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Review Article

Diagnosis and Treatment of Scaphoid Waist Fractures: A Literature Review

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Abstract

Scaphoid fracture can cause serious complications and its diagnosis and treatment approaches are still contentious. Tenderness of anatomical snuffbox (ASB), longitudinal compression (LC) of the thumb, and scaphoid tubercle (ST) tenderness are very sensitive tests for clinical diagnosis of scaphoid factures all together. Previous studies recommend taking four standard views of the wrist for non-displaced scaphoid fractures diagnosis. Magnetic resonance imaging (MRI), computed tomography scan (CT scan), bone scintigraphy, and ultrasound are used for triage of suspected scaphoid fractures. MRI has the highest sensitivity and specificity. CT scan images captured in planes by the long axis of the scaphoid guide the diagnosis of nondisplaced scaphoid fracture. Displaced fractures need surgical treatment, but the best way of treating a nondisplaced fracture is controversial. Same results have been determined using a short arm or long arm cast for treatment of nondisplaced scaphoid fractures as well as similar outcomes with or without a thumb-spica component to the cast. Wrist position immobilization did not affect the rate of nonunion, wrist flexion, pain, or grip strength. Percutaneous screw fixation can shorten return to work time. CT scan and MRI both can be applied for assessment of union of fracture during follow-up period. This study aims to review the literature on challenges about clinical and radiologic diagnosis of nondisplaced scaphoid fractures and also present concepts about definite management of nondisplaced and minimally-displaced scaphoid waist fractures.

Keywords: Scaphoid Bone; Fracture Fixation; Bone Screws; Diagnosis; Orthopedic Procedures

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Background

Scaphoid is a critical component of natural wrist function. Maltreatment of nondisplaced scaphoid fractures could lead to major problems such as pain, swelling, avascular necrosis (AVN), and arthritis. Scaphoid fractures incidence rate is almost about 2-7 percent of all fractures and it is common among young male adults. Besides, 82-89 percent of carpal fractures involve scaphoid fractures (1-3).

The scaphoid fractures are diagnosed by clinical examination and radiographic procedures. Cast immobilization method is often used to treat suspicious fractures in the acute phase following injury, and follow-up evaluation and radiographies are used to prevent mismanagement of probable fractures (4-6). However, the choice of management of nondisplaced and minimally-displaced scaphoid waist fractures stays dubious. Previous reports recommend to manage these cases with either invasive procedures (percutaneous or open) or non-invasive, as both techniques bring about high rates of fracture union and subsequent functional recovery (7, 8).

Evaluation of appropriate healing of the scaphoid fracture is crucial to avoid any probable complications. Serial X-ray, computed tomography (CT) scan, or magnetic resonance imaging (MRI) can perform this task (9).

The aim of this study is to review the challenges in clinical and radiological diagnosis of non-displaced scaphoid fractures. We also report present concepts in the management of nondisplaced and minimally-displaced scaphoid waist fractures.

When a Scaphoid Fracture Should Be Clinically Suspected?

The most common scaphoid fracture signs are swelling and tenderness in the anatomical snuffbox (ASB) and on the scaphoid tubercle (ST). Although these signs are highly sensitive, the specificity is low: snuffbox tenderness about 9%, ST tenderness 30%, and the tenderness on thumb movement 48%. The combination of all three signs after 24 hours showed a specificity of 74% (10, 11).

DaCruz et al. concluded that patients with suspected scaphoid fractures with negative radiologic assessments should be rested in a sling or a splint for a week until they be reexamined in an orthopedic outpatient clinic. They found that it was easier to make a clinical diagnosis 3–7 days after injury, as patients would be more capable of localizing pain and tenderness (12).

Although with a high sensitivity of 87% to 100%, tenderness seems to be a reliable sign in clinical evaluation after wrist trauma, up to 13% of scaphoid fractures may remain unidentified using ASB tenderness alone. Longitudinal compression (LC) of the thumb is reported in some studies with a sensitivity of 48% to 100%. Parvizi et al. inspected a novel approach using ASB tenderness in addition to LC and ST tenderness, which resulted in 100% sensitivity (13).

