Treatment of Scaphoid Waist Nonunion Using Olecranon Bone Graft and Stryker Asnis Micro Cannulated Screw: A Retrospective Study—80 Case Studies and 6 Years of Follow-Up

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Abstract

Background Screw fixation and bone grafting are the gold standard for scaphoid waist nonunion without avascular necrosis.

Question/Purpose Assesses the scaphoid waist nonunion healing rate with use of an uncommon cancellous bone graft (olecranon) and an unusual fixation system (Asnis Micro Cannulated Screw System; Stryker Inc., Kalamazoo, MI, USA).

Material and Methods A series of 102 consecutive patients were treated for scaphoid waist nonunion (without deformity). Of these, 80 patients subjected to clinical (Modified Mayo Wrist Score (MMWS), Jamar hydraulic dynamometer) and radiographic examination before and after surgery were evaluated. Ipsilateral olecranon cancellous bone graft and the ASNIS Micro 3.0-mm diameter screw, were used. The average follow up was 6 years (min 3; max 10).

Results Radiographic consolidation was achieved in 90% of patients; dorsal intercalated segment instability (DISI) deformities were corrected in 71.4% of cases. Ninety percent improved the range of motion of the wrist and grip strength. All patients showed a significant reduction of peak force in the operated hand. In 6.25% we observed clinical and radiographic screw head–trapezium impingement. Twenty-six patients developed a degenerative wrist sign. The MMWS yielded 68 optimal, 8 good, and 4 bad results.

Conclusions To treat scaphoid waist nonunions without misalignment, low-profile headed screw and olecranon bone graft allowed a high consolidation rate with positive results to long-term follow-up. The Asnis Micro 3.0 mm diameter screw may be a suitable option for treating scaphoid waist nonunion.

Level of Evidence IV.

Keywords

- scaphoid waist nonunion
- olecranon bone graft
- low-profile headed screws (Stryker Asnis Micro 3.0 mm diameter)

Management of scaphoid nonunion continues to be a challenge for hand surgeons, and the optimal treatment remains controversial. Many factors contribute to the development of a nonunion, including the particular scaphoid vasculariza-

tion, the degree of fracture displacement, the complex scaphoid anatomy, and delayed treatment.^{1,2}

Nonunion rates of up to 12% have been reported.³ Adams and Leonard⁴ were the first authors to describe bone grafting

Table 1 Herbert and Fisher scaphoid fractures classification

Scaphoid Fracture: Herbert and Fisher Classification			
A	Acute, stable	A1	Tubercle
		A2	Nondisplaced crack in the waist
B	Acute, unstable	B1	Oblique, distal third
		B2	Displaced or mobile, waist
		B3	Proximal pole
		B4	Fracture-dislocation
		B5	Comminuted
C	Delayed union		
D	Established nonunion	D1	Fibrous
		D2	Sclerotic

for scaphoid nonunion, but this was not widely accepted. Afterwards, Matti and Russe described their technique, changing the general attitude toward bone grafts.²⁻⁶ There is a general consensus that corticocancellous bone graft is necessary for large defects, cancellous bone chip graft for small defects, wedge bone graft for correction of a humpback deformity, and vascularized bone graft for avascular necrosis of the proximal fragment. Accordingly, headless screw fixation and bone grafting have represented the gold standard for treatment of nonunion in the absence of avascular necrosis.⁷

The aim of this study was to evaluate the incidence of bony union obtained in 80 scaphoid nonunions without a humpback deformity that were treated by an olecranon cancellous bone graft and a low-profile headed screw.

