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Three-dimensional comparison of alternative screw positions versus actual fixation of scaphoid fractures

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ABSTRACT

Purpose: The recommended technique for the fixation of a scaphoid waist fracture involves a headless compression screw placed in the proximal fragment center. This is usually accomplished by placing a longitudinal axis screw as visualized by fluoroscopy. The screw length has been shown to have a biomechanical advantage. An alternative to these options, which has been debated in the literature, is a screw placed perpendicular to the fracture plane and in its center. The perpendicular screw may have a biomechanical advantage despite the fact that it may be shorter. This study examined the differences in location and length in actual patients between a screw in the center of the proximal fragment with a longitudinal axis screw, and the actual fixating screw. These were then compared to a perpendicular axis screw.

Methods: Pre- and post-operative CT scans of 10 patients with scaphoid waist fractures were evaluated using a 3D computer model. Comparisons were made between the length, location and angle of actual and virtual screw alternatives; namely, a screw along the central third of the proximal fragment (central screw axis) where the scaphoid longitudinal axis was calculated mathematically (longitudinal screw axis) and a screw placed at 90° to the fracture plane and in its center (perpendicular screw axis).

Results: The longitudinal axis screw was found to be significantly longer than the other axes (28.3 mm). There was a significant difference between the perpendicular axis screw and the location and angle of the other screw axis, but it was only shorter than the longitudinal screw (23.6 mm versus 25.5 mm for the actual screw; ns.).

Conclusions: A computed longitudinal axis screw is longer than a central or actual screw placed longitudinally by visual inspection by the surgeon. Although it needs to be placed using computer assisted (CAS) techniques, it may have the biomechanical advantages of a longer screw in a similar trajectory. The perpendicular screw was found to be significantly different in position and angle but not shorter than the actually placed screw. It has biomechanical advantages and does not require visualization with CAS methods, making it the more attractive alternative.

Introduction

Acute displaced scaphoid fractures are considered unstable. The treatment of choice for these injuries is operative reduction and fixation. Reduction may be open, through a volar or dorsal approach, percutaneous using Kirschner wires (K-wires) as "joy-sticks" or arthroscopy [1,2]. Different methods are employed for the fixation of the fracture although the most common implant is a single cannulated headless screw [2,3].

There is an ongoing debate as to which location of the screw is biomechanically superior and achieves better clinical results in waist fractures. Placement of the screw in the central third of the proximal scaphoid was recommended in a cadaver study that demonstrated its superiority over an eccentric screw [4]. Based on this evidence, a longitudinally placed screw has become common practice [3,5].

However, computer simulated finite element analysis (FEA) has indicated that a screw placed perpendicular (90°) to the fracture has as biomechanical advantage over a longitudinal axis screw [6]. Although not shown in cadaver studies [7,8], there is still interest in this approach [9,10] because it adheres to a basic biomechanical principle of fracture fixation. Another FEA report found greater surface area available for healing with a perpendicular screw in common distal oblique fractures [11]. This is not an eccentric screw

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examined previously [4], but one that may be placed in the center of the fracture and perpendicular to its plane.

Several issues are involved when comparing these screw-positioning alternatives. Central or longitudinal screw methods disregard the fracture angle. In transverse waist fractures, a longitudinal screw may not be significantly different from a perpendicular screw. Recently, using a 3D model, it was shown that most waist fractures are horizontal oblique and not transverse [12]. In a horizontal oblique fracture, there should be a considerable difference between the longitudinal axis screw and a screw perpendicular to the fracture.

Central placement of the screw throughout the length of the scaphoid is not simple to achieve [13] and can be done by implementing either a proximal or a transtrapezidal approach [14]. With a standard volar approach through the tuberosity, the screw will only be in the center of the proximal scaphoid, and possibly its waist [15,16]. To obtain a more centrally placed screw, some recommend excising part of the trapezium, although the trajectory of this screw has not been definitively characterized and the consequences to the well-being of the scapho-trapezial joint remain unclear.

Another biomechanical factor to consider is the length of the screw. One cadaver examination indicated that a longer screw would be biomechanically superior when placed along the same trajectory [17]. When examining different trajectories, it is obvious that its maximal possible length as well as its biomechanical characteristics will differ [6–8].

