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ORIGINAL STUDY

Functional evaluation of unstable distal radius fractures treated with an angle-stable volar T-plate

Serge AYONG, Alidou TRAORE, Didier POSTLETHWAITE, Olivier BARBIER

From Université Catholique de Louvain, Cliniques Universitaires St-Luc, Bruxelles, Belgium

Evaluation of the levels of function, disability and quality of life of 23 patients with an unstable fracture of the distal radius treated with an angle-stable volar T-plate. During the period from 24/10/2004 to 01/02/2006 we carried out a prospective study including 23 patients. The fractures were 23A22 (n = 5), 23C11 (n = 4), 23C12 (n = 4) and 23C13 (n = 6). Impairment, disability and quality of life were evaluated 6 months after the injury. The evaluation of impairment included assessment of mobility of the wrist, global hand strength, key pinch strength and sensibility. There was an average loss of 0.715 for the Zscore of the grip strength and 0.531 for the Z-score of the key pinch strength. For sensibility, there was no significant difference between the fractured side and the uninjured side. The radiographs demonstrated a correction of volar tilt from -11.2° to 4.9°, of ulnar inclination from 14.3° to 22.9°, of radial shift from 19.9 mm to 16.8 mm, of radial length from 5.7 mm to 11.2 mm and of the RUI from -1.9 mm to 0.6 mm. The global DASH score was 55.7. The level of pain was 1.3 on the VAS. The mental SF-12 score was 48.4 and the physical SF-12 score 46.4.

Treatment of unstable distal radius fractures with volar fixed-angle plates without additional bone graft led to good reduction of the fractures without significant secondary displacement

Keywords : volar plate ; functional ; distal radius fracture ; ability ; quality of life.

INTRODUCTION

Fractures of the distal radius are common injuries ; they account for 15% to 20% of all fractures (*23*). The majority of distal radius fractures (DRF's) are stable and there is a consensus that stable fractures should be treated with closed reduction and cast immobilization with a satisfactory outcome (*6*). Some DRF's are considered unstable or insufficiently reduced (*6*) and require additional fixation. Residual volar (*22*) or dorsal angulation of the distal radius affects carpal kinematics (*18*) and function (*19*). The aim of the treatment is to achieve an anatomical reduction and early mobilisation with a minimum of complications. Among the possible complications are hardware impingement, secondary displacement, irritation of tendons or nerves, and infection. Use of the volar surgical approach according to Henry has decreased the incidence of complications wich occured with the dorsal approach (*1,3,8,11,21*). A volar plate is indeed separated from the flexor tendons by the pronator quadratus muscle (*9*). The vascularization of the dorsal metaphysis is preserved. The intraoperative vision of the fracture is optimal and the reduction is easi-

■ Alidou Traoré, MD, Orthopaedic surgeon, Fellow.
■ Serge Ayong, MD, Orthopaedic surgeon.
■ Didier Postlethwaite, MD, Resident.
■ Olivier Barbier.
Cliniques Universitaires St-Luc, Université Catholique de Louvain, Bruxelles, Belgium.
Correspondence : Alidou Traoré, Department of Orthopaedic Surgery, Cliniques Universitaires Saint-Luc, 10, avenue Hippocrate, B-1200 Bruxelles, Belgium
E-mail : tralidou@yahoo.fr

