The Importance of Central Screw Placement in the Distal and Proximal Pole in Scaphoid Waist Fractures

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SUMMARY
The purpose of this investigation was to evaluate the biomechanical properties of centrally and eccentrically positioned cannulated screws in the internal fixation of acute fractures of the scaphoid waist. Biomechanical testing demonstrated that central placement of the screws in the distal fragment of the scaphoid compared with eccentric positioning resulted in greater stiffness. During fixation of scaphoid waist fractures, the surgeon should aim for central placement of the screw throughout the scaphoid to provide optimal biomechanical fixation.

INTRODUCTION
Currently, the most widely accepted treatment for acute scaphoid waist fractures is immobilisation in a cast, with union rates ranging from 88-95%. However, the long period of immobilisation ranging from 8-12 weeks is not appealing to the young and active population who sustain these kinds of injuries. Besides that, the literature identifies other disadvantages of cast treatment, including stiffness and decreased grip strength. Therefore in this group, screw fixation is becoming a popular option of treatment. This avoids the long period of immobilisation and allows more rapid return to work and athletic activities.

Open reduction and internal fixation is technically demanding with the dangers of damage to the radiocarpal ligaments, the scaphotrapezial joint, and the blood supply to the scaphoid. Percutaneous scaphoid fixation is becoming increasingly popular because many of the risks of the open techniques can be avoided.

McCallister et al [1] in a biomechanical study showed that the strength of the fixation is greatest when the screw is placed centrally in the proximal pole as opposed to eccentric positioning. Dodds et al [2] confirmed these data and stated that a long, centrally placed screw, with purchase of the screw threads in the subchondral bone, provides better fixation. However, central screw placement can be technically difficult and requires a high level of surgical skill.

When using a standard percutaneous volar approach, central screw placement is complicated by the shape of the scaphoid and obstruction by the trapezium. This can be avoided by opening the scaphotrapezial joint and manipulation of the scaphoid or by using a transtrapezial approach. Alternatively, a more radial entry point on the distal pole of the scaphoid can be used, but this does not allow central placement of the screw in the distal pole.

The aim of this study is to determine whether central placement of the screw in the proximal and distal pole of the scaphoid offers a biomechanical advantage over a screw that has a more radial entry point and is central only in the proximal pole.

METHODS
Twelve matched pairs of scaphoids were removed from fresh cadaveric wrists for use in this study. Each pair consisted of the right and left scaphoids from one individual. Initially the proximal and distal carpal row were removed. Exceptionally small or large scaphoids, scaphoids with an unusual geometry or evidence of previous injury were excluded. The scaphoids within each pair were then randomly assigned to either central or eccentric screw placement.

A guidewire was drilled in the scaphoid using a transtrapezial approach reproducing a central position throughout the scaphoid and a standard volar approach, avoiding the trapezium, reproducing an eccentric position at the distal and central position at the proximal pole.[3] Radiographs in the lateral and anteroposterior plane were taken to confirm correct placement of the guidewire. The drill-bits recommended for the screw system were used. A smooth transverse osteotomy was made along the scaphoid waist perpendicular to the long axis of the screw with use of a thin-blade bone-saw.

For mechanical testing, the proximal fragment of each specimen was potted in a holder with use of polymethylmethacrylate and a Kirschner wire was passed through the proximal end of the scaphoid to provide additional anchoring stability. The scaphoid was oriented at a 45° angle to the horizontal plane of the holder to mimic its normal position in a wrist held in the neutral position. This enabled delivery of a dorsal-to-volar cantilever load, which represents the primary physiologic load encountered by the scaphoid. Each specimen was then placed into a fixture with a pneumatically driven plunger resting on the surface of the distal pole, with its center a fixed distance from the osteotomy surface (Fig 1).
The load was applied by using a load-controlled test protocol in a hydraulic testing machine (Dartec 9600) at a rate equivalent to 10 N per second. Load was then increased until the fixation failed by bone fracture and loss of reduction. Data acquisition was done with specialized software at 25 point per second. Load at 2 mm of displacement and load at failure were recorded.

Statistical analysis was done with the use of GraphPad Prism. A paired t-test was used to load to 2 mm of displacement and load to failure of the specimens. A power analysis performed using previous biomechanical testing data showed that eight matched pairs provide significant data.

RESULTS AND DISCUSSION
Radiographic evaluation of all of the specimens confirmed placement of the screw within the central one-third of the proximal fragment of the scaphoid in both the anteroposterior and lateral radiographs. The specimens with an eccentrically positioned screw had at least one radiograph in which the screw was not completely contained within the central one-third of the distal fragment. Radiographic analysis of the specimens with a centrally positioned screw confirmed placement of the screw within the central one-third of the distal fragment.

The load at 2 mm of displacement and load at failure were 353.3 N ± 83.44 and 424.1 N ± 70.62 for the centrally placed screw. For the eccentrically placed screw the load at 2 mm of displacement and load at failure were 135.0 N ± 24.80 and 217.5 N ± 37.38 respectively. Statistical analysis comparing load to displacement and load to failure of the specimens demonstrated a significant difference between both techniques (p<0.01).

The results of our investigation suggest that the central position of the screw in the distal fragment of the scaphoid is biomechanically superior to the eccentric position. On the basis of these data, we concluded that significantly greater force is required to generate fracture displacement when screws are positioned in the central portion of the proximal fragment of the scaphoid than when they are eccentrically positioned.

CONCLUSIONS
Internal fixation has been advocated in scaphoid waist fractures when it is displaced or unstable and when the patient desires a quicker return to function. The results of our investigation suggest that the central position of the screw in the proximal and fragment of the scaphoid is biomechanically superior to the eccentric position. Clinical efforts and techniques that facilitate placement of the screw in the central portion of the proximal fragment of the scaphoid during fixation of an acute fracture of the scaphoid waist should be encouraged.

REFERENCES

Table 1: Results of biomechanical testing of matched pairs of scaphoids.

<table>
<thead>
<tr>
<th></th>
<th>central</th>
<th>eccentric</th>
<th>p value</th>
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<td>load at 2 mm displacement (N)</td>
<td>353.3 ± 83.44</td>
<td>135.0 ± 24.80</td>
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</tr>
<tr>
<td>load at failure (N)</td>
<td>424.1 ± 70.62</td>
<td>217.5 ± 37.38</td>
<td>0.006</td>
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