DOI: https://doi.org/10.53350/pjmhs2115123839

**ORIGINAL ARTICLE**

# Vascularized Bone Graft Based on First and Second Inter-Compartmental Supraretinacular Artery in the Treatment of Scaphoid Nonunion: Our Experience

NAUMAN HUSSAIN RAJPUT[1], ADEEL AHMED SIDDIQUI[2], ASIF JATOI[3], BADARUDDIN SAHITO[4], IRFAN MUHAMMAD RAJPUT[5], RAHAT ZAHOOR MOTON[6]

*[1]Assistant Professor Orthopedics, Dow University of Health Sciences, Karachi*
*[2]Associate Professor Orthopedics, Dow University of Health Sciences, Karachi*
*[3]Consultant Orthopedic Surgeon, Dr Ruth KM Pfau Civil Hospital, Karachi*
*[4]Associate Professor Orthopedics, Dow University of Health Sciences, Karachi*
*[5]Assistant Professor Orthopedics, Dow University of Health Sciences, Karachi*
*[6]Consultant Orthopedics Surgeon, Dr. KM Ruth Phau Civil Hospital, Karachi*
*Corresponding author: Nauman Hussain Rajput, Email: dr_nhrajput@hotmail.com, Cell: 03453050009*

## ABSTRACT

**Objective:** We aimed to evaluate the results of using a First and Second Inter-Compartmental Supraretinacular Artery (1,2-ICSRA) based vascularized bone graft (VBG) when performing Herbert screw fixation in scaphoid nonunion.

**Methodology:** This is a retrospective study from January 2017 to August 2020 with a total of 16 patients. All those aged<50 years, fracture <2 yrs old, no previous surgical intervention on the fracture, and stage 1 or 2 degenerative changes at the fracture site were included. Patients with avascular necrosis of the scaphoid were excluded. All patients were radiologically examined. Herbert screw fixation was done under general anesthesia and a wedge-shaped VBG from the radius was placed at the nonunion site.

**Results:** There were 12 males and 4 females with a mean age of 30.25±8.88 years. Chronic wrist pain at rest was completely relieved in all patients while the pain with motion was markedly diminished in 10 and eliminated in two. The average range of motion, pinch, and grip strength of the wrist improved after surgery. Power assessment showed that the mean power before surgery was significantly raised from 67.50±5.83 to 95.06±4.45 Kgs (p=0.001). The mean intensity of pain before surgery i.e. 5.54±1.36 reduced to 2.25±0.78 (p<0.001).

**Conclusion:** We found excellent results when used Herbert screws along with a 1,2-ICSRA based VBG in patients with scaphoid nonunion, where the union was achieved in all and significant improvement was seen when power and pain were assessed.

## INTRODUCTION

The Scaphoid is involved in 60% of carpal fractures. Scaphoid fractures lead to nonunion with an estimated prevalence of 5-30%.[1]More than 70% of the scaphoid is covered by cartilage and there is a lack of periosteal covering with limited vascularity. This is the reason why the healing and callus formation is delayed, leading to nonunion.[2,3] Another reason for the high rates of failure of union is the delicate blood supply, where 80% comes from the dorsal carpal branch of the radial artery that enters the non-articular dorsal ridge through retrograde blood flow, while 20 % comes from the superficial palmar arch, which primarily supplies the distal pole. Due to this tenuous proximal pole blood supply, avascular necrosis (AVN) (especially involving the proximal one-fifth of the scaphoid) occurs, ultimately leading to delayed union or nonunion.[4,5] AVN is believed to affect 3% of all scaphoid fractures.[6]

Approximately 70% to 80% of scaphoid fractures occur at the waist, 10% to 20% at the proximal pole, and the remainder at the distal pole.[7]Conservative treatment with cast immobilization has remained the standard mode of management, although about 20% of these fractures fail to heal.[8] Since the advances in percutaneous techniques and the advent of headless screws, surgical fixation of scaphoid fractures has become increasingly popular, with significant improvement in outcomes.[9]Bone grafts have been used for additional stability, which according to the indications can be an arthroscopic cancellous bone graft, a non-vascularized bone graft, or a vascularized (VBG) one.[10] There is no consensus on the usage of graft in scaphoid nonunion with a lot of authors concluding with good to excellent results after using the different VBGs like the First and Second Inter-Compartmental Supraretinacular Artery (1,2-ICSRA) based grafts of the distal radius, volar carpal artery grafts, or the Pronator Quadratus pedicled vascularized graft.[11–14] They prefer VBGs over non-vascularized grafts as there is a better healing potential.

