



## Outcome of four-corner arthrodesis for advanced carpal collapse : Circular plate versus traditional techniques

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**Twenty eight patients with advanced carpal collapse (20 with scapho-lunate advanced collapse [SLAC] and 8 with scaphoid-nonunion advanced collapse [SNAC]) who were treated with a four-corner arthrodesis were reviewed ; 23 had a good or excellent outcome. The mean DASH score was 41. The flexion/extension arc decreased from 72° to 52°. Gripping force increased from 46% to 72%. The range of motion was better in those with a traditional fixation (K-wires or screws) compared to the newer circular plates. There was no significant difference concerning pain relief, gripping force and disability.**

**Keywords :** wrist ; limited arthrodesis ; carpal collapse ; four-corner ; scaphoidectomy.

excision of the scaphoid, replacement by a silicone spacer and fusion between the lunate, capitate, hamate and triquetrum (four corner fusion). Later on the spacer was omitted because of silicone synovitis. Fixation of the arthrodesis was done initially with K-wires. Later staples and Herbert® screws were used to achieve more rigid fixation. The circular (Spider®) plate subsequently became available and rapidly gained in popularity.

The purpose of this retrospective study was to evaluate the pain relief, functional outcome and the disability after this procedure. We also compared two methods of fixation : a circular plate versus a traditional fixation with Herbert screws and K-wires.

### INTRODUCTION

Since Watson and Ballet (24,25) described and graded scapholunate advanced collapse (SLAC) and Krakauer (13) later described scaphoid non-union advanced collapse (SNAC), there has been discussion about the treatment for those two common patterns of wrist osteoarthritis (OA). When conservative treatment fails, several surgical options are available : proximal row carpectomy (PRC), scaphoidectomy and four corner fusion, total wrist arthroplasty, wrist denervation and total wrist arthrodesis. Watson and Ballet (24), in describing the patterns of wrist osteoarthritis following scapholunate instability noted that the radiolunate joint is rarely involved in wrist OA. He proposed

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## MATERIALS AND METHODS

Between November 1998 and May 2007, 35 patients underwent four-corner arthrodesis at the wrist. Six patients were lost to follow-up. One patient with an osteoid osteoma of the scaphoid was excluded.

The other 28 patients were evaluated by the same observer. The mean age was 55.2 years (range : 28-74). Minimum follow-up was 12 months (range : 12-72), with an average of 29 months. Twenty dominant wrists and 8 non-dominant wrists were involved ; 20 SLAC and 8 SNAC-wrists.

One patient had Parkinson's disease, one patient had a contralateral hemiplegia with wrist arthrodesis. Two patients had Blatt capsulodesis before. Two patients had ipsilateral carpal tunnel release previously. Two scaphoid nonunions were treated with a bone graft, without success.

Fourteen patients were at work (10 blue collars and 4 white collars). Ten were retired and four were disabled for other reasons. The DASH-score (disability of the arm, shoulder and hand, Dutch language version (10)) and the PRWE (patient rating wrist evaluation) (15,16) were used to evaluate the outcome. The PRWE function score consists of 10 questions scored from 0 to 10 and the overall result is calculated and scored from 0 to 100. The PRWE pain score consists of five questions (scored from 0 to 50).

Physical examination included flexion, extension, ulnar deviation and radial deviation measured on both wrists with a hand held goniometer and compared with preoperative values. Grip force was measured with a Jamar® Dynamometer.



*Fig. 1.* — Fixation with Herbert screws

## Surgical technique

The wrist was approached dorsally and a ligament sparing capsulotomy was used to explore the carpus (2). The scaphoid was freed from adhesences and excised. The articular cartilage between the lunate, capitate, triquetrum and hamate bones was removed. A K-wire in the dorsal lunate was used as a joystick to correct the dorsal intercalated segment instability (DISI) and the correction was temporarily fixed. In twenty six cases we used the excised scaphoid as an autologous bone graft. In two cases, autologous cancellous bone from the iliac crest was used. Four different methods of fixation were used : Herbert® screws (11 cases) (Zimmer, Warsaw, IN, USA), K-wire (5 cases), staples (once) and Spider® plate (11 times) (KMI, San Diego, CA, USA). The wrist was immobilized for 6 weeks in a below-elbow cast.

