International Journal of Research and Review
[Indexed, Peer-Reviewed Journal]
Volume 12; Issue: 6; June 2025
Website: www.ijrrjournal.com
Review Paper *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Comparative Review of Volar and Dorsal Techniques in Scaphoid Waist Fracture Fixation

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DOI: https://doi.org/10.52403/ijrr.202506100

ABSTRACT

Background: Scaphoid fractures are the most common type of carpal fractures, with the majority (approximately 70–80%) occurring at the waist region, an area with limited blood supply and high risk of non-union. Two primary approaches for internal fixation are the volar (retrograde) and dorsal (antegrade) techniques, but the optimal choice remains controversial.
Objective: To evaluate the advantages and disadvantages of volar and dorsal approaches in the fixation of scaphoid waist fractures based on biomechanical, radiological, and clinical outcome data.
Methods: A literature review was conducted on clinical, biomechanical, and radiological studies comparing both approaches, focusing on screw positioning, fixation stability, bone healing, complications, and functional outcomes (DASH, PRWE, VAS).
Results: The dorsal approach allows for more central screw placement along the scaphoid axis, provides greater biomechanical stability, and avoids injury to volar ligaments. However, it poses risks to extensor tendons and the articular surface of the radius. Conversely, the volar approach is more suitable for distal fractures and deformity correction but carries a higher risk of injury to the STT joint. Functional outcomes and union rates between the two approaches show no clinically significant differences. Complications such as non-union and post-traumatic arthritis may occur, particularly with suboptimal screw positioning or delayed intervention.
Conclusion: The success of scaphoid waist fracture fixation is more dependent on achieving central screw placement than on the surgical approach itself. Technique selection should be tailored to the fracture pattern and surgeon expertise to optimize healing and minimize complications.

Keywords: Scaphoid fracture, volar approach, dorsal approach, central screw placement

INTRODUCTION

Scaphoid fractures are the most frequently encountered carpal fractures, with the majority (approximately 70–80%) involving the waist region of the scaphoid—a segment with poor vascularization and high risk of non-union if not properly treated (Buijze et al., 2014; Grewal et al., 2015). Operative management of scaphoid waist fractures has advanced significantly to enhance bone union, reduce complications, and restore wrist function. The two primary surgical approaches for internal fixation are the volar

(retrograde) and dorsal (antegrade) techniques.

The choice between these techniques remains debated. The volar approach is more familiar and widely used, particularly for distal fracture patterns. However, the dorsal approach provides improved access to the scaphoid's central axis, which is critical for achieving central screw placement and, thus, superior biomechanical stability (Chan & McAdams, 2004; Lucenti et al., 2020). Central axis screw placement has been shown to offer uniform compression and facilitate primary bone healing (Lucenti et al., 2020).

Nevertheless, clinical functional outcomes do not consistently demonstrate significant differences between the two approaches. Several studies suggest that the selection of technique largely depends on the fracture pattern and the surgeon's experience and preference (Acar et al., 2018; Kang et al., 2016). Therefore, it is essential to systematically review and compare the strengths and limitations of each technique to guide evidence-based decision-making in the treatment of scaphoid waist fractures.

Screw Placement: Volar versus Dorsal

In scaphoid waist fractures, studies have biomechanically demonstrated that screw placement along the central axis yields better outcomes than off-axis positioning (Figure 1). Central axis alignment allows maximal screw length and distributes compression evenly across the fracture line—similar to placing screws perpendicular to a transverse fracture pattern. Accordingly, current recommendations emphasize central screw placement along the longitudinal axis of the scaphoid (Lucenti et al., 2020).

Chan et al. reported that the dorsal approach more effectively facilitates central screw positioning, particularly in the distal pole, compared to the volar approach. No significant difference was found in central positioning at the proximal or waist regions (Chan & McAdams, 2004). Likewise, Jeon et al. (2009) showed that the dorsal approach provides better access to the scaphoid axis and allows screws to be aligned perpendicularly to the fracture line. In cadaveric studies, Chan et al. also observed that dorsal screw placement offers more consistent central alignment and superior mechanical stability. Additionally, the dorsal approach improves exposure of the proximal fragment and preserves volar radiocarpal ligaments, maintaining carpal kinematics and optimizing fracture healing. In contrast, the volar approach requires guide wire insertion near the scaphotrapezial joint, which often leads to screw deviation toward the volar surface of the distal scaphoid due to the trapezium's anatomy (Kang et al., 2016).

Figure 1. Classification of screw placement via dorsal and volar approaches. (A) PA view: screws between the two lines are considered central; outside line "a" is ulnar, outside line "b" is radial. (B) Lateral view: screws between the lines are central; outside line "a" is dorsal, outside line "b" is volar (Gürbüz et al., 2012).

