 64 years old male showing distal end radius fracture after road traffic accident. (C-d) AP and lateral radiographs of the wrist after two weeks showing only radius fracture MRI was done and revealed an additional scaphoid fracture at the waist. (E-f) AP and lateral X-rays taken after one month showing sclerotic line at the site of scaphoid fracture.

B - Regarding the 81 suspicious radiolucent lesions in initial X-rays

From *Figure 6*; follow up after two weeks of the 81 initially suspicious scaphoid lesions on initial X-ray revealed that 58 of them had normal clinical examination and negative repeat X-rays; so they were followed by reassessment and repeat X-ray after six weeks and they were proven to be normal so they were discharged.

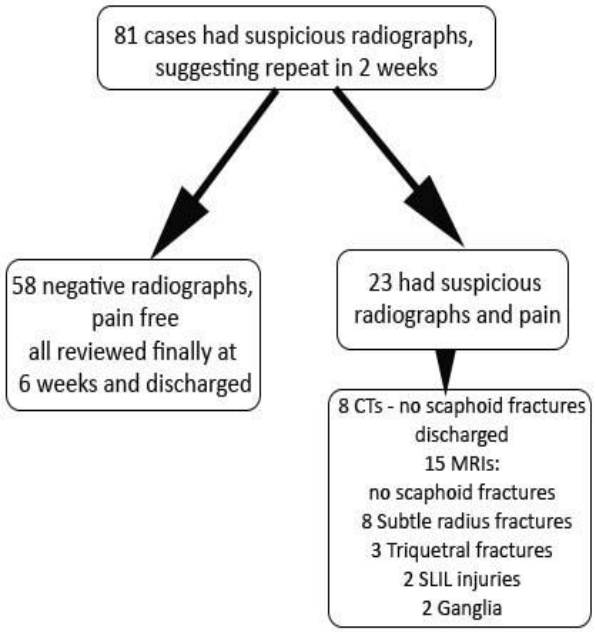

Figure 6: The follow up of the initial radiologically suspicious cases

Regarding the rest of the cases which are 23 cases, all of them were having still pain in the wrist and suspicious X-rays. Eight cases of them had CT scan of the wrist which revealed normal study in all of them. MRI scan was done in 15 cases of them which revealed no scaphoid fractures in all of them. However it revealed subtle radial styloid fracture in eight, triquetrium bone fractures in three, wrist ganglia in two, and (SLI) in the last two of them.

From the data above, only 28 cases (20.7%) were proven to have fractures, X-rays succeeded to diagnose 20 cases of them from the first X-ray (71.4%). Only two cases (7.1%) appeared normal at the first radiograph then presented as fracture in the second X-ray (*Figure 2*). Six cases of fracture scaphoid have not been diagnosed by X-ray at initial presentation or after two weeks (*Figures 3-5*). Three cases of them were diagnosed by CT scan and another three by MRI.

Calculating sensitivity, specificity, accuracy, positive and negative predictive values

From *Table 1*; to calculate the quality values of the initial and two week repeat X-rays, we excluded the initially proven 20 scaphoid fractures when we had to assess the two week X-ray, but included them for that of the initial X-ray. Regarding the initial X-ray population (135 cases), true positives were 20 cases, false negatives were 8 cases, false positives were 81 cases, and the true negatives were 26 cases. On the other hand, regarding the X-ray repeated after two weeks, the total population for that were 115 (135 excluding the 20 cases proven to have fractures from initial X-ray). From these 115 cases, only two were true positives, six cases false negatives, 23 were false positives, and 84 were true negatives.

From the data above, about the initial X-ray, sensitivity was 71.4%, specificity was 24.2%, accuracy was 34%, positive predictive value was 19.8%, and negative predictive value was 28.8%. Regarding the repeat X-ray after two weeks, sensitivity was 25%, specificity was 78%, accuracy was 74.7%, positive predictive value was 8%, and negative predictive value was 93.3% (*Table 1*).

