Comparison of external fixation, locking and non-locking palmar plating for unstable distal radius fractures in the elderly

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Abstract This study compares the effectiveness of locking and non-locking palmar plating and external fixation for unstable distal radius fractures in the elderly. In a retrospective match-paired study, 45 patients aged 50 to 70 years who underwent surgery for C1/C2 distal radius fractures were evaluated. The surgical procedures were external fixation or plating with locking or non-locking palmar plates. Radiological and functional outcomes were assessed. Outcomes according to Gartland and Werley, Martini and the Disability of the Arm, Shoulder and Hand (DASH) questionnaire were compared. The locking palmar plate fixation method demonstrated significantly better radiological and functional results in comparison to external fixation and the non-locking palmar plating methods. The subjective assessment of plate fixation proved to be better than that of external fixation. Complications and reoperations were fewer for both plate fixation groups. Our data indicates that most displaced intra-articular distal radius fractures can be treated successfully with the locking palmar plate.

Résumé cette étude a pour but de comparer les synthèses par plaques verrouillées ou non verrouillées ou la fixation externe pour fracture instable du radius distal, chez les personnes âgées. nous avons réalisé une étude rétrospective, comparative chez 45 patients âgés de 50 à 70 ans qui ont tous bénéficié d'une chirurgie après fracture du radius distal. Le traitement chirurgical a été soit une fixation externe soit une ostéosynthèse par plaque verrouillée ou non verrouillée. Les résultats ont été appréciés sur le plan radiologique et fonctionnel selon Gartland et Werley, Martini et le questionnaire Dash. la plaque palmaire verrouillée démontre à l'évidence un meilleur devenir fonctionnel et radiologique en comparaison à la fixation externe ou à la plaque palmaire non verrouillée. Les complications et les ré-interventions ont été moins importantes dans les deux groupes plaque. Ces données permettent donc de confirmer que la plupart des fractures de ce type peuvent être traitées avec succès à l'aide de plaques palmaires verrouillées.

Introduction

One of the most common injuries in elderly people is fracture of the distal radius. As the elderly often have osteoporosis, the distal fragment becomes unstable because the cortex is severely comminuted. A number of different surgical strategies are available for treating this type of fracture, such as external fixation or open reduction and internal fixation (ORIF) with locking or non-locking palmar plates. The use of external fixation on the basis of ligamentotaxis has produced good to excellent results [1]. Nevertheless, it is often necessary to revise the operation due to a loss in reduction [24]. Orbay and Fernandez [18] showed that most dorsally displaced distal radius fractures can be anatomically reduced and fixed using a palmar

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approach. Many new plates have been developed for the internal fixation of distal radius fractures [11, 20]. The locking plate technique overcomes the difficulty with the dorsal fragments and failure when a palmar plate is used for displaced distal radius fractures [10]. However, non-locking palmar plates are still used regularly for the fixation of these fractures. Although some studies [1, 18, 22, 24] have shown good to excellent results for various methods, the choice of the best option still remains controversial [5]. The aim of this retrospective clinical matched-pair study was to determine the most appropriate surgical treatment out of the three for unstable fractures of the distal radius in the elderly. The types of outcome measured included several anatomical, functional and clinical outcomes.

Materials and methods

Forty-five patients with distal radius fracture type C1/C2 and a mean age of 60 years (range 50–70 years) who underwent surgery with external fixation ($n=15$), locking ($n=15$) or non-locking palmar plates ($n=15$) were included in this study. The patients were matched according to the type of fracture (according to the AO classification in C1/C2), age (± 5 years) and sex. Patients with open fractures were excluded. The type of fracture was classified according to the AO classification and the patients were divided into three groups: those who underwent ORIF with palmar locking plate, those who underwent ORIF with a palmar non-locking plate and those with external fixation. Each group included 15 patients. The follow-up time needed to be at least 12 months. For patients with external fixation or palmar non-locking plate, the mean follow-up was 72 months (SD=12 months). For patients with palmar locking plates, it was 38 months (SD=8 months). The results were assessed by two examiners who collected data independently of each patient. The mean of both findings was used for the results. All fractures were initially reduced and immobilised in a plaster cast. If possible, the operation was performed on the day of injury. In all patients receiving external fixation, the Martini fixator (Gaedigk, Bochum, Germany) was applied after closed reduction of the fracture. In two patients, external fixation was supplemented by percutaneous K-wire pinning.

