

## Scaphoid Nonunion Treatment with Reverse Flow Vascularized Bone Graft from Distal Metaphysis of Radius

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**Background:** The scaphoid is the most frequently fractured carpal bone. Those fractures are commonly difficult to diagnose and usually go undetected. If the patient does not get medical attention considering that it was a trivial wrist trauma, or if the patient is not appropriately immobilized for enough time, Healing will not occur, partially due to the scaphoid peculiar vascularity. The scaphoid nonunion treatment method is controversial. The aim must be bone healing with scaphoid shape restoration and ligament structure preservation. This study was aimed to evaluate the results of treatment of scaphoid nonunion with reverse flow vascularized bone graft from distal metaphysis of radius. **Materials & Methods:** In a quasi-experimental setting, 20 patients with scaphoid nonunion in Shohada Trauma Center of Tabriz were evaluated during 13 months. All these were operated and a reverse flow vascularized bone graft from distal metaphysis of radius was employed. Long and short thumb spike casting was applied tow times for 1.5 and 2 months respectively. Radiological union, range of motion, presence of pain and the degree of patients' satisfaction were assessed. **Results:** Twenty patients, 19 males and 1 female with mean age of  $25.15 \pm 6.62$  (17-40) years were recruited. There were 17 waist and 3 proximal pole fractures. Preoperative pain and pain with decreased grip strength was seen in 11 and 9 cases, respectively. Postoperatively, the range of motion did not change significantly. The frequency of patients suffering from pain was significantly decreased at the end of study (100% to 25%;  $p < 0.001$ ). There were 7(35%) complications: pin fracture (2 cases), occupation change (2 cases), nonunion (1 case), delayed union (1 case), and the irritation of pin place (1 case). The man time of union-achievement was  $10.71 \pm 1.62$  (8-14) weeks. Eighty percent of the patients were highly to very highly satisfy with the procedure. Mayo wrist score was significantly increased after operation. **Conclusion:** This study showed that the treatment of scaphoid nonunion with reverse flow vascularized bone graft from distal metaphysis of radius is safe and effective. The risk of nonunion should be evaluated studies with larger sample sizes.

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### 1. Introduction:

Scaphoid fracture is the most common fracture among carpal bone fractures (about 71% of all carpal bone fractures). About 345 thousand scaphoid fractures occur every year in USA. This kind of fracture mainly occurs in young and middle-age people (15-60 years of old). About 5-12% of scaphoid fractures are associated with other kinds of fractures and 1% of fractures are bilateral. Scaphoid bone fracture diagnosis is very important because, 90% of the fractures are cured by an early procedure (1). 40% of these fractures remain undetected after primary examination. Consequent nonunion results in: pain, progressive and destructive changes in wrist

joints, deformation of the wrist, erosional changes (osteoarthritis), mobility limitations and a consequent defect in life, especially young and active people (1). The important point is that, it is articulated with distal end of radius and four other carpal bones and moves with every wrist motion. Any change in this joint due to fracture, dislocation, semi-dislocation or any other change in joint stability because of torn ligaments causes severe secondary changes in whole of the wrist joint. If scaphoid fracture remains undetected for 4weeks, we will expect nonunion scaphoid. Many solutions have been proposed to solve this problem (2).

Primary mechanism of scaphoid bone damage is falling on outstretched hand. In adults, it occurs in waist (70%), distal part (10-20%), proximal part (5-10%) and tubercle (5%). the frequency is somehow different in children; tubercle (52%), distal (33%), waist (15%) and proximal part fracture is rare and is often healed without any problem but, because of rising participation of children in group sports this pattern is turning into adults' pattern(3). Associated fractures with scaphoid fracture are: Radius styloid fracture, triquetrum fracture, capitate fracture and trans-carpal peri-lunate fracture. An associated distal fracture is rare (4). Scaphoid fracture problems include:

- Mal-union
- Delayed union
- Nonunion.

There are some classification methods for scaphoid fractures. One of them is classifying based on anatomical details of fracture. According to this classification, scaphoid fractures are divided into four groups:

- Tubercle
- Distal end
- Proximal end
- Waist fraction.