Patients and Methods

We retrospectively reviewed 80 patients who underwent bone grafting and screw fixation for a symptomatic scaphoid waist nonunion. We used Herbert and Fisher's classification to identify those fractures most applicable for operative fixation, either due to inherent instability or delayed nonunion.⁷ We reported 7 fibrous nonunions (Herbert type D1) and 73 sclerotic nonunions (Herbert D2; ▶ **Table 1**). There were 61 male and 19 female patients. The dominant wrist was involved in 72 cases; the mean age was 35.2 years (range 14–45 years). The trauma occurred during sporting activities in 55 patients (10 football, 8 rugby, 12 skiing, 25 snowboarding); motor vehicle accidents in 18 cases (12 major injuries, 6 motorcycle falls); and work-related injuries in 7 cases (5 porters, 2 miners). The average delay from the time of the injury to the operation was 13.9 months (SD ± 8.5). Before surgery, all the patients filled out the Modified Mayo Wrist Score (MMWS) and underwent a radiographic examination that included posteroanterior (PA), anteroposterior (AP), and lateral views and a 45-degree partially supinated scaphoid view (▶ **Fig. 1**).⁸ The angles between the scaphoid and the lunate and between the lunate and the radius were measured to rule out a dorsal or volar intercalated segment (DISI/VISI) deformity. The scapholunate angle is formed by the intersection of a line tangential to

the palmar aspect of the scaphoid with the long axis of the lunate: angles > 60° indicate a DISI malalignment. The radiolunate angles give an objective evidence of the lunate tilt. We observed a preoperative DISI deformity in 7 cases with a scapholunate angle ≥ 60° (range 60–83°) and a radiolunate angle > 15° (range 15–18°). We also measured the carpal translation and carpal height with the McMurtry index (the ratio between the distance within the axis of the ulna and the capitate) and the Nattrass index (ratio between length of third metacarpal bone and the length of the capitate).^{9,10} Two patients had signs of osteoarthritis (OA) of the wrist before the surgery, consisting of radial styloid OA, or scaphoid nonunion advanced collapse (SNAC) wrist stage 1.

The procedure was performed under brachial plexus anesthesia. The nonunion was exposed through a volar Russe approach modified by Garcia-Elias.¹¹ A 25–30-mm skin

Fig. 1 PA radiographic view of scaphoid nonunion.

Fig. 2 Volar surgical scaphoid approach following curettage of the fibrous nonunion.

incision was made. The capsule was opened on the radial side of the flexor carpi radialis (FCR) tendon. Care was taken not to violate the scaphotrapezial joint. Where possible, we sectioned only the proximal two-thirds of the radioscaphocapitate ligament.

Bone grafting was performed after removal of all the fibrous tissue down to bleeding bone (► **Fig. 2**). In two cases we performed a radial styloidectomy. The bone graft was harvested through a 30-mm vertical incision on the ipsilateral olecranon. Two periosteal flaps were made and the cortical bone was exposed. A 30 mm × 10 mm graft was outlined with drill holes, and then the osteotomy was completed with an osteotome. The proximal side of the block was used as a hinge. The cancellous bone was harvested from the inner cortical surface and the marrow bone. Then the cortical window was closed and the two periosteal flaps were sutured to prevent a postoperative hematoma. The bone graft was placed into a wet saline-soaked gauze (► **Fig. 3**).

Fig. 4 Nonunion fixed with low-profile headed screw (Stryker Asnis Micro 3.0 mm) after cancellous bone graft position.

Fig. 3 Cancellous bone harvested from the ipsilateral olecranon.

The DISI deformity (if present) was reduced by exposing the lunocapitate joint and using 1.2-mm Kirschner wires (K-wires) as joysticks. The nonunion was stabilized with longitudinal K-wires before the graft was inserted under fluoroscopic control.

After scaphoid reduction, the nonunion was bone grafted followed by insertion of a low-profile headed cannulated titanium screw (Asnis Micro Cannulated Screw, 3.0-mm diameter, Stryker Inc., Kalamazoo, MI, USA) from a distal to a proximal direction¹² (► **Fig. 4**). The screw position was checked fluoroscopically using four views. At the end of the procedure, the wrist was immobilized with a below-elbow cast full-time for 4 weeks with the first metacarpophalangeal joint included. After this period, the patient started hand therapy wearing a removable brace during manual activities for an additional 2 weeks. The average follow-up was 6 years (range 3–10).

