

Prognostic factors in the treatment of distal radial fractures: volar plate vs. external fixation

R. Lax-Pérez, J. Vicent-Vera, B. Picazo-Gabaldón, M.C. Sánchez-Baeza and J.L. Díaz-Almodóvar

Department of Orthopedic and Trauma Surgery. Castellón General Hospital. Castellón. Spain.

Purpose. The purpose of this study was to compare the outcomes of 2 kinds of treatment for unstable distal radial fractures (open reduction internal fixation (ORIF) and standard external fixation [EF]) and to determine the factors that might have lain behind the achievement of excellent results, using two different scales: the Mayo functional scale and Castaing's radiological scale.

Materials and methods. This is a cross-sectional retrospective study including patients with unstable distal radial fractures treated between 2001 and 2005. The inclusion criteria were: patients with unstable distal radial fractures treated with ORIF or EF, with complete clinical and radiological studies, and who agreed to be enlisted in the study (30 ORIF and 27 EF). The two groups were compared for sex, age, mechanism of injury, profession, Fernández's fracture classification, range of motion, surgical technique, time to surgery, duration of physical therapy, follow-up time, the Mayo functional scale and Castaing's radiological scale. We performed a multivariate logistic regression analysis, evaluating the factors that were involved in obtaining excellent results.

Results. We studied 30 patients treated with ORIF (24 men and 7 women) and 27 treated with EF (10 men and 17 women). The factors related to excellent results on the Mayo functional scale were occupation and time to surgery. On the Castaing's radiologic scale, these factors were surgical technique and fracture degree according to Fernández's classification.

Conclusions. For each day of surgical delay, there is a 20% decrease in the probability of obtaining an excellent result. Patients with self-owned businesses achieve better functional results. Grades III, IV and V of the Fernández classification and the use of EF are associated with poorer radiological results.

Key words: distal radial fractures, volar plate, Pennig-type external fixation.

Factores pronósticos en el tratamiento de las fracturas de radio distal: comparación entre placa volar y fijador externo

Objetivo. Determinación de los factores que influyen en conseguir un resultado excelente en las escalas de valoración funcional de Mayo y radiológica de Castaing en pacientes con fractura de radio distal inestable, operados con placa volar o fijador externo.

Material y método. Se realiza un estudio trasversal incluyendo pacientes con fractura de tercio distal de radio intervenidos desde 2001 a 2005. Las variables estudiadas fueron: sexo, edad, mecanismo de lesión, actividad laboral, clasificación de la fractura según Fernández, técnica quirúrgica, demora quirúrgica, tiempo en rehabilitación, tiempo de seguimiento, escala funcional de Mayo y escala radiológica de Castaing. Considerando la puntuación excelente en estas escalas se realizó un análisis multivariante, determinando qué variables influían en ese resultado.

Resultados. Se estudiaron 30 pacientes intervenidos con placa y 27 con fijador externo. En el resultado excelente según la escala funcional Mayo influye la actividad laboral y la demora quirúrgica. En la puntuación excelente según la escala radiológica de Castaing influye la técnica quirúrgica y el grado de la fractura según la clasificación de Fernández.

Conclusiones. Por cada día de demora quirúrgica disminuye en un 20% la probabilidad de obtener un resultado funcional final excelente. Los trabajadores autónomos consiguen mejores resultados funcionales. Se obtienen peores resultados radiológicos en los grados III, IV y V de Fernández y al utilizar fijador externo.

Palabras clave: fractura tercio distal radio, placa volar, fijador externo tipo Pennig.

Corresponding author:

R. Lax Pérez.
C/ San Roque n.º 86, 9.º puerta 17.
12004 Castellón. Spain.
E-mail: Laxpe@yahoo.es

Received: February 2007

Accepted: January 2008

Distal fractures of the radius are very frequent in our hospital, accounting for 6% of the fractures treated in the Emergency Department. The severity of fractures depends on the magnitude of the trauma that caused them and the degree of existing osteopenia. The treatment of choice continues to be controversial^{1,2} due to:

1) The different types of treatment that can be used³⁻¹⁰ (spica cast, Kirschner wires, external fixator, dorsal plate, volar plate and the combination of two or more of these techniques), none of which is free from complications¹¹.