Patients who initially underwent open reduction received either a 3.5-mm AO non-locking T-plate (Synthes, Umkirch, Germany) or a locking palmar plate (ITS, Lassnitzhöhe, Austria). In cases of palmar fixation, we used a longitudinal incision directly over the flexor carpi radialis tendon. The flexor carpi radialis tendon, the flexor pollicis longus tendon and the median nerve were retracted to the ulnar side and the pronator quadratus was detached from its radial side, thus, providing good exposure for anatomical reduction of

the palmar cortex of the distal radius and for application of the plate. A carpal tunnel release was not performed since none of our patients showed decreased sensibility of the median nerve preoperatively. If possible, the pronator quadratus was sutured after plate fixation.

In cases of external fixation, the fixator was placed by pinning the index metacarpal and the radius with two Schanz screws each. These screws were attached to a connector rod. Repositioning of the fracture was performed and the screws and rod were firmly fixed, according to the method standardised by Martini [15].

Patients with ORIF were immobilised in a plaster cast for four weeks; patients with external fixation were immobilised for six weeks. After this period, all patients underwent physiotherapy.

The functional outcomes measured were range of motion (ROM) and grip strength. Radiographic parameters (radial inclination, palmar tilt) were measured before and after surgery and at the final follow-up. Anatomical outcomes were measured from the X-rays of the injured wrist in standard views (antero-posterior and lateral) [17]. All X-ray measurements were carried out by three different people, using a goniometer as described by Wright et al. [25]. Palmar tilt, palmar inclination and radial length were measured. Further wrist scores according to Gartland and Werley, Martini and the Disability of the Arm, Shoulder and Hand (DASH) questionnaire were used [4, 14]. The number and type of complication were documented for each group.

All data were analysed using SPSS for Windows 11.0 statistical software (SPSS Inc., Chicago, IL, USA). Categorical data were analysed with the χ^2 -test. Comparison of the three treatment groups was performed by analysing the mean values using a paired test for match-paired analysis. A p -value of <0.05 was considered to be significant.

Results

Of the 45 patients, 24 had a C1 fracture and 21 had a C2 fracture of the distal radius. The data on functional outcome and radiological outcome are given in Tables 1, 2 and 3 and Figs. 1, 2 and 3. The functional parameters showed significant differences between the external fixation group and the locking plate group in supination and pronation, as well as in subjective pain as measured on the visual analogue scale (VAS). The locking plate system showed the most positive results (Tables 1 and 2). There were also significant differences with regard to the functional criteria and pain between non-locking plates and fixator in favour of palmar non-locking plate osteosynthesis.

No significant differences in preoperative radiographic parameters were found between the three groups, but significant differences were seen postoperatively and at

Table 1 Comparison of functional outcome between locking palmar plate, non-locking plate and external fixation

Functionality	Locking plate	Non-locking plate	External fixation	<i>p</i> -score		
				Locking plate vs. external fixation	Locking plate vs. non-locking plate	Non-locking plate vs. external fixation
Flexion (°)	61 (SD=3.2)	57 (SD=7.7)	50 (SD=7.9)	0.001*	0.3	0.03*
Extension (°)	64 (SD=8.8)	60 (SD=11)	57 (SD=7.2)	0.6	0.4	0.2
Supination (°)	79 (SD=5.7)	73 (SD=4.5)	71 (SD=7.5)	0.001*	0.006*	0.01*
Pronation (°)	79 (SD=5.5)	72 (SD=6.2)	71 (SD=4.1)	0.001*	0.001*	0.3
Radial abduction (°)	21 (SD=3.3)	18 (SD=5.23)	17 (SD=5.6)	0.02*	0.7	0.1
Ulnar abduction (°)	26 (SD=4.5)	21 (SD=4.5)	22 (SD=4.9)	0.009*	0.004*	0.03*

*Data is significant

the final follow-up for palmar inclination. The anatomical restoration of the palmar tilt was better for the palmar locking plate than for external fixation ($p=0.04$).