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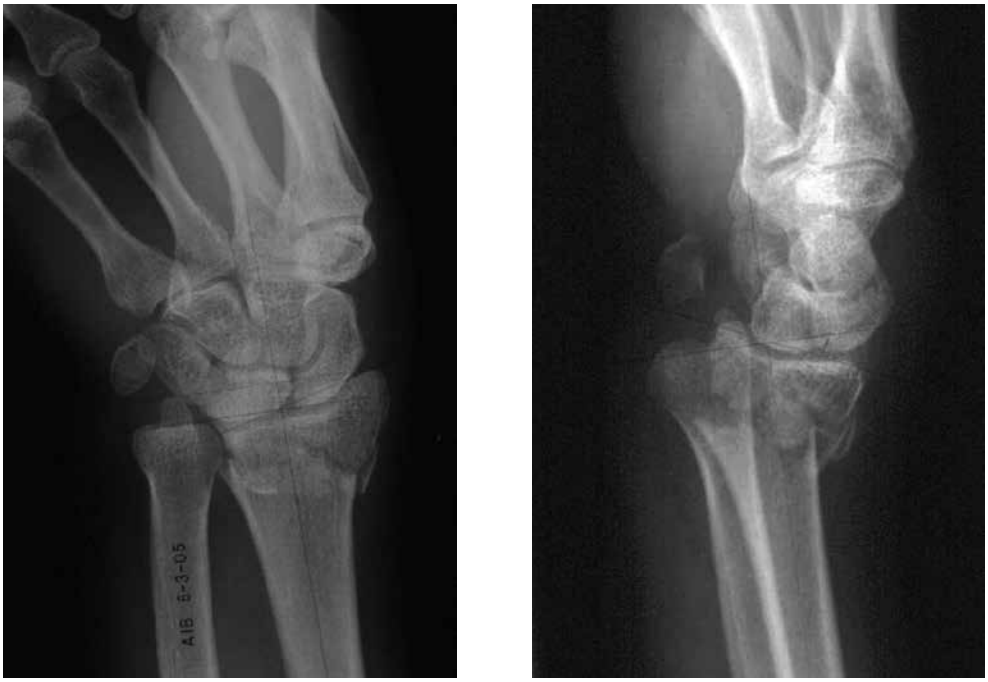

Fig. 1A-B. — Anteroposterior (A) and (B) lateral radiography at time of injury

er. The morphology of the volar aspect of the radius is more suitable for application of a plate, as compared to the dorsal aspect. In some cases the stabilization of the fracture is optimized by the use of a K-wire through the radial styloid. The use of screws locked into the plate gives an axial and angular stability which decreases the possibility of migration of the screws and prevents secondary displacement of the fracture. The plate used was the LCP® (Synthes) volar radial plate. The method provides sufficient fracture stability to allow for early mobilization of the wrist (*14*). Finallly, the trend to wider use of internal fixation with a locking-screw plate should be justified by an easy postoperative evolution with few complications and an excellent final result. These points are addressed by our study, which includes and evaluation of the levels of function, disability and quality of life according to WHO model (*2*).

MATERIALS AND METHODS

During the period 24/10/2004 to 01/02/2006 we carried out a prospective study including 23 patients. During this period, 4 patients could not be evaluated (2 living abroad, 1 for lack of comprehension and 1 dissatisfied with the billing price). The only inclusion criterion was the presence of an unstable fracture of the distal radius (Fig. 1A-B). A list of instability criteria can be defined from the literature (*14*) (Table I).

The average age of our patients was 61.7 years (range : 21-86) at the time of surgery. We had 6 men and 13 women ; 12 fractures were on the right side and 7 on the left side, with 9 on the dominant side and 9 on the non-dominant side ; 1 patient was ambidextrous The origin of the fractures was a fall in 16 cases, a sport accident, a motor vehicle accident and a suicide attempt in one case each. We classified the fractures according to AO/ASIF classification (*12*) : five fractures were type 23A22, 4 were type 23C11, 4 were type 23C12, 6 were type 23C13.

The time interval between the injury and plate fixation averaged 2.36 days (range : 0-15 days) with 10 patients operated on the day of the injury, 3 after one day, 3 after two days, one after seven days, one after 11 days and one after 15 days (patient under intensive care following a suicide attempt). No patients had median nerve symptoms before surgery. The patients were operated by 6 different surgeons. Fifteen patients had regional anaesthesia and 4 general anaesthesia. The surgical approach carried

Table I. — Criteria of unstable distal radius fracture (14)

1. Volar tilt angle less than -10° or greater than15°
2. Radial inclination angle less than 15°
3. Radial height less than 9 mm
4. Intra-articular step greater than 2 mm or gap greater than 2 mm
5. Intra articular comminution present
6. Severe dorsal comminution
7. Fracture redisplacement after initial acceptable reduction

out was according to Henry : incision between the tendons of the flexor carpi radialis and the brachioradialis, access to the radius through the pronator quadratus muscle. Excellent visualization of the fracture is possible. In several cases temporary percutaneous fixation with K-wires was performed after reduction, before placement of the volar T-plate. Fluoroscopy was performed to verify the anatomical reduction. No bone grafting was performed. The fracture was stabilized with a titanium plate with volar angulation and locking screws 3.5 mm in diameter (Synthes® Switzerland). The duration of immobilization was 4.63 weeks on average (range : 3-8 weeks) before commencing rehabilitation. Three patients required an additional K-wire on the radial styloid to increase stability. These K-wires were removed after 2 months.