2) The characteristics of the fracture¹² (number of fragments, intra or extra-articular fracture line, fragment displacement, etc.).

3) The characteristics of the patient (age, occupation, general status, subsequent challenges the limb must stand up to, etc.).

Surgical treatment has improved due to better initial clinical assessment of the fracture (determination of the fracture grade using different classifications, assessment of associated lesions, etc.) and the development of new surgical materials for fracture stabilization.

Different assessment scores have been created, both functional (Mayo score¹³, Garland score¹⁴, Castaing functional score¹⁵ and DASH questionnaire^{16,17}) and radiological (Castaing's radiological score¹⁵), with the aim of assessing the outcome achieved.

The aim of this study is to establish possible factors that can influence the final result in patients with a distal radius fracture treated surgically with a volar plate or a Pennig-type external fixator.

MATERIALS AND METHODS

We performed a cross-sectional study of patients with a distal radius fracture treated with a volar plate or external fixator during the period from January 2001 to December 2005. The inclusion criteria were: patients with mature bones, unstable distal radius fracture of less than 4 weeks' evolution, treated by open reduction and volar plate (according to the surgical technique described by Moser et al¹⁸) or closed reduction and external Pennig-type fixator (according to the technique described by Pennig¹⁹), and complete clinical and radiological history. We excluded: all radial fractures with proximal involvement of the distal third of the radial shaft that were treated by means of other techniques (Kirschner wires, dorsal plate, or a combination of two or more treatments), or had an incomplete clinical or radiological history.

Patients were contacted by telephone. Those who voluntarily agreed to participate in the study were given an appointment to come in for a functional assessment using the

Table 1. Variables analyzed

Age	Years
Gender	Man/woman
Occupation	Housewife Manual worker Self-employed
Mechanism of injury	Fortuitous fall Occupational accident Traffic accident Sports lesion
Fracture classification	Fernández Classification
Affected side	Right/left
Surgical delay	Days
Functional result	Modified Mayo score
Joint mobility	Degree
Complications	Reflex sympathetic dystrophy Lack of reduction Infection Deep vein thrombosis Scapho-lunate separation De Quervain tendinitis Carpal tunnel syndrome
Rehabilitation time	Months
Follow-up time	Months
X-ray result	Castaing radiological score

Mayo scale and a radiological assessment using the Castaing scale.

The data collected (socio-demographic, of the fracture and postoperative complications) can be seen in Table 1.

The fractures have been classified using the Fernández scale²⁰ (Figure 1) that describes the fracture anatomically and relates this to the mechanism that caused the lesion.

To assess the clinical and radiological results of each of the patients we used the functional-clinical modified *Mayo Wrist Scale*¹³ (table 2) and the Castaing radiological scale¹⁵ (table 3). The Mayo scale assesses the functionality of the damaged wrist taking into account pain, work activity, range of motion and prehensile strength. The Mayo scale was used because it assesses parameters, and is therefore stricter when determining outcome. Castaing's radiological scale assesses frontal tilt, sagittal tilt, radio-ulnar joint-line (measurements made with a goniometer) and the degree of radio-carpal arthritis present using the Knirk score²¹. The results used for the study were scores above 90 on the Mayo scale and over 6 on the Castaing scale, both indicating an excellent outcome.

Chi square was used to compare discrete variables. To determine which variables were related to the outcome (excellent score on the Mayo Wrist scale or excellent score on the Castaing scale) a preliminary study was carried out using univariate analysis, and selecting variables with $p < 0.1$. In a second phase the selected variables were subjected to multivariate analysis by logistical regression. SPSS 12.0 was the software program used to determine results.

