Long-Term Results after Midcarpal Arthrodesis

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Abstract

Background and Purpose Midcarpal arthrodesis is a well-accepted treatment option for advanced carpal collapse. In this study, we retrospectively assessed survival, analyzed complications and reviewed the long-term follow-up after midcarpal fusion.

Materials and Methods The computerized medical records of 572 patients who had undergone 594 four-corner fusions between 1992 and 2001 were explored. Furthermore 56 patients with 60 midcarpal fusions were randomized for clinical and radiological follow-up at a mean of 14.7 years.

Results Forty midcarpal fusions (6.7%) had to be converted into complete wrist arthrodesis. The reasons were ongoing pain in spite of a well-healed midcarpal fusion (31) or nonunion (9). Sixty-three patients (11%) required revision surgery because of nonunion (22), hematoma (8), wound infection (3) or persisting pain (31). In clinical follow-up the mean Disabilities of the Arm, Shoulder, and Hand (DASH) score was 20.4. Pain at rest was infrequent, a mild increase with daily activity was complained of (mean visual analog scale [VAS] 3.3). The mean active range of wrist motion for extension and flexion, ulnar and radial deviation and supination and pronation reached 62.5%, 68.4%, 94.7%, and mean grip strength 84.9% of the unaffected side. All patients had radiographic abnormalities, with frequent evidence of osteoarthritis of the lunate fossa. Patients with preserved carpal height appeared to have less pain, better DASH scores and a better range of motion.

Conclusions The midcarpal arthrodesis is a long-lasting treatment option for advanced carpal collapse and has good long-term results.

Level of Evidence Level IV, Therapeutic study.

Keywords
- four-corner fusion
- long-term results
- midcarpal arthrodesis
- SLAC-wrist
- SNAC-wrist

The validation of reconstructive joint surgery requires long-term surveys that include late complication and assess survival. This holds true for limited wrist fusion. Midcarpal arthrodesis with scaphoid excision is a well-accepted surgical option for the treatment of an advanced carpal collapse due to scaphoid nonunion or scapholunate dissociation.[1] Despite early and intermediate good results, however, there is a paucity of data on the long-term outcome of midcarpal fusion.[2–7] The purpose of this study was to (1) assess survivorship, (2) analyze complications, and (3) review the long-term follow-up of a cohort of patients with advanced carpal collapse, who were treated with a midcarpal fusion with scaphoid excision at a single institution.

Materials and Methods

We conducted an institutional review board-approved retrospective study analyzing the outcome of all patients who underwent midcarpal fusion with scaphoid resection at the Clinic for Hand Surgery Bad Neustadt with a minimum 10 years of follow-up. In the period between February 1992 and December 2001, 594 four-corner fusions were performed

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in 572 patients. We reviewed the patient computerized medical and radiographic records and recorded information pertaining to their demographics, indication for surgery, and the number and type of subsequent surgical procedures. The computerized database allowed the identification of any complication that occurred during hospitalization or during the course of clinical follow-up.

When a midcarpal fusion was converted into a total wrist arthrodesis, it was deemed a failure, as opposed to nonunion of a midcarpal fusion that healed after revision surgery, in which the midcarpal fusion was deemed to have survived.

Additionally, 62 patients (66 wrists) with midcarpal fusions were randomized by external block randomization for a clinical and radiological follow-up. Of these 56 patients (60 wrists) agreed to return for postoperative evaluation at a mean of 14.7 years (range, 10 to 19 years, SD: 3) postoperatively. One patient had died. The remaining 5 patients declined to participate in the study for no other reason than being unwilling or unable to travel. When comparing patient characteristics (age, gender) and surgical data (indication, use of structural and non-structural bone graft, time of immobilization) between the 56 patients who returned for postoperative follow-up and the 516 patients whose data were obtained from medical record review, there was no noticeable differences except for follow-up (mean 14.7 years versus 13.6 years; $p = 0.005$). All other patient characteristics and surgical data were similar between the 56 patients who returned for postoperative follow-up and the 516 patients whose data were collected from medical record review.