For the evaluation of impairment, we analysed the range of motion at 6 months. We studied the grip force (Jamar) and the key pinch. We calculated the Z-score of each individual for each of these two items, by taking into account the account the hand dominance, its gender and its age, in order to compare this individual with an identical population. For sensibility we determined its level of detection and the distance for two-point discrimination. For the radiographic analysis (12), we measured the volar tilt (index of Friberg and Lundstrom, normal value 10°-12° ; range 4-22°), the ulnar inclination (index of Castaing, normal value, 22°-23° ; range 13°-30°), the radial shift (Van der Linden and Ericson), the radial length (Gartland and Werley, normal value 11-12 mm ; range 8-18 mm) and the RUI at the time of injury at 1 month (Fig. 2A-B) and at 6 months (Fig. 3). All the values are reported in comparison to the norm reported in literature in order to quantify the initial displacement and the capacity of the surgical procedure to obtain and maintain the reduction.

The ability in daily life was evaluated at 6 months using the self administrated ABILHAND and DASH questionnaires. The ABILHAND questionnaire was analyzed by the Rash method which permits to construct a scale for ability and to place patients and activities on it. The scale depends on the difficulty of the activity and the level of ability of the population studied. The values on the scale are expressed in logarithmic values (logit) with an ability of 2 logits being 2.7 times more important than 1 logit.

The health related quality of life was evaluated by the questionnaire SF-12. DASH and SF-12 analysed the patient performances and compared with the normal population (z-score). A high DASH score corresponds to a high disability whereas a high SF-12 score corresponds to a high health related quality of life. The normal population has a score of 50 with a SD of 10 for these two scores. We evaluated the pain with the VAS (scale from 0 to 10).

The data were treated with SigmaStat for Windows Version 2.03 (SPSS Inc.), which was used to analyse the data with basic statistics. The radiological evolution of each patient over time was analysed with a paired t-test. To measure the strength of association between pairs of variables, the Pearson Product Moment Correlation was used. We reported the functional values of the patients in comparison with the general population (Z-score for strength, sensibility, DASH and SF-12). A scale of linear measurement for manual ability was calibrated for our group of patients with the Rasch 1980 methodology (20). The data were computed with WINSTEPS Version 3.55.0.

RESULTS

Regarding mobility, by comparison with the healthy side, we have an average loss of 8.1° ($p = 0 < 0.001$) for flexion ; 12.1°($p < 0.001$) for extension, 8.9° ($p < 0.001$) for supination ; 5° ($p = 0.008$) for pronation (Table II). Regarding strength, Z-scores show an average loss of 0.715 for grip strength and 0.531 for key pinch strength.

Regarding sensibility, the Semmes-Weinstein's pressure detection test (gram) and the 2 points discrimination (2PD) test (mm) do not show significant difference between the fractured side and the healthy side.

Radiographic results show an average correction of +16° for volar tilt, +8.7° degree for ulnar inclination, -3.1 mm for radial shift, +5.5 mm for radial length, +2.5 mm for the RUI. Statistical analysis did not show secondary displacement (Table II).

The global DASH score was 55.7 (Fig. 4). Eight patients were able to perform without difficulty all