In adults, Scaphoid nonunion has been treated successfully with VBGs from the distal radius, resulting in satisfactory long-term outcomes.[14] We aimed to evaluate the results of using 1,2-ICSRA based VBGs from the distal radius along with Herbert screw fixation in the management of scaphoid nonunions.

## MATERIALS AND METHODS

We conducted a retrospective review of clinical data at the Department of Orthopedics Surgery, Dr. Ruth K.M. Pfau Civil Hospital, Karachi, Pakistan, from January 2017 to August 2020 after ethical approval from the department with a waiver of the requirement of informed consent, being a retrospective study.

A total of 16 patients were found having scaphoid fractures with nonunion i.e. failed bony healing >5 months of injury. Inclusion criteria were age less than 50 years, scaphoid fracture less than two years old, no previous surgical intervention on the fracture, and stage 1 or stage 2

degenerative changes at the fracture site (Watson and Ballet).[9] Fractures more than 2-year old or stage 3 or 4 arthritic changes were excluded from the study as results may be poor even after the scaphoid union. Patients with AVN of the scaphoid were also excluded. All patients had X-rays of the wrist joint to check for the nonunion and a Magnetic resonance imaging (MRI) scan was performed to confirm nonunion and look for the vascularity of the proximal scaphoid.

General anesthesia was used in all patients. The patient was placed supine under tourniquet control and all fractures were approached through a curvilinear incision centered over the dorsolateral wrist. The superficial branch of the radial nerve was protected and 1st-2nd Inter compartmental retinacular artery was identified. Sharp dissection of soft tissue was performed in the line of the vessel and a fracture nonunion site was identified. The margins were refreshed and multiple drill holes were made in the core of either side of the fracture. The nonunion site feasibility of vascularized bone graft was established and bone graft was raised from the distal radius along with nutrient vessels. A wedge-shaped bone was placed at the nonunion site and care was taken to correct humpback deformity. The guidewire was then passed to establish position, checked under the image intensifier. A 2.4 mm Herbert screw was passed over the guidewire to secure fixation and a thumb Spica cast was applied until radiographic evidence of union was observed. The patient was sent home on the second day of surgery. After the removal of the Spica, physiotherapy was advised along with the wrist splint for four weeks. Follow-up was done every four weeks.


Figure-1: (A) Pre-operative radiograph showing scaphoid fracture nonunion. (B) Curvilinear incision on the dorsolateral aspect of the wrist. (C) per-operative presentation after Herbert screw fixation over a guidewire, (D) Per-operative photographs showing 1st-2nd inter-compartmental supraretinacular artery

Clinical assessment included pain on tapping the joint, power (grip-strength), dorsiflexion (DF), and palmar flexion (PF). Pain evaluation was done by using the visual analog scale (VAS) score of 10 points with 0 being the lowest intensity and 10 being the highest. Jamar Dynamometer was used to measure the grip strength in kilograms (Kgs). Mean with standard deviations were used to present the age, duration of injury, and the clinical assessment values. Wilcoxon sign rank test was used to compare the preoperative and postoperative values with p-value<0.05 considered as statistically significant. Some representations of the cases associated with this study are given in Figures 1-4.


Figure 2: Postoperative radiographs after vascularized bone grafting and fixation with Herbert screw

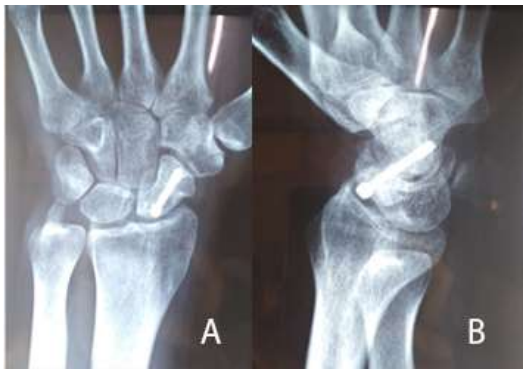


Figure 3: Radiographs after six months of vascularized bone grafting and Herbert screw fixation.

Figure 4: Clinical photographs showing the range of motion after eight months follow-up of vascularized bone graft and Herbert screw fixation

## RESULTS

In all 16 patients, the indications for vascularized distal radius bone graft was long-standing nonunion of the scaphoid associated with chronic wrist pain. There were 12 males and 4 females with a mean age of 30.25±8.88 years. Surgery was done from 6 months to 18 months after injury with a mean duration of 9.88±2.98 months.

