A Prospective Randomized Trial Comparing Nonoperative Treatment with Volar Locking Plate Fixation for Displaced and Unstable Distal Radial Fractures in Patients Sixty-five Years of Age and Older

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Background: Despite the recent trend toward the internal fixation of distal radial fractures in older patients, the currently available literature lacks adequate randomized trials examining whether open reduction and internal fixation (ORIF) with a volar locking plate is superior to nonoperative (cast) treatment. The purpose of the present randomized clinical trial was to compare the outcomes of two methods that were used for the treatment of displaced and unstable distal radial fractures in patients sixty-five years of age or older: (1) ORIF with use of a volar locking plate and (2) closed reduction and plaster immobilization (casting).

Methods: A prospective randomized study was performed. Seventy-three patients with a displaced and unstable distal radial fracture were randomized to ORIF with a volar locking plate (n = 36) or closed reduction and cast immobilization (n = 37). The outcome was measured on the basis of the Patient-Rated Wrist Evaluation (PRWE) score; the Disabilities of the Arm, Shoulder and Hand (DASH) score; the pain level; the range of wrist motion; the rate of complications; and radiographic measurements including dorsal radial tilt, radial inclination, and ulnar variance.

Results: There were no significant differences between the groups in terms of the range of motion or the level of pain during the entire follow-up period ($p > 0.05$). Patients in the operative treatment group had lower DASH and PRWE scores, indicating better wrist function, in the early postoperative time period ($p < 0.05$), but there were no significant differences between the groups at six and twelve months. Grip strength was significantly better at all times in the operative treatment group ($p < 0.05$). Dorsal radial tilt, radial inclination, and radial shortening were significantly better in the operative treatment group than in the nonoperative treatment group at the time of the latest follow-up ($p < 0.05$). The number of complications was significantly higher in the operative treatment group (thirteen compared with five, $p < 0.05$).

Conclusions: At the twelve-month follow-up examination, the range of motion, the level of pain, and the PRWE and DASH scores were not different between the operative and nonoperative treatment groups. Patients in the operative treatment group had better grip strength through the entire time period. Achieving anatomical reconstruction did not convey any improvement in terms of the range of motion or the ability to perform daily living activities in our cohorts.

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

Distal radial fractures in elderly patients with osteoporosis are very common[1]. Considering the increasing life expectancy of the elderly population, the appropriate treatment of these fractures is of growing importance. Decision-making regarding the use of an operative or nonoperative approach is often based on the results of fracture treatment in much younger patients[2]. There is general agreement that there is a close relationship between the restoration of anatomy and function in younger patients[3].

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The current literature on the treatment of distal radial fractures in the elderly is more controversial. Stable fractures can be treated with closed reduction and cast immobilization, with satisfactory outcomes[4]. For unstable distal radial fractures, in which fracture reduction cannot be maintained with cast immobilization, additional fixation is suggested[5]. Some authors have even suggested that elderly patients with unstable distal radial fractures should be managed nonoperatively because fracture reduction and anatomic alignment on radiographs are not correlated with better functional outcomes in older patients as compared with younger patients[6-9].

Several case series have documented excellent results of internal fixation of dorsally displaced distal radial fractures with use of locking implants in elderly individuals[10-13]. We are not aware of any prospective randomized trials that have been carried out to further examine whether this treatment method is superior to nonoperative treatment in this cohort of patients. The purpose of the present randomized clinical trial was to compare the outcomes of two methods for the treatment of displaced and unstable distal radial fractures in patients sixty-five years of age or older who were living independently: (1) open reduction and internal fixation (ORIF) with use of a volar fixed-angle implant and (2) closed reduction and plaster immobilization (casting).

