ORIGINAL ARTICLE

Early results of the conservative treatment of distal radius fractures-immobilization of the wrist in dorsal versus palmar flexion

Maki Grle[1], Miro Miljko[2], Ivana Grle[3], Faruk Hodžić[4], Tarik Kapidžić[4]

[1]Department for Orthopaedics, [2]Department for Radiology, [3]Department for Physiotherapy; University Clinical Hospital Mostar, [4]Department for Traumatology and Orthopaedics, Cantonal Hospital Zenica; Bosnia and Herzegovina

ABSTRACT

Aim To evaluate immobilization with dorsal forearm plaster splint with the wrist in dorsal flexion vs palmar flexion in patients with distal radius fracture.

Methods In the prospective study (2012-2014) 122 patients (of which 22 patients lost) with fractures of the distal radius type A2, A3 and C according to the AO classification were investigated. At the end there were 50 patients in each of the two groups: the dorsiflexion (DF) group had a total of 37 women and 13 men, mean age was 63.48 ± 14.70, and in the palmar flexion (PF) group there were respectively 38/12, and the mean age was 64.20 ± 12.99. In both groups measurements of radiological, clinical and functional parameters were conducted. Patient related wrist evaluation survey (PRWE) and SF12 questionnaire were used for evaluation of pain and function of the wrist and physical and mental condition, respectively.

Results The study showed excellent results in both groups but there was significant improvement in the range of motion (ROM) on every measurement in the DF group: dorsal flexion 47.70±15.29; ulnar deviation 24.10±7.80; radial deviation 11.50±5.65 vs PF 22.80±19.04; 16.00± 9.31; 4.80± 494 ($p<0.001$). Also, radiological parameters showed significant improvement until the end of the follow-up. Functional parameters showed significant improvement of physical component of SF-12 in the DF group ($p<0.014$).

Conclusion Immobilization with forearm plaster splint on the dorsal side and with the wrist in dorsiflexion gives better early clinical, radiological and functional results in patients with fractures of type A2, A3, C1-3 in patients of all age groups, compared to immobilization with the wrist in palmar flexion.

Keywords: wrist, distal radius fracture, conservative treatment, splints

Corresponding author:
Maki Grle
Department for Orthopaedics,
University Clinical Hospital Mostar
Bijeli Brijeg bb, 88000Mostar,
Bosnia and Herzegovina
Phone: +387 36 336 297;
Fax; +387 36 336 297;
E-mail: grlemaki@gmail.com
ORCID ID: http://www.orcid.org/0000-0003-3816-4521

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INTRODUCTION

According to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification, which is the preferred classification system, distal radius fractures are divided into extra-articular (A), partial articular (B) and complete articular (C) (1-4). There is a consensus about the best way of treatment only for the B type fracture, e.g. open reduction and internal fixation (5,6). Fractures without displacement can be treated conservatively and only displaced fractures without stability parameters (shortening of the radius <3mm, articular step<2 mm, and dorsal inclination <10°) should be treated surgically (4). However, the same authors cannot suggest the best type of treatment for the fractures with displacement which are stabile after reposition, means within stability parameters (7-9). On the other hand, any type of surgical treatment of stabile fractures with displacement does not give better results in terms of improvement of function versus conservative treatment (10-14). Today there are different conservative approaches in traumatology in terms of the type of immobilization,duration of immobilization, immobilization level, repositioning techniques and rehabilitation (15,16). For most authors, the treatment of distal radius fracture consists of immobilization with forearm dorsal plaster splint with the wrist in a position of palma reflexion and ulnar adduction (14,17). Ligamentotaxis is based on the preservation of the positions of fracture fragments using strained surrounding soft tissues (18). The first ligamentotaxis techniques consisted of the placement of the wrist in position of maximum palmare flexion which led to a great number of complications in terms of neuropathy of median nerve or extensor pollicis tend on rupture. Therefore, it was replaced by a modification of the same position as suggested by Charlney and Bölerwith the 20° of palmar flexion and 20°of ulnar adduction, which reduced the incidence of these complications (19,20). On the other hand, better functional, clinical and radiological results in the intra and extra articular fractures of the distal radius were demonstrated in patients with the same type of immobilization, but with the wrist in the position of dorsal flexion and ulnar adduction (21-23).

The aim of this study was to compare two types of ligamentotaxis or immobilisation of wrist in dorsal and palmar flexion. Based upon our experience and above mentioned positive results, immobilisation of the wrist in dorsiflexion/adduction should give better results than the immobilisation in palmar flexion/ulnar adduction in patients with distal radius fracture.

