Quality of Life After Volar Plate Fixation of Articular Fractures of the Distal Part of the Radius

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Background: Outcome measurement following surgery is increasingly the focus of attention in current health-care debates because of the rising costs of medical care and the large variety of operative options. The purpose of the present study was to correlate quality of life after volar locked plate fixation of unstable intra-articular distal radial fractures with functional and radiographic results as well as with quality-of-life data from population norms.

Methods: Fifty-four consecutive patients with intra-articular distal radial fractures and a mean age of sixty-three years were managed with a volar locked plate system. Range of motion, grip strength, and radiographs were assessed at a mean of six years postoperatively. The wrist-scoring systems of Gartland and Werley and Castaing were adopted for the assessment of objective outcomes. The Disabilities of the Arm, Shoulder and Hand and Short Form-36 questionnaires were completed as subjective outcome measures, and the results were compared with United States and Austrian population norms.

Results: Functional improvement continued for two years postoperatively. At the time of the latest follow-up, >90% of all patients had achieved good or excellent results according to the scoring systems of Gartland and Werley and Castaing. The results of the Short Form-36 questionnaire were similar to the United States and Austrian population norms. The mean Disabilities of the Arm, Shoulder and Hand score was 5 points at two years, and it increased to 13 points at six years. The twenty patients with radiocarpal arthritis had significantly poorer results in the physical component summary measure of the Short Form-36 questionnaire ($p = 0.012$).

Conclusions: The results of the present single-center study show that, following distal radial fracture fixation, wrist arthritis may affect the patient's subjective well-being, as documented with the Short Form-36, without influencing the functional outcome. Well-designed longitudinal clinical trials are needed to confirm the findings of the present investigation in terms of quality of life after surgical treatment of intra-articular distal radial fractures.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Distal radial fractures are very common[1,2] and their incidence can be expected to increase with increasing life expectancy. Whereas most extra-articular fractures can be treated nonoperatively, anatomic reduction with stable fixation is the treatment of choice for displaced intra-articular fractures of the distal part of the radius[3-7]. The operative treatment goals are the prevention of radial shortening, malunion, and articular incongruity because these factors have been reported to be associated with poor outcomes and an increased risk of development of posttraumatic arthritis[2,3,8,9]. Over the past decade, there has been increasing interest in plate fixation, especially volar plate fixation, of distal radial fractures[5-7,10-14].

Traditionally, the results of treatment of wrist fractures have been evaluated on the basis of measures of impairment and abnormalities of physiological or anatomical structures, such as radiographic appearance, range of motion, and grip strength. Recently, there has been an increased emphasis on patient-rated outcomes, reflecting a global shift in how operative treatments are evaluated. Currently, there are a number of validated health measures that focus on general health and quality of life and that can be used for comparisons with the health status of the general population[15,16].

The purpose of the present study was threefold: (1) to correlate functional and radiographic outcomes after volar plate fixation of intra-articular distal radial fractures with the

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quality of life of the patient, (2) to compare the quality-of-life data for our patients with United States and Austrian population norms, and (3) to evaluate whether functional outcome continues to improve for two years or more following a fracture.

Materials and Methods

We conducted a six-year prospective single-center study of sixty-five consecutive patients with intra-articular distal radial fractures that were treated with a volar locked plating system (I.T.S. [Implantat-Technologie-Systeme], Lassnitzhoehe, Austria). Adult patients with an age of eighteen years or more and with acute AO type-C1, C2, and C3[17] fractures were considered for inclusion in the study. In addition to being an intra-articular fracture, the indications for surgical treatment included volar or dorsal fracture angulation of >10°, radial inclination of <15°, or an intra-articular step-off of >2 mm. Open and pathological fractures were excluded.

Patients

Of the sixty-five consecutive patients with complete intra-articular AO type-C fractures, eleven patients died or were lost to follow-up: five patients died of unrelated causes, one patient sustained an ischemic stroke and was unable to return for clinical follow-up, and five patients moved abroad and were lost to follow-up. Thus, the final study group consisted of fifty-four patients (seventeen men and thirty-seven women). The patients ranged in age from twenty-four to ninety-three years (mean, sixty-three years). The average age (and standard deviation) of the female patients (68 ± 16 years) was significantly higher than that of the male patients (50 ± 17 years) ($p < 0.001$). The dominant wrist was involved in twenty-seven patients; one patient sustained an extra-articular fracture of the distal part of the contralateral radius during the follow-up period.