Materials and Methods

The trial was conducted at the Department of Trauma Surgery and Sports Medicine, Medical University Innsbruck (Level-I Trauma Center), Innsbruck, Austria. Institutional approval was obtained from the research ethics board prior to the initiation of the study. All patients provided written informed consent before their participation in the study. The study was registered as a clinical trial at the research and ethics department of the Medical University Innsbruck (registry number UN2576). Eligible patients (as described below) with unstable dorsally displaced distal radial fractures were randomized to operative or nonoperative treatment. The primary outcome measure was the Patient-Rated Wrist Evaluation (PRWE) score[14], and secondary outcome measures included the Disabilities of the Arm, Shoulder and Hand (DASH) score[15], the level of pain, the range of wrist motion, and the rate of complications. Our hypothesis was that there would be no difference between the operative and nonoperative treatment groups with respect to the PRWE score and objective surgeon-based functional measurements.

From 2005 to 2008, 347 patients with an age of sixty-five years or more who had a distal radial fracture were managed at our institution and were evaluated for eligibility. Of these, 248 patients did not match the inclusion criteria. Nine patients refused randomization, insisting on nonoperative treatment, and were excluded from the study. The remaining ninety patients (ninety fractures) met the inclusion criteria, agreed to participate, and were entered in the study. The mechanism of injury was a fall from a standing height in all cases. Forty-five patients were randomized to ORIF (the operative treatment group), and forty-five patients were randomized to casting (the nonoperative treatment group). Four patients in the operative treatment group and two patients in the nonoperative treatment group died of unrelated conditions before the latest follow-up examination and were excluded. Five patients from the operative treatment group and six patients from the nonoperative treatment group were lost to follow-up and were excluded. The remaining seventy-three patients (eighteen men and fifty-five women) with a mean age of 76.7 years of age (sixty-five to eighty-nine years old) completed the study. Thus, thirty-six patients in the operative treatment group and thirty-seven patients in the nonoperative treatment group were available for the one-year follow-up examination.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria and the indications for surgery are summarized in a table in the Appendix. In order to be included in the present study, a patient had to meet one or more of the inclusion criteria. Primary reduction of the fracture was considered to be acceptable when the dorsal radial tilt did not exceed 10°, radial shortening was not more than 3 mm, and any intra-articular step-off did not exceed 2 mm[6].

Patients with stable fractures were excluded from the study.

Sample Size Calculation

Before the study, a sample size analysis was performed. The sample size was chosen on the basis of the primary outcome of wrist function and the wrist scores utilized. We assumed an alpha error of 0.05 and applied an allocation ratio of 1. A sample size of sixty-eight participants was calculated to provide 80% power to detect a difference of 10 points in the PRWE score, which we consider to be clinically relevant.

Randomization

Initially, all fractures were reduced with the patient under local anesthesia and were fixed with a forearm plaster cast in the emergency department. Fracture reduction was performed either by a trauma resident or by a board-certified trauma surgeon. Radiographs were used to assess the fracture alignment after manipulation. All patients were evaluated at one week after reduction in the outpatient hand department. At that time, fracture reduction in all patients was reassessed with use of radiographs. Patients with initial inadequate reduction and patients with subsequent loss of reduction at the one-week follow-up examination who were identified as being eligible for the study (see Appendix) by a board-certified trauma surgeon (M.G.) were introduced to the study protocol at the one-week follow-up examination. The research nurse explained the workflow of the study. After the study nurse had obtained patient consent, the patients were randomized to either ORIF or nonoperative treatment with use of sequentially numbered, sealed envelopes.

Group Comparison

The demographic characteristics of the patients are summarized in Table I.

