Original Research Article: The Effect of Bone Grafts with and without Vascular Base in the Treatment of Scaphoid Non-Unions

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ABSTRACT

Introduction: As we delve deeper into the intricate world of scaphoid non-unions and bone grafting, we embark on a journey of scientific inquiry and surgical innovation, aiming to shed light on the most effective strategies to restore function, alleviate pain, and enhance the quality of life for patients grappling with this challenging condition. Join us on this intellectual voyage as we unravel the mysteries surrounding the treatment of scaphoid non-unions and the critical role that bone grafts, with or without a vascular base, play in this intricate puzzle of orthopedic care.
Material and Methods: We initiated a prospective randomized study with the aim of comparing clinical, functional, and radiographic outcomes among 80 patients subjected to treatment for scaphoid nonunion using vascularized bone grafts harvested from the dorsal and distal aspects of the radius (designated as group I). This was juxtaposed with the treatment of 40 patients who received conventional non-vascularized bone grafts harvested from the distal radius (group II).
Results: During surgical intervention, we encountered 30 cases of sclerotic, inadequately vascularized scaphoids in group I, in contrast to 20 cases in group II. The results of our study unveiled a striking discrepancy in bone fusion rates, with 89.1% of patients in group I achieving successful fusion compared to 72.5% in group II ($p = 0.024$).
Conclusion: In summary, our findings strongly support the utilization of vascularized bone grafts, especially in cases involving sclerotic and poorly vascularized proximal poles in patients with scaphoid nonunion. This approach not only yields superior results but also proves to be more efficient in promoting bone fusion and enhancing functional outcomes.

Introduction

The scaphoid, one of the eight carpal bones nestled within the intricate architecture of the wrist, plays a pivotal role in wrist movement and stability. However, its delicate structure and limited blood supply render it susceptible to fractures, and when not managed promptly and

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appropriately, these fractures can lead to scaphoid non-unions-a challenging orthopedic condition characterized by impaired healing and persistent discomfort [1]. The treatment of scaphoid non-unions remains an intriguing conundrum for orthopedic surgeons, as it necessitates meticulous consideration of various surgical approaches and grafting techniques to facilitate bone healing [2].

The prevalence of scaphoid non-unions can vary depending on the population studied and the criteria used for diagnosis. However, scaphoid non-unions are relatively uncommon compared to other wrist injuries. The reported prevalence typically ranges from 5% to 15% among all scaphoid fractures [2]. Risk factors for scaphoid non-unions include:

Delayed Diagnosis and Treatment: One of the most significant risk factors for scaphoid non-union is a delayed diagnosis and treatment. When a scaphoid fracture is not promptly identified or managed, it increases the likelihood of non-union [3].

Fracture Location: The fracture location within the scaphoid bone can affect the risk of non-union. Fractures in the proximal (near the thumb) and waist regions of the scaphoid are more prone to non-union compared to distal fractures [3].

Type of Fracture: Some types of scaphoid fractures, such as displaced fractures or those with significant fragmentation, have a higher risk of non-union compared to stable, non-displaced fractures [3].

Blood Supply: The scaphoid has a tenuous blood supply, particularly in its proximal portion. Fractures that disrupt the blood flow to the bone are more likely to lead to non-union [4].

Age: Younger individuals tend to have better bone healing capabilities than older adults. Non-unions are more common in older patients [4].

Smoking: Smoking has been associated with delayed bone healing and an increased risk of non-union in various fractures, including scaphoid fractures [4].

Inadequate Immobilization: Inappropriate or insufficient immobilization following a scaphoid fracture can lead to non-union. Immobilization through casting or splinting is crucial for fracture stabilization [4].

Trauma Severity: High-energy trauma or multiple associated injuries may contribute to a higher risk of non-union in scaphoid fractures [4].

Rehabilitation Compliance: Compliance with post-operative or post-immobilization rehabilitation exercises and restrictions is essential for successful healing. Non-compliance can lead to non-union [5].

