



## RESEARCH ARTICLE

### NON-VASCULARISED CORTICO-CANCELLOUS GRAFTS FOR CARPAL SCAPHOID PSEUDARTHROSIS ARE THEY STILL RELEVANT?

\*Yassine Rachdi, Adnane Lachkar, Abdeljaouad Najib and Hicham Yacoubi

Morocco

#### ARTICLE INFO

##### Article History:

Received 16<sup>th</sup> August, 2021  
Received in revised form  
29<sup>th</sup> September, 2021  
Accepted 20<sup>th</sup> October, 2021  
Published online 30<sup>th</sup> November, 2021

##### Keywords:

Scaphoid, Pseudarthrosis,  
Graft, Cortico-Cancellous.

#### ABSTRACT

The aim of this retrospective study was to analyse the results obtained in 12 carpal scaphoid pseudarthroses that had benefited from a non-vascularised cortico-cancellous graft, in order to specify the factors influencing the results and to determine the ideal indications and limitations. Between 2015 and 2021, 12 patients received a non-vascularised cortico-cancellous graft. The average follow-up was 36 months. The average age was 31 years. For 5 patients, the fracture was not initially diagnosed and the average delay of diagnosis was 2 months. In the Schernberg classification, the fracture was located: 3 times in zone II, 7 times in zone III and 2 times in zone IV. According to Alnot's classification, the stages of pseudarthrosis were divided into: stage I (3), stage IIA (4), stage IIB (4), stage IIIA (1) and stage IIIB (0). The average postoperative immobilisation was 2.7 months. Consolidation was obtained in 10 cases, on average, after 3 months. 7 patients were very satisfied, 3 satisfied and 2 not satisfied. Five patients had significant pain at the time of grafting, but this disappeared within a few months, and all patients had no sequelae in retrospect. Compared to the healthy wrist, the range of motion was reduced in flexion (average 7.2q), extension (average 13.5q) and radial tilt (average 11.5q). The other areas of wrist mobility were respected (in particular supination and pronation). The carpal height index averaged 0.52, and 3 wrists had decreased height. The mean radiolunate angle was 4.2q. 4 wrists had a DISI deformity. 7 patients had little or no osteoarthritis. 2 pseudoarthroses could not be consolidated. All patients were improved for pain. The occurrence of osteoarthritis was favoured by the persistence of a DISI deformity. Although this technique allows 81% consolidation, it is outdated for advanced stages of arthrosis. The correction of an intra-carpal deformity in DISI appears to be essential to prevent the onset of arthrosis. This technique should not be used in cases of necrosis of the proximal pole, and a vascularised graft should probably be preferred.

Copyright © 2021, Yassine Rachdi et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

## INTRODUCTION

Scaphoid fracture is the most common carpal bone fracture [Leslie and Dickson (1)]. And 5 to 10% progress to pseudoarthrosis [Alnot (2)]. Pseudoarthrosis inevitably progresses to osteoarthritis, in the more or less long term, when it is not treated surgically. Classically, the treatment of pseudoarthrosis uses cancellous or cortico-cancellous grafts most often taken from the iliac crest. In recent years, thanks to the development of microsurgery, vascularised grafts have been proposed [Doi et al (3), Gabl et al (4), Guimbertau and Panconi (5), Mathoulin and Haerle (6)]. It is therefore questionable whether the classical non-vascularised graft techniques are still relevant. The aim of our retrospective radioclinical study was to determine: 1) the limitations of this method of grafting carpal scaphoid pseudarthroses, factors influencing the results, 3) the ideal indication.

## PATIENTS AND METHODS

**Patients:** Between 2015 and 2021, 12 patients with scaphoid pseudarthrosis were treated with a non-vascularised graft. During the study period, no other treatment was offered for the treatment of scaphoid pseudarthrosis. There were 11 men and one woman. There were 7 right, 5 left lesions. 8 patients were affected on the dominant side. The average follow-up time was 36 months. The average age of the patients at the time of the operation was 31 years. In 5 patients, the fracture was not initially diagnosed; 7 fractures were initially diagnosed. 4 fractures had no initial treatment, 2 had a cast for 9 weeks, and 1 had a pinning. The average time from fracture to surgical management was 2 months. According to the classification of Schernberg et al (7) (fig. 1) the fracture was located 3 times in zone II, 7 times in zone III and 2 times in zone IV. According to Alnot (2), the stages of pseudoarthrosis and arthrosis were divided into 3 stages I, 4 stages IIA, 4 stages IIB, only one stage IIIA and no stage IIIB cases (Table I).