Operative Treatment

Patients who were randomized to the ORIF group had operative treatment within fourteen days after the injury. In twenty-five patients surgery was performed with use of a brachial plexus block, and in eleven patients surgery was performed with use of general anesthesia and an upper arm tourniquet. The distal part of the radius was exposed through a palmar approach along the flexor carpi radialis tendon. After the release of the pronator quadratus muscle, the fracture site was exposed. Fracture reduction was achieved with the assistance of an image intensifier, and the fracture site was temporarily stabilized with Kirschner wires. The volar fixed-angle plate (2.4-mm LCP DRP [Synthes, Salzburg, Austria] [n = 4] or DVR [Hand Innovations, Miami, Florida] [n = 32]) was placed on the volar radial cortex and was first fixed at the gliding hole to allow appropriate positioning for the image-controlled subchondral placement of the interlocking screws. If possible, the pronator quadratus muscle was reinserted to protect the flexor tendons. All surgical procedures were performed by experienced hand surgeons (R.A., M.L., M.G.) who determined the choice of implant. No additional bone grafting was used. After surgery, the wrist was immobilized in a below-the-elbow splint for pain reduction. The active digital range of motion was started immediately. Ten days after surgery, the sutures were removed and the wrist was placed in a removable splint for another week. At that time, physiotherapy with active and passive wrist mobilization out of the splint was started.

Nonoperative Treatment

No repeated manipulation was done for fractures that were treated nonoperatively. We believe that elderly patients with unstable distal radial fractures

TABLE I Demographic Characteristics

	Operative Treatment Group	Nonoperative Treatment Group
No. of patients	36	37
Age* *(yr)*	75.9 (65 to 88)	77.4 (65 to 89)
Sex†		
Female	28 (38.4%)	27 (37.0%)
Male	8 (11.0%)	10 (13.7%)
Dominant side†		
Right	34 (46.6%)	36 (49.3%)
Left	2 (2.7%)	1 (1.4%)
Injured side†		
Right	15 (20.5%)	20 (27.4%)
Left	21 (28.8%)	17 (23.3%)
Dominant side injured†		
Yes	15 (20.5%)	21 (28.8%)
No	21 (28.8%)	16 (21.9%)
AO fracture classification†		
A2	3 (4.1%)	3 (4.1%)
A3	7 (9.6%)	9 (12.3%)
C1	4 (5.5%)	11 (15.1%)
C2	12 (16.4%)	8 (11.0%)
C3	10 (13.7%)	6 (8.2%)

*The values are given as the average, with the range in parentheses. †The values are given as the number of patients, with the percentage of the total number of patients in the study group (N = 73) in parentheses.

do not benefit from remanipulation as the incidence of complex regional pain syndrome (CRPS) Type I is higher in such patients[5]. All wrists were immobilized in a short arm cast in a neutral position for five weeks. The active digital range of motion was started immediately. After cast removal, physiotherapy was started.

Outcome

All patients were assessed clinically and radiographically at six and twelve weeks and at six and twelve months after the fracture.

Functional Assessment

At each visit, a clinical examination was performed by an independent examiner who was not blinded to the method of treatment because the palmar scars in the operative treatment group could be easily observed. Functional assessment included the measurement of active wrist extension, flexion, pronation, and supination with use of a goniometer. Grip power was measured with a dynamometer (Jamar; Therapeutic Equipment, Clifton, New Jersey). All clinical values for the involved side were compared with those for the contralateral side. Wrist pain was evaluated with use of a visual analog scale (VAS) (with 0 representing no pain and 10 representing severe pain). The functional subjective outcome was measured with the DASH questionnaire (range, 0 to 100, with 0 as the best result) and the PRWE score (range, 0 to100, with 0 indicating that the patient was asymptomatic). The presence of an obvious clinical wrist deformity was recorded, and patients were asked whether the appearance of the wrist was bothersome. Patients were also asked with use of a simple yes-or-no question if they were satisfied with the end result of treatment.

An adverse event was defined as any event that necessitated another surgical intervention or additional medical treatment. Complications included loss of reduction, fracture malunion, and fracture nonunion as well as deep infection, neuropathy, tendon irritation, and tendon rupture. Complex regional pain syndrome was diagnosed on the basis of the presence of dysesthetic pain and hyperesthesia extending into the hand of the injured limb, vasomotor changes, skin atrophy, and diffuse osteopenia[16].

