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Wrist Biomechanics and Instability

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Carpal instability following scaphoid fracture

Scaphoid fractures generally progress to a certain type of carpal instability, i.e. DISI, if the fracture was not appropriately treated and turned to nonunion. Usually such instability produces incongruity between carpal bones followed by synovitis, becomes painful within a few years, and often requires surgical treatment in due course. However, it is also true that some types of scaphoid fractures are less symptomatic and often left untreated. Long after fracture around more than ten years, fracture nonunion becomes symptomatic and radiographic examination reveals massive osteophytes formation around the scaphoid. Moreover, despite the long duration after injury, we often encounter cases without severe DISI deformity.

Recent 3-dimenssional analysis of scaphoid nonunion has revealed that carpal instability following scaphoid nonunion is closely related to whether the fracture line passes distal or proximal to the scaphoid apex. The scaphoid apex, which is the most dorsal and ulnar nonarticulating part of the scaphoid[1], where the dorsal scapholunate interosseous ligament and the proximal fiber of the dorsal intercarpal ligament attach. In their article, there were two clear patterns of the interfragmentary motions of the scaphoid based on the fracture location. In the unstable (mobile) type scaphoid nonunion, the fracture was located distal to the scaphoid apex, and the distal scaphoid was unstable relative to the proximal scaphoid. In the stable type scaphoid nonunion, the fracture was located proximal to the scaphoid apex, and the interfragmentary motion was considerably less than with the distal type.

Through several researches investigating scaphoid nonunions 3-dimensionally[1,3-5] I have noticed that for ordinary clinician, judgments of fracture locations using 2-dimensional and conventional x-rays were often inaccurate when compared to judgments using 3-dimensional CT images. For example, figure 1 shows two types of scaphoid nonunions; On the left, 3-D image shows that stable fracture (type 1 B1 fracture) has its fracture line proximal to the scaphoid apex. On the right, unstable fracture (B2 fracture) has its fracture line distal to the scaphoid apex. Despite relationships between fracture line and the scaphoid apex are totally deferent from each other, fracture lines on the scaphoid waist on the x-ray look very similar. I believe that many people would easily misdiagnose fracture type unless they focus on the scaphoid apex. One of the reasons is super-imposition of the scaphoid apex on the capitate (Fig. 2). It seems that most people do not see the contour of the scaphoid apex on x-rays; that's why it is difficult to recognise the fracture location 3-dimensionally. I believe that recognising the scaphoid apex on x-ray is very important clinically for people to judge fracture type, to predict its natural history, and to choose proper treatment.

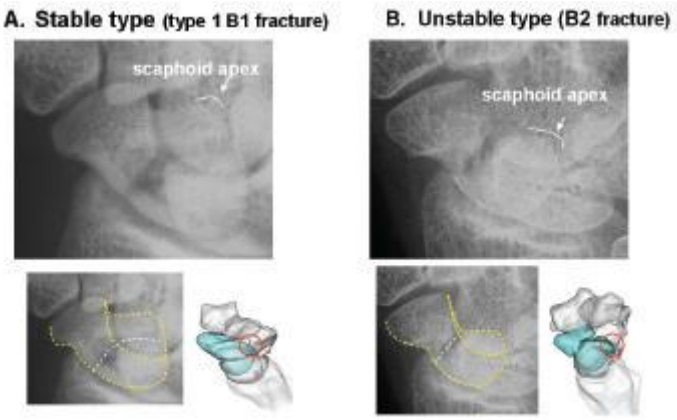


Figure 1: Oblique view X-ray and 3-D images of two patients with A) type 1 B1 and B) B2 scaphoid nonunion. Despite relationships between fracture line and the scaphoid apex are completely different, fracture lines on the scaphoid body on the x-ray look similar.