Lucenti et al. (2020) found that patients who underwent dorsal fixation were more likely to achieve optimal screw placement compared to those treated via the volar approach. The difference was statistically significant. They also noted that a transtrapezial axis could be used to approximate central placement through the volar route, though this increases the risk of STT joint arthritis. However, the anatomical reasons why dorsal access improves screw centrality were not fully elaborated. In contrast, Acar et al. (2018) argued that the volar approach may offer superior mechanical performance if the screw is placed accurately along the central axis.

Functional Outcomes : Volar versus Dorsal

Lucenti et al. (2020) reported no significant differences in clinical outcomes between volar and dorsal approaches. Although the volar approach may not reliably achieve axis-central screw placement, it is often favored in distal and waist fractures and facilitates correction of humpback deformity without the need for wrist flexion as in dorsal access. However, central screw placement through the volar approach typically requires opening the scaphotrapezial joint, which may contribute to degenerative changes and osteoarthritis.

Kang et al. (2016), in a meta-analysis, found no significant differences between volar and dorsal approaches in terms of non-union rates, postoperative complications, pain, grip strength, range of motion (flexion, extension, radial deviation), or overall functional scores. However, volar fixation resulted in greater ulnar deviation postoperatively, with a marginally significant difference ($p = 0.05$). The 4° deviation difference was considered potentially clinically irrelevant and within the margin of error in routine clinical assessments (Acar et al., 2018; Kang et al., 2016; Lucenti et al., 2020).

Assessment of Functional Outcomes

Upper extremity function following scaphoid fracture can be assessed using standardized tools. One of the most widely used is the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, which contains 30 items evaluating pain and function. Scores range from 0 (no disability) to 100 (severe disability), with a population norm around 13 points, depending on age and gender. The shortened version, Quick DASH, includes 11 questions and is also validated for clinical use (Clementson, Björkman, & Thomsen, 2020).

Another tool is the Patient-Rated Wrist Evaluation (PRWE), which is wrist-specific and consists of 15 questions divided into three domains: pain, specific activities, and daily activities. Each is scored from 0 (best) to 100 (worst). Pain intensity is often assessed using the visual analogue scale (VAS), where patients rate their pain from 0 (no pain) to 10 (worst pain imaginable) (Bergh et al., 2014; Torabi et al., 2019).

Functional Outcomes in Scaphoid Fracture Management

In a study evaluating conservative treatment for non-displaced scaphoid waist fractures, Buijze et al. reported favorable outcomes at 10 weeks post-injury, with mean DASH scores of 5 and mean VAS of 1.6. In contrast, McQueen et al. found reduced grip strength and range of motion persisting up to 26 weeks. Dias et al. also noted that 20% of patients reported residual pain and numbness even two years post-injury. Meta-analyses comparing conservative and operative treatments for non-displaced scaphoid waist fractures showed better functional scores at three months and stronger grip at one year in the surgical group (“Journal of Surgery,” 2020; Morgan et al., 2021).

Long-term outcomes suggest that persistent symptoms after union are rare. A randomized trial with 7–12 years follow-up showed no significant difference between surgical and non-surgical groups, with DASH and PRWE scores ranging from 0–8

and minimal reports of pain or strength loss (Lee S., 2017).

Bone Healing

Due to its predominantly cartilaginous surface and minimal periosteum, the scaphoid heals through primary bone healing without visible callus formation. Radiographic signs such as sclerosis or trabecular bridging at the fracture line are unreliable for assessing union, particularly after internal fixation using compression screws, where bridging trabeculae may appear immediately postoperatively (Grewal et al., 2015; Oron et al., 2013).

CT imaging along the longitudinal scaphoid axis is more accurate for assessing union. Singh et al. proposed a method grading trabecular contact as 0–24%, 25–49%, 50–74%, and 75–99% across five sequential sagittal and coronal slices. If >50% contact is achieved, functional union can be assumed (Saltzherr et al., 2013; Schmitt & Rosenthal, 2016).

Regardless of approach, anatomical reduction and rigid fixation are essential for scaphoid healing, as 80% of its surface is articular cartilage, precluding periosteal callus formation. Rigid fixation allows healing through the Haversian system (Acar et al., 2018). Volar approaches risk compromising distal blood supply if the guide wire is misdirected, potentially impairing healing and increasing non-union risk (Chan & McAdams, 2004). Moreover, Kang et al. emphasized the need for further studies to determine whether small differences in ulnar deviation between techniques significantly affect healing outcomes (Kang et al., 2016).