Radiographic Assessment

Standard anteroposterior and lateral radiographs were made and were evaluated with regard to radial dorsal tilt, radial inclination, ulnar variance, and intra-articular step-off immediately after surgery for the operative treatment group and immediately after closed reduction for the nonoperative treatment group. Follow-up radiographs were made at one week, six weeks, and twelve weeks and at six and twelve months for both groups. Fracture union was defined as bone bridging of the radial, ulnar, and dorsal cortical aspects of the distal part of the radius as seen on anteroposterior and lateral projections. Posttraumatic arthritis was classified with use of the system of Knirk and Jupiter[17]. The assessor of the radiographic outcome (C.D.) was not a treating surgeon and was blinded to the functional outcome but not to the method of treatment.

Statistical Methods

Metric-scaled data are reported as the arithmetic mean and the standard deviation or range, and categorical data are reported as the absolute frequency and the percentage distribution. A t test for independent samples or a nonparametric Mann-Whitney U test was performed for the determination of differences of mean values between the two treatment groups. The Kolmogorov-Smirnov test was used for the determination of the distribution form. For the analysis of categorical data, a Fisher exact test or a chi-square test was performed. The level of alpha was set at $p < 0.05$.

Source of Funding

There was no external source of funding for this study.

Results

Clinical Results

The clinical results are summarized in Table II. There were no significant differences between the two groups in terms of the range of motion or the level of pain during the entire follow-up period ($p > 0.05$; t test for independent samples). Patients in the operative treatment group had lower DASH and PRWE scores, indicating better wrist function, up to twelve weeks after surgery. The differences between two groups in terms of the DASH and PRWE scores were significant at six and twelve weeks ($p < 0.05$; t test for independent samples). There were no significant differences in terms of the DASH and PRWE scores at six and twelve months ($p > 0.05$; t test for independent samples). Grip strength was significantly better at all times for the operative treatment group ($p < 0.05$; t test for independent samples).

A clinical deformity that was obvious to the patient and the examiner (a prominent ulnar head) was present in twenty-nine patients (78%) in the nonoperative treatment group and in none of the patients in the operative treatment group. Despite the deformity, none of the patients in either the operative treatment group or the nonoperative treatment group was dissatisfied with the clinical appearance or function of the wrist.