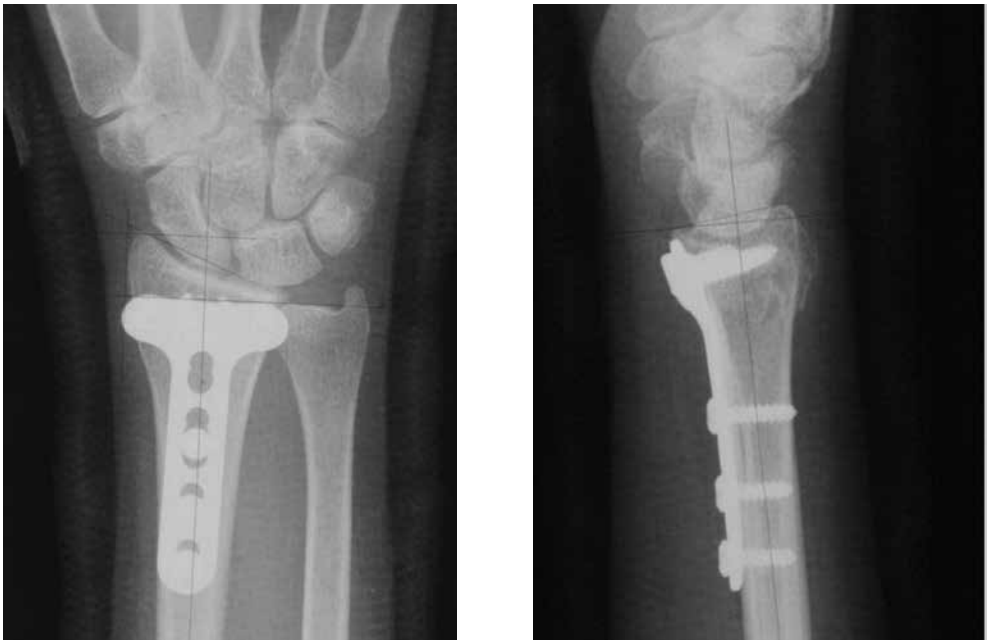

Fig. 2A-B. — Anteroposterior (A) and (B) lateral radiography at 1 month

the activities studied by the ABILHAND questionnaire. Eleven patients encountered some difficulties to perform more difficult activities (Fig. 5). The average level of pain was 1.3 (SD : 1.7) on the VAS with a scale from 0 to 10.

The quality of life score recorded with SF-12 was on average 46.4 for the physical level and 48.4 for the mental level (Fig. 6).

The relation between ABILHAND and DASH showed a good correlation between these two methods of measurements and analysis of ability with a correlation coefficient of -0.918 ($p = 0.0000000305$). However we noted no significant correlation between ability and quality of life evaluated by the SF12 questionnaire. There were no injuries to the median nerve, no infection and no wound disorder. There were 5 complications : 1 complex regional pain syndrome, 1 plate failure and 3 patients reporting pain from hardware impingement.

DISCUSSION

Since the first publications reporting the use of volar plates (7), it is accepted that these implants are very efficient for the stabilization of the unstable fractures of the distal radius. Many fixation techniques have been described for distal radius fractures. Recent advances in plate osteosynthesis have made this latter treatment increasingly popular. In comparison to other groups reported in literature and summarized in a systematic review (14), our patient group has a similar amount of intra-articular comminution 14/19 (74%), the mean age is higher, 62 years in comparison to 52 years. In that review, the grip strength was 0.77 after external fixation and 0.8 after internal fixation in comparison to the contralateral uninjured hand, with variable corrections for hand dominance among the articles. In our series, without correction, the grip strength on the injured side was 0.75 of the normal side. The dominant side was injured in 9 out of 19 cases. Wrist flexion was 55.7° after external fixation and 52.4° after internal fixation, compared with 69° in our group. Wrist extension was 55.4° after external fixation and 59.3° after internal fixation, compared with 62° in our group. Wrist supination was 75° after external fixation and 79° after internal fixation, compared with 74° in our group. Wrist pronation was 84.4° after external fixation and 78.5° after

Table II. — Results of Impairments

A Local functioning

FRACTURED SIDE				HEALTHY SIDE			p Value
Mobility	Value	Sd	Range	Value	Sd	Range	
Flexion(°)	68.9	12.2	40 to 90	77	10.7	55 to 90	<0.001
Extension(°)	61.58	13.65	40 to 85	73.68	9.256	55 to 85	<0.001
Pronation (°)	74.2	14.46	35 to 90	83.16	4.475	75 to 90	0.008
Supination (°)	80	7.8	65 to 90	85	5.53	65 to 90	<0.001
Strenght							
Z Grip Jamar	-0.849	1.137	-2.491 to 1.441	-0.134	1,349	-3,42 to 1,97	0,016
Z Key Pinch	-0.297	1.123	-3.199 to 1.713	0.234	1.605	-1.66 to 5.4	0.136
Sensibility							
Semmes Weinstein (gr)	0.233	0.472	0. 0275 to 2.052	0.111	0.265	0.023 to 1.194	0.273
2 PD Test (mm)	2.895	0.994	2 to 5	2.842	1.068	2 to 5	0.813