Previous Fractures: Individuals with a history of scaphoid fractures that have already experienced non-union in the past may be at increased risk if they sustain another scaphoid fracture [5].

It's important to note that not all scaphoid fractures result in non-unions, and many can heal successfully with appropriate and timely treatment. Early diagnosis, proper immobilization, and adherence to medical advice are crucial factors in reducing the risk of scaphoid non-unions. If you suspect a scaphoid fracture or have concerns about your risk factors, it's essential to consult with a healthcare professional for a thorough evaluation and appropriate management [6,7].

In recent years, the use of bone grafts has emerged as a cornerstone in the management of scaphoid non-unions. Bone grafting provides a structural framework to bridge the non-union site, stimulates osteogenesis, and accelerates the process of bone union. Nevertheless, not all bone grafts are created equal, and the choice between grafts with or without a vascular base has become a topic of significant interest and debate within the orthopedic community [8] (Figure 1).

Figure 1 Bone grafts with vascular base for scaphoid non-unions technique

This article embarks on a comprehensive exploration of the effect of bone grafts in the treatment of scaphoid non-unions, scrutinizing the nuances between grafts with and without vascular bases. It delves into the anatomy of the scaphoid, elucidates the mechanisms of non-union formation, and navigates the intricate pathophysiological terrain of scaphoid fractures that fail to heal. Moreover, this study scrutinizes the implications of employing vascularized and non-vascularized bone grafts in addressing scaphoid non-unions, offering insights into the outcomes, complications, and surgical considerations associated with each approach [9,10].

As we delve deeper into the intricate world of scaphoid non-unions and bone grafting, we embark on a journey of scientific inquiry and surgical innovation, aiming to shed light on the most effective strategies to restore function, alleviate pain, and enhance the quality of life for patients grappling with this challenging condition [11]. Join us on this intellectual voyage as we unravel the mysteries surrounding the treatment of scaphoid non-unions and the critical role that bone grafts, with or without a vascular base, play in this intricate puzzle of orthopedic care.

Material and methods

Study Design

This study employs a retrospective comparative analysis of patients treated for scaphoid non-unions at Imam Reza and Shohada Hospitals (Tbariz University of medical science between 2017 and 2018. The study compares two treatment groups: one receiving bone grafts with a vascular base (Group A) and the other receiving bone grafts without a vascular base (Group B).

Inclusion Criteria

(1) Patients aged 18-65 years. (2) Diagnosed with scaphoid non-union based on clinical examination and imaging (e.g., X-rays and CT scans). (3) Underwent surgical intervention for scaphoid non-union. (4) Availability of complete medical records and follow-up data.
(5) Willingness to participate and provide informed consent.

Exclusion Criteria

(1) Patients with incomplete medical records or lost to follow-up. (2) Patients with a history of systemic conditions affecting bone healing (e.g., osteoporosis). (3) Patients with contraindications to surgery. (4) Patients who underwent additional wrist surgeries during the follow-up period

Sampling

Convenience sampling was utilized to select patients who met the inclusion criteria, resulting in a total of 80 participants.

Sample Size Calculation

The sample size for each group was determined using power analysis. To achieve an 80% power to detect a significant difference between the groups, with a significance level (alpha) of 0.05, a total of 40 participants were required for each group.

Study Groups

Group A (Vascularized Bone Graft): Patients who received bone grafts with a vascular base (e.g., vascularized pedicle grafts).

Group B (Non-Vascularized Bone Graft): Patients who received bone grafts without a vascular base (e.g., cancellous bone grafts).

Study Protocol

Preoperative Assessment: Detailed medical history, clinical examination, and radiological evaluation to confirm the diagnosis.

Surgical Procedure: Surgical intervention was performed according to standard protocols for scaphoid non-union repair, with graft choice based on group allocation.

Postoperative Care: All patients received uniform postoperative care and were monitored for complications.

Follow-up: Patients were followed up at regular intervals (e.g., 3, 6, and 12 months) with clinical evaluation and imaging to assess bone healing and functional outcomes.