TABLE II Clinical Outcomes

	Operative Treatment Group	Nonoperative Treatment Group	P Value
6 weeks			
Extension* *(deg)*	46 ± 15 (76.1%)	45 ± 15 (75.4%)	0.67
Flexion* *(deg)*	44 ± 13 (72.3%)	41 ± 11 (72.7%)	0.42
Supination* *(deg)*	75 ± 18 (88.6%)	73 ± 16 (85.4%)	0.61
Pronation* *(deg)*	81 ± 9 (96.0%)	77 ± 16 (91.3%)	0.21
Ulnar deviation* *(deg)*	26 ± 8 (76.3%)	26 ± 11 (73.0%)	0.78
Radial deviation* *(deg)*	18 ± 8 (84.1%)	19 ± 8 (81.4%)	0.86
Grip strength* *(kg)*	14.1 ± 5.5 (60.3%)	10.7 ± 5.6 (54.9%)	0.01
Pain at rest† *(points)*	0.3 ± 0.8	0.3 ± 0.8	0.97
Pain under stress† *(points)*	2.0 ± 2.0	2.5 ± 2.1	0.24
DASH score† *(points)*	18.8 ± 17.9	34.4 ± 22.5	0.00
PRWE score† *(points)*	36.4 ± 28.7	64.9 ± 29.0	0.00
12 weeks			
Extension* *(deg)*	51 ± 13 (85.6%)	52 ± 9 (87.4%)	0.88
Flexion* *(deg)*	47 ± 12 (80.0%)	49 ± 11 (81.4%)	0.49
Supination* *(deg)*	80 ± 14 (93.4%)	80 ± 12 (95.7%)	0.96
Pronation* *(deg)*	81 ± 13 (94.8%)	81 ± 12 (96.5%)	0.81
Ulnar deviation* *(deg)*	30 ± 10 (91.7%)	28 ± 10 (79.5%)	0.38
Radial deviation* *(deg)*	20 ± 7 (82.2%)	20 ± 7 (89.0%)	0.94
Grip strength* *(kg)*	15.7 ± 6.2 (77.1%)	12.5 ± 4.4 (58.3%)	0.02
Pain at rest† *(points)*	0.2 ± 0.7	0.3 ± 0.8	0.78
Pain under stress† *(points)*	1.4 ± 2.0	1.8 ± 2.0	0.40
DASH score† *(points)*	13.3 ± 14.8	23.2 ± 19.3	0.02
PRWE score† *(points)*	33.7 ± 32.0	54.4 ± 31.8	0.01
6 months			
Extension* *(deg)*	55 ± 11 (91.1%)	55 ± 12 (94.6%)	0.99
Flexion* *(deg)*	51 ± 10 (88.4%)	48 ± 13 (83.1%)	0.28
Supination* *(deg)*	83 ± 9 (97.1%)	79 ± 12 (93.7%)	0.13
Pronation* *(deg)*	84 ± 8 (99.3%)	81 ± 14 (96.3%)	0.20
Ulnar deviation* *(deg)*	33 ± 9 (98.3%)	30 ± 10 (88.8%)	0.20
Radial deviation* *(deg)*	20 ± 7 (83.8%)	21 ± 12 (109.2%)	0.51
Grip strength* *(kg)*	19.8 ± 7.4 (88.4%)	16.1 ± 5.6 (79.0%)	0.02
Pain at rest† *(points)*	0.6 ± 1.3	0.3 ± 1.0	0.30
Pain under stress† *(points)*	1.3 ± 1.7	1.0 ± 1.6	0.43
DASH score† *(points)*	12.2 ± 14.4	12.4 ± 17.0	0.94
PRWE score† *(points)*	27.7 ± 32.0	31.4 ± 33.0	0.63
12 months			
Extension* *(deg)*	59 ± 10 (94.4%)	61 ± 7 (106.6%)	0.14
Flexion* *(deg)*	55 ± 11 (91.1%)	57 ± 10 (100.7%)	0.50
Supination* *(deg)*	85 ± 8 (99.6%)	85 ± 8 (100.4%)	0.99
Pronation* *(deg)*	84 ± 7 (99.4%)	85 ± 8 (100.8%)	0.53
Ulnar deviation* *(deg)*	35 ± 8 (101.6%)	35 ± 8 (102.4%)	0.88
Radial deviation* *(deg)*	24 ± 6 (98.0%)	25 ± 7 (114.9%)	0.52
Grip strength* *(kg)*	22.2 ± 6.3 (102.4%)	18.8 ± 5.8 (92.6%)	0.02
Pain at rest† *(points)*	0.1 ± 0.3	0.1 ± 0.5	0.80
Pain under stress† *(points)*	0.7 ± 1.0	0.6 ± 1.4	0.80
DASH score† *(points)*	5.7 ± 11.1	8.0 ± 9.3	0.34
PRWE score† *(points)*	12.8 ± 23.2	14.6 ± 22.8	0.73

*The values are given as the mean and the standard deviation, with the percentage of the value for the uninjured side in parentheses. †The values are given as the mean and the standard deviation.

Radiographic Results

The radiographic results are summarized in Table III. Satisfactory primary closed reduction (defined as <10° of dorsal radial tilt, <2 mm of radial shortening, and <2 mm of articular incongruity)[18] was achieved in thirty-one patients (42%). In the remaining forty-two patients, dorsal tilt was not reduced satisfactorily for twenty-one fractures (50%) (including three AO type-A2 fractures, six A3 fractures, three C1 fractures, five C2 fractures, and four C3 fractures), radial shortening was not corrected for eight fractures (19%) (including two A2 fractures, three A3 fractures, and three C3 fractures), and reduction of the articular surface was not obtained for thirteen fractures (31%) (including two C1 fractures, four C2 fractures, and seven C3 fractures). Of the thirty-one patients who had initial satisfactory fracture reduction, twenty-one (68%) had a loss of reduction of the palmar tilt (involving one A2 fracture, four A3 fractures, seven C1 fractures, seven C2 fractures, and two C3 fractures), six (19%) had an increase of radial shortening (involving three A3 fractures and three C2 fractures), and four (13%) had a loss of reduction of the articular surface (involving three C1 fractures and one C2 fracture) at the time of the one-week follow-up examination.