PATIENTS AND METHODS

Patients and study design

In this prospective cohort study122 patients admitted to the Trauma Centre of the University Clinical Hospital Mostar, Bosnia and Herzegovina, from spring of 2012 to spring 2014 with distal radius fracture.

Inclusion criteria were patients with distal radius fracture and the age above 25 years. Exclusion criteria were previous fracture in the same place, associated diseases such as diabetes mellitus and rheumatoid arthritis, open distal radius fractures, ulna fracture (except fracture of the styloid process), patients with unstable distal radius fractures (fractures that are unstable immediately after the reposition or on the control after 7-days and Smith's fracture). Patients were selected in the groups, oral clarification was made by an examiner obtaining informed patients' consents. Institutional review board and the Ethical Committee of the University Clinical Hospital Mostar approved the investigation. The patients were divided in two groups: with immobilisation of the wrist in dorsal flexion and ulnar deviation (DF group), and in group with immobilisation of the wrist in palmar flexion and ulnar deviation (PF group).

At the beginning there were 62 patients in the DF group and 60 in the PF group. During the follow-up period 22 patients were lost (15 patients did not come to the control and seven did not satisfy stability parameters). In the PF group seven patients were lost because they did not come to the control and three patients were opted to another type of treatment due to instability.

At the end of the investigation 50 patients remained in each group; mean age was 63.48±14.70 in DF group and 64.20±12.99 in PF group; 25 were males and 75 females.

Methods

After hematoma block with 4mL of 2% lidocaine injected in the fracture site, fractures were manipulated with traction by two assistants with

forearm in pronation. Upon the reduction of fragments, the immobilisation with plaster splint on the dorsal side was done. In the DF group with constant counter traction of two assistants, the surgeon was giving a pressure on the distal radius fragment while the assistant was bringing the wrist in 20° of dorsal flexion and minimal deviation. In the PF group everything was done in the same way, except for the wrist that was positioned in 20°of palmar flexion and minimal ulnar deviation which was completely done by the surgeon, while the upper arm counter traction was done by the assistant. After wrist anteroposterior (AP) and lateral radiographs (L) was done, the measurements of radiological parameters of volar inclination and the radial height and the radial inclination were taken, and in the case of intra articular fracture ‘’step off’’ was measured. Radial height was measured on AP: two lines perpendicular to the radial shaft were drawn; one was drawn along the articular surface and the second one along the styloid tip (a normal measure 9.9mm - 17.3mm). Radial inclination was measured on AP: the angle of the distal radial surface with respect to a line perpendicular to the shaft (a normal slope should be 15° - 25°). Volar inclination was measured on L: the angle of the distal radial surface with respect to a line perpendicular shaft (10°- 25° was considered normal). If the fracture was stable (shortening of the length of radius bone<3mm, dorsal inclination 10° and intra articular step<2mm), the patient would have the next control in 7days; in case that the control radiograph demonstrated the stability, the next control was in four weeks after the immobilisation, and in case of instability at the first appointment the patient left the study and was referred to a different form of the treatment.

After 4 weeks from the beginning of the study the immobilization was removed, a new radiograph control was conducted during which again the radiological measurement of radial height (RH) in millimetres (mm) and radial inclination (RI) and palmar inclination (PI) in degrees (°) were measured, and in addition, clinical measurements of the range of motion (ROM) with goniometer (expressed in degrees) (dorsal and palmar flexion DF/PF, ulnar/radial deviation UD/RD), grip strength (GS) (mmHg, with pressure gauge) were made.

Patient rated wrist evaluation surveys (PRWE) were conducted examining pain and function of the wrist. The PRWE questionnaire consisting of 15 questions related to pain and disability in daily activities of the wrist. The PRWE allows the patient to assess their pain and disability from 0-10 with two sets of questions with regard to pain- 5 items (0 = no pain, 10 = strongest ever) and the function- 10 items (6 specific and 4 common activities; 0 = feasible without difficulty, 10 = impossible). The total number of points for both groups of questions was 100 (0 = no difficulty), where items for pain and function carry the same number of points (24).

The SF 12 questionnaire (short form) that examined the general physical and mental condition of the patient were also conducted. The SF 12 is a questionnaire that measures the quality of health through subjectively described physical and mental condition. It consists of 12 questions taken from the larger questionnaire SF-36. At the end of the questioning, the questionnaire obtained separate sums for both domains (physical and mental component of SF 12 survey SFPCS/SFMCS) through the sum of all 12 questions (25).