At the time of clinical follow-up, the 56 patients who returned to the Clinic for Hand Surgery Bad Neustadt were evaluated by a single surgeon who was not involved in the patientś original surgery. Informed consent was obtained from all participants. The study protocol was approved by the local ethical committee. The evaluation consisted of a clinical history and physical examination, radiographs of the affected hand, and assessment with the DASH questionnaire, and a pain visual analog scale (VAS 1–10) to objectify pain, both at rest and in daily activity. We measured grip strength using a dynamometer on the third setting (Sammons Preston Inc., Bolinbrook, IL, USA), and range of motion (ROM) (wrist flexion, extension, radial and ulnar deviation, and forearm pronation and supination) with use of a small-joint goniometer. The patients were asked (1) whether they were satisfied after the midcarpal fusion, (2) whether the midcarpal fusion had an input on their work, and (3) whether they required analgesics.

Three authors (FN, MM, TP) independently reviewed the radiographs with respect to degenerative changes of the lunate fossa, carpal positioning, and bony healing, and other issues with a high inter rater reliability. The kappa values were calculated after Fleiss ($K > 0.8$). We examined the radiographs for any signs of retained scaphoid fragments, and ulnocarpal impaction. To classify degenerative changes the Knirk and Jupiter classification was used. The carpal height was assessed according to Youm.[8] We measured radiographic evidence of ulnar translocation according to Gilula and Weeks,[9] capitolunate alignment on the lateral radiograph and the scapholunate angle.

Operative Technique

The wrist was exposed through a dorsal approach, mobilizing the extensor retinaculum and opening the second and fourth extensor compartments. The terminal branch of the posterior interosseous nerve was resected. The scaphoid was excised and the articular cartilage between the capitate, lunate, hamate, and triquetrum was removed. Any carpal malposition was corrected followed by Kirschner wire (K-wire) fixation and iliac crest or distal radius bone graft, depending on surgeon's preference. Postoperatively the patients were immobilized in a short arm cast for 6 weeks with removal of the K-wires after 12 weeks.

Statistical Evaluation

Statistical significance of differential findings was analyzed by two-tailed unpaired Student's *t* test or if appropriate by a Fisher's exact test. Pain at rest and with daily activity was compared using a two-tailed, paired Student's *t* test. We constructed a Kaplan-Meier curve to track any midcarpal fusion failures over time. Findings were regarded as significant if *p* values were less than 0.05.

Results

Survivorship, Complications

The computerized medical records of all 572 patients with a total of 594 wrists treated with a midcarpal fusion and a minimum 10-years (mean 13, 6 years; range, 10 to 19 years; SD: 3) of follow-up were reviewed. There were 466 men and 106 women with an average age of 63 years (SD: 11.5). The indications for midcarpal fusion were a scapholunate advance collapse (SLAC) wrist in 280 wrists, a scaphoid nonunion advanced collapse (SNAC) wrist in 262 wrists, and an unclassified osteoarthritis of the wrist without involvement of the radiolunate joint in 52 wrists.

In 40 patients, 40 midcarpal fusions (6.7%) had to be converted to a total wrist arthrodesis. The reasons were ongoing pain in spite of a well-healed midcarpal fusion (31) and nonunion (9). Mostly total wrist fusions were performed in the second year after the initial operation (median second year, range: first to fourteenth year). ►**Fig. 1** shows the cumulative survival curve after a midcarpal arthrodesis. The patients with a nonunion following a midcarpal fusion required a total wrist fusion significantly more often than did patients without a nonunion ($p < 0.001$). The analysis otherwise did not reveal any significant impact of age, gender, source of the bone graft or type of indication for surgery. The characteristics of patients with or without a total wrist arthrodesis are compiled in ►**Table1**.