As the second classification based on fracture surface:

- Vertical oblique
- Horizontal oblique
- Transversal fracture.

In another classification, we consider fracture duration and consequent healing duration. In this method there are:

- Acute union (complete union after 4 months of immobilization)
- Delayed union
- Nonunion.

In another method we use stable and unstable expression to describe the condition of fracture (1, 2, and 8). Also, Hepert and Fisher have proposed another method of classification.

#### **Nonunion Treatment:**

There is still debate about the most appropriate treatment method for nonunion scaphoid fracture. The main purpose of treatment must be complete bone union associated with primary shape return and ligament structure protection.

Different treatment methods are proposed:

- Electrical and electromagnetic stimulation
- Internal fixation
- Bone graft
- Vascularized bone graft
- Multiple methods with each other (9-13).

Although many successes have been achieved in this field, but fracture cases are numerous and lots of time is needed for immobilization.

This condition results in trouble in patients' life, activity limitations and at last socioeconomic statues destruction. Nowadays the most common methods in using graft which contains recurrent radial artery even vascularization from distal radius, ulna, scaphoid tubercle, dorsal metacarpal artery an ulnar artery might be used (14).

According to the results of some researches, one of the treatment procedures is reverse flow vascularized bone graft from distal metaphysis of radius, which is 86-90% successful in proportion to un-vascularized bone graft . This is the first time which this procedure is being executed in Iran, thus we've decided to investigate the results.

## **2. Materials & Methods:**

**2.1. Study Design and Population:** In a quasi-experimental setting, 20 patients (19 males and 1 female with mean age of  $25.15 \pm 6.62$ (17-40) years) with scaphoid nonunion referred to Shohada Trauma Center of Tabriz were evaluated during a 13-months period (Jun-2009 until July-2010). All these were operated and a reverse flow vascularized bone graft distal metaphysis of radius was employed. After patients' admission, patients were questioned with a questionnaire. After an accurate examination of arm and fore arm, acute and chronic problems of sensation, mobility and circulation were searched for and results was compared with other arm and fore arm. Postero-anterior and specific scaphoid view radiography were executed. After MRI, condition of distal and proximal vessels was investigated; at last the operation was performed. A curved incision was made on radial margin of the wrist and scaphoid bone, radius donor end was revealed.

Between first and second compartment, the first and second ICSRA arteries and the vein associated with the bone fraction, were removed about 1.5 cm away from radiocarpal joint and were attached to the prepared nonunion site. Then, internal fixation was performed with kirschner wire. After operation, wrist was dressed with long thumb spika cast for 1.5 months. Then, it was dressed with short thumb spika cast for 2 months more. Medical wrist band was used also. After 4 months kirschner wire was removed and radiologic signs of bone union were investigated. We used simple MRI or CT-Scan to overcome the doubt on curing process. At the end of treatment, patients' satisfaction, pain withdrawal, grip power, and range of motions were investigated and were scored as very good, good, intermediate and bad. Mayo wrist scores before and after operation was measured and compared.

#### **Study Variables:**

Age, sex, duration between injury and operation, primary complaints, follow up duration, dominant hand, injured hand, injury mechanism, pain, deterioration and improvement mechanism, treatments before operation, manipulation, sensation, motion and circulation examination, previous disease history, smoking, nonunion location, AVN, occupation before injury, severity of activity before fracture, pain after operation, simultaneous styloidectomy, operation side effects, duration between operation and union, final result, Mayo wrist score and related classification were studied.

**2.2. Statistical Analysis & Ethical Considerations:**

Statistical analysis was performed by SPSS software package version 16.0 for windows (SPSS Inc., Chicago, USA). Quantitative data were presented as mean ± standard deviation (SD), while qualitative data were demonstrated as frequency and percent (%). In order to statistical analysis, collected quantitative data were studied with Student T-test (independent Samples), paired samples T-test and Man-whitney U test and for Qualitative data statistical methods, the mean difference test for independent groups, and Chi Square<sup>2</sup> test or Fisher’s exact test. P value less than 0.05 was statistically considered significant in all steps. All participants have signed a written consent, and the study protocol was approved by the Ethics Committee of Tabriz University of Medical Sciences (TUMS), which was in compliance with Helsinki Declaration.

