Treatment of Scaphoid Nonunions with Closed-Wedge Osteotomy of the Distal Radius: Report of Six Cases

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Abstract

Background The ideal treatment of nonunion of the scaphoid remains unresolved and controversial. It was hypothesized that scaphoid nonunion could be treated successfully using a closed-wedge osteotomy of the distal radius which reduces the inclination of the joint surface and decreases the pressure between the radial and scaphoid surfaces with a reduction of the force applied by the styloid process. We present a preliminary report in six patients with nonunion of the carpal scaphoid using this procedure. The main objective of the osteotomy is to achieve fusion, alleviate pain, and improve function.

Materials and Methods Six closed-wedge osteotomies to reduce the inclination of the distal radial surface were performed in patients with scaphoid waist nonunion and a viable proximal pole, without posttrauma osteoarthritis or with moderate posttraumatic osteoarthritis confined to the radio-scaphoid joint. The present series of six patients (all men) were followed for at least 8 months (mean follow-up 14.2 months, range 8–21 months).

Results Solid union was achieved in five patients. Postoperatively, three patients were pain-free, two presented mild pain for heavy work, and one had moderate pain. This type of osteotomy reduced the inclination of the joint surface (radial angulation) 6.2° on average. There was an improvement in joint flexion from a preoperative mean of 40° to 52.5° at last follow-up, in extension from 40.8° to 66.7° , in radial deviation from 15° to 22.5° , and in ulnar deviation from 30.8° to 41.7° .

Conclusions This preliminary study suggests that a closed-wedge osteotomy of the distal radius could be an alternative approach for patients with scaphoid waist nonunion and a viable proximal pole, without posttrauma osteoarthritis or with moderate posttraumatic osteoarthritis confined to the radio-scaphoid joint. The number of cases was small; however, further studies with a much larger series are needed before routine use of wedge osteotomy in scaphoid nonunion can be recommended.

Keywords Radius osteotomy · Scaphoid · Nonunion · Carpal collapse

Introduction

Scaphoid nonunions are challenging because they may not always be symptomatic in their early stages, and the success rate of management decreases with the duration of the nonunion [2, 5, 9, 12]. The natural history of nonunions is an eventual carpal collapse and degenerative arthrosis, usually within 10 years.

The most frequent factors involved in the development of scaphoid nonunion are tenuous blood supply in the scaphoid (proximal pole), delay in diagnosis and treatment, fracture displacement/comminution, and inadequate immobilization or poor patient compliance.

The ideal treatment of nonunion of the scaphoid remains unresolved and controversial. Bone grafting with the use of supplemental fixation is recommended to treat established scaphoid nonunions. Vascularized grafts may also be useful for nonunions that fail to heal after adequate fixation and traditional grafting methods. Salvage procedures, such as radial styloidectomy, scaphoid excision with or without limited midcarpal fusion, proximal row carpectomy, and

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Table 1 Demographic data.

Case	Gender, age	Duration of nonunion (months)	Duration of Follow-up (months)
1	M, 32	18	8
2	M, 20	12	21
3	M, 27	24	10
4	M, 38	20	15
5	M, 25	19	18
6	M, 21	26	13

total wrist fusion, are reserved for cases with severe carpal collapse and arthrosis.

Papachristou et al. [7] proposed a closed-wedge osteotomy of the distal radius to treat painful posttraumatic osteoarthritis of the wrist resulting from nonunion of the carpal scaphoid bone.

We present a preliminary report in six patients with nonunion of the carpal scaphoid using this procedure. The main objective of the osteotomy is to achieve fusion, alleviate pain, and improve function.

Materials and Methods

Six closed-wedge osteotomies to reduce the inclination of the distal radial surface were performed in patients with scaphoid waist nonunion and a viable proximal pole, without posttrauma osteoarthritis or with moderate post-traumatic osteoarthritis (joint space narrowing and sclerosis without proximal pole deformity) confined to the radio-

scaphoid joint. The present series of six patients (all men) were followed for at least 8 months (mean follow-up 14.2 months, range 8–21 months). Other demographic data (age, gender, and duration of nonunion) are presented in Table 1.