All fractures were classified according to the comprehensive classification of long bone fractures (AO classification)[17] by the operating surgeon and were reviewed by a blinded radiologist (W.L.). In cases of disagreement, the two observers simultaneously reevaluated their initial ratings and arrived at a consensus decision. There were three surgeons (including one of the authors [K.G.]), each with at least ten years of experience in upper extremity trauma surgery. We classified the site and degree of comminution of the fractures as C1 (simple in both the articular and metaphyseal regions), C2 (simple in the articular region and comminuted in the metaphyseal region), or C3 (comminuted in the articular region). There were five C1, thirty-two C2, and seventeen C3 fractures. Eight fractures resulted from high-energy trauma, and forty-six resulted from low-energy trauma. Associated injuries included five cranial contusions and two cerebral concussions. Apart from four ulnar styloid fractures, there were no ipsilateral extremity fractures or ligament or tendon ruptures associated with the initial trauma. The median time between the injury and operative intervention was six hours (range, two to twenty-nine hours). Forty-four patients (81%) underwent surgery on the day of the injury.

Surgical Technique

Under pneumatic tourniquet control, the surgical site was approached through the sheath of the flexor carpi radialis, as previously described[12]. The flexor pollicis longus was retracted ulnarly and the pronator quadratus insertion was incised and elevated subperiostally from the radius, with care being taken not to divide the volar radiocarpal ligaments distally[18]. This approach offered exposure to both the extra-articular and intra-articular aspects of the fracture. The vast majority of fractures could be reduced with a combination of manual traction, hyperflexion, and manipulation with an elevator. Articular depression could be elevated by working through the fractured cortex. After reduction of the fracture, the fixed-angle plate was then applied so that the distal screws were placed 2 to 3 mm proximal to the subchondral bone. In cases of more difficult intra-articular fractures, provisional Kirschner wires were used to maintain the articular reduction before the plate was applied. The pronator quadratus was carefully closed over the plate. All operations were performed under fluoroscopic assistance. Bone grafts were not used.

After surgery, the wrist was immobilized continuously in a volar splint for four weeks. Active finger motion and forearm rotation were encouraged on the first postoperative day. After splint removal, all patients participated in a four-week structured hand-therapy program with formal sessions two or three days a week in addition to a home exercise program. The program included active and passive finger motion, hand and wrist edema checks, and active wrist motion exercises. Strengthening exercises were initiated six weeks after surgery.

Follow-up Examination

The patients were followed clinically and radiographically at four and twelve weeks routinely and at one, two, and six years postoperatively for study purposes. All physical examinations were performed by two of us (G.G. and C.G.), who were not involved in the initial care of the patients. Swelling, grip strength, sensation, tenderness, and range of motion of the wrist and forearm were evaluated. Grip strength was assessed with a Jamar dynamometer (Asimov Engineering, Los Angeles, California) and was compared with that of the uninjured hand. The range of motion of both wrists was measured in three planes (extension-flexion, radial-ulnar deviation, and pronation-supination) with use of a goniometer that was placed along the axis of rotation of the wrist joint.

The data were quantified with two scoring systems: the system of Gartland and Werley[19] and the system of Castaing[20]. The Gartland and Werley score is based on a demerit point system that involves a subjective evaluation of pain and an objective evaluation of wrist function. Demerit points are given on the basis of the presence of pain and a specific arbitrarily determined degree of loss of range of motion. Depending on the number of points scored, the outcome is classified as excellent, good, fair, or poor. The scoring system of Castaing comprises wrist function and radiographic data. Plain radiographs are used to measure volar tilt, radial inclination, radial length, and articular congruity. Depending on the number of

points scored, the outcome is classified as excellent, good, adequate, fair, poor, or very poor.

