

Radiographic Outcome of Non-Vascularized Bone Graft in Scaphoid Nonunion

Abstract

Introduction: Bone grafting is the main treatment of scaphoid nonunion. In this study, we intend to evaluate the radiographic results in patients with non-vascularized bone graft in scaphoid nonunion with or without AVN.

Materials & Methods: In a cross-sectional study, patients with scaphoid nonunion were chosen in a census sampling method and were followed up and immobilized with plaster for four weeks. Then a radiography was taken and the patients were followed till the union were seen in radiography. Data were analyzed by SPSS 24.

Results & Discussion: In this study, 43 patients were admitted. The mean total age of patients was 29.91 ± 8.58 years. 13 patients had complications, 6 reported limited mobility and 7 reported pain. Fifteen patients (34.9) had avascular necrosis. All patients were able to perform daily activities with hands, and none complained of inactivity. The mean duration of first incision to the end was 49.16 ± 5.98 minutes. The mean time elapsed from scaphoid fracture to surgery was 36.59 ± 47.42 weeks. The mean time from surgery to complete recovery was 145.79 ± 73.85 weeks. The mean time from surgery to the first evidence of healing was 36.59 ± 47.42 days which resulted in scaphoid union in all patients.

Conclusion: This study demonstrated that non-vascularized bone grafting resulted in radiographic union of the scaphoid in all patients, including those with avascular necrosis. All participants regained the ability to perform daily hand activities without functional complaints. Complications occurred in 30.2% of cases, mainly presenting as mild pain and minor limitations in hand motion. These findings suggest that this technique is a safe and effective option for treating scaphoid non-union.

Keywords: Scaphoid bone, Osteonecrosis, Bone transplantation.

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Introduction

The scaphoid is one of the carpal bones, located on the radial (thumb) side of the wrist, forming part of the radial border of the carpal tunnel^(1,2). Scaphoid fractures are the most common fractures among carpal bones and predominantly occur in young, active individuals. In the upper extremity, scaphoid fractures are the second most common after distal radius fractures, but unlike distal radius fractures, they are more frequent in young men in their second and third decades of life^(3,4). The scaphoid is almost completely covered by cartilage, which limits its periosteal healing potential, resulting in a high incidence of delayed union and nonunion^(3,4). Untreated scaphoid nonunion may lead to degenerative changes in the wrist joint. Such degenerative changes are more pronounced in proximal nonunions compared to distal ones^(3,4). Surgical intervention is indicated for scaphoid nonunion or fractures that have failed conservative treatment. A key principle in managing the nonunion of scaphoid is resection of fibrous tissue and nonviable bone at the fracture site. This procedure creates a bone defect that must be filled with a bone graft⁽⁵⁾. Vascularized bone graft is indicated in nonunions of the proximal scaphoid, especially in cases where the proximal fragment is necrotic or when previous nonvascularized bone graft has been unsuccessful⁽⁶⁾. An alternative is using of nonvascularized bone grafts, that constitute a traditional method for achieving scaphoid union^(7,8). Several studies have reported favorable outcomes with nonvascularized grafts, highlighting advantages such as shorter anesthesia duration compared to vascularized grafts, simpler surgical technique, and no requirement for specialized expertise^(7,8).

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Avascular necrosis (AVN) is a common complication in orthopedic trauma patients. Studies have shown that AVN occurs in 13–50% of scaphoid fractures in the proximal fifth of the bone. AVN can result from various causes, including alcohol consumption, glucocorticoid use, hematologic disorders, anemia, trauma, and fractures^(10,11). This complication may lead to nonunion or prolonged healing time, joint destruction, and reduced treatment success^(12,13).

Materials & Methods

This cross-sectional, retrospective study included patients presenting with wrist pain to the orthopedic departments of educational and treatment centers affiliated with Mazandaran University of Medical Sciences, who were diagnosed with scaphoid nonunion. Patients were excluded if their medical records were incomplete, radiographs were unavailable, or if they had undergone a surgical method different from that under investigation. The study period spanned from 2015 to 2019.