## RESULTS

Nineteen patients had no pain during everyday activities, 4 patients had moderate pain and 5 patients had frequent pain during daily activities ; none had pain at rest. The mean preoperative range of flexion was 36° (range 5°-60°) (SD 13.8) ; it was 29° (range 10°-60°) (SD 12.5) at follow-up. The difference is significant ( $p = 0.052$ ) (t-test). The mean preoperative range of extension was 36° (range 5°-65°) (SD 16.3) ; it was 23° (range 0°-58°) (SD 11.9) at follow-up. The difference is significant, with  $p < 0.01$  (paired t-test).



*Fig. 2.* — Fixation with spider plate

Table I. — Summary of data (SD = standard deviation)

	Total Mean (SD)	Traditional fixation Mean (SD)	Spider plate Mean (SD)
Flexion preop.	36 (14)°	38 (15)°	29 (11)°
Flexion postop.	29 (12)°	33 (12.6)°	23 (9.8)°
Extension preop.	37 (16)°	40 (15)°	28 (16)°
Extension postop.	22 (12)°	20 (12 ;6)°	27 (10)°
Radial Deviation postop.	9 (5)°	9 (3.7)°	10 (6.8)°
Ulnar Deviation postop.	23 (10)°	25 (8.6)°	20 (11;2)°
Grip strength preop. (N = 16)	27 (9)kg	26 (7)kg	28 (12)kg
Grip strength postop.	24 (11.9kg)	23 (12.4)kg	23 (12)kg
Grip strength contralateral. side	34 (15)kg	35 (17)kg	28 (15)kg
DASH preop. (N = 14)	39 (21)	38 (25)	41 (16)
DASH postop.	38 (29)	35 (28)	41 (30)
PRWE (/100)	40 (28)	42 (27)	36 (30)
PRWE pain score (/50)	20 (14)	20 (13)	19 (15)

Mean preoperative grip strength increased from 47% to 72% postoperatively (not significant  $p = 0.13$ ). The mean absolute value postoperatively was 24 kg (SD 11.9).

The DASH score preoperatively was only available for 14 patients (mean 39) (SD 20.7). Mean score at follow-up was 38 (range: 2-98) (table I). Postoperative PRWE function score was 40/100 (range 0-96).

There were three complications : one pin tract infection, one articular surface perforation by a screw, one neurapraxia of the radial nerve. Of the 10 blue collar workers, 3 were on permanent compensation, 5 regained their original job, 2 had to switch to a lighter manual job.

Five patients needed secondary surgery : partial denervation in one, Sauvé-Kapandji operation in one, excision of the pisiform in one (protruding screw), trapeziectomy in one, carpal tunnel decompression in one.

There was no significant difference regarding pain, PRWE, DASH score and force between fixation with a circular plate compared to the more traditional fixation methods. Flexion was significantly better in the arthrodeses fixed with screws or K-wires compared to the circular plates (table I) ( $p = 0.05$ , t-test), extension was similar.

## DISCUSSION

Scaphoid excision and four-corner arthrodesis has been accepted as a reasonably good surgical treatment for some types of advanced osteoarthritis of the wrist, particularly for SNAC and SLAC (mainly grade III).

Most series are relatively positive about the outcome with this procedure. However persisting pain and dissatisfaction of a substantial percentage of the patients is surprising. The disability is not lower than following full wrist arthrodesis, but patients seem to prefer preservation of (some) motion.

The outcome in this series can be compared to previous surveys (table II) (1,3-5,7,9,11-13,17,21-24,26). The functional outcome is similar although there is still considerable pain. The DASH score reflects the subjective outcome. In our series it did not change significantly from preoperatively to postoperatively.