The radiographic data were assessed by an independent radiologist (W.L.) who was blinded to the clinical history and outcome for each patient. Standard plain radiographs (posteroanterior and lateral) were used to measure volar tilt, radial inclination, radial length, articular congruity, and posttraumatic arthritis. The degree of articular congruity was classified, on the basis of the magnitude of the step-off of the articular surface of the distal part of the radius, as grade 0 (no step-off), grade 1 (≤2 mm of step-off), or grade 2 (>2 mm of step-off). Posttraumatic arthritis was analyzed with use of the classification system of Knirk and Jupiter[3], with grade 0 indicating no arthritis; grade 1, slight joint-space narrowing; grade 2, marked joint-space narrowing and osteophyte formation; and grade 3, bone on bone, with osteophyte and cyst formation.

Follow-up measurements were compared with those on the immediate postoperative radiographs. For the comparison at the time of the six-year follow-up, plain radiographs of the uninjured wrist were made.

For patient-related outcome assessment, the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire[21] and the Short Form-36 (SF-36) questionnaire[15] were completed at the two and six-year visits, prior to the clinical examination. The DASH outcome measure consists of thirty self-reported questions designed to measure upper extremity disability and symptoms. The DASH score ranges from 0 to 100, with lower numbers indicating a lower level of disability. The SF-36 enables individuals to describe their health status from their own perspective. It can be used to compare the health status of different patients who have the same condition or treatments with the health status of the general population. The questionnaire is divided into a series of health and well-being categories, including eight subscales for health-related domains and two summary scores[15]. The eight subscales portray various domains of health and quality of life: physical function, role physical, bodily pain, vitality, general health perception, social function, role emotional, and mental health. The physical component summary and mental component summary scores represent the main dimensions of health. The answers are plotted on a 100-point scale. High scores equate to good health, and low scores equate to poor health. The physical domains of health and bodily pain are most conceptually relevant to distal radial fractures. Their good responsiveness has been reported[22]. The results of the SF-36 were compared with those for United States and Austrian age and sex-adjusted population norms.

All patients signed consent forms approved by the local university ethics board.

Statistical Methods

All baseline and follow-up parameters were described with standard descriptive statistics. Normally distributed data are presented as the mean and the standard deviation, whereas data with a nonparametric distribution are presented as the median and the range or the 95% confidence interval. Changes in continuous outcomes between follow-up investigations were evaluated with measures of analysis of variance and Friedman tests, followed by post hoc tests with a Bonferroni-corrected significance level with use of the Student t test or the Wilcoxon test where appropriate. Correlations were carried out with use of Pearson correlations for parametric data and Spearman correlations for nonparametric distributed data. All tests were two-sided, and the level of significance for all tests was set at $p < 0.05$.

Source of Funding

There was no external funding source.

Results

Objective Follow-up

There were no significant differences in terms of wrist motion between the two and six-year follow-up evaluations. Slight improvement in range of motion was observed between the one and two-year follow-up evaluations, but the difference was not significant. There were significant functional differences between the injured and contralateral sides in terms of radial deviation at the time of the six-year follow-up (25° ± 10° compared with 30° ± 9°; $p < 0.001$). The average ranges of motion at the time of the six-year follow-up, as measured on the injured and uninjured sides, were 58° ± 18° and 62° ± 13° of extension, 57° ± 11° and 60° ± 11° of flexion, 33° ± 10° and 36° ± 11° of ulnar deviation, 83° ± 14° and 85° ± 11° pronation, and 68° ± 20° and 70° ± 20° of supination, respectively.

TABLE I Differences Between the Sexes in Terms of Quality of Life at Six Years of Follow-up

	Male* (N = 17)	Female* (N = 37)	P Value
Castaing score *(points)*	1.8 ± 0.4	1.8 ± 0.6	0.911
Gartland and Werley score *(points)*	1.3 ± 0.8	1.5 ± 0.7	0.360
DASH score *(points)*	2 ± 3	17 ± 19	0.056
SF-36 score *(points)*			
Physical functioning	92 ± 22	74 ± 27	0.012†
Role physical	92 ± 24	71 ± 36	0.013†
Bodily pain	90 ± 16	74 ± 31	0.018†
General health	80 ± 19	66 ± 24	0.027†
Vitality	75 ± 24	64 ± 25	0.121
Social functioning	93 ± 24	90 ± 16	0.610
Role emotional	93 ± 24	86 ± 24	0.331
Mental health	83 ± 16	74 ± 15	0.047†
Physical component summary	55 ± 6	47 ± 13	0.002†
Mental component summary	47 ± 12	51 ± 12	0.308

*The values are given as the mean and the standard deviation.
†Significant.