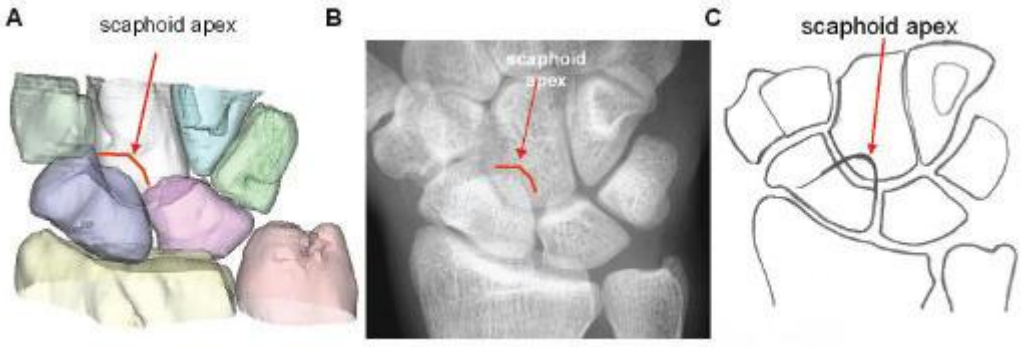


Figure 2: Contour of the scaphoid apex. Note the scaphoid apex superimposes on the capitate.

What we want to clarify is that there are two types of a mid-third fracture, which are 1. Type 1 B1 (distal oblique fracture) and 2. B2 (complete waist fracture). Both fractures have a similar fracture location at the palmar side but a different fracture location at the dorsal side. Type 1 B1 fracture is not a proximal third fracture but a fracture that could be categorised as a mid-third fracture because its fracture line passes through the palmar waist of the scaphoid. In the current committee report, I would like suggest mainly 2 points; 1. how to diagnose fracture type using x-rays whether stable or unstable, and 2. recommended treatment option for each type.

1. How to diagnose fracture types using x-rays

There are at least two radiographic tips to judge if fracture is stable or mobile.

First, on the semi-pronated oblique view x-ray (Fig. 1), after recognising the outline of the scaphoid apex, which is seen around the capitate head, stable or unstable fracture can be judged as present when the fracture line passes distal or proximal to the scaphoid apex, respectively. Second, stable fracture can be considered present when the fracture line is clearly visible on the P-A view with the wrist in neutral position (Fig. 3A). In Type 1 B1 (stable fracture), fracture line usually is seen clearly because fracture line runs almost parallel to the x-ray beam. In B2 (unstable fracture), fracture line is not often visible in neutral position because fracture line runs obliquely relative to the x-ray beam (Fig. 3B). In a P-A view with ulnar deviated position, however, fracture line becomes visible because scaphoid rotates dorsally and fracture line becomes parallel to the x-ray beam (Fig. 3C).

