

Treatment of scaphoid non-union with 1,2 intercompartmental supraretinacular artery (1,2 ICSRA) vascularised graft

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ABSTRACT

Introduction: The purpose of this paper is to share the outcome of cases of scaphoid non-union treated with 1,2 intercompartmental supraretinacular artery (1,2 ICSRA) vascularised graft at our institution, as well as to identify the possible factors for the failure of the procedure.

Methods: This was a retrospective review of 13 cases of scaphoid fracture non-union treated with 1,2 ICSRA vascularised bone grafting from October 2000 to March 2003. A clinical and radiological review was conducted. Linear regression was performed in order to identify the factors associated with a negative outcome.

Results: Out of the 13 patients with scaphoid non-union, ten (77 percent) had avascular necrosis of the proximal pole. The patients were followed up for a mean duration of 13 (range 3–28) months. Ten out of the 13 (77 percent) patients achieved union.

Conclusion: Our results are comparable to those reported by other studies and indicate that avascular necrosis was associated with failure to achieve union.

Keywords: avascular necrosis, bone grafting, non-union, scaphoid

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INTRODUCTION

The scaphoid bone is the most commonly fractured carpal bone. Undisplaced fractures are usually treated conservatively, while open reduction and internal fixation is the standard treatment for displaced fractures. With the introduction of percutaneous screw fixation, there is now an increasing preference for closed reduction and percutaneous fixation, even for minimally displaced or



Fig. 1 Posteroanterior radiograph with the wrist in ulnar deviation shows non-union of the scaphoid, as indicated by the sclerotic margins around the fracture fragments.

undisplaced fractures.⁽¹⁻³⁾ Despite these well-established treatment options, the tenuous blood supply to the scaphoid through the retrograde vessels predisposes it to non-union and avascular necrosis (AVN), especially in cases of proximal pole fractures. Hence, there is a move toward vascularised bone graft for the treatment of non-union, especially when there is associated AVN.⁽⁴⁾

Vascularised bone grafts from the distal radius have been used for many years. They are based on the pronator quadratus,⁽⁵⁾ the volar carpal artery,⁽⁶⁾ and more recently, the 1,2 intercompartmental supraretinacular artery (1,2 ICSRA), as described by Zaidenberg et al⁽⁷⁾ and Sheetz et al.⁽⁸⁾ This graft has been increasingly used over the years.⁽⁴⁾ In our institution, it has been used for reconstruction of scaphoid non-unions since the year 2000.

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Fig. 2 Radiograph shows fracture non-union and loosening of screw fixation.



Fig. 3 Radiograph shows healed fracture after vascularised bone grafting.

The technique has been well established as a treatment for scaphoid non-union; however, the results vary among different published studies. Thus, the purpose of our study was to review and share the local outcome of cases of scaphoid non-union treated with 1,2 ICSRA vascularised graft at our institution. No such studies carried out in Singapore have been previously reported. We also aimed to identify the possible factors for failure in the local population.

METHODS

This was a retrospective review of 13 cases of scaphoid non-union treated with 1,2 ICSRA vascularised graft⁽⁸⁾ at our centre from October 2000 to March 2003. Out of the 13 male patients, eight were Chinese, four were Malay and one was from Myanmar. The mean age of

Table I. Patient demographics.

Demographic	No. (%)
Male gender	13 (100.0)
Mean age (yrs)	23.76
Race	
Chinese	8 (61.5)
Malay	4 (30.8)
Others	1 (7.7)
Avascular necrosis	10 (76.9)
Associated injuries	0 (0.0)

Table II. Mechanism of injury and initial treatment.

	No. of patients	
	Fracture union (n = 10)	Fracture non-union (n = 3)
Mechanism of injury		
Sports	5	1
Motorcycle accident	1	1
Military training	3	0
Work injury	1	1
Initial treatment		
Missed diagnosis	5	2
Casted	4	1
ORIF	0	0
Traditional medicine	1	0

ORIF: open reduction and internal fixation

the patients was 23.76 (range 16.3–35.1) years. All the patients had their index injury (Fig. 1) more than six months prior to diagnosis and all presented with wrist pain. The diagnosis of scaphoid non-union was made on plain radiographic assessment (Fig. 2). Preoperatively, magnetic resonance (MR) imaging was performed in three patients, and AVN was diagnosed based on the findings of low signal intensity on both T1 and T2 MR imaging sequences. The diagnosis was confirmed at the time of surgery as an absence of punctuate bleeding in the proximal pole upon release of the tourniquet, with no decreased bleeding. There were three proximal pole and three waist fractures. AVN was present in ten cases, seven (70%) of which occurred in patients with proximal pole fractures.

All cases were treated with the 1,2 ICSRA vascularised graft via a dorsal approach after a mean of 325 days, and the mean follow-up period was 13 (range 3–28) months. We preferred the 1,2 ICSRA vascularised graft for treatment of non-union, especially in cases with AVN, due to its efficacy and relative ease of harvest. The approach is a standard dorsal approach, which allows for easy identification of the 1,2 ICSRA between the first and second dorsal compartments. We found the 1,2 ICSRA to be a constant and reliable vascular pedicle on which to base our bone graft. The fracture site was curetted

Table III. Patients' age, time to fracture, fixation type and fracture union rate.