Evaluation

Evaluation included three items: pain, wrist motion, and radiographic results. All patients were evaluated before and after osteotomy.

Pain scale [7]: 1=no pain, 2=mild exercise-induced pain, 3=moderate pain incompatible with the pretrauma activity level and requiring a change in occupational activity, and 4=severe persistent pain incompatible with permanent occupational activity.

Wrist motion was measured with a goniometer in the sagittal and frontal planes: extension, palmar flexion, radial inclination, and ulnar inclination (Fig. 1a,b,c, and d, respectively).

Radiographic Evaluation

Radiographs were made every 4 weeks for the first 6 months to assess union. Radiographs also were made at the latest follow-up evaluation. Union was considered to be present when there was no gap at the site of the former nonunion and bridging trabeculae were seen on the anteroposterior and lateral radiographs (Fig. 2).

Classification of nonunion: type I (“fibrous union”)= visible fracture line and neighboring sclerotic tissue without

Figure 1 Wrist motion: There was an improvement after the operation: **a** extension; **b** flexion; **c** radial inclination; **d** ulnar inclination.

Figure 2 **a** (Before osteotomy) Nonunion of the scaphoid with joint space narrowing between the distal end of the scaphoid and the radial styloid. **b** (After osteotomy) Bone fusion was achieved.

significant displacement of the fragments, type II (“pseudarthrosis”) = nonunion characterized by cyst formation, bone reabsorption, increased sclerosis, abnormal motion, displacement with dorsal angulation, and shortening.

On the anteroposterior radiograph, the radial angulation was measured as the angle between the long axis of the radius and the distal radius articular surface (Fig. 3). In order to assess the degree of collapse and lateral migration of the carpus, the method of Youm et al. [14] was followed (Fig. 4).

Surgical Technique

An open S incision was made laterally to allow two radial cuts toward the medial cortical directed toward the distal radio-ulnar joint. The first cut began 2 cm above the tip of the styloid process and directed toward the center of the distal radio-ulnar joint. The second cut was made in the same direction, 0.5 cm above the first cut. This removed a small lateral wedge (base = 0.5 cm) without affecting either the length of the radius or the function of the distal radio-ulnar joint. After removing the bony wedge, the osteotomy was closed by osteoclasis of the medial cortical and fixed with plate and two cortical screws (3.5 mm ϕ). This protocol was used for all patients. The radio-ulnar joint was left totally intact. No immobilization with arm–thumb spica cast was applied after surgery. Active hand and wrist motion was encouraged early.

Figure 3 Radial angulation (A): before (a) and after (b) osteotomy. Osteotomy reduced the inclination of the joint surface (radial angulation = 7°).

Figure 4 Carpal collapse and lateral migration: (a) before osteotomy and (b) after osteotomy. L1 Length of the third metacarpal, L2 carpal height, L3 ulna–carpal distance. Note: L2/L1 (carpal height ratio) normal value, 0.57–0.51; L3/L1 (ulna–carpal distance ratio) normal value, 0.33–0.27 [14].

Results

Solid union was achieved in five patients (four patients with nonunion type I and one patient with nonunion type II), and one patient (nonunion type II) had a persistent nonunion. Postoperatively, three patients were pain free, two presented mild pain for heavy work, and one had moderate pain.

This type of osteotomy reduced the inclination of the joint surface (radial angulation) 6.2° on average. None of the patients had carpal collapse and lateral migration of the carpus (carpal height ratio 0.52; ulna–carpal distance ratio 0.30) before and after the osteotomy (Table 2).

There was an improvement in joint flexion from a preoperative mean of 40° to 52.5° at last follow-up, in extension from 40.8° to 66.7°, in radial deviation from 15° to 22.5°, and in ulnar deviation from 30.8° to 41.7° (Table 3).