Comparison of the results in these series with those of proximal row carpectomy (PRC) and radiocarpal fusion indicate that proximal row carpectomy usually gives superior results, but the outcome following 4-corner fusion is similar to that of radiocarpometacarpal arthrodeses, while preserving a functional range of motion. This has been reported by several other authors (8,13,14,18,21,26).

Table II. — Review of recent literature (NA : not applicable)

Series	N	Follow-up (months)	Pain %	Force/CL %	Mobility		Pseudarthr. %
					F/E	UD/RD	
Watson (25)	20	24	10	82	82	44	5
Voche (24)	16	19	25	57	44,5	18	0
Ashmead (1)	100	48	15	82	72	36	3
Tomaino (22)	9	54,5	5	76	52	22	0
Wyrick (27)	17	26,5	35	74	67	26	17
Krakauer (14)	37	50	17	80	54	30	9
Dagregorio (5)	57	36	7	79	54	38	0
Bertrand (3)	17	40	35	59	70	35	5,8
Sauerbier (20)	36	25	23	65	54	45	/
Garcio Lopez (10)	16	39	19	55	61	32	/
Cohen (5)	19	28	12	71	81	31	5
Vance (plate) (23)	15	59	53	70	50	55	26
Vance (other) (23)	14	59	21	80	50	60	3
Chung (4)	10	12	30	NA	73	58	/
Kendall (12)	8	20	38	56	61	NA	63
Merrell (18)	26	46	28	82	61	NA	0
This series	28	29	19	72	58	33	/

The potential advantage of circular plates is to reduce the risk of pin tract infection which is present with K-wire fixation. Another advantage is the absence of protruding wires, which should be more comfortable. Herbert screws necessarily protrude through the articular cartilage and this damage can potentially cause discomfort. Neither this series nor other previously published series have demonstrated any advantage concerning pain reduction and disability with the circular plate compared to traditional fixation methods (6,20,22). In this series the flexion range was better with traditional fixation methods, but this did not influence the overall disability. The incidence of complications in terms of non-union seems to be higher. Compared to Herbert® screws, which are available in this country at a cost of 176 to 179 €, the circular plate is more expensive, at 583 €+ 37.5 € per screw. The value of circular plate fixation can be questioned for further use in routine cases.

## REFERENCES

1. Ashmead D, Watson K, Damon C *et al.* Scapholunate advanced collapse wrist salvage. *J Hand Surg* 1994 ; 19-A : 741-750.
2. Berger RA, Bishop AT, Bettinger PC. New dorsal capsulotomy for the surgical exposure of the wrist. *Ann Plast Surg* 1995 ; 35 : 54-59.
3. Bertrand M, Coulet B, Chammas M *et al.* [Four-bone fusion of the wrist : review of 17 cases at an average 3.4 years follow-up.] (in French). *Rev Chir Orthop* 2002 ; 88 : 286-292.
4. Chung KC, Watt AJ, Kotsis SV. A prospective outcomes study of four-corner wrist arthrodesis using a circular limited wrist fusion plate for stage II scapholunate advanced collapse wrist deformity. *Plast Reconstr Surg* 2006 ; 118 : 433-442.
5. Cohen M, Kozin S. Degenerative arthritis of the wrist : proximal row carpectomy versus scaphoid excision and four-corner arthrodesis. *J Hand Surg* 2001 ; 26A : 94-104.
6. Collins ED, Nolla J. Spider plate fixation : no significant improvement in limited wrist arthrodesis. *Tech Hand Upper Extrem Surg* 2008 ; 12 : 94-99.
7. Dagregorio G, Saint Cast Y, Fouque P. [Influence of the capitulate fusion angle on the functional result of Watson's procedure in 58 cases of established carpal collapse.] (in French). *La Main* 1998 ; 3 : 363-373.
8. De Smet L, Degreeef I, Robijns F, Truyen J, Deprez P. Salvage procedures for degenerative osteoarthritis of the wrist due to advanced carpal collapse. *Acta Orthop Belg* 2006 ; 72 : 535-540.
9. Garcia-Lopez A, Perez-Ubeda J, Marco F, Molina M, López-Duran L. A modified technique for four-bone fusion for advanced carpal collapse (SLAC/SNAC wrist). *J Hand Surg* 2001 ; 26-B : 352-354.