The next examination was made after two months when all radiographic, clinical and functional measurements were made. The patients were observed for all related recognized complications during the follow-up.

Statistical analysis

Data were processed using descriptive and inferential statistical methods. Continuous variables were presented as arithmetic mean and standard deviation. Distribution of the sample population was tested using Kolmogorov-Smirnov test. It was assessed the normality of the distribution for all measures and for each group. Student t-test used for testing of differences for continuous variables was used. The p-value of <0.05 was taken as statistically significant for all measurements.

RESULTS

Two groups of patients were equalac cording to all observed parameters, i.e. they were comparable.

On the first and second measurement, patients in DF group had a significantly greater range of motion. The parameter of range of motion was significantly higher on each control in the DF group (DF 40.70°, UD 24.10°, RD 11.50°; p<0.001) vs PF group (Table 1).

Table1. Comparison of clinical parameters between dorsiflexion (DF) and palmar flexion (PF) groups

Variable	Group				t	p
	DF		PF			
	$\bar{X}$	SD	$\bar{X}$	SD		
Age	63.48	14.70	64.20	12.99	0.260	0.796
After immobilisation removal						
Palmar flexion(°)	47.80	16.39	42.50	21.07	1.404	0.164
Dorsal flexion(°)	40.70	15.29	22.80	19.04	5.184	<0.001
Ulnar deviation (°)	24.10	7.80	16.00	9.31	4.714	<0.001
Radial deviation (°)	11.50	5.65	4.80	4.94	6.312	<0.001
Strength (mmHg)	49.50	19.20	43.40	15.99	1.726	0.087
Two months after immobilisation removal						
Palmar flexion (°)	63.60	13.52	64.90	14.41	0.465	0.643
Dorsal flexion(°)	60.70	14.95	53.90	20.78	1.878	0.064
Ulnar deviation (°)	29.00	4.95	24.40	6.52	3.974	<0.001
Radial deviation (°)	17.80	5.55	14.80	7.28	2.317	0.023
Strength (mmHg)	76.80	23.40	70.10	16.80	1.645	0.104

Radio logical parameters demonstrated a significant difference between the two groups in terms of better restoration of anatomy in the DF group (RH 11.67 mm; p=0.003; RI 5.34°; p<0.001), except for palmar inclination that was significantly better resort on the first measurement in PF group (PI 11.84°; p=0.001). Both types of immobilization give radiological results that have a positive effect on the improvement of the patient's condition, but with statistically better improvement in the DF group (p=0.001) (Table 2).

Table 2. Comparison of radiological parameters between dorsiflexion (DF) and palmar flexion (PF) groups

Variable	Group				t	p
	DF		PF			
	$\bar{X}$	SD	$\bar{X}$	SD		
Age	63.48	14.70	64.20	12.99	0.260	0.796
After reposition						
Radial height (mm)	11.67	1.67	10.36	2.53	3.056	0.003
Radial inclination (°)	24.32	3.14	20.00	4.98	5.191	<0.001
Palmar inclination (°)	5.34	6.28	11.84	11.16	3.589	0.001
After immobilisation removal						
Radial height (mm)	10.41	1.73	9.34	1.81	3.017	0.003
Radial inclination (°)	20.64	4.43	18.18	4.63	2.713	0.008
Palmar inclination(°)	3.30	7.01	3.50	6.26	0.150	0.881
Two months after immobilisation removal						
Radial height (mm)	10.18	1.83	9.12	1.89	2.851	0.005
Radial inclination (°)	20.02	4.76	17.34	4.52	2.889	0.005
Dorsal inclination (°)	2.70	7.35	3.18	5.91	0.360	0.720

The PRWE survey showed no significant differences between the two groups. The results of the SF12 survey showed a significant difference on the second control a in physical component between the two groups with a better out come in the DF group (SFPCS43.10, p=0.014). Functional results showed a particularly significant decrease in pain and increase in functions proven through results of the SF 12 survey (Table 3).