B. Radiographic anatomy

Day of injury		1 month		6 months			p Value (1 to 6 months)			
RX RESULTS	Value	SD	Range	Value	SD	Range	Value	SD	Range	
Volar tilt (°)	-11.2	17.013	-3.8 to 21	5.222	5.776	-8 to 12	4.895	5.999	-10 to 12	0.867
Ulnar inclination (°)	14.267	11.492	-18 to 30	22.5	3.959	12 to 28	22.947	3.659	14 to 29	0.723
Radial shift (mm)	19.93	1.3	12 to 33	17	2.679	12 to 22	6.895	2.622	12 to 22	0.905
Radial lenght (mm)	5.67	5.78	-5 to 16	11	3.272	4 to 16	11.158	3.167	5 to 16	0.882
RUI (mm)	-1.93	2.086	-5 to 2	0.556	1.854	-4 to 3	0.579	2.036	-5 to 3	0.5

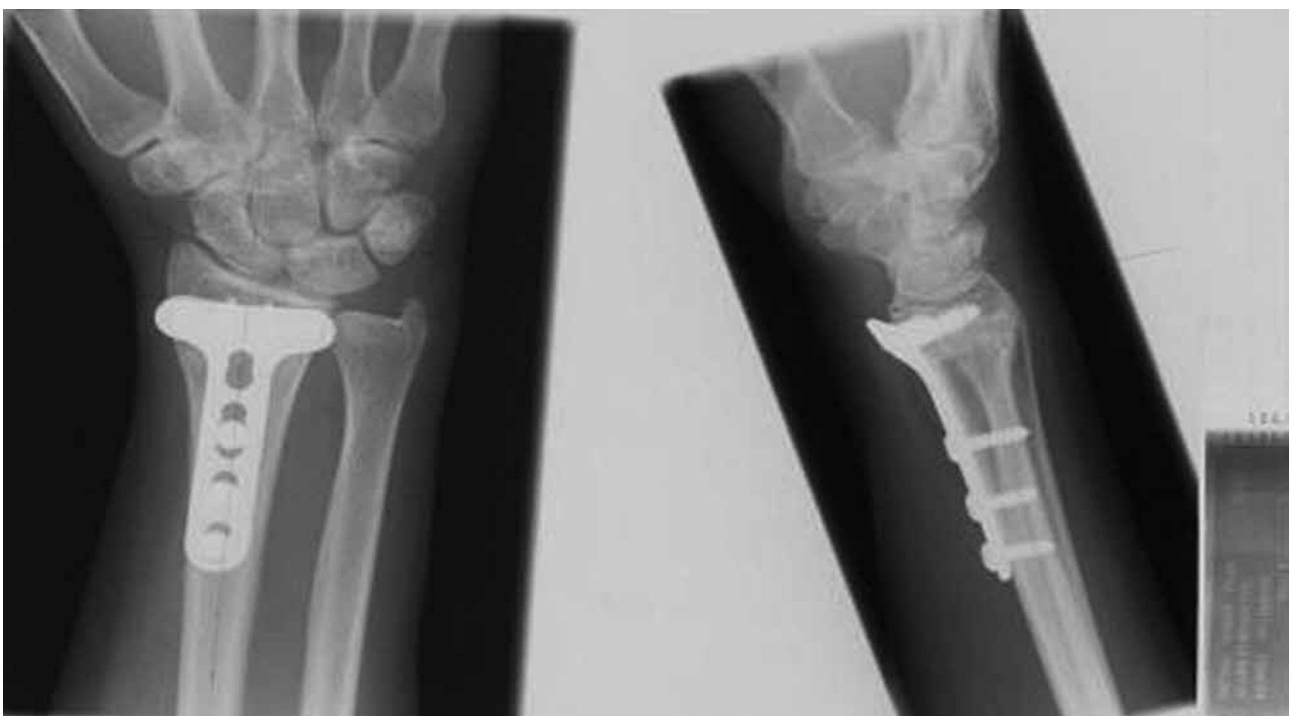

Fig. 3. — Anteroposterior (A) and (B) lateral radiography at 6 months

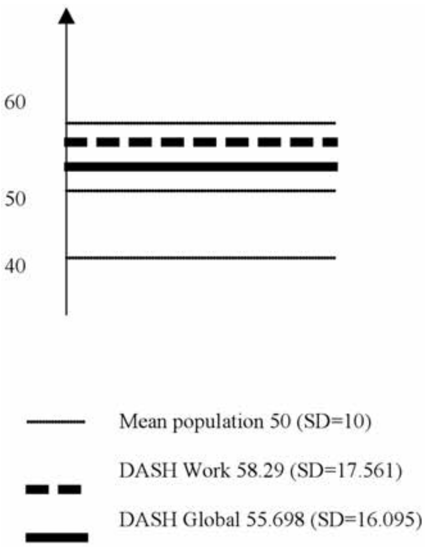

Fig. 4. — Results of disability : DASH-Score.