**3. Results:**

We studied 20 patients using reverse flow vascularized bone graft from distal metaphysis of radius. The mean age was 25.15±6.62 (17- 40) and the mean duration between injury and operation was 28.03±41.22 (2-180 months). The mean follow up duration was 8.60±1.64 months. Other primary information are showed in tables (Table 1).

**Table 1, Primary Information about patients**

	Right	left
<b>Dominant hand</b>	<b>19(95%)</b>	<b>1(5%)</b>
<b>Injured hand</b>	<b>12(60%)</b>	<b>8(40%)</b>

All patients complained of pain. Pain had increased with activity in all cases, but resting in 12 patients relieved the pain. 18 of the patients had fracture dislocation. Sensation and circulation in forearm and hand was normal. None of them had chronic diseases before. 11 patients were smoker. MRI revealed AVN in 11 patients. The patients had different jobs such as: mechanic, farmer (5 patients), car painter, turner, welder, carpenter (2patients), shop keeper (2 patients), slaughter-house worker, confectionery worker, simple worker, student, clerk and teacher. 5 patients complained of pain after

operation which was severe in 3 of them. Styloidectomy was executed on 12 patients (Chart 1).

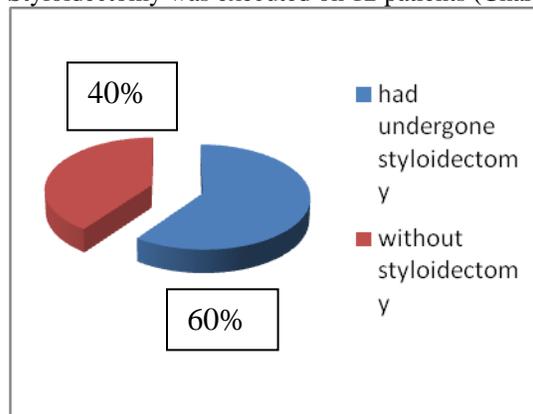


Chart 1. Styloidectomy Cases

In some cases there were side-effects like: pin breakage (1cases), change in occupation (2 cases), nonunion, delayed union and stimulation of pin location. 19 patients (95%) after operation achieved complete union (final result). Mean time between fracture and union was 10.71±1.62 weeks (8-14weeks). 80% of patients were pleased with the results (Table 2). Range of motion didn’t change after operation. Mayo wrist score was significantly increased after operation (Table3).

**Table 2. Patients’ satisfaction after operation**

Bad	Medium	Good	Very good
<b>3(15%)</b>	<b>1(5%)</b>	<b>8(40%)</b>	<b>8(40%)</b>

**Table 3, Comparison between before and after operation, between before operation and intact hand and between after operation and intact hand**

P <sup>3</sup>	P <sup>2</sup>	P <sup>1</sup>	Intact hand	After operation	Before operation	Parameters
<0.001	<0.001	0.330	72.8±5.0	63.3±7.5	62.8±6.8	Flexion (degree)
0.010	0.006	0.267	63.0±12.3	54.3±7.7	53.5±7.6	Extension(degree)
<0.001	<0.001	0.330	39.3±6.7	31.8±5.7	31.0±5.8	Ulnar deviation(degree)
0.001	<0.001	0.083	16.4±4.2	11.8±2.5	11.3±2.2	Radial deviation(degree)
-	-	0.091	-	4(20%)	(45%)9	Grip power
-	-	<0.001	-	88.0±7.7	44.8±14.2	Mayo wrist score
-	-	<0.001	-	-	17(85%)	Poor
				3(15%)	3(15%)	Satisfactory
				6(30%)	-	Good
				11(55%)	-	Excellent

**4. Discussion:**

In this study we investigated the results of 20 cases of scaphoid nonunion treatment with reverse flow vascularized bone graft from distal metaphysis of radius, in which 95% union after operation was seen. Mean time of bone fraction union was 10.71 weeks in current study, but in a case union was delayed.