Table 3. Comparison of functional parameters between dorsiflexion (DF) and palmar flexion (PF) groups

Variable	Group				t	p
	DF		PF			
	$\bar{X}$	SD	$\bar{X}$	SD		
After the immobilisation removal						
PRWE	73.17	17.56	73.12	23.74	0.012	0.990
SFMCS	61.58	10.30	63.84	9.67	1.131	0.261
SFPCS	32.14	5.64	30.08	5.80	1.800	0.075
Two months after the immobilisation removal						
PRWE	27.13	22.53	25.87	20.05	0.295	0.769
SFMCS	60.32	10.04	61.90	8.76	0.839	0.404
SFPCS	43.10	8.35	39.26	7.00	2.492	0.014

PRWE, Patient related wrist evaluation; SFPCS, Short Form Physical Component Survey; SFMCS, Short Form Mental Component Survey;

There was a significant difference between males and females in the power grip strength in terms of a stronger grip strength in males (62.40mm Hg; p=0.001). Palmar flexion increased in both sexes, but again significantly in males (PF 70.40°, p=0.010). The functional results of the PRWE survey and the SF12 questionnaire scores demonstrated a significant improvement in males (PRWE 17.46, p=0.013; SFPCS33.28; p=0.030) (Table 4).

Table 4. Comparison of clinical, radiological and functional parameters by gender

Variable	Gender				t	p
	M		W			
	$\bar{X}$	SD	$\bar{X}$	SD		
Age	53.00	14.37	67.45	11.62	5.067	<0.001
After immobilisation removal						
Palmar flexion(°)	50.00	19.69	43.53	18.58	1.485	0.141
Dorsal flexion(°)	39.00	22.64	29.33	17.69	1.946	0.060
Ulnar deviation(°)	22.40	8.79	19.27	9.61	1.441	0.153
Radial deviation (°)	9.40	7.68	7.73	5.71	1.154	0.251
Strength (mmHg)	62.40	18.83	41.13	14.01	5.189	<0.001
PRWE	74.56	23.37	72.67	19.98	0.392	0.696
SFPCS	33.28	5.84	30.39	5.62	2.207	0.030
SFMCS	64.00	6.34	62.28	10.96	0.960	0.340
Two months after immobilisation removal						
Palmar flexion(°)	70.40	14.78	62.20	13.08	2.627	0.010
Dorsal flexion(°)	63.40	18.01	55.27	18.10	1.948	0.054
Ulnar deviation(°)	28.00	5.59	26.27	6.37	1.213	0.228
Radial deviation (°)	18.00	7.22	15.73	6.35	1.493	0.139
Strength (mmHg)	93.80	20.07	66.67	15.73	6.953	<0.001
PRWE	17.46	18.83	29.55	21.22	2.530	0.013
SFPCS	44.68	8.64	40.01	7.34	2.632	0.010
SFMCS	62.56	5.24	60.63	10.42	1.211	0.229
After reposition						
Radial height (mm)	11.08	2.06	10.99	2.30	0.167	0.867
Radial inclination (°)	22.28	4.81	22.12	4.66	0.147	0.883
Palmar inclination (°)	7.72	9.49	8.88	9.66	0.522	0.603
After immobilisation removal						
Radial height (mm)	10.12	1.76	9.79	1.87	0.765	0.446
Radial inclination (°)	20.12	4.09	19.17	4.86	0.875	0.384
Palmar inclination (°)	4.16	6.43	3.15	6.70	0.662	0.510
Two months after immobilisation removal						
Radial height (mm)	9.96	1.79	9.55	1.97	0.929	0.355
Radial inclination (°)	19.48	4.33	18.41	4.95	0.960	0.339
Palmar inclination (°)	4.72	5.13	2.35	7.00	1.559	0.122

PRWE, Patient related wrist evaluation; SFPCS, Short Form Physical Component Survey; SFMCS, Short Form Mental Component Survey;

Data comparison revealed that there was a significantly better grip strength at the second measurement and better results of functional score in patients without complications (GS 74.95 mm Hg, p=0.003; PRWE 24.30; p<0.001) (patients with complication had Morbus Sudeck and were in DF group). The patients with complications had significantly reduced grip strength, and worse functional results. More common complications were found in the group with dorsal immobilisation (Table 5).

Table 5. Comparison of clinical, radiological and functional parameters by presence of complication