Follow-up evaluations were performed at 30 days, 60 days, 6 months, and 1 year. The patients were evaluated using the MMWS for pain, grip strength, time of return to daily activities, and complications. We evaluated the range of motion (ROM) of the wrist with a goniometer (Wright Medical Technology Inc., Arlington, TN, USA). The grip strength (peak force) was measured with a Jamar dynamometer (Smith and Nephew, Minneapolis, MN, USA), and the unaffected versus the operated side were compared.¹³ The best result among the three measurements was chosen and the average value was calculated for each group of patients. X-ray images were obtained at each follow-up visit until radiographic union was achieved. Any arthritic changes were graded using the SNAC classification.¹⁴ It involves three stages: stage 1, OA between the distal scaphoid fragment and the radial styloid process; stage 2, stage 1 plus OA between the scaphoid and the capitate; and stage 3, OA affecting the radial styloid, distal scaphoid, and scaphocapitate with progression to the lunocapitate articulation.

Fig. 5 Radiographic evaluation after 6 years, nonunion healing and no radiographic signs of impingement with trapezium.

Statistical analysis: Mean values and standard deviation (SD) were calculated for continuous parameters (time, age, scores, ROM, and radiologic indexes). The association between two continuous variables was evaluated with the Student *t*-test. The data were presented stratified by age, stating the maximum handgrip peak strength value of the three measurements in both upper limbs after surgery, as well as the standard deviation and 95th percentile. A single observer who was not an operating surgeon analyzed the data to reduce the bias.

Results

Radiographic healing (defined as the restoration of bony architecture across the fracture site and identify trabeculae crossing the fracture or sclerosis of at least 50% of the fracture line) was achieved in 72 of 80 (90%) patients, on average within 58 days (range 45–71 days; ►Fig. 5). At an average follow-up of 6 years (range 3–10 years), the patients were pain-free 60 days after surgery, except for 5 cases who had continued pain. Seventy-five of 80, or 93.7%, of the patients returned to their previous sports and work activities at a mean time of 3 months (range 1.5–4.5 months); 90% (72) of

the patients showed an improvement in the wrist ROM in all planes. However, there was a statistically significant reduction of ROM of the wrist in all cases compared with the healthy wrist, but this did not affect work-related or daily activities (►Table 2). McMurtry index averaged 0.28 ± 0.03 (carpus translation index calculated as the ratio between the distance within the axis of the ulna and the capitate), and Natrass index averaged 0.31 ± 0.03 (carpal height ratio between length of the third metacarpal bone and the length of the capitate). Both values remained virtually unchanged after surgery (►Table 3).

Before surgery, the MMWS⁸ showed 18 fair and 60 poor results. Postoperatively there were 68 excellent results (average score 95), 8 good (average score 85), and 4 poor results (average score <65) from the MMWS. Two patients had a temporary neurapraxia of the sensory branch of the radial nerve, but there were no other complications. Furthermore, there were no olecranon donor site complications, such as hematoma, pathological fracture of the olecranon, infection, or pain or tenderness when resting the elbow on a hard surface.

The grip strength showed a significant reduction of peak force in the operated hand in all patients healed as well as nonhealed (►Table 3). Eight patients developed partial graft resorption with persistent nonunion. If the pain was mild and there were no radiographic signs of screw loosening, the patients were treated nonsurgically. If the pain was severe and there were signs of arthritic change (SNAC I/II or more), salvage and palliative procedures for SNAC wrist were used.