Table 1: Calculation of the quality values

	Initial X-ray	**X-ray after 2 weeks**
True negative cases	26	84
True positive cases	20	2
False negative cases	8	6
False positive cases	81	23
Total cases	135	115
Sensitivity	71.4%	25%
Specificity	24.2%	78%
Positive predictive value	19.8%	8%
Negative predictive value	28.8%	93.3%
Accuracy	34%	74.7%

CT and MRI reasons and results

Overall, CT was done in 19 cases, in six cases of them it was for preoperative evaluation and in 13 cases it was for confirming the diagnosis. From these 13 cases, it confirmed scaphoid fractures in three of them, while it was completely normal in the remaining 10 cases.

MRI scan was requested in 22 cases, from which 20 cases to confirm diagnosis, and in two cases to assess union. It revealed scaphoid fracture in three cases, SLI in three cases, subtle radius fractures in eight cases, triquetrial fractures in three cases, and was normal in one case.

Treatment

Operative fixation of scaphoid fracture was needed in 11 cases (8.1%) from the overall 28 scaphoid fracture cases. Eight cases of these 11 cases were diagnosed as fractures from the first X-ray, one case from X-ray at two weeks, one case by MRI (*Figure 4*), and one case by CT scan (*Figure 3*) three weeks after the injury; being missed from both initial and repeat X-rays after two weeks.

DISCUSSION

Pain in the anatomical snuff box is a very sensitive indication of a scaphoid fracture (sensitivity is 100%), but it is nonspecific (specificity is 9%) as it can occur in normal wrists due to compression of the radial nerve sensory branch, which passes through the snuffbox. Other signs of scaphoid fracture are pain with longitudinal thumb compression (sensitivity 100%, specificity 48%), and on palpating the scaphoid tubercle (sensitivity 100%, specificity 30%). It is a good practice to compare both wrists during the examination [10-12]. Decrease of the grip strength by more than 50% as compared to the contralateral side increases the positive predictive value for a scaphoid fracture [13,14].

Regarding the initial radiographs, Pillai and Jain [15] found that > 80% of clinically suspected scaphoid fractures which were immobilized were proven fracture free at the end. Also they found that only 6.7% of the initially radiographically negative patients had a scaphoid fracture. In one prospective trial [3], the sensitivity of initial radiographs was 86%. This is near to the sensitivity that we detected in our study (71.4%). Regarding repeating radiographs after two weeks, many studies illustrated the futility of this approach [16-20].

Regarding accuracy of MRI, one clinical study showed that doing MRI after initially negative X-ray for suspected scaphoid fracture changed management strategies 90% of the time [21]. Thorpe *et al* [22] studied 59 patients with clinically suspected scaphoid fractures but negative initial X-rays. All of them underwent MRI, clinical follow up and bone scintigraphy. The clinical follow up was proven to be the most important for diagnosis. MRI was noted to have fewer false positive results among other investigations. Also, other sources of pathology as carpal instability and ligamentous injury could be confirmed in MRI but not from the bone scan. The authors finally found that the costs were similar. In another study conducted by Fowler *et al* [23], MRI was again found to be more sensitive for detecting occult scaphoid fracture than bone scan.

Regarding the cost effectiveness of early MRI compared to immobilizing patients and repeat assessment and radiology, many studies have been conducted in that field and the results of them varied widely [24,25]. Brooks *et al* [26] conducted a study on 28 patients and proved that MRI was cost effective; he classified them into 17 patients in the control group and 11 in the MRI group. Of the patients without fracture, the MRI group had significantly fewer days immobilised. The median cost of health care in the MRI group (594.35 dollars AUD, 551.35-667.23 dollars) was slightly higher than in the control group (428.15 dollars, 124.40-702.65 dollars) (p = 0.19 for the difference). Dorsay *et al* [27] conducted a similar study and he concluded that the cost differential between standard follow-up and MRI was small.