Variable	Complication				t	p
	NO		YES			
	$\bar{X}$	SD	$\bar{X}$	SD		
Age	63.54	14.01	68.50	9.85	0.852	0.397
After immobilisation removal						
Palmar flexion (°)	45.64	18.63	37.50	24.44	1.019	0.311
Dorsal flexion (°)	31.70	19.24	32.50	23.61	0.097	0.923
Ulnar deviation (°)	20.11	9.30	19.17	12.81	0.235	0.815
Radial deviation (°)	8.09	6.27	9.17	6.65	0.408	0.684
Strength (mmHg)	46.76	17.62	41.67	22.29	0.675	0.501
PRWE	73.41	21.07	69.00	16.26	0.502	0.617
SFPCS	31.03	5.91	32.33	3.56	0.532	0.596
SFMCS	63.09	9.70	56.83	13.64	1.493	0.139
Two months after immobilisation removal						
Palmar flexion(°)	65.37	12.81	46.67	19.66	2.299	0.067
Dorsal flexion(°)	58.09	18.01	45.00	20.74	1.712	0.090
Ulnar deviation(°)	26.91	6.10	23.33	7.53	1.377	0.172
Radial deviation(°)	16.33	6.69	15.83	5.85	0.177	0.860
Strength (mmHg)	74.95	19.86	50.00	17.89	2.998	0.003
PRWE	24.30	19.39	60.50	20.60	4.417	<0.001
SFPCS	41.62	7.88	34.33	4.84	2.232	0.028
SFMCS	61.63	8.69	53.00	16.17	1.295	0.250
After reposition						
Radial height(mm)	11.10	2.27	9.67	.82	1.537	0.128
Radial inclination (°)	22.19	4.72	21.67	4.27	0.265	0.791
Palmar inclination (°)	9.06	9.58	1.17	6.34	1.986	0.050
After immobilisation removal						
Radial height (mm)	9.92	1.87	9.17	1.17	0.970	0.334
Radial inclination (°)	19.48	4.69	18.33	4.80	0.580	0.564
Palmar inclination (°)	3.66	6.48	0.67	8.07	1.565	0.121
Two months after immobilisation removal						
Radial height (mm)	9.71	1.94	8.67	1.37	1.295	0.198
Radial inclination (°)	18.74	4.79	17.67	5.43	0.531	0.597
Palmar inclination (°)	3.17	6.52	0.67	8.07	1.378	0.171

PRWE, Patient related wrist evaluation; SFPCS, Short Form Physical Component Survey; SFMCS, Short Form Mental Component Survey

DISCUSSION

Fracture of the distal radius breaks the continuity of the shaft, and the flexor and extensor muscles indirectly cause dislocation of the fragments (20). It is therefore very important to cancel this force. Palmar flexion is required at the point of fracture to tighten intact periosteum from the dorsal side of the fracture and to give more stability to the fracture (20). The dorsal carpal ligaments are attached only to the triquetrum, while most of the palmar flexion occurs in the mid carpal joint, and in palmar flexion immobilisation, those ligaments are not tense and they are unable to stabilize the fracture displacement (20). Therefore, in the dorsiflexion position of the wrist radiotriquetral and radiocapitate ligaments are tense. They are attached to the distal row of carpal bones causing in that way a double positive effect on fracture reposition preservation through the stabilization of those two rows and relaxation of extensor apparatus. This kind of "S" shape immobilisation performed by this technique stabilizes the fracture fragments in both types of fractures, especially in intra articular fractures (26). There is no consensus on the best treatment of fractures of the distal part of the radius, even though the fracture has been recognized and therapeutic approaches investigated in detail for the past 200 years (27,28). The good clinical practice in most centres throughout the world is made up of conservative treatment of these fractures with the wrist in a palmar flexion of 20° and mild ulnar deviation and the results of this treatment are satisfactory especially in older people (29). However, in people under 65 years of age, results, particularly short-term, are not very satisfactory (30). Therefore, Guptain the 90's worked on different types of conservative treatment with the immobilization under elbow cast with the wrist in the dorsal flexion of 20° and mild ulnar deviation, and showed better radiological results with better flexibility of wrist and faster recovery of the hand grip strength (20). In this study, which is different from Gupta´s study, under elbow plaster splint immobilization was used instead of complete cast in both groups. Data in this study showed that immobilization in dorsiflexion really improves the mobility of the wrist in earliest period, which is certainly important for a faster recovery and a quicker return to work activities. Radiological measurement has demonstrated a significant difference in all of the observed parameters in the first control. Reduction of the radial height significantly affects the results of the initial range of motion of the wrist and this study observed a significantly better preservation of this parameter in the DF group and that had an impact on better functional result of the treatment (31,33). In the second control, palmar inclination

showed no significant difference between the two groups in this study. The reason of this equalization is again a better stabilization of reposition of this parameter in the DF group, which in the first control was significantly better restored in the PF group, probably because of better knowledge about the technique of the reposition by the orthopaedist. Palmar inclination is normally around 12° and when it is over 10° of dorsal and over 15° of palmar, it has a negative influence on the incidence of pain, reduction of grip strength and mobility of the wrist (33). It is extremely important to preserve this parameter for better functional outcome in patients with fractures of the distal radius, as it has been observed in the DF group in our study (32,35).