All patients exhibited decreased power grip and range of motion compared with the contralateral side. Fractures had been initially missed in eight patients. All patients were treated by a VBG based on the 1,2-ICSRAwhich lead to the union in2-3 months. Chronic wrist pain at rest was completely relieved in all patients while the pain with motion was markedly diminished in 10 patients and eliminated in two. The average range of motion (degrees), pinch, and grip strength (Kgs) of the wrist improved after surgery with no significant complications encountered in any patient.

Power before and after surgery when compared showed that the mean power before surgery was significantly raised from 67.50±5.83 to 95.06±4.45 Kgs (p=0.001). The mean intensity of pain before surgery was 5.54 ± 1.36 and it significantly decreased to 2.25 ± 0.78 (p<0.001)

Table 1: General Statistics (n=16)

| | Power-BS | DF-BS | PF-BS | Pain-BS | Power-AS | DF-AS | PF-AS | Pain-AS |
|---|---|---|---|---|---|---|---|---|
| Mean±SD | 67.50±5.83 | 33.44±9.43 | 38.44±9.43 | 5.44±1.36 | 95.06±4.45 | 56.56±7.46 | 64.69±7.84 | 2.25±.77 |

Abbreviations: SD, standard deviation; DF, dorsiflexion; PF, palmar flexion; BS, before surgery; AS, after surgery

## DISCUSSION

Fractures of the scaphoid are quite common and very easily missed due to more focus on the distal radius fractures[15]. Missed diagnosis and delayed presentation may lead to scaphoid nonunion that creates serious functional impairment of wrist function and other biochemical changes.[16] The goals of treatment for scaphoid nonunion include union, correction of deformity, relief of symptoms, and limitation of arthrosis.[17] In our study, we treated all patients of scaphoid nonunion with herbert screws ± K-wires supported by a VBG taken from the distal radius based on the 1,2-ICSRA, achieving union in all in around three months.

Malizos et al. treated 14 patients of scaphoid nonunion with a VBG and closing-wedge osteotomy of the distal radial metaphysis in three years. The average delay in surgery was 4.9 years (range, 2-13 years). Union was achieved in all patients within nine weeks and the pain was reduced from 6.1 to 0.8 on the VAS. There was no change in range of motion and a minor improvement in grip strength with corrected instability of dorsal intercalated segment and preservation of carpal height.[18] In six years, Goel et al treated seven cases of the scaphoid non-union with Pronator Quadratus vascularized bone graft. The outcome was assessed in terms of fracture union, range of motion of the wrist, strength, and pain relief, where six out of seven cases showed good bone union radiologically with satisfactory clinical outcome [19]. Jerome et al analyzed the outcome of 1,2-ICSRA based VBG in scaphoid nonunion with AVN concluding with a good radiological union in all and revascularization within 18 weeks. There was a significant improvement in grip strength and VAS score.[12] Zaidemberg et al., Lim et al, and many other authors also gave good union results by using the 1,2-ICSRA based VBG and Kirschner wire fixation.[13,20,21]

In the current evaluation, wrist pain at rest was completely relieved in all patients while the pain with motion was markedly diminished in 10 and eliminated in two. The average range of motion, pinch, and grip strength improved after surgery with no significant complications. Power assessment showed that the mean power before surgery significantly raised from 67.50±5.83 to 95.06±4.45 Kgs (p=0.001) while the mean intensity of pain before surgery was 5.54 ± 1.36 which significantly decreased to 2.25 ± 0.78 (p<0.001).

This study was limited by the retrospective study design, small sample size, shorter follow-up, and lack of a comparison group. Long-term complications' like the development of osteoarthritis and implant failure could not be assessed because of short follow-up.

## CONCLUSION

To conclude, we found excellent results when used Herbert screws along with a 1,2-ICSRA based VBG in patients with scaphoid nonunion, where the union was achieved in all and significant improvement was seen when power and pain intensity was assessed.