Moreover, Duckworth et al. showed that clinical prediction rules had a significant impact on the possibility of an unsure scaphoid fracture. When these four independently significant factors (male gender, sports injury, ASB pain on ulnar deviation of the wrist within 72 hours of injury, and ST tenderness at two weeks) were positive, the risk of fracture occurrence was 91% (14).

Imaging Studies in Clinically-Suspected Scaphoid Fracture

X-Ray: Leslie and Dickson reported that among 222 scaphoid fractures, 98% were detectable in the X-ray. The remaining 2% became visible after two weeks. However, other authors reported less promising results as low as 84% detection on the first radiologic examination (15).

The most important point about X-ray views is to get one clear view of the scaphoid showing the trabecular pattern. For accurate diagnosis of nondisplaced scaphoid fractures, at least four radiographic views of the wrist posteroanterior (PA), lateral, PA with ulnar deviation, and 45-degree pronated oblique view are needed. The middle third of the scaphoid is best seen on the semi-pronated oblique view as well as the distal third of it. The dorsal ridge is best seen on the semi-supinated oblique view (16).

Radiologists will consider closer assessment of all bony structures in same compartment if there is a swelling in any component. The soft tissue shadows found in the PA view of the hand and wrist facilitate hand and wrist fractures localization (17).

CT Scan: For CT scan examination, most patients take wrist CT scan with reconstructions in the coronal and sagittal planes along the long axis of the scaphoid. The mean diagnostic values of CT are as follows: 94% sensitivity, 96% specificity, 98% accuracy, 0.75 prevalence-adjusted positive predictive value (PPV), and 0.99 prevalence-adjusted negative predictive value (NPV). The diagnostic characteristics of CT scans reformatted along the long axis of the scaphoid were more efficient than CT scans in the planes of the wrist for defining true fractures amid suspected scaphoid fractures. In this technique, the patient lies prone on the CT scan table and puts the hand overhead. The forearm position is in pronation for all views except for the coronal, in which it lies in a neutral position (18).

MRI: The best use of MRI is for ruling out a fracture especially for the athletes returning to the sport or workers getting back to the regular activities. The high price and low availability of MRI are the current drawbacks. However, some studies offer that when the accuracy of this modality is high, early use of MRI to detect occult fractures probably decreases the overall costs, considering individuals' productivity losses (19).

Previous publications reported that between MRI, CT scan, bone scintigraphy, and ultrasound for triage of suspected scaphoid fractures, MRI had the highest sensitivity and specificity, which were 94.2% and 97.7%, respectively (18).

The study of Brydie and Raby on the use of early MRI scanning in the management of clinical scaphoid fractures showed that patient management was changed with MRI in over 90% of the cases. They proposed that MRI caused an early definitive diagnosis and should be regarded as a gold standard investigation in this population (20).

Studies by Dorsay et al. (21) and Raby (22) on the cost-effectiveness of immediate MRI in comparison with traditional radiological follow-up of occult scaphoid fractures demonstrated that both protocols were financially similar. Early MRI screening could avoid the loss of productivity for patients who were unnecessarily immobilized in casts or splints.

Fowler et al. reported that MRI had a higher sensitivity and specificity than bone scintigraphy. Using fast scanning protocols, the cost of MRI was comparable with that of bone scintigraphy. They concluded that MRI was the appropriate second-line investigation for occult scaphoid fractures and was more effective than bone scintigraphy (23).

CT and MRI had comparable diagnostic value in suspected scaphoid fractures. Demonstrating the best standard reference method is still contentious, and it is ambiguous whether bone edema on MRI or small lines on CT indicate actual fracture (24, 25).

Bone scintigraphy, MRI, and CT all had high pooled sensitivity, specificity, and diagnostic odds ratio (DOR) in a meta-analysis conducted by Yin et al. They found that there were no differences in sensitivity among the three tests. The specificity of bone scintigraphy was much lower than that of MRI and CT scan. No significant difference in specificity was found between MRI and CT. The DOR of MRI was higher than that of bone scintigraphy. There was no significant difference in DOR between MRI and CT or CT and bone scintigraphy (26).

Which Fracture Is Displaced? Which Ones Are Nondisplaced?