Sixty-six complications were observed in 594 midcarpal fusions, resulting in a complication rate of 11.1%. One patient developed a hematoma that required drainage and ultimately nonunion, which was treated by total wrist fusion. In two patients there was a laceration of an extensor tendon during the initial procedure (0.34%). Both were immediately repaired. 63 patients required a revision surgery. The indications for revision surgery were nonunion (22 = 3.7%), hematoma (8 = 1.4%), and wound infection (3 = 0.5%). As

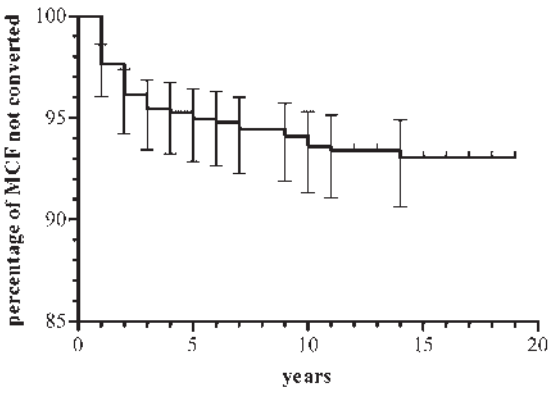

Fig. 1 Survival curve for midcarpal fusion (MCF) shown is the percentage of MCF not converted as a function of time. Bars represent 95% CI.

Fig. 2 AP and lateral x-ray views revealing advanced radiolunate arthrosis 15 years after a midcarpal fusion. Shown is a severe degenerative arthritis of the lunate fossa and regenerated bone in the resection cavity. The carpal height was preserved (Youm index = 0.54).

reported, 31 patients required a total wrist fusion because of persisting pain that could not be managed by conservative means.

Clinical Results

The clinical part of the study included 56 randomized patients (60 midcarpal fusions) out of the 572 patients. They consisted of 49 men and 7 women, with an average age of 65.9 years (standard deviation: 9.3). The indications for midcarpal fusion were SLAC wrist in 31 wrists, SNAC wrist in 27 wrists, and unclassified osteoarthritis of the wrist joint without involvement of the radiolunate joint in 2 wrists. The dominant hand was affected in 34 patients (60.7%) and the nondominant hand in 18 patients (32.1%). Four patients had a bilateral midcarpal fusion (7.1%).

After an average follow-up time of 14.7 years (SD: 3), the mean DASH score was 20.4 (range: 0–78.3, SD: 18.3). Pain at rest was infrequent with a mean VAS pain score of 1.4 (range: 0–6). More common was pain with daily activity with a mean VAS pain score of 3.3 (range: 0–8). The increase of pain under stress was statistically significant ($p < 0.001$). However, even patients with high pain level and a poor DASH score declared that they would undergo surgery again. All the patients were satisfied overall with the operative result and had less pain than before surgery. Only one patient (1.8%) sometimes needed painkillers because of the affected wrist. Two had to retire early; four had to change their job because of an unrelated disease or because of the impairment after a midcarpal fusion.

On the affected wrist, mean active range of wrist extension and flexion was 63.4° (SD: 17.1) or 62.5% of the opposite unaffected sides. The mean active range of wrist ulnar and

Table 1 Conversion into complete arthrodesis—patient characteristics

	All MCF ($n = 594$)	Complete arthrodesis ($n = 40$)	No complete arthrodesis ($n = 554$)	*p*-Value
Age (mean)	63.0	60.3	63.1	n.s ($p = 0.134$)
Female	108	9	99	n.s ($p = 0.523$)
Male	486	31	455	n.s ($p = 0.523$)
Radius bone graft	345	24	321	n.s. ($p = 0.869$)
Iliac creast graft	249	16	233	n.s. ($p = 0.869$)
SNAC	262	15	247	n.s ($p = 0.724$)
SLAC	280	19	261	n.s ($p = 0.724$)
Nonunion	22	9	13	***($p < 0.001$)**

Abbreviations: MCF, Midcarpal fusion; n.s., not significant; *, significant difference ($p < 0.05$).