Biomechanical Perspective: Volar vs. Dorsal Approach

In their finite element analysis study, Acar et al. (2018) used 3D stress modeling on isotropic materials with static linear analysis to evaluate scaphoid waist fractures. They reported minimal biomechanical differences between the volar and dorsal approaches. However, notable distinctions were found under specific wrist positions. In neutral and full flexion, fracture gap displacement was lower with the volar approach. Conversely, in full extension, the dorsal approach yielded less displacement. Additionally, across various wrist positions, relative rotation of fracture fragments around the scaphoid's longitudinal axis was generally lower with the volar approach. In full extension, however, rotational differences were negligible between the two techniques.

The study concluded that volar fixation, when followed by immobilization in a neutral position, optimizes conditions for minimal displacement, reduced rotational forces, and more favorable stress distribution on the bone and screw. For dorsal fixation, immobilization in either extension or neutral may be suitable, as displacement is minimized in extension and stress distribution is best in neutral. Nonetheless, the clinical significance of these biomechanical differences is uncertain, as the measurements were in micrometer to nanometer ranges (Acar et al., 2018).

Other studies recommend continued wrist protection for at least four months postoperatively before initiating full weight-bearing activities (Kang et al., 2016; Lucenti et al., 2020).

Time to Union

Accurately estimating fracture union requires clear imaging criteria, consistent evaluation protocols, and appropriate time intervals. Fracture healing is a dynamic process involving matrix remodeling and mineralization. "Union at 10 weeks," for instance, indicates that union was confirmed at the 10-week assessment, not that healing occurred precisely over 10 weeks (Grewal et al., 2015; Oron et al., 2013; Clementson et al., 2015).

In a CT-based study excluding dislocated and proximal scaphoid fractures, Buijze et al. (2014) reported an 88% union rate by week 10. In another study using conventional radiography, Adolfsson found similar rates—85% in conservatively treated

cases and 87% in surgical patients (Grewal et al., 2015). Grewal et al. also evaluated actual healing durations using CT: waist fractures united by day 65, distal by day 53, and proximal by day 113. Comminuted and translational fractures required longer healing times. In a study by Geoghegan et al., early mobilization at week 4 showed consistent union in non-displaced waist fractures (Grewal et al., 2015; Oron et al., 2013).

Surgical Complications in Scaphoid Waist Fractures

While dorsal fixation allows more precise central axis screw placement, it is associated with complications in up to 29% of cases. These include screw prominence causing damage to the articular surface of the radius and injury to dorsal structures such as extensor tendons and the posterior interosseous nerve (Kang et al., 2016). The volar approach carries its own risks, notably damage to the STT joint cartilage, potentially increasing the risk of osteoarthritis (Oron et al., 2013).

Non-union is typically defined as failure of healing between 12–26 weeks post-injury. Risk factors include displacement >1 mm, angular deformity, and delayed treatment (>4 weeks). Proximal fractures have the highest non-union rate (~31%), while distal fractures almost always unite (Oron et al., 2013).

Post-traumatic arthritis occurs in 10–39% of cases and is more frequent following surgical fixation than conservative management (Grewal et al., 2015). CT imaging is more sensitive than radiography in detecting degenerative changes (Clementson, Björkman, & Thomsen, 2020). Nearly all non-union cases show radiologic signs of arthritis on long-term follow-up, although some remain asymptomatic for years (Grewal et al., 2015; Oron et al., 2013).

CONCLUSION

Both volar and dorsal approaches in scaphoid waist fracture fixation have distinct advantages and limitations, and their selection should be individualized based on fracture morphology and surgical expertise. The dorsal approach generally facilitates more accurate central axis screw placement, enhancing biomechanical stability and promoting primary bone healing. However, it is associated with potential complications involving dorsal structures. The volar approach provides easier access for distal fractures and deformity correction but may compromise the STT joint or healing if screw placement is suboptimal.

Clinically, both approaches yield comparable short- and long-term outcomes, particularly in non-displaced fractures. Biomechanical and clinical evidence consistently highlight that accurate central screw placement is more critical to healing than the choice of surgical approach. Thus, surgical decision-making should prioritize anatomical alignment, minimize biomechanical compromise, and consider long-term function and complication risks to optimize outcomes and reduce the likelihood of non-union and post-traumatic arthritis.

Declaration by Authors

Ethical Approval: Not Applicable
Acknowledgement: None
Source of Funding: None
Conflict of Interest: No conflicts of interest declared.

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How to cite this article: Made Bramantya Karna, Anak Agung Gde Yuda Asmara, Stedi Adnyana Christian, Dary Gunawan. Comparative review of volar and dorsal techniques in scaphoid waist fracture fixation. *International Journal of Research and Review*. 2025; 12(6): 896-901. DOI: *https://doi.org/10.52403/ijrr.202506100*

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