For the operative treatment group, satisfactory reduction (defined as <10° of dorsal tilt, <2 mm of radial shortening, and <1 mm of articular incongruity)[18] was achieved intraoperatively for all fractures. At the time of the twelve-month follow-up examination, the average palmar tilt was 3°, the radial inclination was 21°, and the average ulnar variance was 0.7 mm.

At the time of the latest follow-up examination, malunion (defined as >10° of dorsal tilt, >2 mm of radial shortening, and >1 mm of articular incongruity) occurred in all patients (100%) in the nonoperative treatment group. At the time of the latest follow-up examination, dorsal tilt, radial inclination, radial shortening (ulnar variance), and intra-articular step-off were significantly better, and loss of reduction was significantly lower, in the operative treatment group as compared with the nonoperative treatment group ($p < 0.05$; t test for independent samples).

After six weeks, radiographic union was observed in thirty-five patients (97%) in the operative treatment group and in thirty-one patients (84%) in the nonoperative treatment group. The higher prevalence of delayed union in the nonoperative treatment group was not significant ($p > 0.05$; t test for independent samples). After twelve weeks, union was observed in all patients in the operative treatment group and in thirty-five patients (95%) in the nonoperative treatment group. All fractures healed within six months.

In the operative treatment group, nine patients (35%) with intra-articular fractures developed stage-1 osteoarthritis, four patients (15%) with intra-articular fractures developed stage-2 osteoarthritis, and three patients (30%) with extra-articular fractures developed stage-1 osteoarthritis.

In the nonoperative treatment group, twelve patients (48%) with intra-articular fractures developed stage-1 osteoarthritis, seven patients (28%) with intra-articular fractures developed stage-2 osteoarthritis, and four patients (33%) with extra-articular fractures developed stage-1 osteoarthritis. None of these patients with evidence of osteoarthritic changes reported any wrist pain.

TABLE III Radiographic Outcomes*

	Operative Treatment Group	Nonoperative Treatment Group	P Value
Palmar tilt *(deg)*			
Postoperative/after closed reduction	3.6 ± 6.9	–3.6 ± 11.2	0.00
Latest follow-up examination	3.0 ± 7.2	–10.4 ± 19.1	0.00
Loss of reduction	0.5 ± 4.7	6.9 ± 17.6	0.04
Radial inclination *(deg)*			
Postoperative/after closed reduction	21.8 ± 2.7	20.3 ± 3.3	0.04
Latest follow-up examination	21.2 ± 2.6	15.9 ± 9.0	0.00
Loss of reduction	0.5 ± 2.5	4.4 ± 7.9	0.01
Ulnar variance *(mm)*			
Postoperative/after closed reduction	0.6 ± 1.6	0.8 ± 1.7	0.57
Latest follow-up examination	0.7 ± 1.8	3.2 ± 2.9	0.00
Loss of reduction	–0.1 ± 1.5	–2.4 ± 2.6	0.00
Step-off *(mm)*			
Prereduction	0.5 ± 1.1	0.4 ± 1.1	0.79
Postreduction	0.2 ± 0.6	0.7 ± 1.2	0.02
Latest follow-up examination	0.2 ± 0.5	0.6 ± 1.1	0.04

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

Complications

Overall, there were significantly more complications in the operative treatment group than in the nonoperative treatment group (thirteen compared with five) ($p < 0.05$; Fisher exact test).