In one case, signs of loosening of the screw were present, but bone healing was achieved. The DISI deformity was corrected in 5 of 7 cases, with a decrease in the scapholunate angle less than 60°. At the end of the follow-up, the degenerative wrist changes were as follows: 44 patients had no radiographic signs of osteoarthritis; 30 patients had SNAC wrist stage 1 (OA between the distal scaphoid fragment and the radial styloid process) and 6 patients stage 2 (stage 1 plus OA between the scaphoid and the capitate) (►Fig. 6). Five patients (6.25%) showed radiographic signs of impingement between the screw head and the trapezium. Three of these patients were symptomatic (radial-side wrist pain), which resolved with screw removal without progression of arthritic changes.¹⁵

Table 2 Range of motion of injured wrist before surgery and both wrist during follow-up evaluation

ROM	Preop ROM	Postop ROM	Preop vs Postop (<i>t</i> -test)	Nonoperated hand	Postop vs nonop hand (<i>t</i> -test)
Flexion	36.1° (SD 4.9°) (42.5% of normal side)	66.9° (SD 4.2°) (78.7% of normal side)	$p < 0.05$	87.0° (SD 2.5°)	$p < 0.05$
Extension	45.8° (SD 14.8°) (54% of normal side)	62.2° (SD 5.1°) (73.1% of normal side)	$p < 0.05$	83.0° (SD 3.3°)	$p < 0.05$
Ulnar deviation	16.3° (SD 4.7°) (54.3% of normal side)	26.7° (SD 2.2°) (89% of normal side)	$p < 0.05$	30.2° (SD 2.2°)	$p < 0.05$
Radial deviation	13.1° (SD 2.9°) (65.5% of normal side)	17.4° (SD 1.7°) (87% of normal side)	$p < 0.05$	18.8° (SD 2.1°)	$p < 0.05$

Table 3 Grip strength analysis, carpal height index, and carpal ulnar side translation index between the age-related groups

Age range (y)	Number	Mean operated hand grip strength (kg)	Mean nonoperated hand grip strength (kg)	Difference between means (t-test)	McMurtry index	Natras index
14–24	17	56.4 (67.6% of opposite site)	80.7	$p < 0.05$	0.28 ± 0.03	0.29 ± 0.03
25–31	24	54.2 (54.7% of opposite site)	88.7	$p < 0.05$	0.29 ± 0.03	0.31 ± 0.03
32–39	37	55.7 (58% of opposite site)	93.5	$p < 0.05$	0.27 ± 0.03	0.27 ± 0.03
40–45	12	47.5 (53.7% of opposite site)	87.2	$p < 0.05$	0.30 ± 0.03	0.30 ± 0.03

The 27 patients who remained symptomatic despite radiographic healing (pain or scar tissue pain) underwent screw removal under local anesthesia and fluoroscopic control after a 1-year period. The context improved in 25 patients. Most of these patients were athletes who practiced contact sports or heavy workers (total: 27 patients; 33.7%). No refracture was recorded after the removal of the screw.

Discussion

Olecranon cancellous bone graft and low-profile headed screw (Asnis Micro Cannulated 3.0-mm) in the treatment of scaphoid waist nonunion without a humpback deformity resulted in healing in 90% of cases.

These data are consistent with the previous literature.^{16–19} The common sites of cancellous bone graft harvesting for scaphoid filling are the iliac crest and the distal radius, but other locations (tibia, trochanter, distal ulna) have been reported.^{20–23} The olecranon is an uncommon source of

cancellous bone graft for medium/small bone defects of the phalanges or metacarpals, with or without cortical strut. This graft can be harvested within the same sterile operative field under the same regional anesthesia. In our opinion the olecranon is one of the donor sites of choice for scaphoid nonunion in young patients with good quality and quantity of cancellous bone.

Impingement between the screw head and the trapezium can be avoided if the surgeon adheres strictly to the direction of screw insertion as described by Leventhal et al.^{24,25}

The olecranon cancellous bone graft and the cannulated low-profile headed screw (Asnis Micro 3.0-mm diameter) fixation can be considered as a treatment option for symptomatic scaphoid waist nonunion without humpback deformity.

Conflict of Interest

None

Fig. 6 SNAC grade II after 6 years of follow-up.

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