\*Corresponding author: Yassine Rachdi,  
Morocco.

**Surgical method:** The approach was anterior in all our cases. The graft was harvested 8 times from the anterior iliac crest and 4 times from the distal radial epiphysis. The graft was cortico-cancellous 8 times and pure cancellous 4 times.

The grafting was performed with a curette. In 7 cases, a bone graft was embedded and in 5 cases an intercalary graft. For the osteosynthesis material, the patients benefited from screw fixation in 9 cases and pinning in 3 cases. The average immobilisation period was 2.7 months (1.5 to 4 months).

**Evaluation method:** In addition to the level of patient satisfaction, wrist pain was assessed in 4 stages (severe, moderate, We compared the range of motion of the affected wrist with that of the healthy side. We compared the range of motion of the affected wrist with that of the healthy side. The height of the carpus was assessed by the Mac Murtry index [Sintzoff and Fumiere (9)]. The radiolunate angle was measured on a profile X-ray of the wrist using a planchette (Fig. 2). A value greater than or equal to 10q was considered to be DISI (dorsal lunate tilt). A value less than or equal to -25q was considered VISI (ventral lunate tilt).

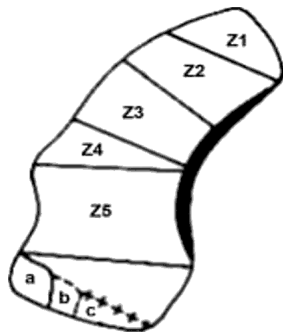


Fig. 1. Distribution of locations according to Schernberg zones

Proximal pole necrosis was only looked for on plain radiographs and on the following signs: densified appearance, bone resorption, multiple geodes. The function was assessed by the Shah and Jones score (10) (Table II), which we felt was the most appropriate for this condition and which includes an objective and subjective evaluation. A score of 90 or more is considered excellent, between 80 and 89 good, between 70 and 79 average and below 70 poor. Following the same divisions as Shah's score, we have introduced a personal score (table III) which takes into account the mobility in radio-ulnar tilt and for which the subjective side no longer counts for half but for 1/5th of the score.

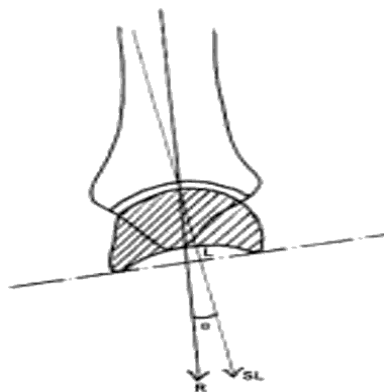


Figure 2. Measurement of the radiolunate angle, to assess the lunate tilt (if > 10q = DISI; if < -25q = VISI)

**RESULTS**

**Complications:** No infections were observed at any of the 12 wrists or iliac harvest sites. Of the 8 patients who received an iliac graft, 5 experienced significant immediate postoperative pain. However, none of them had any pain at the graft site in retrospect. 2 pseudarthroses did not consolidate. 7 patients were very satisfied, 3 satisfied and 2 not satisfied.

Table II. - Shah and Jones score (10).

Shah's score			
Objective score		Subjective score	
Consolidation		Function	
No	10	Limitation of all activities	0
Fibrous union	15	Unable to find a job	10
Partial bone healing	20	Unable to return to previous job	20
Complete bone healing	25	Able to return to previous work	30
Osteoarthritis		Normal activity	
Complete (the whole carp)	5	Pain	
Advance	10	Needed a medication	0
Moderate	15	Daily pain	6
Beginner	20	Pain during of the grip, when carrying heavy loads	10
No	25	Pain after intensive work	16
Mobility (flexion-extension arc to the opposite side)		Pain more once a month	
25 - 50 %	10	Pain less than once a month	26
51 - 75 %	15	No	30
76 - 100 %	20	Mobility	
Normal	25	Decrease limits performance	0
Force (in relation to the opposite side)		The reduction does not limit performance	
26 - 50 %	10	Force	
51 - 75 %	15	Decrease limits performance	0
76 - 100 %	20	The reduction does not limit performance	10
Normal	25	Satisfaction	
		Quality of life has not improved	0
		Quality of life has improved	10
Total	100	Total	100

Table III. - Specific evaluation score for our series.