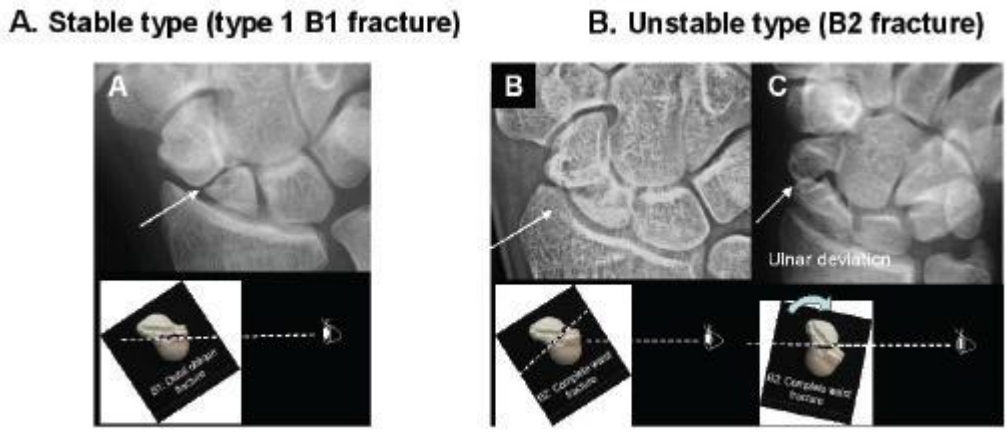


Figure 3: P-A view. A) In Type 1 B1 (stable fracture), fracture line usually is seen clearly because fracture line runs almost parallel to the X-ray beam. B) and C) In B2 (mobile fracture), fracture line is not often visible in neutral position because fracture line runs obliquely relative to the x-ray beam. In a P-A view with ulnar deviated position, however, fracture line becomes visible because scaphoid rotates dorsally.

2. Appropriate treatment option for each stable and unstable scaphoid nonunion (Table 1)

Stable fractures essentially do not alter the equilibrium of forces between the scaphoid and the lunate. Because wrist stability is not at risk, the bone defect should be smaller,

and the patient should have fewer symptoms. Degenerative change develops slowly with massive osteophyte formation. When symptom is brought only by osteophyte impingement, resection of osteophyte with styloidectomy would be enough, especially in elderly. When the patient is young, ORIF with bone graft is applied. As fracture line runs transversely from volar to dorsal, volar screw risk eccentric placement in the proximal fragment with very few of the screws across the fracture line. Dorsal screw with small cancerous bone graft would be preferable even if the proximal fragment is relatively big because resection of dorsal osteophyte is often necessary.

In unstable fracture, a humpback deformity of the scaphoid and a DISI deformity almost always occur because fractures distal to the insertion of the proximal fiber of the dorsal intercarpal ligament and the dorsal scapholunate interosseous ligament are destabilised and this allows the distal fragment to flex and the proximal fragment to extend creating a large bone defect. Pain is severe and bone defect develops rapidly. Therefore, immediate volar screw with a large, wedgeshaped, and cortico-cancerous bone graft would be appropriate regardless of age.

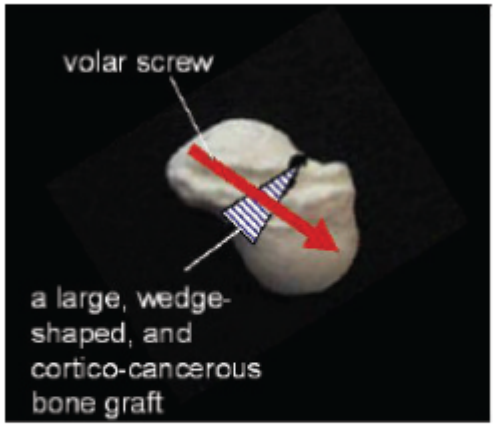
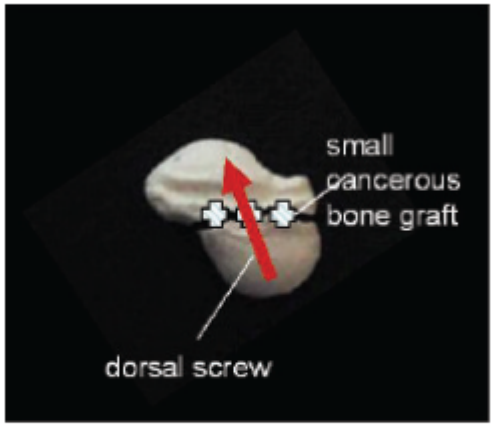
Unstable (mobile type	Stable type
	
• A humpback and a DISI deformity predominantly occurs. • Very painful with large bone defect. • Volar screw with a large wedge-shaped, and cortico-cancerous bone graft would be appropriate.	• Do not alter the equilibrium of forces between the scaphoid and the lunate. • The bone defect should be smaller with fewer symptons. • Styloidectomy and/or dorsal screw with small cancerous bone graft would be appropriate

Table 1: Comparison of pathology and recommended treatment for unstable and stable scaphoid nonunion.

References

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