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FUNCTIONAL RESULTS OF TREATMENT OF NONUNION SCAPHOID FRACTURES (COMPARISON BETWEEN VASCULARIZED AND NONVASCULARIZED BONE GRAFTING)

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ABSTRACT

Background: Scaphoid fractures, accounting for a significant proportion of carpal fractures, carry a notable risk of non-union (approximately 10%) and avascular necrosis (AVN) of the proximal pole (around 3%), a complication linked to the bone's unique vascular supply. Both vascularized and non-vascularized bone grafting are used to address scaphoid non-union. **Objective:** Optimizing treatment for scaphoid non-union by comparing vascularized and non-vascularized bone grafting techniques to identify the optimal method for rapid union, return to function, and minimal complications. **Materials and Methods:** A prospective Comparative study at Tishreen University Hospital between 2023 and 2024, enrolled young patients presenting with scaphoid non-union who were surgically treated with either vascularized or non-vascularized bone grafting. The cohort was divided into two groups based on the grafting technique used: vascularized bone grafting versus non-vascularized bone grafting. **Results:** This study investigated 20 patients with scaphoid non-union (average age 25.50 years, 80% male) with 90% of injuries occurring on the dominant, right side. Avascular necrosis was present in 20% of patients. All vascularized bone grafts were performed using the Matti-Russe technique, while non-vascularized grafts utilized the Kawai & Yamamoto (60%) and Zeidemberg (40%) procedures. While no significant associations were found between graft type and patient sex, affected side, dominance, or surgery timing, the vascularized graft group was older and had a higher rate of avascular necrosis. Both groups demonstrated improved Mayo and Quick DASH index scores post-surgery, with the vascularized group exhibiting greater improvement. Notably, vascularized bone grafts showed a significantly faster union rate (12.4±0.8 months shorter) compared to non-vascularized bone grafts (14.46±0.6 months, p=0.0001). This faster union is likely due to the improved blood supply provided by vascularized grafts, which is critical for accelerating bone union and enhancing overall recovery. **Conclusion:** For non-unions not complicated by avascular necrosis, a non-vascularized bone graft is recommended as it is technically simpler and does not require special expertise. However, for scaphoid non-union complicated by avascular necrosis, a vascularized bone graft is the optimal treatment.

KEYWORDS: Scaphoid nonunion, Vascularized bone graft, Nonvascularized bone graft, Functional outcome, Treatment.

INTRODUCTION

The fracture of the scaphoid bone account for 50%-80% of all carpal bone fractures in young and active individuals. A common cause is a fall onto an outstretched hand with the wrist bent back. The fracture can sever the blood flow to the bone, causing the fracture to heal slowly (delayed union) or not at all (non-union).[1]

Nonunion of the fracture occurs in approximately 5%-10% of fractures of undisplaced scaphoid. The incidence increases to up to 90% for displaced proximal pole fractures.[2]

Posttraumatic avascular necrosis (AVN) of the scaphoid is a common complication probably due to the precarious blood supply.[3] The rate of incidence is about 13% to 40% and almost all are seen in the proximal fragment.[4]

The management of scaphoid non-union has been controversial. Internal fixation with bone grafting is the current recommended treatment.[5,6]

Vascularized bone graft (VBG) involves transplanting bone with its own blood supply to the fracture site; a VBG can be harvested from the distal radius.[7] In contrast, a non-vascularized bone graft (NVBG) involves

transplanting bone without a direct blood supply to the fracture site; the iliac crest can be used as a source for NVBG. NVBG is generally less technically demanding than VBG.[8]

Importance and objectives of the research

The importance of this research stems from the prevalence of these injuries in young people during their peak professional and athletic activity. The high incidence of complications following non-union, resulting from delayed diagnosis and improper treatment, affects range of motion, grip strength, and the patient's daily activities. Therefore, this research aims to improve the outcomes of treating scaphoid non-union fractures by studying and comparing the functional results between two surgical treatment methods (vascularized and non-vascularized bone grafting), in order to select the optimal treatment method that achieves union as quickly as possible, returns the patient to activities, and minimizes complications.

PATIENTS AND METHODS

Study population

The study included young patients (aged over 18 years) who visited the emergency and clinics departments of Tishreen University Hospital between 2023-2024 with non-union of scaphoid fractures and were treated surgically (vascularized bone grafting) or (non-vascularized bone grafting). The sample was divided into two groups.

- Group 1: Patients treated surgically with vascularized bone grafting.
- Group 2: Patients treated surgically with non-vascularized bone grafting.

Congenital wrist deformities, previous scaphoid surgeries, carpal collapse, and degeneration were excluded.

Patients were monitored both clinically and radiographically at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months following surgery. Assessments were conducted preoperatively and postoperatively using two standardized indices.

Modified Mayo Wrist Index

This index evaluates four key components: pain intensity, functional status, range of motion, and grip strength. Each component is scored on a scale from 0 to 25, yielding a maximum total score of 100 points. The scoring criteria are as follows.