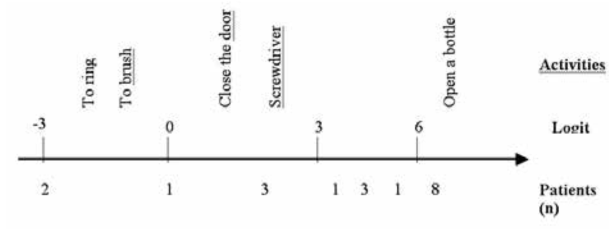

Fig. 5. — Results of Disability : ABILHAND.

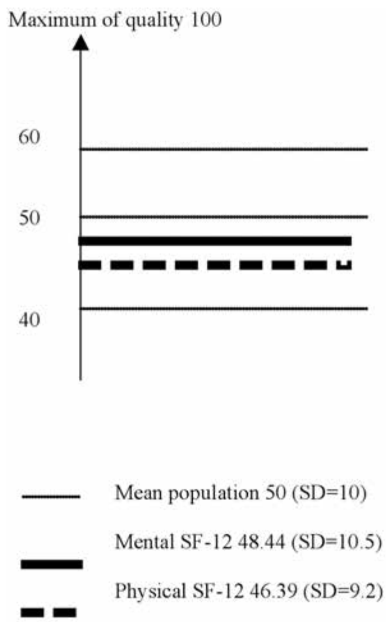

Fig. 6. — Results of the Health Related Quality of life SF-12.

internal fixation, compared with 80° in our group. With regard to the radiographic outcome, internal fixation usually leads to accurate and reproducible reduction with lower variability than external fixation (*15*). The results in our study are very similar to those reported in literature (*14*) regarding volar tilt : 4.89° (versus 4.6°) ; radial inclination : 22.95° (versus 21.1°) ; radial height : 11.16 mm (versus 11.16 mm) ; ulnar variance : 0.58 mm (versus 0.5 mm)).

Leung *et al* (*13*) demonstrated no signifiant difference between axial load transmission through the intact radius and through a distal radius fracture fixed with a volar locking plate. The surgical approach is simple and has less complications than the dorsal approach. Our results for the ROM were comparables with those Wong *et al* (*24*) and Orbay *et al* (*16*). Similar to Constantine *et al* and Kamano *et al* (*4,10*), none of our patients presented a type B fracture according to the AO/ASIF classification. The expected advantages of fracture fixation with a an angle-stable volar plate with angle stability are the ability to obtain an anatomic reduction of the fracture, a lasting stability, the ability to achieve bone healing without the need for grafting and the limitation of conflict with soft tissues. Our results support the hypothesis that fixation with an angle-stable volar plate without bone grafting can effectively achieve bone healing with anatomical reduction and without secondary displacement in unstable fractures of the distal radius. However, the high rigidity (*17*) of the construct with angular stability can lead to plate failure in case of delayed consolidation as observed in one in our series. We allowed mobilization at 4.6 weeks on average. We used the Z-score for the study of strength, taking account of dominance, gender and age of our patients and thus of being able to compare them with a comparable healthy population. The results show a diminution of strength in the fractured side of less than 1 standard deviation. Regarding the ability and health related quality of life, our patients are in the range of the normal population. We did not highlight of immediate relation between the impairments, disability and handicap. In all the cases an excellent anatomical result was obtained. Our study does not claim the best treatment for distal radius fractures but gives an evaluation of the outcome for distal radius fractures treated with recently developed plates for stabilisation according the international Classification of Functioning, Disability and Health (*13*).

CONCLUSION

Treatment of unstable, dorsally displaced fractures of the distal radius with volar fixed-angle plates without additional bone graft led to good reduction of the fractures without significant secondary displacement. The functional recovery was rapid and good. The technically simple palmar access and the fracture reduction were reproducible by the young surgeons in our training center. The complications were limited in comparison to other surgical techniques.

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