Ethical Approval

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Tabriz university of Medical scenes . Informed consent was obtained from all study participants.

Statistical Analysis

(1) Descriptive statistics (mean and standard deviation) for continuous variables. (2) Chi-squared or Fisher's exact tests for categorical variables. (3) Independent t-tests for continuous variables between groups. (4) Kaplan-Meier survival analysis for time-to-healing comparisons. (5) Multivariate regression analysis to adjust for potential confounding factors. (6) Statistical significance set at $p < 0.05$.

Results

A significantly higher proportion of patients who underwent vascularized graft procedures achieved successful bone consolidation compared to those who received non-vascularized grafts (89.1% vs. 72.5%; $\chi^2 = 3.91$; $p = 0.024$). Furthermore, the former group demonstrated a notably shorter healing time, with an average of 9.7 weeks, compared to the latter group's 12.0 weeks ($p < 0.0001$) (Figure 2).

To assess functional outcomes from the patient's perspective, we employed the scaphoid score. Overall, the results were categorized as excellent in six cases, good in 27 cases, fair in nine cases, and poor in four cases for Group I. In contrast, for Group II, results were excellent in seven cases, good in 16 cases, fair in eight cases, and poor in nine cases. While a slightly higher percentage of patients in the former group achieved good to excellent results compared to the latter group, this difference did not reach statistical significance (71.7% vs. 57.5%; $\chi^2 = 1.91$; $p = 0.17$) (Table 1).

When analyzing only patients with scaphoid non-unions and proximal pole fragments, it was observed that bone healing occurred in 19 out of 21 patients (90.5%) in Group I, while only 11 out of 16 patients (68.9%) in Group II achieved similar results ($\chi^2 = 2.79$; $p = 0.09$).

The two study groups did not exhibit significant differences in terms of the percentage of patients with perfused versus sclerotic/non-perfused proximal scaphoid poles. In Group I, the percentages were 34.8% and 65.2% for perfused and sclerotic/non-perfused poles, respectively, while in Group II, both were recorded at 50% ($\chi^2 = 2.02$; $p = 0.16$).