There was no postoperative complication and no reflex dystrophy. All radial osteotomies healed.

Table 2 Radial angulation, carpal height ratio, and ulna–carpal distance ratio.

Radial angulation		Carpal height ratio		Ulna–carpal distance ratio	
Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery
110°	105°	0.50	0.50	0.32	0.32
112°	105°	0.53	0.53	0.28	0.28
120°	115°	0.51	0.51	0.30	0.30
117°	110°	0.51	0.51	0.30	0.30
118°	110°	0.55	0.55	0.31	0.31
110°	105°	0.54	0.54	0.29	0.29

Table 3 Wrist motion.^a

Extension	Flexion	Radial Deviation	Ulnar Deviation
35°/70°	35°/50°	15°/25°	25°/40°
40°/65°	40°/55°	10°/20°	35°/40°
45°/65°	35°/50°	10°/15°	20°/35°
25°/60°	45°/55°	15°/25°	30°/45°
55°/70°	35°/50°	20°/25°	40°/50°
45°/70°	50°/55°	20°/25°	35°/40°

^a Joint motion before surgery and at last follow-up

Discussion

Scaphoid nonunion results in increased pressure in the radio-scaphoid joint, joint space narrowing and progressive degenerative changes, and it appears that a new articulation between the radial styloid, the distal end of the scaphoid, and sometimes the trapezium results.

If the ligamentous complex remains intact, a gradual relaxation of these intercarpal elements takes place, and instability and carpal collapse occurs. If there is associated ligamentous injury, this entire process takes place quickly.

The choices of treatment of scaphoid nonunion are numerous, varied, and often controversial. The only treatment that prevents the progression of scaphoid nonunion to osteoarthritis is early repair of the nonunion.

When a scaphoid waist nonunion is present with normal vascularity of the proximal pole, internal fixation and nonvascularized grafting is recommended. Scaphoid waist fractures with osteonecrosis of the proximal fragment can be managed with a vascularized bone graft.

Vascularized bone grafts are used for proximal pole nonunions and occasionally for scaphoid waist fractures with osteonecrosis or when traditional bone grafting has failed to achieve union.

Once significant radiocarpal or intercarpal arthrosis has developed because of a scaphoid nonunion, it is difficult to decide which treatment to adopt. Salvage procedures are needed to treat scaphoid nonunion advanced collapse (SNAC).

As the scaphoid collapses, the carpus rotates, with progression of arthritis that resembles the four stages of the arthritis from a scapholunate ligament disruption [1, 4, 6, 10, 11, 13]. Stage I shows beaking of the radial styloid. Stage II is marked by arthrosis of the radioscaphoid joint. Stage III occurs when the arthrosis extends to involve the capitolunate articulation. Stage IV is the presence of pancarpal arthrosis.

According to the classification for posttraumatic carpal collapse proposed by Krimmer et al. [4], two patients had stage II (corresponding with type II scaphoid nonunion), and the other four patients had scaphoid nonunion without

advanced collapse (corresponding with type I scaphoid nonunion).

The effect of osteotomy in relief of pain symptoms result either from a biomechanical factor (change in the pressure exerted on the radioscaphoid joint) [7], or by a biological factor [3]. These two mechanisms could be concomitant.

Papachristou et al. [7] emphasized the aspect of the stylo-radial process and the risk of impaction into the distal part of the scaphoid during certain wrist movements.

Closed-wedge osteotomy can stimulate, as in corticotomy, revascularization and trophicity. Pastacaldi et al. [8] published their concept of the treatment of scaphoid pseudarthrosis using a bone graft in 1987, harvesting the bone graft from a wedge osteotomy of the distal radial epiphysis and closing the osteotomy with staples. The good results were attributed to a biological factor (bone graft) and a biomechanical factor (modification of the wrist joint configuration).