Table 2 Radiological findings compared with clinical data

		VAS rest	VAS stress	DASH	AROM E/F	AROM U/R	AROM S/P	Grip strength
Degenerativ arthritis of lunate fossa	Mild	2	3.5	22.3	58.2	29.2	155.8	97.2
	advanced	1.1	3.3	19,5	66.0	30.1	151.7	86.9
	p-Value	n.s. ($p = 0.051$)	n.s. ($p = 0.680$)	n.s. ($p = 0.606$)	n.s. ($p = 0.099$)	n.s. ($p = 0.707$)	n.s. ($p = 0.405$)	n.s. ($p = 0.296$)
DISI	With	1.3	4.5	28.9	60.0	30.0	153.3	88.1
	Without	1.4	3.3	20.0	63.6	29.8	153.5	90.5
	p-Value	n.s. ($p = 0.937$)	n.s. ($p = 0.396$)	n.s. ($p = 0.420$)	n.s. ($p = 0.726$)	n.s. ($p = 0.972$)	n.s. ($p = 0.987$)	n.s. ($p = 0.911$)
Carpal height	Low	1.9	4.4	28.3	57.6	26.5	152.4	82.0
	Normal	1.2	2.9	17.3	65.7	31.2	153.9	93.6
	p-Value	n.s. ($p = 0.195$)	*(**$p = 0.029$**)	*(**$p = 0.036$**)	n.s. ($p = 0.101$)	*(**$p = 0.049$**)	n.s. ($p = 0.757$)	n.s. ($p = 0.253$)
Lateral lunatocapital shift	With	0.8	4.3	11.3	74.0	28.0	150.0	72.9
	Without	1.5	3.3	21.3	62.5	30.0	153.8	91.9
	p-Value	n.s. ($p = 0.398$)	n.s. ($p = 0.356$)	n.s. ($p = 0.256$)	n.s. ($p = 0,150$)	n.s. ($p = 0.614$)	n.s. ($p = 0.651$)	n.s. ($p = 0.253$)
Ulnocarpal translocation	With	1.1	3.5	14.5	66.8	31.8	160.0	87.2
	Without	1.5	3.3	21.7	62.7	29.4	152.0	91.0
	p-Value	n.s. ($p = 0.488$)	n.s. ($p = 0.759$)	n.s. ($p = 0.242$)	n.s. ($p = 0.470$)	n.s. ($p = 0.390$)	n.s. ($p = 0.184$)	n.s. ($p = 0.747$)
Ulnar impaction	With	1.2	3.7	23.5	61.8	31.1	147.7	93.8
	Without	1.6	3.1	18.6	64.3	29.1	156.8	84.4
	p-Value	n.s. ($p = 0.382$)	n.s. ($p = 0.378$)	n.s. ($p = 0.324$)	n.s. ($p = 0.586$)	n.s. ($p = 0.364$)	n.s. ($p = 0.056$)	n.s. ($p = 0.325$)
Partial nonunion	With	1.4	3.6	17.6	62.2	29.4	145.6	88.5
	Without	1.4	3.3	20.9	63.6	29.9	154.9	90.7
	p-Value	n.s. ($p = 0.970$)	n.s. ($p = 0.719$)	n.s. ($p = 0.625$)	n.s. ($p = 0.823$)	n.s. ($p = 0.882$)	n.s. ($p = 0.149$)	n.s. ($p = 0.867$)
Regenerated bone in resection cavity	with	1.4	3.4	19.7	62.8	28,8	155.8	92.7
	without	1.4	3.3	21.2	64.1	31.1	150.9	87.6
	p-Value	n.s. ($p = 0.886$)	n.s. ($p = 0.785$)	n.s. ($p = 0.752$)	n.s. ($p = 0.773$)	n.s. ($p = 0.289$)	n.s. ($p = 0.294$)	n.s. ($p = 0.584$)