A census sampling method was used, meaning that all patients meeting the inclusion criteria were enrolled; therefore, no sample size calculation was necessary. Informed consent was assigned from the participants. The time of operation was recorded from the initial incision to complete skin closure.

All surgeries were performed by a hand surgery specialist. Corticocancellous bone grafts were harvested from the iliac crest. The Mattheissen technique was used for grafting, and fixation was achieved using either Herbert screws or 1.0 mm K-wires. Postoperatively, a sugar-tong splint was applied for two weeks and then was converted to a thumb spica cast. Radiographs were obtained at six weeks postoperatively to assess scaphoid union by both the surgeon and a radiologist. Thereafter, monthly radiographs were taken until radiographic union was confirmed. Patients remained immobilized in a cast throughout the follow-up period until complete union was achieved, and healing and complications were closely monitored. Data entry and analysis were performed using SPSS version 24. Continuous and categorical variables were summarized using mean, standard deviation, median, interquartile range, and percentages. The Shapiro–Wilk test was used to assess normality. Comparisons of variables were performed using the chi-square test or Fisher’s exact test, while continuous variables were compared between groups using independent

t-tests or the nonparametric Mann–Whitney test, as appropriate

Results

A total of 43 patients were enrolled in this study. The mean age of participants was 29.91 ± 8.58 years (range: 14–53 years). Twenty-five patients (58.1%) had involvement of the right scaphoid, while 18 patients had the left hand affected. All patients presented with scaphoid nonunion, and all bone grafts used were nonvascularized. Demographic characteristics of the study population are shown in Table 1. The majority of fractures occurred in the proximal region (40 patients), and all patients presented with wrist pain. All patients underwent MRI evaluation, with the most frequent finding being scaphoid nonunion in 43 patients. Fifteen patients (34.9%) also exhibited avascular necrosis (AVN) (Table 2).

Table 1: Mean Age of All Patients

Variable	Mean	Standard Deviation	Maximum	Minimum
Age (years)	29.91	8.58	53	14

Table 2: Frequency of Affected Side

Affected Side	Frequency	Percentage
Right	25	58.1
Left	18	41.9
Total	43	100.0

Fixation was achieved using 1.0 mm K-wires in 35 patients and Herbert screws in the remaining 8 patients. Complete scaphoid union was achieved in all 43 patients following nonvascularized bone grafting. Thirty patients reported no postoperative complications, while 13 patients experienced complications: six reported limited range of motion and seven reported pain. All patients were able to perform daily activities with the affected hand, and none reported functional limitations. (Table 3). The mean operative time, from the starting incision to completion of surgery, was 49.16 ± 5.98 minutes. The mean duration from scaphoid fracture to surgical intervention was 36.59 ± 47.42 weeks. The mean follow-up period from surgery to complete recovery was 145.79 ± 73.85 weeks. The mean time from surgery to the first radiographic evidence of union was 36.59 ± 47.42 days (Table 4).

Table 3: Clinical Characteristics of Patients

Variable	Frequency	Percentage
Postoperative Complication	Yes	13
	No	30
Type of Postoperative Complication	Limited Motion	6
	Pain	7
Type of Fixation	1.0 mm K-wire	35
	Herbert Screw	8
Fracture Location	Proximal	40
	Waist	3
Presence of Avascular Necrosis	Yes	15
	No	28
MRI Findings	Nonunion	43
	Avascular Necrosis	15

Table 4: Duration of Surgery, Time from Fracture to Surgery, Time to First Radiographic Evidence of Union, and Time to Complete Recovery

Variable	Mean	Standard Deviation	Minimum	Maximum
Duration of Surgery (minutes)	49.16	5.98	42.00	65.00
Time from Fracture to Surgery (weeks)	36.59	47.42	6.00	206.83
Time from Surgery to First Radiographic Evidence of Union (days)	36.59	47.42	6.00	206.83
Time from Surgery to Complete Recovery (weeks)	145.79	73.85	59.00	330.00

Discussion

Nonvascularized bone grafting combined with rigid internal fixation has been shown to successfully improve healing in scaphoid nonunion fractures, even in cases with vascular compromise, as demonstrated by preoperative, intraoperative, and histopathological evaluations⁽¹⁴⁾.