Malizos et al (2007) used this kind of operation on 30 patients with nonunion Scaphoid bone fraction,

that union was completed in 12 weeks (15). In a study by Dailiana et al. (2006) on 9 patients, the union was obtained in 6-12 months (17). In a study by Caporrino et al (2003) on 29 patients, union was obtained in 46 days in 93% of patients (16). Dailiana et al (2004) in another study on 47 cases of nonunion scaphoid fracture observed complete union for all cases in 12 months, Although MRI (with radio opaque substance) in one case revealed a nonunion after 3 months which was healed in 12 months (14). Chaug et al (2006) in a study on 50 cases of nonunion scaphoid fracture in 49 patients, detected 34 cases (68%) of complete union after operation, mean time for union is 15.6 weeks (18). In a study by Uerpaiojkit et al (2000) on 10 patients, complete union was obtained 6.5 weeks after operation in all cases (19). Sotereanos et al (2006) studied on 13 patients and investigated the results in 19 months, union was observed in 76.9% of patients (20). In a study by Water et al (2002) on 3 patients, complete union was obtained in 3-4 months (21). Malizos et al (2000) Studied 22 cases of nonunion scaphoid fracture with this method and in this study all cases achieved complete union after 6-12 weeks (22). Chen et al (2006) studied on 11 patients and observed complete union after 13 weeks (23). Sauerbier et al (2001) studied on 15 patients and observed complete union after 11.1 weeks (24). Bertelli et al (2004) used this method on 24 patients in 5 years. In 87.5% of them the treatment was successful (25). In study of Steinmann et al (2002), 14 patients obtained fracture union after 11.1 weeks (26). According to the mentioned results, union was obtained in most of the patients after reverse vascularized bone graft from distal metaphysis of radius.

General results are:

- Union rate after operation was 68-100%.
- Mean duration between operation and union was 4.3-19 weeks.

So published results are rated ((very good)) but we should consider that many factors affect study results, for example: patients' quantity and surgeons' skill.

Chaung et al (2006) studied risk factors affecting union after operation on 50 patients, in this study they mentioned:

- High age
- Female sex
- A vascular necrosis of proximal end
- Humpback deformity
- Fixation without bolt
- Smoking

As risk factors (18). In our study we couldn't determine the risk factors because of insufficient nonunion scaphoid cases (1 case). To determine risk

factors further studies about risk factors with higher nonunion population is needed. Patients' differences in different studies about risk factors cause wide range of results. In our study range of motion was measured before and after operation. This factor was improved after operation although it was not significant.

Malizos et al (2007), Caporrino et al (2003) and Steinmann et al (2002) didn't observe any significant improvement after operation (15, 16 and 26). Boyer et al (2007) observed deterioration after operation (27).

According to the insufficient samples, further studies are needed. In our study, we couldn't examine grip power because of some limitations. So, comparison is based on patient's description of his or her grip power. In several studies, grip power was increased after operation significantly (15, 17, 19, 21, 22, 24, 25 and 28). On the other hand, patients' complaints of pain were decreased significantly. In other studies, achieved results were similar to the results mentioned above. Also, according to scoring scale, patients' satisfaction was rated good – very good in 80% of cases. This score in study of malizos et al (2007) was 77% (15), in Dailiana et al (2006) study was good-very good (17). In Chans' (2006) study it was good-very good in 91% of patients (23). In Sauerbier (2001) study, all of the patients' satisfaction was rated good-very good (24). The score was 64.3% in Steinmann et al (2002) study (26).

### 5. Conclusion:

After operation, union was obtained in 95% of cases. Mean duration between operation and union was  $10.71 \pm 1.62$  weeks. Pain in 80% of cases was decrease or completely relieved after operation. Range of motion didn't change after operation. Return to the primary occupation was observed in 80% of patients. Mayo wrist score was significantly increased after operation. Percentage of the group with high-very high Mayo wrist score was increased significantly after operation.

### Suggestions:

According to the results, scaphoid nonunion treatment with reverse flow vascularized bone graft from distal metaphysis of radius is suggested. Further studies with more population are needed to determine the risk factors of scaphoid nonunion fracture.

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