This study explored specific questions regarding these alternatives by evaluating actual surgically treated patients: 1. Is there any significant difference between the location and length of the longitudinal screw axis and the central screw axis? 2. How is the actual screw placed in relation to these alternatives? 3. Does the perpendicular screw differ in location and angle and is it shorter than the other options? Our hypothesis was that there would be no significant difference between the longitudinal axis, central axis and actual screw axis in position or length but that there would be a significant difference between them and a perpendicular screw, both in position and length.

Materials and methods

The hospital archives were searched for patients from 2010 to 2014 with acute scaphoid fractures, who were treated surgically. All patients between 18 and 60 years old that had been treated with fracture reduction and cannulated screw fixation within 30 days of the injury and had CT scans available from before and after fracture fixation, were included in the study. Patients were contacted to obtain their consent and to try to locate the CT scans

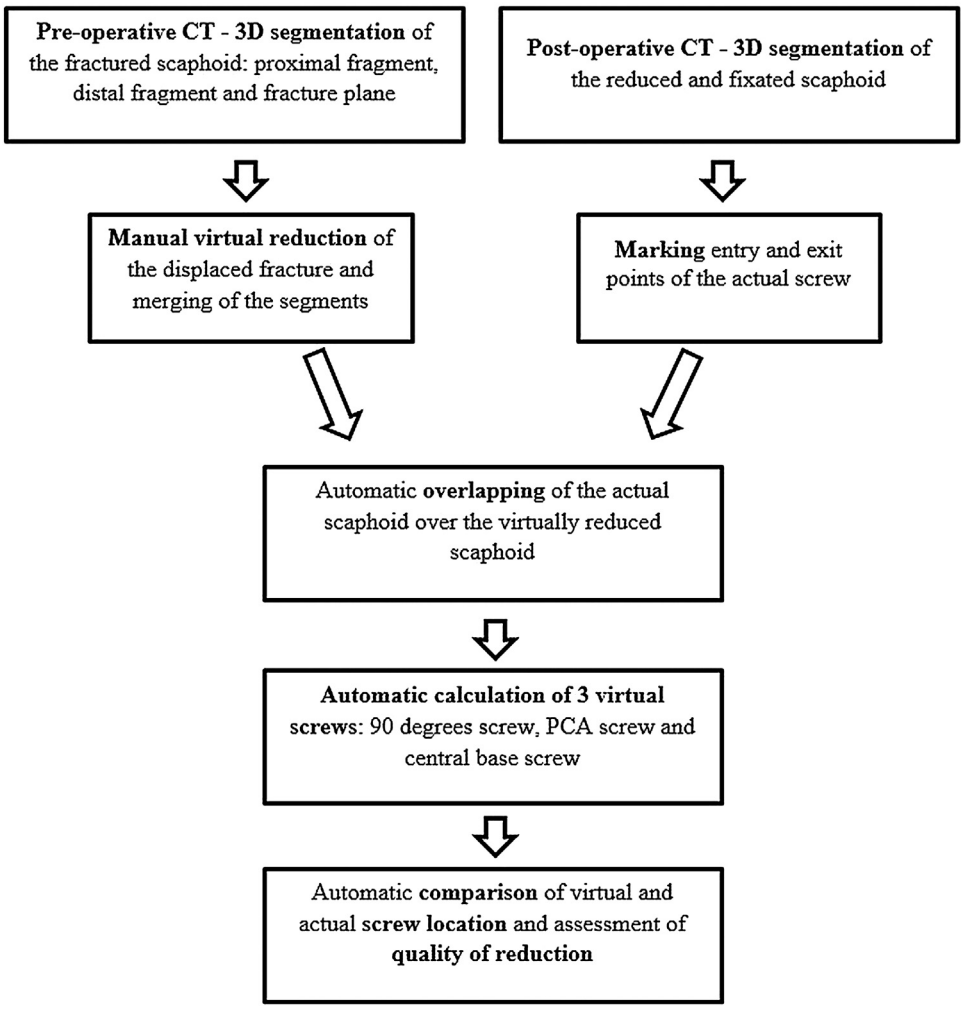

Fig. 1. Flowchart of the steps carried out for each patient.