## REFERENCES


1. Morsy M, Sabbagh MD, van Alphen NA, Laungani AT, Kadar A, Moran SL. The Vascular Anatomy of the Scaphoid: New Discoveries Using Micro–Computed Tomography Imaging. J Hand Surg Am. 2019;44(11):928–38.
2. Berger RA. The anatomy of the scaphoid. Hand Clin. 2001;17(4):525—532.
3. Guss MS, Mitgang JT, Sapienza A. Scaphoid Healing Required for Unrestricted Activity: A Biomechanical Cadaver Model. J Hand Surg Am. 2018;43(2):134–8.
4. Winston MJ, Weiland AJ. Scaphoid fractures in the athlete. Curr Rev Musculoskelet Med. 2017;10(1):38–44.
5. Kawamura K, Chung KC. Treatment of scaphoid fractures and nonunions. J Hand Surg Am. 2008;33(6):988–97.
6. Severo AL, Lemos MB, Lech OLC, Barreto Filho D, Strack DP, Candido LK. Bone graft in the treatment of nonunion of the scaphoid with necrosis of the proximal pole: a literature review. Rev Bras Ortop. 2017;52(6):638–43.
7. Kozin SH. Incidence, mechanism, and natural history of scaphoid fractures. Hand Clin. 2001;17(4):515–24.
8. Schädel-Höpfner M, Marent-Huber M, Gazyakan E, Tanzer K, Werber KD, Siebert HR. Acute non-displaced fractures of the scaphoid: earlier return to activities after operative treatment. A controlled multicenter cohort study. Arch Orthop Trauma Surg. 2010;130(9):1117–27.
9. Alnaeem H, Aldekhayel S, Kanevsky J, Neel OF. A Systematic Review and Meta-Analysis Examining the Differences Between Nonsurgical Management and Percutaneous Fixation of Minimally and Nondisplaced Scaphoid Fractures. J Hand Surg Am. 2016;41(12):1135-1144.e1.

10. Uesato R, Toh S, Hayashi Y, Maniwa K, Ishibashi Y. Non-vascularized bone grafting in scaphoid nonunion: principles and type of fixation. Eur J Orthop Surg Traumatol. 2017;27(1):11–21.
11. Siddiqui A, M A, Kaimkhani G, Adeel M, Jamil M, U Y. Use of pronator quadratus pedicle vascularized bone graft with headless compression screw in nonunion scaphoid fractures. Rawal Med J. 2021;46(1):102–5.
12. Jerome TJ, Prabu R, Terrence TK, Bhalaji S, Shanmugasundaram B. 1,2 Intercompartmental Supraretinacular Artery-Based Vascularized Graft for Scaphoid Nonunion With Avascular Necrosis. Cureus. 2020;12(11):e11290.
13. Rancy SK, Schmidle G, Wolfe SW. Does Anyone Need a Vascularized Graft? Hand Clin. 2019;35(3):323–44.
14. Karaismailoglu B, Fatih Guven M, Erenler M, Botanlioglu H. The use of pedicled vascularized bone grafts in the treatment of scaphoid nonunion: clinical results, graft options and indications. EFORT Open Rev. 2020;5(1):1–8.
15. Rajagopalan B, Squire D, Samuels L. Results of Herbert-screw fixation with bone-grafting for the treatment of nonunion of the scaphoid. JBJS. 1999;81(1).
16. Koutalos AA, Papatheodorou L, Kontogeorgakos V, Varitimidis SE, Malizos KN, Dailiana ZH. Scaphoid nonunions in adolescents: Treatment with vascularized bone grafts. Injury. 2019;50:S50–3.
17. Pao VS, Chang J. Scaphoid Nonunion: Diagnosis and Treatment. Plast Reconstr Surg. 2003;112(6).
18. Malizos KN, Koutalos A, Papatheodorou L, Varitimidis S, Kontogeorgakos V, Dailiana Z. Vascularized Bone Grafting and Distal Radius Osteotomy for Scaphoid Nonunion Advanced Collapse. J Hand Surg Am. 2014;39(5):872–9.
19. Goel V, Bhardwaj N, Dhariwal J, Jaiswal S, MS D. Vascularized bone graft in Herbert type D scaphoid fractures. Int J Orthop. 2019;5(2):241–3.
20. Zaidemberg C, Siebert JW, Angrigiani C. A new vascularized bone graft for scaphoid nonunion. J Hand Surg Am. 1991;16(3):474–8.
21. Lim TK, Kim HK, Koh KH, Lee H Il, Woo SJ, Park MJ. Treatment of avascular proximal pole scaphoid nonunions with vascularized distal radius bone grafting. J Hand Surg Am. 2013;38(10):1906-12.e1.