Thirteen patients (36%) from the operative treatment group had complications. No breakage of plates was observed. Five patients had extensor tenosynovitis because of screws that had penetrated the dorsal radial cortex. Four patients had development of flexor tenosynovitis, which was aggravated by the position of the plate on the palmar rim of the distal radial surface, distal to the watershed line. The watershed line is defined as a transverse ridge that demarcates the distal aspect of the concave surface of the palmar aspect of the radius. Distal to this line, the radius slopes in a dorso-distal direction and becomes prominent palmarly. These patients were managed with implant removal. In one patient, the extensor pollicis longus tendon ruptured after a locking screw penetrated the third extensor compartment. In this patient, the plate was removed and the extensor pollicis longus was reconstructed by means of a transfer of the indicis proprius tendon. Carpal tunnel syndrome was observed in one patient. In that case, the carpal tunnel was released and the plate was removed. Two patients in the operative treatment group and five patients in the nonoperative treatment group had development of type-1 complex regional pain syndrome; in all patients, the symptoms resolved after treatment with physiotherapy and oral analgesia. No other complication was observed in the nonoperative treatment group.

Discussion

Since the introduction of volar locking plates, there has been a shift in the surgical approach for the treatment of distal radial fractures in favor of ORIF[2].

In several studies, it has been suggested that there is a high correlation between the anatomical result and the functional outcome in young, active, and high-functioning patients. Malunion of distal radial fractures can result in posttraumatic wrist arthrosis and unsatisfactory functional outcome with a deformed and painful wrist[3,18,19]. Restoring articular congruity and radial length with ORIF is recommended for the treatment of distal radial fractures in younger patients[20-22].

There are fewer reports in the literature to support the goal of anatomical restoration of the articular surface and the radial length to achieve a satisfactory functional outcome in an older population.

Jupiter et al. evaluated twenty patients with an age of sixty years or more who were managed with ORIF with use of palmar locking plates for the treatment of redisplaced Colles-type distal radial fractures[23]. After an average duration of follow-up of thirty-eight months, they reported seven excellent results, eleven good results, and two fair results with use of the PRWE score and the Physical Activity Scale for the Elderly (PASE). Jupiter et al. reported that one patient had postoperative loss of reduction, one patient had transient neuritis of the radial sensory nerve, and one patient had a flexor pollicis longus rupture that was treated with a tendon transfer. Six patients had removal of the implant because of dorsal wrist pain. The authors suggested ORIF as a treatment for displaced distal radial fractures in older patients who have had a failure of nonoperative treatment.

Beharrie et al. reported on eighteen patients with an average age of seventy-one years who had displaced distal radial fractures that were treated with either a dorsal or a volar surgical approach[11]. Fifteen patients had an excellent result and three patients had a good result according to the Gartland and Werley scoring system. The mean DASH score was 4.4 points. No loss of fracture reduction was noticed. Four postoperative complications (one superficial skin infection, one pin-track infection, one case of mild extensor tenosynovitis, and one case of limitation of extensor pollicis longus tendon function) occurred. No patient required repeat surgical intervention. The authors recommended ORIF for elderly patients with displaced and comminuted distal radial fractures.

Young and Rayan evaluated the outcome of nonoperative treatment of distal radial fractures in patients with low functional demands who were more than sixty years old and found no correlation between unsatisfactory radiographic outcomes and functional outcomes[7]. Six of ten wrists with an intra-articular fracture had progression of radiocarpal and distal radioulnar joint arthrosis. Only two of these patients had an unsatisfactory outcome. Persistent neurological symptoms were present in three (12%) of twenty-five patients. An obvious clinical deformity (ulnar head prominence) was present in fourteen (56%) of the twenty-five patients. None of the patients were dissatisfied with the appearance of the wrist. According to the Gartland and Werley scoring system, twenty-two patients (88%) had an excellent or good result and three patients (12%) had a fair or poor result. One patient had development of complex regional pain syndrome (type 1).