The present study was designed to assess radiographic outcomes following surgical treatment with nonvascularized bone grafting in scaphoid nonunion, both with and without avascular necrosis (AVN).

In this study, operative time, duration until union, and union rates were evaluated. Reported union rates for nonvascularized grafting in the literature range from 60% to 95%, whereas vascularized grafts demonstrate higher rates, ranging from 80% to 100%^(15,16).

Meta-analyses have shown that union rates in vascularized graft groups are 1.13 times higher than those in nonvascularized graft groups ($P = 0.002$). Additionally, vascularized grafts achieve bony union significantly earlier, by an average of 1.73 weeks ($P < 0.01$). No significant differences were observed

between the groups in functional outcomes, including active range of motion and grip strength, and the rates of reoperation were similar between groups ($P = 0.65$)⁽¹⁷⁾.

In the study by Soleimanpour et al., 20 patients with a mean age of 25.62 years (range, 17–40) were evaluated, which is a smaller cohort than in the present study. Seventeen fractures involved the waist, and three the proximal pole. In contrast, in our study, the proximal pole were the majority of the fractures site. Pain and decreased grip strength were reported in 11 and 9 patients, respectively.

The range of motion after surgery did not significantly change. The number of cases reporting pain at final follow-up decreased significantly (from 100% to 25%). Reported complications included pin fracture (2 cases), change in occupation (2 cases), nonunion (1 case), delayed union (1 case), and pin site irritation (1 case)⁽¹⁸⁾.

In our study, the most frequent postoperative complications were pain in five patients and limited wrist motion in five patients. Schneider and colleagues treated patients with scaphoid nonunion using nonvascularized grafts.

In their study, 35 nonunion cases were evaluated. MRI results showed ischemia without necrosis in the

proximal region in 9 of 23 patients. Trabecular necrosis was observed in 14 of 32 patients, and tissue necrosis in 4 of 33 patients. Ultimately, 30 of 33 patients achieved solid bone union with this method⁽¹⁴⁾.

In the study by Severo et al., vascularized grafts demonstrated union rates ranging from 27% to 100%, whereas patients with AVN had a minimum union rate of 12.5%. Nonvascularized grafts showed union rates between 52% and 100%, which remained consistent even in the presence of necrosis⁽¹⁹⁾.

In the present study, MRI findings revealed that most patients exhibited nonunion, and 15 of 43 patients had both AVN and nonunion simultaneously. Nevertheless, we achieved 100% union with nonvascularized grafting, even among patients with AVN.

The recommended immobilization period for nonvascularized grafts ranges from 4 to 6 months, whereas for vascularized muscle-based grafts with pin fixation, union and immobilization periods range from 7 to 16 weeks⁽¹⁰⁾. In our study, the mean time to radiographic union from surgery to complete recovery was 5 months.

This study has few limitations. As a cross-sectional study, causal relationships cannot be established. Its descriptive nature limited further analysis and interpretation of data. Additionally, the sample size was relatively small.

Conclusion

The present study demonstrates that nonvascularized bone grafting resulted in radiographic union of the scaphoid in all patients, including those with AVN, indicating that this method can be effective in promoting scaphoid healing. During the follow-up period, no signs of osteoarthritis were observed. All patients were able to perform daily activities with the affected hand, and none reported functional limitations. Postoperative complications occurred in 30.2% of patients, manifesting as mild pain or limited wrist motion.

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