The survey data confirm the fact that better radiological and also clinical results give a better functional outcome (35).The comparison between the genders in this study showed significant difference between males and females in the improvement of the power grip strength, range of motion (ROM) and function. These data only partially correlate to the global studies that have shown that regardless of gender, better grip strength and mobility give better functional results, whereas this study shows that these results are evident only in males (35). A significantly better improvement of grip strength and better results of function in all parameters were observed in patients without complications in our study. There was no significant difference in terms of incidence of complications between two groups and the data confirm that patients with poor clinical parameters have more complications, and these patients have shown worse functional results, but there is no parameter that could be used for early detection of possible complication.

In this study stronger exclusion criteria were applied, similarly to other studies, in order to get more statistically relevant results. Both types of immobilization give radiological results that have a positive effect on improving the condition of the patient, but with statistically better improvement in the DF group, thus confirming the hypothesis of the study.

In conclusion, immobilization with forearm plaster splint on the dorsal side and with the wrist in dorsiflexion gives better early clinical, radiological and functional results in patients with fractures of type A2, A3, C1, C2, C3 according to AO classification in patients of all age groups, compared to the treatment with immobilization of the wrist in palmar flexion and ulnar deviation. The results of this study have shown that conservative treatment can be an excellent tool for the treatment of the major parts of distal radius fractures and that the immobilization in dorsal flexion of the wrist gives better preservation of reduction of the fracture of distal radius compared to other immobilization techniques.

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TRANSPARENCY DECLARATION

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Rani rezultati konzervativnog liječenja pacijenata s prijelomom distalnog okrajka palčane kosti – usporedba imobilizacije ručnog zgloba u dorzalnoj ili palmarnoj fleksiji

Maki Grle[1], Miro Miljko[2], Ivana Grle[3], Faruk Hodžić[4], Tarik Kapidžić[4]

[1]Odjeljenje za radiologiju,[2] Odjeljenje za radiologiju,[3] Odjeljenje za fizikalnu medicinu i rehabilitaciju; Sveučilišna klinička bolnica Mostar,[4] Odjeljenje za traumatologiju i ortopediju, Kantonalna bolnica Zenica; Bosna i Hercegovina

SAŽETAK

Cilj Procijeniti prednosti imobilizacije podlaktičnom gips-longetom s ručnim zglobom u dorzalnoj fleksiji naspram položaja ručnog zgloba u palmarnoj fleksiji kod pacijenta s prijelomom distalnog dijela palčane kosti.

Metode U ovoj prospektivnoj kohortnoj studiji (2012-2014) bila su ispitivana 122 pacijenta (od kojih su 22 izgubljeni za vrijeme praćenja) s prijelomom distalnog okrajka palčane kosti tip A2, A3 i C prema AO klasifikaciji. Na kraju su dobivene dvije skupine od po 50 pacijenta: u dorzifleksijskoj (DF) grupi bilo je ukupno 37 žena i 13 muškaraca srednje životne dobi od 63.48 ± 14.70 godina, a u palmarnofleksijskoj (PF) grupi bilo je 38 žena i 12 muškaraca srednje životne dobi od 64.20 ± 12.99 godina. Mjereni su radiološki, klinički i funkcionalni parametri u obje grupe. PRWE-anketa i SF-12 upitnik bili su korišteni za procjenu razine bola i funkcije zgloba, te općeg tjelesnog i psihičkog stanja pacijenta.

Rezultati Pokazali su značajno poboljšanje kliničkih parametara opsega pokreta na svakom mjerenju u DF grupi: dorzalna fleksija 47.70±15.29; ulnarna devijacija 24.10±7.80; radijalna devijacija 11.50±5.65, naspram PF grupe: 22.80±19.04, 16.00± 9.31, odnosno 4.80± 4,94 ($p<0,001$), te radioloških i funkcionalnih parametara kroz anketu SF-12 u DF grupi ($p<0,014$).

Zaključak Imobilizacija ručnog zgloba u dorzifleksiji daje bolje rane kliničke, radiološke i funkcionalne rezultate naspram imobilizacije u plamarnoj fleksiji kod pacijenata s prijelomom distalnog radijusa tip A2, A3, C prema AO klasifikaciji.

Ključne riječi: ručni zglob, prijelom distalnog radijusa, konzervativno liječenje, imobilizacije.