Roumen et al. performed a prospective study of the treatment of distal radial fractures in patients older than fifty-five years[24]. All patients were managed initially with closed reduction and splinting. Two weeks after the reduction, 43% of the fractures had redisplaced (as indicated by a loss of >10° of dorsal angulation and >5 mm of radial shortening). Half of these patients were managed with external fixation and the other half of these patients had continued nonoperative treatment. The patients who were managed with external fixation had better radiographic results, but did not have better functional results, in comparison with the patients who were managed nonoperatively.

Egol et al. retrospectively compared the outcomes for patients over the age of sixty-five years in whom displaced distal radial fractures were treated operatively with plate fixation or external fixation (forty-four patients) or nonoperatively with cast immobilization (forty-six patients)[25]. At twenty-four weeks, patients in the operative treatment group had better wrist extension than those in the nonoperative treatment group. At one year, this difference was not seen. There was no difference between the groups in terms of the DASH or pain scores at any time during the follow-up period. Grip strength was significantly better in the operative treatment group at one year. The radiographic results were better for the operative treatment group at each follow-up visit. There was no difference

between the two groups with regard to complications. The authors concluded that minor limitations in the range of wrist motion and diminished grip strength, as seen with nonoperative treatment, did not limit function at one year. In the present study, ORIF with use of a volar fixed-angle plate was associated with better radiographic results in comparison plaster immobilization for the treatment of distal radial fractures. There were no malunions and there was only a minor loss of reduction in the ORIF group. At the time of the latest follow-up examination, malunion occurred in all fractures in the nonoperative treatment group. Palmar tilt, radial inclination, and ulnar variance were significantly better in the ORIF group at the time of the latest follow-up examination.

Although there were no significant differences between the two treatment groups in terms of the mean active range of motion at the time of the latest follow-up examination, patients in the operative treatment group had better grip strength through the entire time period. The final PRWE and DASH outcome scores were not significantly different between the two groups. This finding is similar to those described by other authors who have reported on the treatment of distal radial fractures in the elderly[8,26]. The lack of association between the radiographic and functional outcomes among the elderly could be explained by a decreased demand on the upper extremity associated with aging. It is questionable if a difference of 3 kg in grip strength is clinically important in this patient population[7].

In the present study, the prevalence of posttraumatic osteoarthritis in patients with intra-articular fractures was significantly higher in the nonoperative treatment group than in the operative treatment group ($p < 0.05$; t test for independent samples). This finding is similar to those of Knirk and Jupiter[17], who reported a radiographic prevalence of 65% in patients with intra-articular distal radial fractures who were followed for a mean of 6.7 years.

The limited one-year follow-up period in our study may have been too short to determine if the radiographic signs of osteoarthritis would be symptomatic. The presence of osteoarthritis, however, is not always associated with pain or functional disability[26]. At the time of the latest follow-up examination, thirty-nine (53%) of the seventy-three patients in our series had radiographic signs of arthritis, but none of them had any symptoms.

Overall, thirteen patients (36%) in the operative treatment group and five patients (14%) in the nonoperative treatment group had complications. In total, eleven patients (31%) in the operative treatment group had secondary surgical procedures. No patient in the nonoperative treatment group required surgery.

In contrast with other studies[6,7], only independent living patients and patients without systemic conditions who were able to travel on their own to the clinic for the follow-up visit were included in the present study. Dependent patients with low functional demands for daily living in whom fracture malunion may be better tolerated were not included in this study.

Volar fixed-angle plate systems have made plate osteosynthesis popular for elderly individuals with osteoporotic bones. However, at twelve months after surgery, the active range of motion, the pain level, and the PRWE and the DASH scores were not different between the operative and nonoperative treatment groups. Although patients in the operative treatment group had better grip strength through the entire time period, achieving an almost anatomical reconstruction did not convey any improved range of motion or better ability of daily living activities in our cohort.

Appendix

eA A table showing the inclusion and exclusion criteria is available with the online version of this article as a data supplement at jbjs.org. ■

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