Eighty percent of the patients in the external fixation group demonstrated an excellent or good result according to the rating system recommended by Gartland and Werley, compared to 100% for the palmar locking plate and 85% for the palmar non-locking plate group. According to the Martini score, there were significantly better results in the locking plate group in comparison to the external fixation group ($p=0.003$) and the non-locking plate group ($p=0.03$). Differences between the locking plate group and the two other groups clearly indicate better results for the locking plate group with regard to the DASH score (Table 2).

Table 3 shows that there were more complications in the external fixation group than in both palmar plate groups. Reflexdystrophia and revision surgery were more frequent in the external fixation group. Carpal tunnel syndrome (CTS) was only seen in the ORIF groups.

Discussion

Many surgical techniques are described in the literature for the treatment of fractures of the distal radius. The most common types of fracture fixation are by means of external

fixation, K-wires and plates, but other options are also available. Open reduction and palmar plate fixation is an established surgical procedure for palmar angulated distal radius fractures with or without involvement of the joint line. The fixation of fractures with dorsal displacement has long been considered as biomechanically unfavourable.

Due to new developments in fixed-angle plate systems, there is increasing interest in this technique and the first clinical studies have been published. Functional parameters for these systems now reach a level comparable to normal function [6, 9]. In this study, functional outcome (supination, pronation) was significantly better for the locking plate group in comparison to the external fixation group (Table 1). Furthermore, the locking plate group demonstrated better function and less pain than the external fixation and the non-locking plate groups. Radiological parameters were comparable with other authors [8, 13, 20]. All told, the locking plate does well in the rating system according to Gartland and Werley, with 85% to 100% excellent to good results (in our study, 100%) [1, 9, 24, 26]. The number of complications for the palmar locking plate fixation ranged from 0% to 10% (in our study, 7%) [22, 23]. Osada et al. [19] showed that there were no significant differences in plate fixation stability between the locking and the non-locking system in a cadaver model, although Fernandez and Orbay [3] described the locking plate system

Table 2 Comparison of radiological outcome and functional scores between locking palmar plate, non-locking plate and external fixation

Functional scores and radiological outcome	Locking plate	Non-locking plate	External fixation	<i>p</i> -score		
				Locking plate vs. external fixation	Locking plate vs. non-locking plate	Non-locking plate vs. external fixation
Palmar tilt (°)	23 (SD=6.5)	22 (SD=6.5)	17 (SD=2.6)	0.04*	0.4	0.5
Palmar inclination (°)	18 (SD=4.5)	17 (SD=6.2)	11 (SD=8.5)	0.05	0.6	0.3
DASH score (0–100)	7 (SD=5.1)	14 (SD=6.4)	20 (SD=11.3)	0.007*	0.9	0.7
Martini score (0–40)	33 (SD=2.8)	30 (SD=1.6)	28 (SD=4.1)	0.003*	0.4	0.8
VAS (0–10)	1.2 (SD=1.1)	1.8 (SD=1)	2.0 (SD=1.3)	0.03*	0.04*	0.6

Table 3 Complications

Complications	External fixation (<i>n</i> =15)	Locking palmar plate (<i>n</i> =15)	Non-locking palmar plate (<i>n</i> =15)
CTS	0	1	1
Infection	2 (pin infection)	0	0
Non-union	1	0	0
Reflexdystrophia	2	0	1
Malunion	2	0	0

CTS=carpal tunnel syndrome

as being three times as strong as any other commercially available device. If distal pins were securely fixed to the locking plate in the subchondral zone, subchondral support was achieved.

The distal screws of the non-locking plate may loosen, as they are not fixed to the plate. Functional parameters of the non-locking palmar plate are only slightly below the functional level of the normal population [6, 9, 24]. The rating systems according to Gartland and Werley showed excellent to good results in 80% to 100% of the patients (in our study, 95%) [1, 2, 9, 24, 26]. In a non-matched paired study on 53 patients, Kamano et al. [8] found no significant differences between the palmar locking and non-locking system in unstable fractures of the distal radius in the elderly. Pre- and postoperative radiographic assessments

were comparable and both systems showed good reduction and results. However, we cannot confirm that there are no differences between the two systems. In our study, there were significantly better results, particularly in functional criteria, in the locking plate system. The better functional outcome with the palmar locking plate in comparison to the non-locking plate in our study may be due to the higher rigidity of the fixation, which enables a faster rehabilitation. However, no significant differences were seen in the radiological outcome. The complications of the palmar non-locking plate fixation ranged from 0% to 13.2% (in our study, 14%) [8, 18].