TABLE II Comparison of Age Groups at Two and Six Years of Follow-up

	All	<60 Years	≥60 Years	P Value
Group characteristics				
No. of patients (% of total group)	54 (100%)	21 (39%)	33 (61%)	<0.001*
No. of female patients (% of total group)	37 (69%)	9 (17%)	28 (52%)	<0.001*
Group age† *(yr)*	63 ± 18	44 ± 10	75 ± 10	<0.001*
6-year follow-up				
Castaing score† *(points)*	1.8 ± 0.6	1.6 ± 0.6	1.9 ± 0.6	0.138
Gartland and Werley score† *(points)*	1.4 ± 0.7	1.2 ± 0.4	1.5 ± 0.8	0.029*
DASH score† *(points)*	13 ± 19	4 ± 8	20 ± 22	<0.001*
SF-36 score† *(points)*				
Physical functioning	80 ± 27	97 ± 7	69 ± 29	0.001*
Role physical	78 ± 34	92 ± 26	68 ± 35	0.006*
Bodily pain	79 ± 28	92 ± 17	71 ± 31	0.002*
General health	71 ± 23	82 ± 23	64 ± 21	0.005*
Vitality	68 ± 25	78 ± 23	60 ± 24	0.009*
Social functioning	91 ± 19	98 ± 11	86 ± 22	0.013*
Role emotional	88 ± 24	100 ± 0	81 ± 29	0.001*
Mental health	77 ± 16	83 ± 13	73 ± 16	0.018*
Physical component summary	50 ± 12	55 ± 9	45 ± 12	0.001*
Mental component summary	50 ± 12	48 ± 8	51 ± 14	0.389
2-year follow-up				
Castaing score† *(points)*	2.0 ± 0.4	1.8 ± 0.4	2.1 ± 0.4	0.008*
Gartland and Werley score† *(points)*	1.2 ± 0.5	1.0 ± 0.0	1.4 ± 0.6	<0.001*
DASH score† *(points)*	5 ± 10	3 ± 5	7 ± 12	0.030*
SF-36 score† *(points)*				
Physical functioning	81 ± 23	94 ± 8	73 ± 27	<0.001*
Role physical	70 ± 28	81 ± 27	62 ± 26	0.010*
Bodily pain	68 ± 29	80 ± 23	59 ± 29	0.005*
General health	67 ± 22	72 ± 20	63 ± 22	0.104
Vitality	56 ± 22	54 ± 18	56 ± 24	0.705
Social functioning	78 ± 27	78 ± 28	76 ± 28	0.823
Role emotional	73 ± 29	74 ± 31	70 ± 29	0.587
Mental health	69 ± 20	69 ± 19	69 ± 20	0.966
Physical component summary	49 ± 10	55 ± 7	45 ± 11	<0.001*
Mental component summary	47 ± 12	40 ± 12	51 ± 10	0.001*

*Significant. †The values are given as the mean and the standard deviation.

The average grip strength as measured with the Jamar dynamometer on the injured side was 71% ± 16% (range, 50% to 102%) of that on the uninjured side. The majority of patients (93%) were right-hand dominant, and in twenty-six patients (48%) the distal part of the radius on the dominant side had been fractured. Grip strength was significantly different between the injured dominant hand and the injured nondominant hand (86% ± 9% compared with 57% ± 6%; $p < 0.001$). The patient with the contralateral fracture was excluded from the measurement of grip strength. There were no significant differences regarding grip strength at one, two, or six years postoperatively.

At the time of the latest follow-up, fifty-one patients (94%) had a good or excellent result according to the Gartland and Werley score, and fifty patients (93%) had an excellent or good result according to the Castaing score. A comparison of the one, two, and six-year follow-up results revealed no significant differences between the scoring systems of Castaing and Gartland and Werley. We found no significant differences between male and female patients.

Subjective Follow-up

The mean DASH score was 5 ± 10 points at two years of follow-up and 13 ± 19 points at six years of follow-up ($p = 0.01$).