Displacement can be determined by four bone measures: translation, gap, rotation, and angulation. A fracture is displaced when the offset (step-off) is ≥1 mm at the radial or dorsal cortical surface on PA or oblique radiographic views. Any step seen on the radiographs suggests instability (27).

Criteria for instability are:

a) 1 mm displacement
b) Angle of lateral intrascaphoid > 35° (Figure 1)
c) Bone loss or commination
d) Perilunate fracture dislocation
e) Dorsal intercalated segmental instability (DISI)

Fractures of the proximal pole which is unstable (27)

Figure 1. Lateral intra-scaphoid angle > 35°

According to Bhat et al., the reproducibility of evaluation of the lateral intra-scaphoid angle is relatively poor, whereas dorsal cortical angle and the height-to-length ratio measurements are moderate and excellent, respectively (Figure 2). Moreover, they highlighted using MRI or CT scan of the scaphoid along its axis to evaluate all scaphoid fractures (28).

Figure 1. Unacceptable lateral intra-scaphoid angle

Treatment

While displaced fractures need surgical treatment, nondisplaced fractures can be treated conservatively. Casting for three months treats 90% to 95% of scaphoid waist fractures, but some surgeons prefer internal fixation with a screw, considering the problems that a cast may cause for the patients' work activities (29). Comparing different treatment plans shows that using percutaneous fixation leads to a faster union by near five weeks in comparison with the cast immobilization. Also, it yields an earlier return to work by approximately seven weeks with similar union rates. Open reduction and internal fixation (ORIF) shows no difference in time to return to work compared with the cast. ORIF has a higher complication rate (30%), while the casting has a higher nonunion rate (30).

Furthermore, in another research by Saeden et al., 62 fractures on 61 random patients were selected. 30 patients went under conservative treatment with a below-elbow cast and the thumb immobilization, and the rest went under ORIF, treated with a Herbert bone screw. Incidence of radiographic scaphotrapezial osteoarthritis (OA) was significantly higher in surgery group than conservative group. However, this finding was not in accordance with subjective patient symptoms (31).

In an investigation conducted by Bond et al. on 25 military men with nondisplaced scaphoid waist fractures, patients were randomly assigned to two treatment groups, immobilization in a long-arm cast with free thumb (group 1) and fixation with a percutaneous cannulated Acutrak screw (group 2). The 2-year follow-up result of the research showed that patients undergoing screw fixation had the shorter mean time to fracture union and return to work, but there was no statistically significant difference in union rate, motion, and grip strength between the two groups (32).

In another similar study by Adolfsson et al., 53 patients were randomly divided between two groups. 28 patients of the first group were treated with immobilization in a below-elbow plaster cast with the thumb immobilized for ten weeks, and 25 patients of the second group were treated with percutaneous insertion of an Acutrak screw. Patients undergoing surgical treatment had a significantly better range of motion 4 months after injury (P = 0.020). In other variables like rate of union, time to union, grip strength, and final motion, no statistically significant differences were observed between the two methods (33).

Through some worldwide studies including Dias et al. (34), McQueen et al. (35), Vinnars et al. (36), and Yin et al. (37) casting and surgical approaches were investigated. They concluded no statistically significant difference in time to return to work or union rate. Minor complications such as infection were more routine in operatively-managed patients.

Furthermore, in another research performed by Davis et al., not only ORIF resulted in more quality-adjusted life-year (QALY), but also it was more economic than cast immobilization, because of a longer period of lost productivity with casting. The result of the cost-utility analysis overcharged the indirect cost associated to surgery, because absence from work during the recovery was not necessary for all patients (38).

In an investigation carried out by Arora et al., 47 patients with an acute nondisplaced scaphoid waist fracture were divided into 2 groups: 21 patients in group of percutaneous screw fixation and 23 patients in cast immobilization group. The average time to union was 43 and 74 days and the average time of return to work was 8 and 55 days for internal fixation and cast immobilization groups, respectively. Both fracture union time and time to return to work in the screw fixation group were significantly lower than cast immobilization group ($P < 0.050$). It was concluded that the internal fixation method was more cost-effective than conservative treatment (39).