After surgery, stable fusion was achieved in five patients (four patients with type I without SNAC pattern and one patient with type II, and stage II SNAC pattern). No radiographic bone fusion was observed in one patient with type II and stage II SNAC pattern. Wedge osteotomy reduces the pressure applied on the radio-scaphoid joint surfaces, (Giannikas), and could have a positive effect because it modifies the dynamics of the wrist, protects the joint surface of the scaphoid from a risk of impaction of the styloid process, and offers the same beneficial effects as styloidectomy.

This preliminary study suggests that a closed-wedge osteotomy of the distal radius could be an alternative approach for patients with scaphoid waist nonunion and a viable proximal pole, without posttrauma osteoarthritis or with moderate posttraumatic osteoarthritis confined to the radio-scaphoid joint. The number of cases was small; however, further studies with a much larger series are needed before routine use of wedge osteotomy in scaphoid nonunion can be recommended.

References

1. Garcia-Lopez A, Perez-Ubeda MJ, Marco F, Molina M, Lopez-Duran L. A modified technique of four-bone fusion for advanced carpal collapse (SLAC/SNAC wrist). *J Hand Surg [Br]* 2001;26:352–4.
2. Gelberman RH, Wolock BS, Siegel DB. Fractures and non-unions of the carpal scaphoid. *J Bone Jt Surg Am* 1989;71:1560–65.
3. Harrison MHM, Schajowicz F, Trueta J. Osteoarthritis of the hip: A study of the nature and evolution of the disease. *J Bone Jt Surg* 1953;35:598.
4. Krimmer H, Krapohl B, Sauerbier M, Hahn P. Post-traumatic carpal collapse (SLAC- and SNAC-wrist)-stage classification and therapeutic possibilities [German]. *Handchir Mikrochir Plast Chir* 1997;29:228–33.

5. Mack GR, Bosse MJ, Gelberman RH, Yu E. The natural history of scaphoid nonunion. *J Bone Jt Surg Am* 1984;66:504–9.
6. Moritomo H, Tada K, Yoshida T, Masatomi T. The relationship between the site of non-union of the scaphoid and scaphoid non-union advanced collapse (SNAC). *J Bone Jt Surg Br* 1999;81:871–6.
7. Papachristou G, Giannikas A, Liodakis C. Management of painful pseudarthrosis of the carpal scaphoid bone with closed wedge osteotomy of the distal radius: a prospective study with long-term follow-up. *Rev Chir Orthop Répar Appar Mot* 2004;90:714–21.
8. Pastacaldi P, Curini-Galletti F, Londini P. Distal radial epiphysis osteotomy and cortico-cancellous bone graft in the treatment of the carpal scaphoid pseudarthrosis. *Chir Mano* 1987;24:159–63.
9. Ruby LK, Stinson J, Belsky MR. The natural history of scaphoid nonunion: A review of fifty-five cases. *J Bone Jt Surg Am* 1985;67:428–32.
10. Sauerbier M, Bickert B, Trankle M, Kluge S, Pelzer M, Germann G. Surgical treatment possibilities of advanced carpal collapse (SNAC/SLAC wrist) [German]. *Unfallchirurg* 2000;103:564–71.
11. Sauerbier M, Trankle M, Linsner G, Bickert B, Germann G. Midcarpal arthrodesis with complete scaphoid excision and interposition bone graft in the treatment of advanced carpal collapse (SNAC/SLAC wrist): Operative technique and outcome assessment. *J Hand Surg [Br]* 2000;25:341–5.
12. Trumble TE, Clarke T, Kreder HJ. Non-union of the scaphoid: Treatment with cannulated screws compared with treatment with Herbert screws. *J Bone Jt Surg Am* 1996;78:1829–37.
13. Watson HK, Ballet FL. The SLAC wrist: Scapholunate advanced collapse pattern of degenerative arthritis. *J Hand Surg [Am]* 1984;9:358–65.
14. Youm Y, Mac Murtry RY, Flatt AE, Gillespi TE. Kinematics of the wrist. *J Bone Jt Surg Am* 1978;60:423–431.