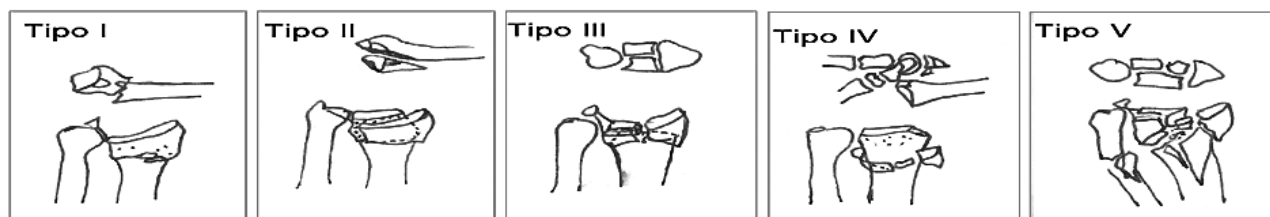


Figure 1. Fernández Classification, modified from Fernández DL20. Type I, Type II, Type III, Type IV, Type V

RESULTS

Reviewing the histories of 194 patients operated for distal radius fracture during the period between January 2001 and December 2005, we saw that 64 subjects were treated with volar plates and 60 with external fixators. Of these we studied 31 treated with volar plates and 27 treated with external fixator. We excluded 10 patients because of incomplete clinical or radiological data in their case histories, and the others refused to participate in the study when we contacted them by telephone.

The group we studied was formed by 34 men and 24 women. The mean age of the female population was 60 ± 5 years and the men 30 ± 5 years.

For surgical reasons based on presumed bone quality criteria, external fixators were used more frequently in the over 60 population, whereas plates were used more frequently in the under 40 population. As far as the mechanism of injury was concerned, the external fixator was more fre-

quently used in fractures caused by accidental falls and the plate in fractures caused by traffic accidents. Plates were used in fractures classified as grades I, II, III and V using the Fernández Classification, whereas external fixators were used more frequently in fractures classified as grades III and IV. Time to surgery was greater in patients that were treated with volar plates. The time of immobilization was longer in patients treated with plates (tables 4 and 5).

No cases of infection, deep vein thrombosis, or scapholunate separation were seen. During the postoperative period one patient had DeQuervain tendinitis that resolved spontaneously. Two cases of reflex-sympathetic dystrophy (6.5%) were seen during the first months after surgery; these resolved with rehabilitation and drug treatment. Three patients (9.7%) showed clinical signs of carpal tunnel syndrome and required surgical neurolysis.

It was necessary to extract the hardware in 4 patients due to discomfort. There was incipient Knirk stage I²¹ radio-carpal arthritis in 6 cases.

Using univariate analysis we selected previously those variables associated with excellent outcomes on the Mayo scale and Castaing radiological scale. Subsequently, the selected variables were subjected to multivariate analysis and

Table 2. Modified clinical-functional Mayo scale

Pain	
No pain	25
Slight-occasional	20
Moderate	15
Severe	0
Work status	
Works regularly	25
Work restrictions	20
Capable of working but unemployed	15
Unable to work due to pain	0
Range of mobility (degrees)	
> 120	25
100-119	20
90-99	15
60-89	10
30-59	5
0-20	0
Prehensile strength (% del normal)	
90-100	25
75-89	15
50-74	10
25-49	5
0-24	0

Adapted from Amadio PC et al¹³.

Score from 90-100: Excellent; score from 80-89: good; score from 65-79: fair; score < 65: Poor.

Table 3. Castaing radiological assessment scale

Castaing score	Score
Frontal tilt	
20-30°	2 points
10-20°	1 points
< 10°	0 points
Sagittal tilt	
15-8	2 points
8-0	1 points
< 0°	0 points
Radio-ulnar joint line	
From -2 mm a 0 mm	2 points
From 0 mm a 2 mm	1 point
From -2 mm or more than 2 mm	0 points
Radio-carpal joint-line	
Stage 0 (regular joint-line)	2 points
Stage 1 (narrow or irregular joint-line)	1 points
Stage 2 (arthritis with joint-line narrowing)	0 points

Adapted from: Castaing J15.

Score from 7-8: Excellent; score from 5-6: good; score from 3-4: fair; score from 0-2: poor.