Of the trials cited which used external fixation, only one study by Rommens et al. [21] reported loss in the ROM. The rating systems according to Gartland and Werley showed excellent to good results in 74% to 85% of the patients (in our study, 90%) [11, 24, 26]. Compared to the data reported in this study, ROM deficits were similar to our own values for external fixation and palmar plate fixation. Westphal et al. [24] found no differences between the external fixation and ORIF with palmar non-locking plates. The complications reported for external fixators ranged between 4.5% and 30% (30% in our study) [7, 14, 26].

In this study, the palmar non-locking plate was found to be significantly better than external fixation in terms of functional criteria (Table 1).

At the final follow-up, the restoration of palmar inclination showed that the anatomical restoration of palmar tilt could be better achieved with a palmar locking t-plate than with external fixation ($p=.04$). According to the Martini score, there were significantly better results in the locking plate group than in the external fixation ($p=0.003$) and the non-locking plate group ($p=0.03$). The best DASH scores were seen in patients with palmar locking plate fixation (7 points) followed by palmar non-locking plate fixation (14 points) and external fixation (20 points) (Table 2). Other authors reported comparable values from 13 to 17 points [20, 22], which are close to normal values. The mean of a representative sample of the normal US population was 10.1 points [6]. Comparison to the data presented here shows that a large number of treated patients reached a functional level only slightly below that of the

Fig. 1 **a** Fracture of the distal radius before operation in a 65-year-old woman.(a.p. and lateral view). **b** Palmar locking plate postoperatively (a.p. and lateral view)

Fig. 2 **a** Fracture of the distal radius in a 70-year-old woman (a.p. and lateral view). **b** Martini fixator postoperatively (a.p. and lateral view)

normal population and, thus, be can be considered to be recovered.

The number of complications found in our patients was comparable with other reports [14]. We had no ruptures of the flexor pollicis longus tendon during the follow-up period. Other authors reported this complication when using the palmar locking plate in up to 12% of the cases [2]. This could happen due to attrition by a plate positioned too distally, since the screws have sharp edges. CTS was only seen in the ORIF groups. Westphal et al. [24] also described CTS only in the palmar plate fixation group, possibly because a carpal tunnel release was not performed. Other authors who performed carpal tunnel release had lower numbers of CTS [22]. Malunions, which are defined as 20° loss of palmar tilt or palmar inclination, were only seen in the fixator group. Although this study is a retrospective clinical comparative trial, the comparison was performed using a matched-pair study, which to our knowledge, has never been done before. One drawback of the study is the difference in follow-up times between in the three groups. However, it is not likely that the data obtained here were much influenced by the different follow-up times. As a result, we excluded the assessment of postoperative osteoarthritis from the study.

The rating system of Gartland and Werley is sometimes difficult to apply accurately, particularly for the radiological and subjective demerit points. This fact might be the cause of the wide variance of results in groups with similar radiological and clinical findings. Neither reliability nor validity of the score has been reported [16]. However, it is a popular score which is used in most of the present literature and which includes subjective and objective parameters. Thus, we decided to apply it in addition to the Martini and DASH scores.

The AO classification is not always regarded as being the most precise classification system. However, in 2003, a study illustrated that it is the second most detailed classification after the Cooney classification [12]. In the patient groups described here, fracture patterns could be adequately graded with the AO classification.

According to our data, the locking plate fixation demonstrated the best radiological and functional results. Subjective assessment of ORIF proved that it was better than that of external fixation. Complications and revision operations were also less frequent for plate fixation. Our data indicate that most displaced intra-articular distal radius fractures can be treated successfully with the locking palmar plate.

Fig. 3 **a** Fracture of the distal radius in a 60-year-old patient (a.p. and lateral view). **b** Palmar non-locking plate postoperatively (a.p. and lateral view)

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