	Fracture union (n = 10)	Fracture non-union (n = 3)	p-value
Mean age at injury (yrs)	23.17	25.73	0.412
Mean age at operation (yrs)	23.97	27.05	-
Time interval to operation (days)	290.40	441.73	0.949
Type of fixation (no.)			
Variable pitch	6	2	0.462
K wires	4	1	

until healthy bleeding bone was seen. The required bone graft was then harvested with a sleeve of periosteum containing the 1,2 ICSRA. The arc of rotation provided by the pedicle also allowed for rotation of the graft into the recipient site. The vascularity of the bone graft was checked by deflating the tourniquet and the graft placed as an interpositional bone graft. Fixation was achieved with either a variable pitch headless screw (62%) or Kirschner wires (38%).

Radiological union was assessed by plain radiographs in all cases (Fig. 3). Computed tomography (CT) was performed at the six-month follow-up in seven patients using bridging trabeculae as the criteria for union. This was to assess for persistence of fracture lines or lack of progress on serial radiographs. Outcome scoring was performed at the end of the follow-up period with the modified Green and O'Brien score and the Disabilities of the Arm, Shoulder and Hand (DASH) score. The data was statistically analysed using Mann-Whitney U test for quantitative data and Fisher's exact test for qualitative data. In addition, the following factors were analysed using linear regression for association with fracture union: age (Table I); mechanism of injury (Table II); initial treatment modality (Table II); time to bone grafting (Table III); method of fixation (Table III); location of fracture (Table IV); and presence of AVN (Table IV).

RESULTS

Fracture union was achieved in ten (77%) patients after a mean period of 152 (range 77–255) days. The fracture united in all patients who did not have AVN, as opposed to only 70% of patients with AVN. This was clinically significant, although our sample size may have limited our ability to prove statistical significance. The union rate for proximal-pole AVN was 80% (eight of ten patients) and that for waist AVN was 66% (two of three patients). As a whole, waist fractures had a lower union rate, as all these fractures were associated with AVN. For

Table IV. Location of fracture, avascular necrosis and union rate.

	No. of patients (%)		p-value
	Fracture union (n = 10)	Fracture non-union (n = 3)	
Type of fracture			
Proximal pole fracture	8 (80.0)	2 (20.0)	0.396
Waist fracture	2 (66.0)	1 (33.0)	
Presence of AVN			
Yes	7 (70.0)	3 (30.0)	0.516
No	3 (100.0)	0 (0.0)	

AVN: avascular necrosis

Table V. Functional outcome.

Scoring method	Score; range	
	Fracture union (n = 10)	Fracture non-union (n = 3)
Green and O'Brien		
Good	9	1
Fair	1	2
Mean DASH	10.3; 2.5–26.7	9.2; 4.17–14.17

ORIF: open reduction and internal fixation

the union group, the mean postoperative intrascaphoid angle after bone grafting was 50.4° (range 30.0°–78.0°), while that for the non-union group was 84.0° (range 33.5°–104.6°), as compared to a normal angle of 35.0° on the lateral view. This was, however, not found to be statistically significant ($p = 0.088$).

Of all the patients who had united fractures, nine had a good Green and O'Brien score (Table V), while the remaining patient had a fair score. The mean DASH score was 10.3 (Table V), and the mean wrist flexion-extension arc was 117.5° (range 110°–125°). The mean wrist radial and ulnar deviation was 38.3° (range 30°–45° and 10°–55°, respectively) each. At follow-up, patients in whom the fractures did not unite reported minimal wrist pain that did not affect their return to work. The DASH score for this group was 9.2 (Table V). Age, race, mechanism of injury, location of fracture, initial treatment modality, presence of AVN, time to bone grafting, method of fixation and postoperative intrascaphoid angle were not found to have any statistical significance with fracture union. Although statistically insignificant ($p = 0.516$), patients with AVN had a lower rate of fracture union than those without AVN (70% vs. 100%).

DISCUSSION

Non-union of the scaphoid is a difficult problem to treat. Despite advances in bone grafting technique, the rate of healing is still not optimum. This is especially so for those with associated AVN. Bone grafting, in addition to

scaphoid fixation, is the preferred treatment, with most surgeons favouring a vascularised bone graft for AVN.^(4,9,10) This allows for the import of osteogenic progenitors to enhance the healing potential of the fracture, together with its inherent blood supply to improve graft survival rather than depend on the unreliable vasculature of the scaphoid. Since its description by Zaidenberg et al⁽⁷⁾ and Sheetz et al,⁽⁸⁾ the 1,2 ICSRA distal radius bone graft has been increasingly popular for the treatment of non-union of fractures.⁽⁴⁾ Despite this, the union rates for such fractures are still highly variable and can range from 12.5%⁽¹¹⁾ to 100%.⁽¹²⁾ A series from the Mayo Clinic by Chang et al⁽⁴⁾ reported a union rate of 89.5%. Boyer et al reported that in the presence of AVN, the fraction union rate dropped to 60%.⁽¹³⁾ The various reported reasons for failure^(4,10,11,14) included older age, proximal pole AVN, preoperative humpback deformity, non-screw fixation, tobacco use and female gender.

In our series, we were able to achieve a union rate of 70% for patients with AVN and 100% for those without AVN using the 1,2 ICSRA vascularised graft. This result was similar to the experience in other countries. AVN is almost universally reported as a factor for poor outcome, even with vascularised bone grafting. The results still vary greatly among studies. However, it is not clear whether this is due to differences in study methodology, i.e. the definition of AVN is not clear. The three cases of failure encountered in our series were all associated with AVN, although we were unable to establish statistical significance. Two of the failures also had fracture comminution. The limitation of this study was the small sample size, which could have led to our inability to identify any statistically significant factors that adversely affected the outcome.

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