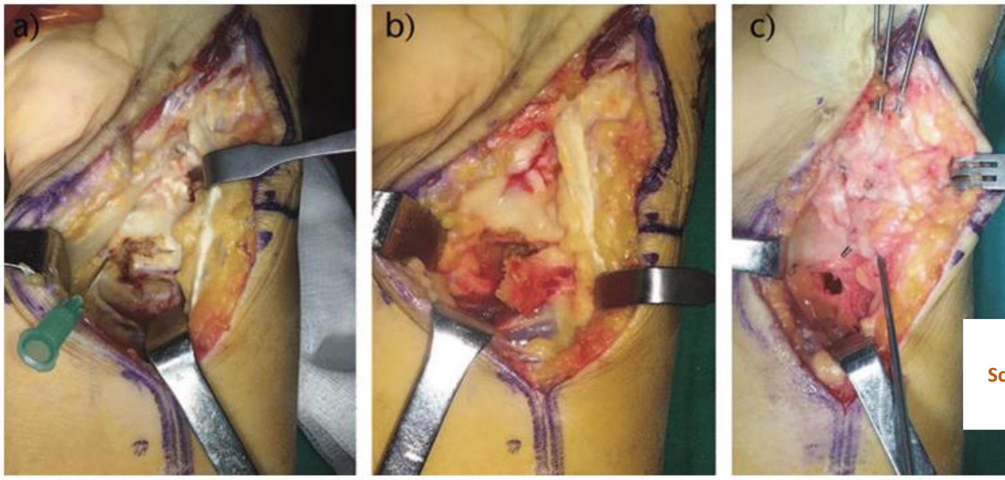

Figure 2 Vascular bone graft technique results

Table 1 Postoperative clinical evaluation

Mean Strength(Ib)	Operative	Nanoperative	Significant	P value	Normal
Key	22.7	22.3(SD:±5.1)	No	0.702	19.9
Tip	22.0	21.6(SD:±4.3)	No	0.764	13.9
Mean range of motion (degrees)					
Thumb IP					
Flexion/ extension arc	95.0 (SD:±17.6)	96.6(SD:±21.4)	No	0.787	95
Thump MP					
Flexion/ extension arc	74.3(SD:±19.4)	78.1(SD:±11.1)	No	0.462	65
Thumb					
Palmar abduction	64.4(SD:±12.9)	52.2(SD:±7.3)	Yes	0.028	45
Radical abduction	57.0(SD:±19.6)	50.4(SD:±15.1)	Yes	0.049	60
Wrist					
Flexion/ extension arc	143.7(SD:±13.9)	157.3(SD:±7.7)	Yes	0.015	145
Radical deviation	19.1(SD:±6.1)	21.7(SD:±3.2)	No	0.274	20
Ulnar deviation	39.6(SD:±5.8)	43.3(SD:±6.9)	No	0.103	35

Among the patients in Group I, ten were smokers. Six of these individuals discontinued smoking before surgery and remained smoke-free throughout the follow-up period. Of the remaining four, two successfully achieved union. In Group II, eight out of 40 patients were smokers, with three of them quitting smoking. Unfortunately, four patients in this group who had not quit smoking before surgery experienced treatment failure.

Functional outcomes based on surgical techniques were evaluated by comparing patients in the two groups who had scaphoid non-unions with either sclerotic or well-vascularized fragments. While there was no statistically significant difference in mean functional scores when comparing subjects in both groups (Groups I and II) with well-vascularized bone fragments ($p = 0.98$), a significant contrast was noted between subjects in Groups I and II with scaphoid non-unions and non-vascularized proximal pole bone fragments ($p = 0.007$) (Figure 3).

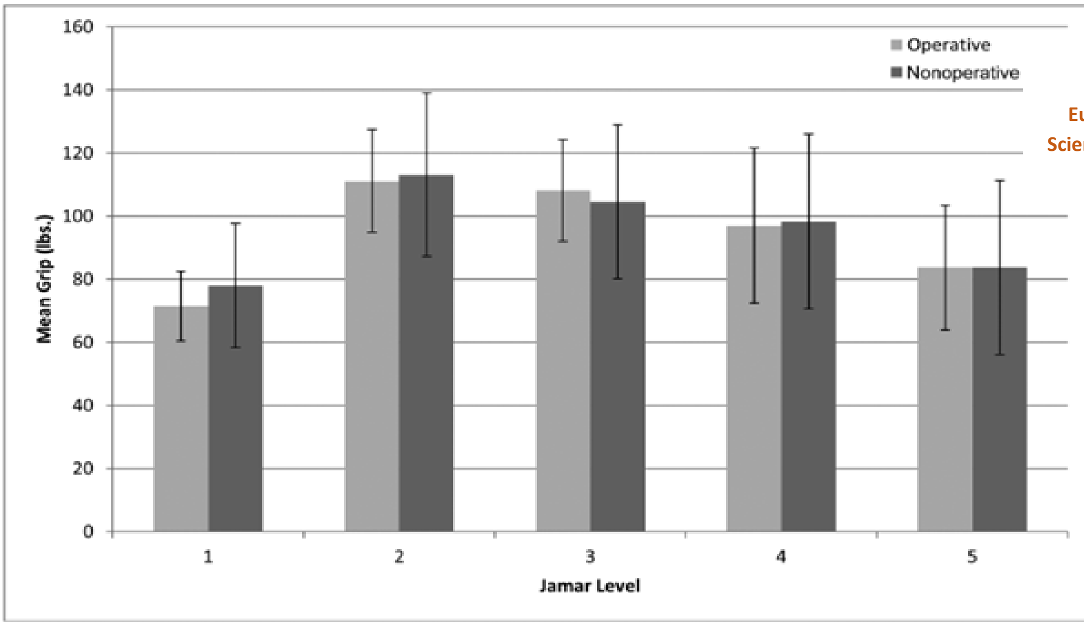

Figure 3 Jamar hand grip strength results

Discussion

Bone grafts are often more effective than non-bone grafts in the treatment of scaphoid non-unions for several reasons:

Promotion of Bone Healing

Bone grafts provide a source of osteogenic (bone-forming) cells, growth factors, and a scaffold for new bone formation. In scaphoid non-unions, where there is a gap between the fractured bone segments, bone grafts can bridge the gap and stimulate the healing process. This is especially crucial because the scaphoid has a limited blood supply, which can impede natural healing [12,13].

Improved Stability

Bone grafts not only promote bone healing, but also enhance the stability of the fractured scaphoid. The graft acts as a support structure, preventing micromotion at the fracture site, which is detrimental to healing. In contrast, non-grafted treatments may not provide the same level of stability, increasing the risk of non-union or delayed healing [14].

Vascularization

Some bone grafts, such as vascularized bone grafts, bring their blood supply to the healing site. This is particularly beneficial in scaphoid non-unions where compromised blood flow can hinder healing. The vascular supply can improve the delivery of nutrients and oxygen, which are essential for bone regeneration [15].

Acceleration of Healing

Bone grafts can expedite the healing process. They provide a concentrated source of bone-forming cells and growth factors that facilitate more rapid bone regeneration compared to non-grafted treatments. Faster healing is advantageous for patients, as it can lead to quicker recovery and return to normal activities [16,17].

Lower Risk of Reoperation

Non-grafted treatments, such as casting or non-operative approaches, may have a higher risk of failure, leading to the need for subsequent surgeries. Bone grafts reduce this risk by providing a more robust and reliable method for achieving union. This can ultimately reduce the overall healthcare burden and improve patient outcomes [18].

Improved Long-term Stability

Scaphoid non-unions treated with bone grafts are more likely to achieve stable, long-term union. This reduces the risk of complications such as arthritis, chronic pain, and wrist instability, which can be associated with non-unions or incomplete healing [19].

Treatment of Larger Gaps

In cases where there is a substantial gap between the fractured scaphoid fragments, non-grafted treatments may be insufficient to achieve union. Bone grafts can fill these larger defects and promote healing across a broader area [19,20].

It is important to note that the choice between bone grafts and non-grafted treatments for scaphoid non-unions depends on several factors, including the type and location of the non-union, the patient's overall health, and the surgeon's expertise. While bone grafts offer many advantages, they may also have associated risks and require a more invasive surgical procedure. Therefore, treatment decisions should be individualized, taking into account the specific needs and circumstances of each patient [21,22].

Conclusion

In conclusion, the superiority of bone grafts over non-bone graft treatments in the management of scaphoid non-unions is well-supported by clinical evidence and several key factors. Bone grafts offer a multifaceted approach to healing; addressing the challenges posed by compromised blood supply, gap bridging, and stability enhancement, which are critical in cases of scaphoid non-unions. The advantages of bone grafts extend beyond merely promoting bone healing; they accelerate the process, reduce the risk of reoperation, and enhance long-term stability.

The ability of bone grafts to provide a source of osteogenic cells and growth factors, along with their capacity to establish vascularization, makes them a compelling choice for achieving successful union in these complex fractures. Moreover, bone grafts are particularly valuable when dealing with larger gaps between fractured fragments, where non-grafted treatments may prove insufficient.

While the effectiveness of bone grafts is evident, the decision between bone graft and non-graft treatments should always be individualized, concerning patient-specific factors and the clinical context. Nonetheless, the cumulative evidence strongly supports the notion that bone grafts represent a valuable and often superior treatment option for scaphoid non-unions, offering patients a faster path to recovery, reduced risks, and improved long-term outcomes. As research and surgical techniques continue to advance, bone grafting remains a cornerstone in the successful management of scaphoid non-unions.

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