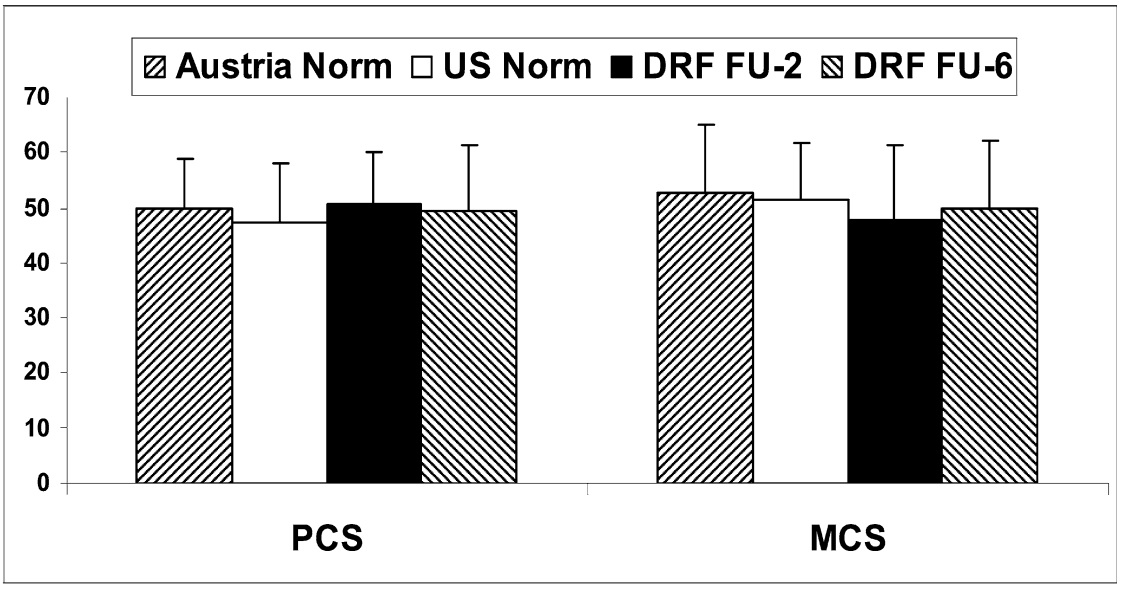

Fig. 1

Bar graph illustrating the results of the SF-36 at two and six years of follow-up (FU-2 and FU-6, respectively) and the United States (US) and Austrian population norms. PCS = physical component summary, MCS = mental component summary, DRF = distal radial fracture. The error bars indicate the standard deviation.

Differences between the sexes at the time of the six-year follow-up are listed in Table I. Patients who were less than sixty years old had better results in comparison with those who were sixty years old or more (Table II). The results of the SF-36 questionnaire at two and six years of follow-up were compared with sex and age-matched norms for the United States population[22] and with unpublished data for an Austrian control group. The only significant difference was observed between the bodily pain subscale at the time of the six-year follow-up and the United States norm (53 ± 12 compared with 48 ± 11; $p = 0.038$) (Figs. 1 and 2).

Seventeen patients (31%) with osteoporosis, diagnosed with dual x-ray absorptiometry, had poorer results in terms of the physical component summary (44 ± 11 compared with 52 ± 12; $p = 0.028$), general health perception (58 ± 23 compared with 76 ± 21; $p = 0.009$), and vitality (57 ± 24 compared with