Abbreviations: AROM, Active range of motion for extension/flexion (E/F), ulnar/radial deviation (U/R) and supination/pronation (S/P) (mean, degree); DASH-score (mean, points); Grip strength compared with opposite side (mean, percent); n.s., not significant; VAS, Visual analogue scale (mean, points 0 up to 10) at rest and under stress; *, significant difference ($p < 0.05$).

radial deviation was 29.8° (SD: 8.4) or 68.4% of the opposite unaffected sides. The mean active range of forearm supination and pronation was 163.5° (SD: 17.6) or 94.7% of the unaffected sides. Mean grip strength of the affected sides was 27.4 kg (SD: 11.4), or 84.9% of the unaffected sides.

Radiological Results

The radiological investigation included anteroposterior (AP) and lateral views of the affected wrist in the 56 patients. Radiographic signs of degenerative arthritis of the lunate fossa were found in 40 wrists (66.6%). In 17 wrists (28.3%) the carpal height was decreased. Ulnar translocation was seen in 11 wrists (18.3%). Malalignment of the fusion mass was seen in 5 wrists (8.3%) consisting of a lateral shift between the lunate and capitate. The lunate was fused in an extended position in 3 wrists (5%). 22 wrists (36.3%) showed obvious signs of an impaction between ulna head and carpus. Patients with a restored carpal height (Youm index > 0.51) had less pain ($p = 0.029$), better DASH-scores ($p = 0.036$) and greater active range of wrist motion ($p = 0.049$). Regenerated bone in scaphoid fossa was detected in over a half of the cases (53.3%). An incomplete fusion was detected in 9 cases (15%), involving either the hamate alone, or an incomplete fusion between the capitate and lunate, the hamate and triquetrum the hamate and capitate or the lunate and triquetrum.

The clinical data are compared with radiological findings in ►**Table 2**. Patients often had more than one radiographic abnormality; hence it is impossible to separate out the effect of each radiographic abnormality.

Discussion

Pain, dysfunction and posttraumatic arthritis are common sequels of scaphoid nonunion and scapholunate dissociation. If painful secondary conditions require further treatment, there are several surgical options. Total wrist fusion may yield predictable and lasting pain relief. Partial or complete wrist denervation preserves wrist motion and has a low morbidity, but has inconsistent results which usually deteriorate with time.[10,11] The value of a midcarpal fusion has been questioned because of the lack of published long-term outcomes. It was also theorized that there would be a high conversion rate to a complete wrist arthrodesis because of the load transmission which is concentrated in the lunate fossa after four-corner-fusion.[12]

In our retrospective study of 572 patients, a midcarpal fusion was a durable treatment option with a low complication rate. Age, gender and surgical indication were not significant predictors of the outcome. A midcarpal nonunion however had a high incidence of conversion to total wrist fusion and should be prevented at all costs.

Palmer et al postulated that a functional arc of wrist motion included 30° of extension 5° of flexion, 15° of radial and 10° ulnar deviation.[13] In this study, these criteria were achieved. An average DASH-score of 20.4 and nearly unimpaired grip strength leads to the assumption that the abilities of daily life are not restricted. Pain was uncommon, validated by the fact that only one patient sometimes needed analgesics because of the affected wrist.

In this study signs of degenerative arthritis in the lunate fossa were common as compared with previously published short- and mid-term studies.[4,14,15] The assumption is that the lunate fossa does progressively develop degenerative osteoarthritis over time. Patients with a restored carpal height appeared to have less pain, especially under stress, better DASH scores and increased ROM, but again this relationship cannot be determined with certainty because of the other confounding variables.

This study demonstrates that a midcarpal arthrodesis is a good long-lasting treatment option for SLAC and SNAC wrist. Shortcomings of this type of study include the inherent bias in a retrospective study, the lack of a control group and power analysis and the confounding variables may have contributed to the outcomes.

Note

The authors hereby declare that they have no conflicts of interest.

The study protocol was approved by the local ethical committee.

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