10. **Hudak P, Amadio P, Bombardier C.** Development of an upper extremity outcome measure : the DASH. *Am Ind Med* 1996 ; 29 : 602-608.
11. **Kendall CB, Brown TR, Millon SJ et al.** Results of four-corner arthrodesis using dorsal circular plate fixation. *J Hand Surg* 2005 ; 31-A : 903-907.
12. **Kirschenbaum D, Schneider L, Kirkpatrick W et al.** Scaphoid excision and capitulate arthrodesis for radioscaphoid arthritis. *J Hand Surg* 1993 ; 18-A : 780-785.
13. **Krakauer J, Bishop A, Cooney W.** Surgical treatment of scapholunate advanced collapse. *J Hand Surg* 1994 ; 19-A : 751-759.
14. **Krimmer H, Lanz U.** [Posttraumatic carpal collapse.] (in German). *Unfallchirurg* 2000 ; 103 : 260-266.
15. **MacDermid JC.** Development of a scale for patient rating of wrist pain and disability. *J Hand Ther* 1996 ; 9 : 178-183.
16. **MacDermid JC, Totterham V.** Responsiveness of the disability of the arm, shoulder and hand (DASH) and patient-rated wrist/hand evaluation (PRWHE) in evaluating change after hand therapy. *J Hand Ther* 2004 ; 17 : 18-23.
17. **Merrell GA, McDerott EM, Weiss AP.** Four-corner arthrodesis using a circular plate and distal radius bone grafting : a consecutive case series. *J Hand Surg* 2008 ; 33-A : 635-642.
18. **Nagy L, Buchler V.** [Is panarthrodesis the gold standard in wrist joint surgery ?] (in German). *Handchir Mikrochir Plast Chir* 1998 ; 30 : 291-297.
19. **Sauerbier M, Tranke M, Linsner G et al.** Midcarpal arthrodesis with scaphoid excision and interposition bone graft in the treatment of advanced carpal collapse (SLAC/SNAC wrist) : operative technique and outcome assessment. *J Hand Surg* 2000 ; 25-B : 341-345.
20. **Shindle MK, Burton KJ, Weiland AJ et al.** Complications of circular plate fixation for four-corner arthrodesis. *J Hand Surg Eur* 2007 ; 32 : 50-53.
21. **Tomaino M, Miller R, Cole I et al.** Scapholunate advanced collapse wrist : proximal row carpectomy or limited wrist arthrodesis with scaphoid excision. *J Hand Surg* 1994 ; 19-A : 134-142.
22. **Vance MC, Hernandez JD, Didonna ML, Stern PJ.** Complications and outcome of four-corner arthrodesis : circular plate fixation versus traditional techniques. *J Hand Surg* 2005 ; 30-A : 1122-1127.
23. **Voch Ph, Merle M. Voch Ph, Merle M.** [Four-bone arthrodesis of the wrist.] (in French). *Rev Chir Orthop* 1993 ; 79 : 456-463.
24. **Watson K, Ballet F.** The SLAC wrist : scapholunate advanced collapse pattern of degenerative arthritis. *J Hand Surg* 1984 ; 9-A : 358-365.
25. **Watson HK, Ryu J.** Evolution of arthritis of the wrist. *Clin Orthop* 1986 ; 202 : 57-67.
26. **Wyrick J, Sern P, Kiefhaber T.** Motion preserving procedures in the treatment of scapholunate advanced collapse wrist : proximal row carpectomy versus four-corner arthrodesis. *J Hand Surg* 1995 ; 20-A : 975-970.