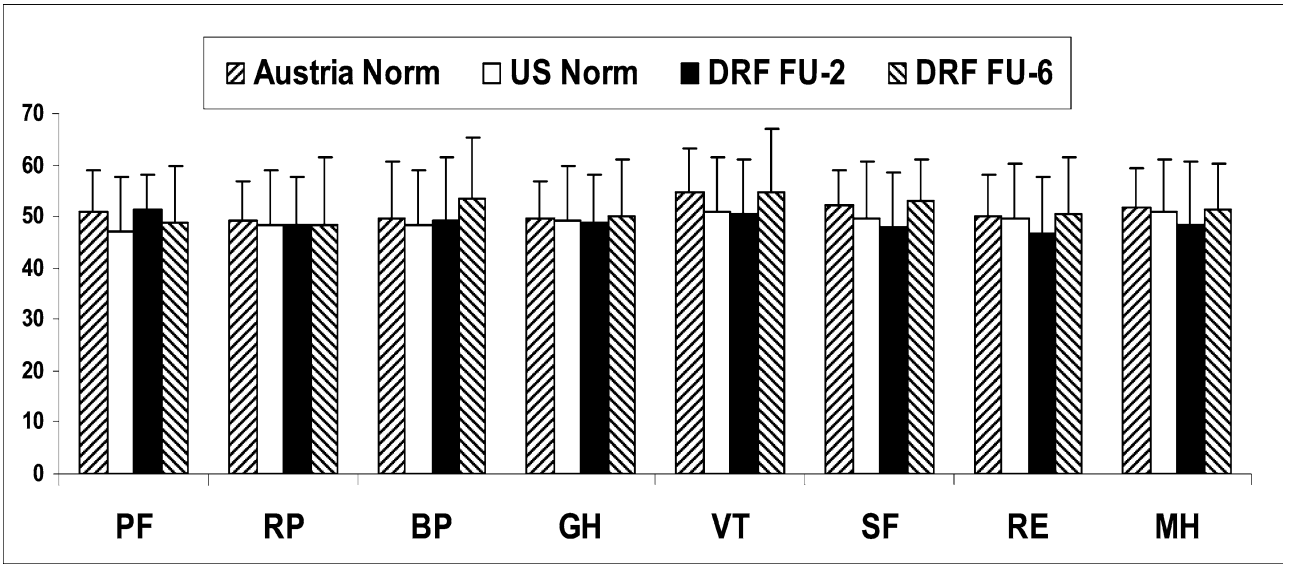

Fig. 2

Bar graph illustrating the United States (US) and Austrian population norms and the SF-36 subscales at two and six years of follow-up (FU-2 and FU-6, respectively). PF = physical functioning, RP = role physical, BP = bodily pain, GH = general health, VT = vitality, SF = social functioning, RE = role emotional, MH = mental health, and DRF = distal radial fracture. The error bars indicate the standard deviation.

72 ± 25; p = 0.044) domains of the SF-36 as well as in terms of the DASH score (25 ± 21 compared with 8 ± 16; p < 0.001).

Twenty patients (37%) with radiographic signs of arthritis had poorer results in terms of the physical component summary (45 ± 12 compared with 53 ± 10; p = 0.012), physical function (70 ± 29 compared with 88 ± 22; p = 0.020), role physical (68 ± 37 compared with 87 ± 28; p = 0.046), and general health perception (61 ± 25 compared with 78 ± 19; p = 0.012) domains of the SF-36 as well as in terms of the DASH score (21 ± 23 compared with 7 ± 13; p = 0.002). With the numbers studied, loss of reduction had no apparent influence on outcome as measured with the DASH and SF-36 scores. The DASH score correlated significantly with the mental component summary score at both two and six years (p = 0.002 and p < 0.001, respectively), showing that patients with lower DASH scores had better mental component summary scores. In contrast, the physical component summary score showed a highly significant negative correlation with the DASH score at two and six years (p < 0.001).

At the time of the six-year follow-up, the DASH score correlated significantly with the presence of radiocarpal arthritis, with higher scores for patients who had higher degrees of arthritis as determined for the dominant hand (p = 0.011), the injured side (p = 0.002), and the noninjured side (p = 0.015). When the latest results on the scoring systems of Gartland and Werley and of Castaing were correlated with the DASH score, patients with poorer clinical and radiographic results had significantly worse DASH scores (p < 0.001).

There was a significant positive correlation between seven of the eight subscales and the summary scores (p < 0.001 for physical component summary, p = 0.002 for mental component summary) of the SF-36 and the DASH scores (Table III).

TABLE III Comparison of Results of SF-36 and Other Scoring Systems*

	P Value			
SF-36	DASH	Gartland and Werley	Castaing	Arthritis Score (Injured Side)
Physical functioning	NS	NS	0.004	0.012
Role physical	<0.001	<0.001	0.015	0.041
Bodily pain	<0.001	0.001	<0.001	0.013
General health	<0.001	<0.001	0.003	NS
Vitality	<0.001	<0.001	0.006	NS
Social functioning	<0.001	<0.001	0.020	NS
Role emotional	<0.001	<0.001	0.022	NS
Mental health	0.006	NS	NS	NS
Physical component summary	<0.001	<0.001	<0.001	0.011
Mental component summary	0.002	NS	0.001	0.010

*NS = not significant (p > 0.05).