Although NICE guidelines are perfect when declaring that MRI following clinical examination is the most accurate for diagnosis of suspected scaphoid fracture, these guidelines do not take the long time that MRI takes until being done. As illustrated in *Figure 7*, our suggested algorithm for a suspected scaphoid fracture is to do X-ray with four standard views (AP, lateral, oblique and scaphoid). If fracture of scaphoid is revealed, then we will do CT scan for evaluation of displacement. If no fracture is obvious from the initial X-ray, then we have two pathways taking the time to do MRI in the trust into consideration. When MRI takes from two to four weeks to be done, we request it from the initial presentation of the patient to avoid delays and development of complications. If MRI can be done in less than two weeks, we will therefore have two options, whether to request MRI from the start, or to wait two weeks in cast then reassess the patient clinically and request MRI scan only if there is still pain. The later approach seems acceptable in hospitals where MRI request cannot be done initially. Our reason not to delay diagnosis more than one month was due to many studies that stated that complications of delayed scaphoid fracture diagnosis arise when the delay is more than one month [28].

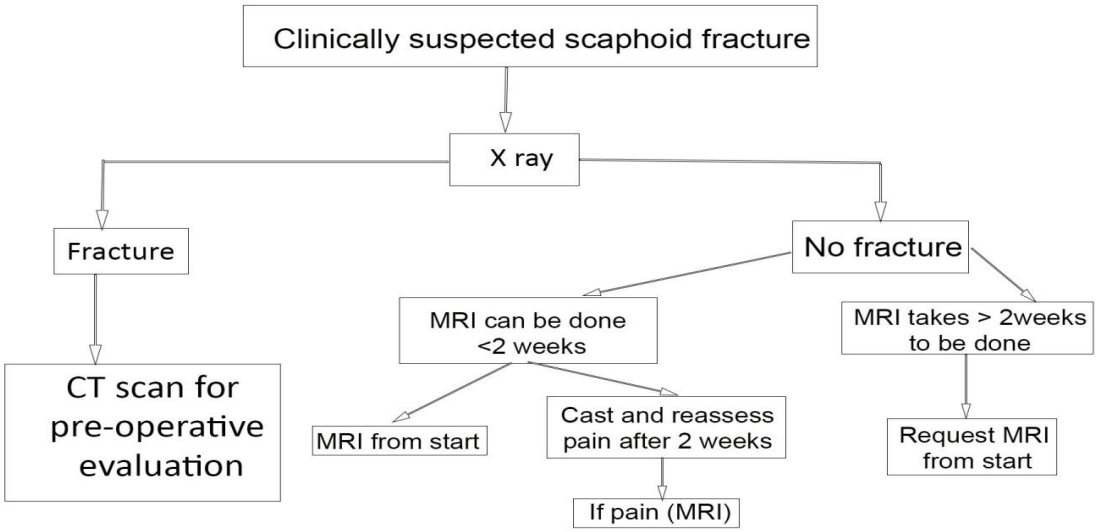

Figure 7: Suggested algorithm for suspected scaphoid fracture imaging

Advantages of waiting two weeks in cast then repeating the clinical examination is that if there is no pain after two weeks, this will mean that the patient is not having scaphoid fracture; this will save the National Health Service (NHS) the cost of doing a needless MRI. This cost effectiveness will be to both the NHS and community if the MRI takes more than 10 days to be done; as the patient will be already immobilized during this period and no rule for comparing early MRI and repeat X-rays cost-effectively. Disadvantages of repeating clinical assessment after two weeks is that there is no enough literature whether waiting for two weeks can aggravate the complication rate if operative fixation was needed from the start. Also this approach will not be applicable if MRI

takes more than two weeks to be done; as this will increase the period of immobilization to nearly one month.

CONCLUSION

No clear pathway at the current moment in St George's Hospital for investigating a suspected scaphoid fracture. Repeating X-rays at two weeks is useless due to its low sensitivity and specificity. As recommended by the NICE guidelines, MRI is the best diagnostic test for these lesions, not only due to its high sensitivity and specificity, but also due to its ability to discover hidden soft tissue lesion (e.g. SLI). However we need to consider the long waiting time before MRI is done; that is why considering the cost effectiveness of early MRI is not applicable in our hospital. The radiologists' advice about clinical reassessment after 10 days and further imaging is the best approach available now. We should emphasize that this further imaging should be only MRI to confirm diagnosis.

Conflicts of interest

There are no conflicts of interest.

Source of funding

Not applicable.

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