In a prospective study by Vinnars et al., 52 patients with scaphoid fractures were divided randomly into internal fixation and cast treatment groups. The patients who underwent surgery had a shorter time off work than cast group (median: 61 days and 100 days, respectively; P = 0.030). Hospital costs were significantly lower in cast treatment in comparison with surgery ($P < 0.001$) (40).

Saeden et al. showed that although treatment by a Herbert screw by an experienced surgeon was a safe procedure, it might result in the development of OA of the scaphotrapezial joint (31).

Therefore, the type of treatment plan offered to the patients must meet their preferences, to choose a cost-saving treatment (i.e., casting) or time-saving treatment (i.e., surgery) (29). Here, we only discussed scaphoid waist fractures, so fractures of proximal pole of scaphoid and their treatment were not presented.

How a Nondisplaced Scaphoid Fracture Must Be Immobilized?

High percentage of nondisplaced scaphoid fractures can be treated by below-elbow cast. Clay et al. randomly divided 392 patients with scaphoid waist fractures using below-elbow casts with or without immobilization of the thumb to the interphalangeal joint. The results were classified as mentioned by the pattern of the fracture and showed a nonunion rate of 10% for transverse fractures, which was not related to the type of the cast (41). In contrast, Gellman et al. in a prospective study, randomly divided patients with nondisplaced scaphoid fractures into two groups to compare below-elbow thumb-spica cast with above-elbow thumb-spica cast. Patients who were managed initially with long thumb-spica casts for six weeks and then changed to short thumb-spica casts had a significantly shorter time to union (9.5 weeks vs. 12.7 weeks) and a lower incidence of nonunion (0% vs. 8.7%) (42).

The recent evidence in a well-designed review supports equal outcomes using a short arm or long arm cast as well as with or without a thumb-spica component to the cast for the closed treatment of nondisplaced scaphoid fractures (43).

Hambidge et al. randomized 121 distal and waist fractures of scaphoid into two groups of immobilization

with slight flexion or slight extension. They used a below-elbow plaster cast, leaving the thumb free. The immobilization of the wrist position did not impress nonunion rate, wrist flexion, pain, or grip strength. However, patients who were immobilized in flexion had more problems at resuming extension (44).

How to Assess Union?

Primary and secondary healing, depending on the degree of displacement can be a part of healing mechanisms. Maximum healing happens when fracture surfaces are extremely held in contact without the formation of a visible callus (45). Serial radiographs such as CT scan and MRI have been applied most of the time to demonstrate enough healing of scaphoid fractures and remained the method of choice for union assessment (46).

MRI is also a beneficial modality which can confirm the bony union in a high percentage of patients assumed to be clinically non-united, but MRI is more clinically appropriate to illuminate the presence of a scaphoid fracture, rather than to specify its healing (47).

CT scan detects the scaphoid fracture healing when there is evidence of bridging bone across the fracture site. Most surgeons would rather at least 50% bridging before allowing the patient to get back to normal life and full activity (10).

According to a study performed by Amadio et al., scaphoid malunion is recognized as an increase in the angle between the distal and proximal poles of the scaphoid as measured on lateral tomographic view. Union alone is an inadequate criterion for success after treatment of scaphoid fractures. It is very critical to certify that union happens quickly and with normal scaphoid alignment to provide the maximum potential for a desirable result (48).

Conclusion

Careful clinical examination using different tests can lead to scaphoid fracture diagnosis. It is essential to take four standard views of the wrist for decreasing misdiagnosis of scaphoid fractures. Between MRI, CT scan, bone scintigraphy, and ultrasound for triage of suspected scaphoid fractures, MRI has the highest sensitivity and specificity, despite the fact that CT scan images created in planes by the long axis of the scaphoid can lead to diagnosis of nondisplaced scaphoid fracture almost similar to MRI. Displaced fractures need operative treatment, but the best way of treating a nondisplaced fracture is still controversial. The immobilization of wrist position did not influence on the outcome. Above-elbow or below-elbow cast have similar results, so below-elbow immobilization without thumb incorporation is enough for the treatment. All patients with nondisplaced fractures should be followed up using CT scan or MRI for union assessment.

Conflict of Interest

The authors declare no conflict of interest in this study.

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