TABLE IV Differences in Knirk and Jupiter[3] Arthritis Score for Fractured Wrists Between Two and Six Years*

Grade	2-Year Follow-up	6-Year Follow-up
0	41 (75.9%)	34 (63.0%)
I	12 (22.2%)	17 (31.5%)
II	1 (1.9%)	3 (5.6%)
III	0 (0%)	0 (0%)

*The values are given as the number of wrists, with the percentage in parentheses.

Imaging Evaluation

The average volar tilt was 6° ± 5° immediately after surgery and 6° ± 7° at the six-year follow-up. The average radial inclination changed from 19° ± 4° to 17° ± 4°; the change in radial inclination was significant (p < 0.05).

In terms of congruity, forty-eight wrists (89%) had <1 mm of step-off at the distal radial articular surface, four (7%) had ≤2 mm, and two (4%) had >2 mm. We could not identify a significant correlation between wrist function and the latest radiographic alignment.

Posttraumatic arthritis was assessed on conventional radiographs at two and six years postoperatively with use of the four-grade system of Knirk and Jupiter[3] (Table IV). The average posttraumatic arthritis score increased significantly over the follow-up period (p = 0.006).

Complications

Five patients had a complication, for an overall complication rate of 9%. Two patients presented with extensor pollicis longus tendon ruptures resulting from prominent screw tips three and five weeks postoperatively. Both patients were successfully managed with extensor indicis proprius tendon transfers. Two other patients reported paresthesias in the distribution of the palmar cutaneous branch of the median nerve. One of these patients experienced paresthesias immediately postoperatively, and the other experienced paresthesias after plate removal, most likely as a result of traction during surgery. One of these patients was free of complaints five weeks after surgery, and the other was lost to follow-up. In the fifth patient, a sixty-one-year-old man, the plate loosened nine weeks after surgery as the result of a fall. The original plate was removed and was replaced.

At the time of the two-year follow-up, patients with complications had a median DASH score of 9 (range, 0 to 30) whereas patients without complications had a median DASH score of 5 (range, 0 to 78); this difference was significant (p = 0.006). At the time of the six-year follow-up, there was no longer any discernible difference between the two groups.

In five patients (9%), the plating system was removed at the patient's request after a mean of 36 ± 14 weeks. The patients who had been employed prior to injury (n = 26) were able to return to work at an average of 9 ± 5 weeks following

surgery. All of the remaining retired or unemployed patients (n = 28) had returned to the preinjury level of activity by the time of the one-year follow-up examination.

Discussion

The satisfactory results of the present study confirm what has already been described regarding functional outcome after volar plate fixation of AO type-C distal radial fractures[6,23,24]. When we compared the functional results at the two and six-year follow-up examinations, we could not identify significant differences. Our findings are similar to those of Goldfarb et al.[25], who compared seven and fifteen-year functional results after open reduction and internal fixation of intra-articular distal radial fractures and found no significant differences. Leung et al.[26] demonstrated that improvement in the clinical results following intra-articular distal radial fractures continues for at least twenty-four months; this finding was confirmed by Jupiter et al.[27]. In contrast, Kreder et al.[28] did not observe additional functional improvement more than one year after surgery. We observed only slight improvement of wrist function between the one and two-year follow-up examinations.