- Excellent: 91–100 points.
- Good: 80–90 points.
- Fair: 65–79 points.
- Poor: Below 65 points.[9]

Quick Disabilities of the Arm, Shoulder, and Hand (Quick DASH) Index

The Quick DASH is a shortened version of the DASH Outcome Measure, comprising 11 items that assess physical function and symptoms in individuals with upper limb musculoskeletal disorders. Each item is scored from 1 to 5, and at least 10 items must be completed to calculate a total score. The interpretation of the total score is as follows.

- Excellent: Less than 5.
- Good: 6–15.
- Acceptable: 16–35.
- Poor: Greater than 35.[10]

These indices provide a comprehensive evaluation of wrist function and upper limb disability, facilitating objective assessment of patient outcomes in clinical and research settings.

Statistical analysis

The statistical analysis was conducted utilizing IBM SPSS version 20. The basic descriptive statistics included means, standard deviations (SD), medians, frequencies, and percentages. To assess the differences between paired groups, the Friedman test was employed. All tests held significance at a type I error rate of 5% ($p<0.05$), with $\beta=20\%$, and 80% power for this study.

RESULTS

The study sample included 20 patients with scaphoid non-union, who were treated surgically with vascularized or non-vascularized bone grafts and met the study's inclusion criteria. These patients were seen in the emergency and outpatient departments of Tishreen University Hospital between 2023 and 2024. The patients' ages ranged from 20 to 30 years, with a mean age of 25.50 ± 2.9 years. Males accounted for 80% of the patients, with a sex ratio (M:F) of 4:1. The right side was the most common site of injury, and no bilateral cases were recorded. In most patients, the dominant side was affected.

Table 1: Distribution of the study sample by the occurrence of AVN and the surgical technique.

AVN	N	Percentage %
Present	4	20%
Absent	16	80%
The surgical technique	N	Percentage %
Matti & Russe	15	75%
kawai & Yamamoto	3	15%
Zeidemberg	2	10%

According to Table 1, 20% of the studied research sample had AVN, and 75% of the studied research sample used the surgical technique Matti & Russe.

We studied the relation between the research variables and the study groups and found the following.

Table 2: The relation between the study variables and the study groups.

The study variables		Vascularized bone graft (VBG)	Non-vascularized bone graft (NVBG)	P-value
Gender	Male	5 (100%)	11 (73.3%)	0.1
	Female	0 (0%)	4 (26.7%)	
age (years)		28±1.5	24.66±2.8	0.06
The affected side and dominance	Right	5 (100%)	13 (86.7%)	0.3
	Left	0 (0%)	2 (13.3%)	
AVN	Present	2 (40%)	2 (13.3%)	0.01
	Absent	3 (60%)	13 (86.7%)	
The surgical technique	Matti & Russe	0 (0%)	15 (100%)	0.001
	kawai & Yamamoto	2 (40%)	0 (0%)	
	Zeidemberg	3 (60%)	0 (0%)	
Time of surgery (months)		21.18±1.4	22.85±1.9	0.8

Based on the provided (Table 2), a comparison of the two bone grafting research groups revealed no statistically significant differences in gender, affected side and dominance, or time to surgery after nonunion occurred. However, the vascularized bone graft group was older. Avascular necrosis was significantly more prevalent in the vascularized bone graft group. Furthermore, the surgical techniques differed significantly between the groups. The Matti & Russe technique was exclusively used for non-vascularized bone grafts, while the vascularized bone graft group used the Kawai & Yamamoto technique in 60% of cases and the Zeidemberg technique in 40% of cases. While there was a statistically significant difference between the two groups (p=0.001) based on surgical technique. The preference for Matti & Russe in non-vascularized cases may be due to its familiarity to surgeons, technical simplicity, and lack of microsurgical requirements.

Table 3: Distribution of the study groups according to the Mayo and the Quick DASH indices before surgery an after 8 months of surgery.

Mayo	Vascularized bone graft (VBG)	Non-vascularized bone graft (NVBG)	P-value
Before surgery	42.40±1.8	44±3.1	0.2
After surgery	84.80±1.4	77.80±1.8	0.0001
Quick DASH	Vascularized bone graft (VBG)	Non-vascularized bone graft (NVBG)	P-value
Before surgery	27.40±1.6	27.33±2.6	0.9
After surgery	4.80±0.8	9.73±1.2	0.0001

Based on the previous (Table 3), functional outcomes were significantly improved in the vascularized bone graft group compared to the other group, as measured by both the Modified Mayo Wrist Score and the Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) score. The Modified Mayo Wrist Score showed a statistically significant difference (p=0.0001), indicating better postoperative function in the vascularized graft group. Similarly, the Q-DASH score demonstrated a significant improvement (p=0.0001), reflecting enhanced clinical outcomes.

These improvements may be attributed to the vascularized graft's ability to create a well-perfused environment conducive to healing, leading to earlier rehabilitation and reduced complications such as joint stiffness and reflex sympathetic dystrophy. The enhanced blood supply likely accelerates the healing process, facilitating a quicker return to daily activities and better functional recovery.