Pain		Force (in relation to the opposite side)	
Severe	5	< 25 %	0
Moderate (during and after activity)	10	25 — 50 %	5
Average (with activity)	15	51 — 75 %	10
No	20	76 - 100 %	15
Flexion-extension mobility (relative to the opposite side)		Normal	20
< 25 %	0	Osteoarthritis	
25 — 50 %	5	Stage IV	0
51 — 75 %	10	Stage III	5
76 — 100 %	15	Stage II	10
Normal	20	Stage I	15
Mobility in radio-cubital tilt (relative to the opposite side)		Absent	20
< 25 %	0	Consolidation	
25 — 50 %	5	No	0
51 — 75 %	10	Yes	10
76 — 100 %	15		
Normal	20		
Total		Total	100

**Consolidation and clinical and radiological outcome:** For 47 fractures, consolidation was achieved after an average of 3 months (1.5-6). 98% of the wrists were pain-free or only moderately painful; the course of the pain is detailed in *Table IV*. At follow-up, the mean global mobility (*Table V*) was normal only for pronation and ulnar tilt.

**Table IV. - Pain assessment before and after surgery.**

Pain	In hindsight
No	4
Average (with activity)	2
Moderate (during and after activity)	5
Severe	1

The average objective Shah score was 79.9 and the average subjective value was 92.7. In total the average Shah score was 172.6 (maximum total 200 points). From an objective point of view: 2 wrists had an excellent result, 5 a good result, 3 an average result and 2 a poor result. The carpal height index averaged 0.52 on the side with pseudarthrosis. Of the 58 wrists, 3 patients had decreased carpal height. The mean radiolunate angle was 4.2q. 4 wrists had a radiolunate angle greater than 10q, i.e. pathological dorsal tilt of the lunate (DISI). 7 wrists were free of or had minimal osteoarthritis

**Table V. - Comparison of mean wrist mobility at recoil on the operated and healthy sides**

	Flexion	Extension	Pronation
Operated wrist	56q (25 — 90)	56q (20 — 80)	83q (65 — 90)
Healthy wrist	64,7q (45 — 90)	68,8q (50 — 90)	83q (70 — 90)
Supination	Radial inc.	Ulnar inc.	
83q (65 — 90)	11q (-5 — 30)	32,7q (20 — 50)	
83q (60 — 90)	20,5q (9 — 40)	35,6q (20 — 50)	

## DISCUSSION

The data from our series correspond to those in the literature [Carpentier *et al* (12), Green (13), Hoang and Rombouts (14), Schneider and Aulicino (15)]: these are young patients (average age 26.7 years), mostly manual workers (55.2%), the sex ratio shows a majority of men (87.3% male) Forty-five patients (77.5%) were not immediately diagnosed with a scaphoid fracture, the main causes of pseudarthrosis being errors in diagnosis and initial treatment [Gandin (16)]. Most authors do not use a functional score, and are only interested in whether or not the pseudarthrosis has consolidated [Merrell *et al.* (17)]. However, patients do not complain directly about their pseudarthrosis, but about its consequences (pain, reduced mobility, reduced strength, etc.). It therefore seemed important to us to use a means of assessing function in the form of a numerical score. Although Shah's score seemed to be the most suitable, it has some imperfections which led us to weight it in the form of a personal score: 1) In their objective score, Shah and Jones (10) used nuances for consolidation (none, fibrous union, partial bony union, complete bony union) which seem to us to be difficult to assess. This is why our score is limited to a binary evaluation of consolidation (yes or no). 2) Shah's score studies only the flexion-extension arc, whereas the radio-ulnar inclinations, which are very often disturbed, must be evaluated. As with Stark *et al* (18), the majority of patients are satisfied regardless of the outcome. It seemed more appropriate to us to take into account the subjectivity of 20% in our score, as opposed to 50% in Shah's score.

