Antegrade Versus Retrograde Technique for Fixation of Scaphoid Waist Fractures: A Comparison of Screw Placement

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Abstract

Keywords

- antegrade approach
- retrograde approach
- scaphoid screw fixation
- scaphoid waist fracture

Background Scaphoid waist fractures are often treated using headless compression screws using dorsal or volar approaches.

Objectives The purpose of this study is to compare differences in screw position using a volar (retrograde) or dorsal (antegrade) approach.

Patients and Methods A total of 82 patients were retrospectively evaluated: 41 treated with a volar and 41 with a dorsal approach were selected. Postoperative radiographs were reviewed by three observers who rated screw location in the proximal pole, waist, and distal pole.

Results Thirty-four patients (83%) in the antegrade group had central screw placement in the waist of the scaphoid in posteroanterior and lateral planes compared with 14 (34.9%) in the retrograde group ($p < 0.05$). For the antegrade group, the screw was central in 217 of 246 zones (88.2%) compared with 127 of 246 (51.6%) in the retrograde group ($p < 0.05$).

Conclusions The dorsal antegrade approach appears to allow the surgeon to achieve central screw placement along all three scaphoid regions.

Level of Evidence This is Level III study.

Scaphoid fractures comprise ~3% of all wrist fractures. In addition, they are the most common carpal fracture,¹ representing 70% of carpal fractures seen in the emergency department. The waist of the scaphoid is fractured in ~80% of cases.² When surgery is indicated, several surgical procedures to treat scaphoid waist fractures have been described, most commonly involving open or percutaneous techniques utilizing headless compression screws. Other fixation techniques, such as plates and screws for comminuted fractures, are treatment alternatives.

While open repairs, often from a volar approach, are almost always needed for comminuted fractures or reconstructions for nonunions, both volar (retrograde) and dorsal (antegrade) approaches for nondisplaced or minimally displaced scaphoid waist fractures have been described. The advantages and disadvantages of each approach, including ease of access, mechanical stability, and anatomic visualization, have been debated with no clear superiority of one approach over the other demonstrated to date.³ Thus, the choice as to a volar or dorsal approach is left to the surgeon's preference. Regardless

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of the approach, several biomechanical studies have demonstrated that optimal mechanical fixation is achieved when the screw is placed down the central longitudinal axis of the scaphoid.^{4,5} The purpose of this study is to compare variance in ideal screw position comparing antegrade and retrograde screw fixation of scaphoid waist fractures as it relates to central screw placement. We hypothesized that the dorsal antegrade screw insertion would lead to better screw positioning compared with the retrograde approach.

Patients and Methods

Institutional review board approval was obtained prior to commencing the study. Patients who underwent surgical fixation of a scaphoid fracture were identified from a billing database in our institution using a common procedural terminology (CPT) code 25628 (treatment of carpal scaphoid fracture with or without internal or external fixation) during a 9-year period between January 2009 and December 2017. The surgeon group comprised of 14 fellowship-trained orthopedic hand surgeons. The type of approach and screw (continuous threads versus leading and trailing threads separated by a smooth shaft) used was at the discretion of the treating surgeon. Demographic information was collected including patient age and gender.

After all of the radiographs from the initial roster ($n = 365$) were reviewed, exclusion criteria included patients with (1) an established nonunion; (2) those with inadequate radiographs, defined as lacking orthogonal posteroanterior and lateral views; and (3) fractures treated with implants other than headless compression screws. From this group, only patients with scaphoid waist fractures (defined as a fracture line which is located in the central one-third of the scaphoid on all X-ray views) were included for analysis ($n = 264$). Of these patients, 41 (15.5%) have been treated with a volar approach while 223 (84.5%) were treated with a dorsal approach. All patients were treated with a percutaneous or mini-open technique. Only patients from the seven surgeons who performed both dorsal and volar approaches were selected for inclusion. To compare the same number of X-rays, 41 patients with antegrade screw placement were selected for radiographic evaluation using a random number generator.

The first postoperative radiographs were evaluated to determine the position of the screw with respect to the central axis of the scaphoid in the proximal pole, waist, and distal pole of the scaphoid. Each observer rated screw location as follows: in the posteroanterior (PA) view as central (c), radial (r), or ulnar (u) and in the lateral view as central (c), volar (v), or dorsal (d) (►Fig. 1). Measurements were performed using PACS software (SECTRA, Linköping, Sweden). The radiographs were reviewed by three observers (one fellowship-trained hand surgeon, one hand surgery fellow, and one orthopedic resident). Each observer performed a total of 492 measurements.