The average time to union in the vascularized bone graft group (12.4 ± 0.8 months) was significantly shorter than in the non-vascularized bone graft group (14.46 ± 0.6 months), with a statistically significant difference of p = 0.0001. This can be attributed to the improved blood supply provided by vascularized grafting techniques, which plays a vital role in accelerating union and promoting clinical and radiological healing.

Regarding post-operative complications, three cases of complex regional pain syndrome (CRPS, formerly known as reflex sympathetic dystrophy) occurred in the non-vascularized bone graft group, which were managed with physical therapy and non-steroidal anti-inflammatory drugs. One case of superficial infection occurred in the vascularized bone graft group and was managed with appropriate antibiotics and dressings. Additionally, one case of graft failure complicated by avascular necrosis was observed in the non-vascularized bone graft group.

DISCUSSION

This study compared the outcomes of vascularized and

non-vascularized bone grafting techniques for scaphoid non-union in a cohort of 20 patients. Both grafting methods led to improved functional outcomes; however, the vascularized bone grafts demonstrated a significantly faster union rate.

The accelerated healing observed with vascularized grafts aligns with the understanding that enhanced blood supply is crucial for bone healing, particularly in cases of non-union. This is especially pertinent given the scaphoid's limited vascularity and the associated risk of avascular necrosis (AVN), which was present in 20% of the patients in this study. Interestingly, the vascularized graft group was older and had a higher rate of AVN, suggesting that vascularized grafts may be particularly beneficial in patients with compromised vascularity.

The study acknowledges several limitations, including the small sample size and the use of different surgical techniques (Kawai & Yamamoto, Zeidemberg) for non-vascularized grafts, which could influence the results. Additionally, the lack of random assignment introduces potential selection bias. Despite these limitations, the study provides valuable insights into the comparative effectiveness of vascularized and non-vascularized bone grafts, emphasizing the importance of considering the presence of AVN when selecting the most appropriate surgical approach.

In discussing this study in the context of existing literature, it is necessary to explore how these findings correlate with or diverge from other significant research in the field of the treatment of nonunion scaphoid fractures.

The first study by Tabrizi et al. (2018) This quasi-experimental study was conducted on 30 patients with SN. The patients were divided into two groups of NVBG (n = 15) and VBG (n = 13) and were followed up at 2, 4, 8 weeks, and at least 10 months after surgery. Patients' functional abilities in both groups were compared using the Quick Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire and the Mayo modified wrist score. Union rates between the VBG (92.3%) and NVBG (73.3%) groups were not significantly different (P = 0.1). There was a significant difference in the VAS score (P = 0.03) and grip strength (P = 0.010) between the two groups. However, no significant difference was found regarding the active range of motion between the groups (P = 0.2). The postoperative Quick DASH scores of the VBG and of NVBG groups were 5.6 ± 1.1 and 8.4 ± 2.3, respectively, and the difference was significant (P = 0.001). The functional improvement based on the postoperative Mayo score was significantly higher in the VBG group compared with the NVBG group (85.9 ± 3.04 vs. 80.4 ± 6.6; P = 0.006).[11]

The second study by Maraşli et al. (2021) This study retrospectively analyzed 24 patients with scaphoid waist nonunion, treated with iliac crest non-vascularized bone graft (IC-NBG), vascularized free medial femoral condyle (MFC) graft, or 1,2-intercompartmental supraretinacular artery pedicled vascularized bone graft (1,2-ICSRA-VBG). Union was observed in seven (87.5%) patients after IC-NBG, in six (85.7%) patients after MFC bone graft and nine (100%) patients in the treatment group with 1,2-ICSRA-VBG. There were no statistically significant differences among the IC-NBG, MFC and 1,2-ICSRA-VBG groups in terms of the union rates, the scaphoid height-to-length ratio, VAS score, Q-DASH score, grip strength and flexion, ulnar deviation, radial deviation angles after surgery ($p>0.05$). However, extension was statistically lower in the MFC group than IC-NBG and 1,2-ICSRA-VBG groups after surgery. The Mayo score was better in the IC-NBG group than MFC and 1,2-ICSRA-VBG, indicating a statistically significant difference ($p<0.05$).[12]

CONCLUSION

This study recommends a tailored approach to treating scaphoid non-union based on the presence of avascular necrosis (AVN). For non-unions without AVN, non-vascularized bone grafts (NVBGs), such as the Matti-Russe technique, are preferred due to their technical simplicity and reduced need for specialized expertise. In contrast, for cases complicated by AVN, vascularized bone grafts (VBGs) are advocated, as they address the underlying vascular compromise. This aligns with findings from a systematic review indicating that NVBGs achieve union in 47% of cases with AVN, compared to 94% in the absence of AVN, underscoring the importance of vascular supply in bone healing.

Future studies with larger cohorts, randomized designs, and standardized surgical techniques would strengthen the evidence base for optimal treatment strategies in scaphoid non-union. Such research could provide clearer guidance on the most effective approaches, considering factors like AVN presence, patient demographics, and surgical expertise.

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