Overall, non-vascularised cortico-cancellous grafts give excellent subjective results. In terms of pain, all patients were improved. Although the objective criteria are important (consolidation, necrosis, osteoarthritis), they are not recognised as such by the patient, who places the result on pain in the forefront [Stark *et al.* (19)]. The duration of immobilisation did not influence flexion-extension mobility, which is globally reduced in our population compared to the healthy side. However, in our series, immobilisation was always for at least one and a half months. Although stable osteosynthesis sometimes allows earlier mobilisation, it does not guarantee better mobility [Merrell *et al* (17)]. The hand strength was 89.2% compared to the healthy side. The most advanced stages of pseudoarthrosis and osteoarthritis were accompanied by a greater strength deficit. It therefore seems advisable to start the diagnosis and treatment of scaphoid fractures early. Hooning *et al* (20) suggest that there is no correlation between DISI and osteoarthritis, which we do not confirm in our series. While Nakamura *et al* (21) did not find any significant influence of the quality of the reduction on the results, our medium-term series underlines, like those of Tomaino *et al* (22) and Linscheid *et al* (23), that the correction of the deformity in DISI is necessary for a good result. Linscheid *et al* (23) have shown that instability invariably results in mobility limitation and pain. We do not find this direct correlation, but our series showed that persistent DISI deformity favoured the development of osteoarthritis, which in turn was a source of reduced mobility in extension. In our series, correcting the DISI deformity indirectly allowed for the maintenance of mobility in extension. This spatial correction with restoration of scaphoid height is only possible with an anterior cortico-cancellous graft and not only cancellous graft [Nakamura *et al.* (24)].

Stages IIIA and IIIB are stages where the osteoarthritis is already significant and where a palliative intervention would have been more appropriate than the placement of a graft: partial arthrodesis of the wrist, resection of the first row of the carpus, resection of the proximal pole [Trumble (25)]. Consolidation alone does not resolve overly advanced carpal lesions, as radiological assessment is unreliable [Green (13)]. an MRI should therefore be performed at the slightest doubt and for all proximal fractures. In the case of necrosis discovered preoperatively, 50 to 100% of non-vascularised grafts do not consolidate [Trumble *et al.* (25)]. Green (13) suggested that the vascularisation of the proximal pole should be checked intraoperatively. And, in case of necrosis, a vascularised graft should be used. In addition, fixation is also influenced by the stage of pseudoarthrosis. Other series show the influence of the time between the fracture and surgical management on consolidation [Nakamura *et al.* (21)]. Lindström and Nystrom (29) have shown that 100% of pseudoarthroses, even asymptomatic ones, progress to symptomatic osteoarthritis. All pseudoarthroses, even asymptomatic ones, should therefore be operated on as early as possible, in order to achieve better long-term results. Alnot (2) reached the same conclusion in the SOFCOT symposium. The advantages of non-vascularised grafts are the relative simplicity of the technique, its reliability (between 70 and 97% consolidation depending on the series), and the current hindsight of the technique which allows us to confirm its results. The disadvantages of these grafts are their poor results in the event of necrosis of the proximal pole, the consequences on the site where the graft is harvested (mostly iliac), which is responsible for postoperative pain and requires

general anaesthesia, and an average consolidation time of 3 months. In recent years, thanks to progress in microsurgery, vascularised grafts (free or pedicled) have appeared. They should make it possible to push back the limits of conservative treatment in case of necrosis of the proximal pole of the scaphoid if this vascularised graft allows revascularisation.