Statistical analysis was performed using the Fisher exact test for nonparametric data. A p value of $p < 0.05$ was considered statistically significant. Measures of interobserver reliability

were assessed using a kappa (κ) statistic, with a κ value of < 0.20 considered poor, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 good, and 0.81 to 1.00 very good reliability.

Results

The patient group consisted of 62 (76%) men and 20 (24%) women with an average age of 30.9 years (range 15–67 years). A total of 59 (72%) of the screws had continuous threads while 23 (28%) had leading and trailing threads separated by a smooth shaft. The average κ value between observers was 0.62, denoting substantial interobserver reliability.

Considering all zones separately, for the antegrade group, the screw was central in 217 of 246 zones (88.2%) compared with 127 of 246 (51.6%) in the retrograde group ($p < 0.05$) in both radiographic views (►Table 1).

In both PA and lateral views, 34 patients (83%) in the antegrade group had central screw placement in the waist of the scaphoid compared with 14 (34.9%) in the retrograde group. In both PA and lateral views, these differences between antegrade and retrograde approach were statistically significant ($p < 0.05$).

Combining the results of PA and lateral views, we found that 21 patients (52.5%) in the antegrade group had central screw placement in all three regions compared with 5 patients (12.2%) in the retrograde group ($p < 0.05$).

Discussion

Scaphoid fractures are common injuries that often require surgical treatment with screw fixation.⁶ The current standard of surgical repair for scaphoid fracture is the headless compression screw. Typically, a proximal pole fracture is fixed through a dorsal approach. However, for a scaphoid waist fracture, both volar and dorsal approaches are considered valid options with similarly high fracture union rates.⁷

For a waist fracture, placement of the screw down the central axis has been shown to be biomechanically superior to off axis placement.⁸ This intuitively makes sense as central axis placement allows the longest screw length and best bone purchase for increased construct strength, as well as a perpendicular orientation to the common transverse fracture pattern and a central location at the fracture line, both of which serving to more evenly distribute compression from the screw. Accordingly, the conventional recommendation is to place the screw along the central axis of the scaphoid, irrespective of the fracture pattern.

Chan and McAdams demonstrated in a cadaver model of scaphoid waist fractures that antegrade fixation allows for better centering of the screw in the distal pole, compared with retrograde fixation.⁹ There was no difference in screw location in the proximal pole and waist regions. Similarly, Jeon et al evaluated postoperative X-rays of 41 fixed scaphoid waist fractures and found screws were placed more parallel to the central axis and perpendicular to the fracture line through the antegrade approach.¹⁰ It should be noted that

Fig. 1 Categorization of antegrade and retrograde screw placement. (A) X-ray PA (posteroanterior) of the scaphoid. The screw positioned between the two lines was considered central. A screw placed over line “a” was considered ulnar while a screw placed over line “b” was considered radial. (B) X-ray lateral of the scaphoid. The screw positioned between the two lines was considered central. A screw placed over line “a” was considered dorsal while a screw placed over line “b” was considered volar. (C) Clinical example of an antegrade screw position centrally along all three scaphoid regions. (D) Retrograde screw positioned noncentrally (radial/volar in the distal pole, ulnar location in the proximal pole).

there was no difference with respect to functional outcome and bone union between the antegrade and retrograde techniques.

In the retrograde approach, the trapezium hinders access to the distal pole. To improve the screw trajectory from this approach, Meermans et al investigated a transtrapezium technique compared with starting the screw at the volar scaphoid tubercle.¹¹ They report that the transtrapezium technique can reliably place the screw in the central third of the proximal and distal poles and that this imparted a significant mechanical advantage regarding 2 mm displacement force and load to failure. Another author recommends using a 14-gauge needle to pry open the scaphotrapezium joint to permit more central screw placement without needing to drill through the trapezium.¹²

Our study showed that patients treated with an antegrade approach seem to have a higher possibility of having an ideal position of the screw compared with ones treated with a retrograde screw. The difference between these two groups seems to be statistically significant.

To better center the screw, a transtrapezium trajectory can be used which may predispose the patient to scaphotrapezotrapezoid arthritis. In the dorsal antegrade approach, there is a risk for injury to the posterior interosseous nerve and tendon injury and stiffness. Similarly, the screw entry site could predispose the patient to radioscaphoid arthritis and it may be more difficult to maintain fracture reduction with the wrist in flexion.