Following intra-articular distal radial fractures, there is a well-established correlation between the development of posttraumatic arthritis of the radiocarpal joint and residual displacement of articular fragments, as measured on plain radiographs[3,8,25-27,29-31]. Knirk and Jupiter[3], in an historic long-term follow-up study of forty-three intra-articular fractures, showed a high frequency (91%) of posttraumatic arthritis in patients with fractures that had healed with any degree of articular step-off. In their study, all patients (100%) who had an incongruity of ≥2 mm developed arthritis in the radiocarpal joint. Catalano et al.[29] reported a highly significant correlation between the extents of the step-off and gap displacement at the time of osseous union and the development of arthritis of the radiocarpal joint after an average of 7.1 years. Kreder et al.[29] found a 9.9-fold increase in the risk of wrist arthritis when there was persistent articular incongruity. At one year of follow-up, they did not report functional differences between wrists with and without radiocarpal arthritis, leading to the assumption that longer follow-up may demonstrate deterioration in function with the progression of arthritis. In a fifteen-year follow-up study of intra-articular distal radial fractures that were treated with open reduction and internal fixation, Goldfarb et al.[25] rebutted this hypothesis. Despite the presence and worsening of arthritis as documented with computed tomography over the years, wrist function did not correlate with the degree of radiocarpal arthritis. When we correlated wrist arthritis with quality-of-life scores, we arrived at different results: patients with radiocarpal arthritis had significantly poorer results in terms of the DASH score, the physical component summary score, and several subscales of the SF-36 (physical function, role physical, general health perception). This finding is consistent with the findings of Fernandez et al.[32], who reported that patients with arthritis had significantly lower physical component summary scores than those without radiocarpal arthritis. Our results show that wrist arthritis may very well affect patients' subjective well-being and quality of life without influencing the objective results.

The mean DASH scores of 5 points at two years and of 13 points at six years in our study reflect a low degree of upper-extremity disability and symptoms. A correlation of the DASH score with the Gartland and Werley and Castaing scores showed that patients with poorer functional and radiographic outcomes had significantly higher DASH scores ($p < 0.001$). Rozental and Blazar[5] reported a higher mean DASH score of 14 points at an average of seventeen months postoperatively. Ruch and Papadonikolakis[6] reported comparable results (mean, 12 points) at the time of the one-year follow-up. In a prospective multicenter trial, Jupiter et al.[27] reported a mean DASH score of 7 points at the time of the two-year follow-up, which was comparable with our findings. As most authors present mean values for the DASH score, comparisons with data from the literature have to be evaluated carefully because it is known that, given the construction of the DASH questionnaire, the results most likely appear in a nonparametric distribution. Because of the lack of longer follow-up studies involving the DASH score, we cannot contrast our six-year results with those of other investigations. Comparisons of the SF-36 with the DASH showed significant correlations in seven of eight subscales. We found that the DASH had a significant correlation with seven of the eight SF-36 subscales and a highly significant correlation with the physical component summary and the mental component summary at the time of the six-year follow-up. This finding supports the validity of the DASH questionnaire as a quality-of-life-measurement instrument for the long-term follow-up of distal radial fractures.

When the patients were divided into two age groups, those who were sixty years of age or older had significantly poorer Gartland and Werley, DASH, and SF-36 scores at two and six years. This finding might be explained by the relatively high mean age of seventy-five years in the older age group and the fact that aging goes along with a decrease in quality of life that might occur more quickly in the elderly[15]. When compared with age and sex-matched general populations in the United States and Austria, our study group as a whole scored favorably, with no significant differences in the DASH and SF-36 scores (apart from the bodily pain domain) at the two and six-year follow-up examinations, as similarly reported by Fernandez et al.[32].

The present study is unique in that we are not aware of any other study on volar plate fixation of AO type-C distal radial fractures that has evaluated two quality-of-life measures at two and six years postoperatively. We found that both the SF-36 and DASH instruments were easy to administer and to process, with patient scores being similar to those that have been published previously[27,32]. In contrast, MacDermid et al.[33] stated that the SF-36 was considered to be too lengthy and too difficult to administer and therefore was not readily accepted in upper extremity clinics.

The present study had several limitations. First, the fractures were not randomized, making an accurate comparison

with other operative treatment options impossible. Second, the measurement of articular displacement and the assessment and quantification of radiocarpal arthritis may be imprecise, even with the use of standardized radiographs. Computed tomography could have increased measurement accuracy and reliability. Another possible drawback might be the fact that all patients were managed by one of three senior physicians with long experience in hand surgery and with use of one single volar locked plate system. It remains unknown whether the results of the present study can be generalized to patients who are managed at other centers. Finally, the generality of the SF-36 and other self-administered quality-of-life instruments means that medical disorders other than the one under study may affect the results. For this reason, we believe that the use of region-specific disability measures remains essential. ■

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