## REFERENCES

- LESLIE IJ, DICKSON RA: The fractured carpal scaphoid: natural history and factors influencing outcome. *J Bone Joint Surg (Br)*, 1981, 63, 225-230.
- ALNOT JY : Fractures and pseudarthroses of the scaphoid carpus. Symposium of the SOFCOT. *Rev Chir Orthop*, 1988, 74, 683-752.
- DOI K, ODA T, SOO-HEONG T, NANDA V: Free vascularized bone graft for nonunion of the scaphoid. *J Hand Surg (Am)*, 2000, 25, 507-519.
- GABL M, REINHART C, LUTZ M, BODNER G, RUDISCH A, HUSSL H, PECHLANER S: Vascularized bone graft from the iliac crest for the treatment of nonunion of the proximal part of the scaphoid with an avascular fragment. *J Bone Joint Surg (Am)*, 1999, 81, 1414-1428.
- GUIMBERTEAU JC, PANCONI B : Recalcitrant non-union of the scaphoid treated with a vascularized bone graft based in the ulnar artery. *J Bone Joint Surg (Am)*, 1990, 72, 88-97.
- MATHOULIN C, HAERLE M: Vascularized bone graft from the palmar carpal artery for treatment of scaphoid nonunion. *J Hand Surg (Br)*, 1998, 23, 318-323.
- SCHERNBERG F, ELZEIN F, GÉRARD Y : Anatomical and radiological study of carpal scaphoid fractures. Problème des cals vicieux. *Rev Chir Orthop*, 1984, 70, 55-63.
- KAPANDJI A: Clinical test of apposition and counter-apposition of the thumb. *Ann Chir Main*, 1986, 5, 67-73.
- SINTZOFF S, FUMIERE E: Examen radiologique simple du poignet. In: Imagerie du poignet. *Masson*, Paris, 1993, 35-44.
- SHAH J, JONES WA: Factors affecting the outcome in 50 cases of scaphoid non-union with Herbert screw fixation. *J Hand Surg (Br)*, 1998, 23, 680-685.
- STARK A, BROSTROM LA, SVARTENGREN G: Surgical treatment of scaphoid nonunion: review of the literature and recommendations for treatment. *Arch Orthop Trauma Surg*, 1989, 108, 203-209.
- CARPENTIER E, SARTORIUS C, ROTH H : Scaphoid nonunion : treatment by open reduction, bone graft, and staple fixation. *J Hand Surg (Am)*, 1995, 20, 235-240.
- GREEN DP: The effect of avascular necrosis on Russe bone grafting for scaphoid nonunion. *J Hand Surg (Am)*, 1985, 10, 597-605.
- HOANG P, ROMBOUS JJ: The Matti-Russe operation in the treatment of carpal scaphoid pseudarthrosis. *Acta Orthop Belg*, 1984, 50, 677-685.
- SCHNEIDER LH, AULICINO P: Nonunion of the carpal scaphoid: the Russe procedure. *J Trauma*, 1982, 22, 315-319.
- GANDIN J : Critical study of the surgical treatment of pseudarthroses of the carpal scaphoid. *Rev Chir Orthop*, 1970, 56, 231-252.
- MERRELL GA, WOLFE SW, SLADE JF: Treatment of scaphoid nonunions: quantitative meta-analysis of the literature. *J Bone Joint Surg (Am)*, 2002, 27, 685-691.
- STARK A, BROSTROM LA, SVARTENGREN G: Scaphoid nonunion treated with the Matti-Russe technique. *Clin Orthop*, 1987, 214, 175-180.
- STARK HH, RICKARD TA, ZEMEL NP, ASHWORTH CR: Treatment of ununited fractures of the scaphoid by iliac bone grafts and Kirschner-wire fixation. *J Bone Joint Surg (Am)*, 1988, 70, 982-991.
- HOONING VAN DUUVENBODE JFF, KEIJSER LCM, HAUET EJ, OBERMANN WR, ROZING PM: Pseudarthrosis of the scaphoid treated by the Matti-Russe operation. *J Bone Joint Surg (Br)*, 1991, 73, 603-606.
- NAKAMURA R, HORII E, WATANABE K, TSUNODA K, MIURA T: Scaphoid non-union: factors affecting the functional outcome of open reduction and wedge grafting with Herbert screw fixation. *J Hand Surg (Br)*, 1993, 18, 219-224.
- TOMAINO MM, KING J, PIZILLO M: Correction of lunate malalignment when bone grafting scaphoid nonunion with humpback deformity: rationale and results of a revisited technique. *J Hand Surg (Am)*, 2000, 25, 322-329.
- LINSCHIED RL, DOBYNS JH, BECKENBAUGH RD, COONEY WP, WOOD MB: Instability patterns of the wrist. *J Hand Surg (Am)*, 1983, 8, 682-686.
- NAKAMURA R, IMAEDA T, TSUGE S, WATANABE K: Scaphoid non-union with D.I.S.I. deformity. *J Hand Surg (Br)*, 1991, 16, 156-161.
- TRUMBLE TE: Proximal pole scaphoid fractures and nonunion. *J Am Society Surg Hand*, 2001, 1, 155-171.
- MORGAN WJ, BREEN TF, COUMANS JM, SCHULZ LA: Role of magnetic resonance imaging in assessing factors affecting healing in scaphoid nonunions. *Clin Orthop*, 1997, 336, 240-246.
- HUENE DR, HUENE DS: Treatment of nonunions of the scaphoid with the Ender compression blade plate system. *J Hand Surg (Am)*, 1991, 16, 913-922.
- KORKALA OL, KUOKKANEN HOM, EEROLA MS: Compression-staple fixation for fractures, non-unions and delayed unions of the carpal scaphoid. *J Bone Joint Surg (Am)*, 1992, 74, 423-426.
- LINDSTROM G, NYSTROM A: Natural history of scaphoid non-union, with special reference to "asymptomatic" cases. *J Hand Surg (Br)*, 1992, 17, 697-700.

\*\*\*\*\*