As stated previously, the goal of this study was to determine which approach was superior in achieving central screw placement, which has been a well-established variable in the mechanical stability of the fixation construct. A study by Acar et al suggests that volar screw insertion may be mechanically superior, but as long as the screw is placed centrally,¹³ in accordance to previous studies. Swanstrom et al suggest that a screw trajectory perpendicular to the fracture plane may be mechanically advantageous over screw positioning.¹⁴ While interesting, this study is hampered by the fact that it is a computer simulation of only 10 fractures, screw insertion (volar versus dorsal) is not provided, and

Table 1 Placement of the screw in each zone in the antegrade and retrograde groups

	Retrograde (volar)	Antegrade (palmar)	Total per approach
Number of screws central in any zone	127 (51.6%)	217 (88.2%)	246
Number of screws central in all three zones	5 (12.2%)	21 (52.5%)	41
Number of screws central in the waist in both posteroanterior and lateral view	14 (34.9%)	34 (83.1%)	41
Number of screws central in the proximal pole in posteroanterior view	23 (56.1%)	37 (90.2%)	41
Number of screws central in the waist in posteroanterior view	34 (83.1%)	37 (90.2%)	41
Number of screws central in the distal pole in posteroanterior view	14 (34.9%)	31 (75.6%)	41
Number of screws ulnar in the proximal pole in posteroanterior view	8 (19.5%)	0 (0%)	41
Number of screws ulnar in the waist in posteroanterior view	3 (7.3%)	1 (2.4%)	41
Number of screws ulnar in the distal pole in posteroanterior view	1 (2.4%)	1 (2.4%)	41
Number of screws radial in the proximal pole in posteroanterior view	10 (24.3%)	4 (9.8%)	41
Number of screws radial in the waist in posteroanterior view	4 (9.8%)	3 (7.3%)	41
Number of screws radial in the distal pole in posteroanterior view	26 (63.4%)	9 (21.9%)	41
Number of screws central in the proximal pole in lateral view	30 (73.2%)	41 (100%)	41
Number of screws central in the waist in lateral view	17 (41.5%)	39 (95.1%)	41
Number of screws central in the distal pole in lateral view	9 (21.9%)	32 (78%)	41

screw positioning is not defined as a central third but rather a pole to pole trajectory. Similarly, Kupperman et al posit that screw insertion perpendicular to the fracture is of importance.¹⁵ This study is limited by the fact that only dorsal screw insertion was considered, proximal and distal pole as well as waist fractures were tested, and screw position was defined not as the location of the screw within the scaphoid, but rather as a starting point of insertion.

While it does appear that antegrade screw insertion leads to better positioning, the reasons for the superiority over the retrograde approach are unclear. First, the position of the trapezium directly overlying the point of volar screw insertion may yield difficulties in achieving ideal screw positioning. While the transtrapezial approach can mitigate this problem, this difficulty may be responsible for the differences we found. Second, the dorsal approach may be simpler and easier to learn, and something that is probably more commonly performed in clinical practice for other procedures such as ganglion cyst removals, wrist capsulectomies, and so forth. As such, surgeons may be more facile with the antegrade screw insertion.

There are several limitations to our study. First, since this was a retrospective study, we didn't consider the clinical outcomes of the patients and instead limited our study to radiographic outcomes which we felt were more reliably assessed retrospectively.

Next, actual radiographic union was not compared between groups. Nevertheless, we feel this study provides value given that screw placement within the scaphoid is of substantial importance in the treatment of these injuries. Next, it is possible that assessment of screw position may be better assessed with computerized tomographic (CT) scanning. However, there is no literature to suggest this to be the case, and certainly not worth the increased amount of

ionizing radiation patients would be subjected to with routine CT scan evaluation relative to plain radiographs. Finally, it is possible that X-ray evaluation by a musculoskeletal radiologist may have yielded different results. Nevertheless, given that radiologists are seldom involved in the clinical decision making, we feel that the surgeons' opinion of screw placement is of much more clinical relevance.

Based on our findings, the dorsal antegrade approach appears to allow the surgeon to achieve central screw placement along all three scaphoid regions during fixation of scaphoid waist fractures.

Note

The work was performed at The Rothman Institute of Philadelphia.

Conflict of Interest

None declared.

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