Table 4. Numerical variables

	External fixator Mean (SD)	Volar plate Mean (SD)	Mann-Whitney) U Test
Age (years)	58 (13,83)	41 (6,74)	0,001
Surgical delay (years)	2,78 (4,79)	4 (6,74)	0,93
Time RHB (months)	3,66 (1,93)	4,08 (1,59)	0,25
Time follow-up (months)	6,89 (1,47)	3,77 (1,56)	0,001

SD: Standard deviation; RHB: Rehabilitation.

it was seen that the patient's occupation and time to surgery influenced the possibilities of achieving excellent results on the Mayo clinical-functional scale. Better functional results were seen if the patient was self-employed (*odds ratio* [OR] = 7.1). Time to surgery had a negative influence, for each day of delay there was a decrease of 20% in the probability of achieving an excellent functional result (OR = 0.8). The factors that influenced the possibility of achieving excellent results using the radiological assessment scale were the surgical technique used and the fracture grade (according to the classification used): The worst radiological results were seen in patients treated with an external fixator (OR= 0.0001) who had grade III, IV and V Fernández Classification fractures (OR= 0.0005) (Table 6).

DISCUSSION

The main aim in treating fractures of the distal radius is to achieve anatomical reduction and early mobilization, because both favor functional recovery of the fingers and hand^{22,23}. Comparisons of clinical and radiological results have shown that a correct anatomical reduction is equivalent to a good functional result, although there is not always clinical and radiological agreement²⁴.

To achieve these aims, several options are available.

Most distal radius fractures, including those that involve the joint, do not require open reduction to restore joint congruence. Using classical principles for closed maneuvers and alignment²⁵ it is possible to achieve satisfactory reductions; these must subsequently be maintained by immobilization with spica casts, percutaneous needles or external fixators²⁶.

However, there is a significant group of fractures caused by high energy trauma that may require open reduction and internal fixation to restore joint congruence. Amongst the benefits of plate fixation it is important to highlight direct visualization of the fracture. Indeed this is a stable type of internal fixation that shortens the immobilization period, and, in consequence, permits a speedy functional recovery²⁷.

A Pennig-type external fixator makes it possible to treat complex distal radius fractures. It has biomechanical advan-

Table 5. Categorical variables

	External fixator n (%)	Plate n (%)	p (χ ²)
Sex			
Man	10 (37%)	24 (77,4%)	0,002
Woman	17 (63%)	7 (22,6%)	
Occupation			
Housewife	16 (5,3%)	7 (22,6%)	0,007
Manual worker	8 (29,6%)	11 (35,5%)	
Self-employed	3 (11,1%)	13 (4,9%)	
Mechanism of injury			
Fortuitous fall	24 (88,9%)	12 (38,7%)	0
Occupational accident	2 (7,4%)	1 (3,2%)	
Traffic accident	1 (3,7%)	11(35,5%)	
Sports lesion	0 (0%)	7 (22,6%)	
Side affected			
Right	14 (51,9%)	12 (38,7%)	0,315
Left	13 (48,1%)	19 (61,3%)	

%: percentage; n: number.

tages in comparison with other fixators, since after an initial period of rigid immobilization it allows dynamic movement. It is simpler to apply than plating systems and makes it possible to use associated procedures that will increase stability, such as the placement of percutaneous nails.

The variable analysis presented in this paper includes only the results seen in patients with excellent outcomes, because we hope to achieve excellence with our treatments. This excellent score was obtained using simultaneously both the Mayo functional scale and Castaing's radiological scale.

Results of the multivariate statistical analysis of variables indicated that the factors that most influenced an excellent functional result, according to the Mayo clinical scale, were the patients' occupation and time to surgery. Self-employed workers had better functional results than those that engaged in other activities (housewives and em-

Table 6. Multivariate analysis

Excellent outcome according to the Mayo functional scale		
	OR	confidence interval 95% p < 0,05
Self-employed worker	7,07	1,41-35,32
Self-employed worker	0,817	0,66-0,99
Excellent outcome according to the Castaing radiological scale		
	OR	95% confidence interval p < 0,05
External fixator	0,001	0,01-0,52
Fernández Grade III-IV-V	0,0005	0,0001-4,7

OR: *odds ratio*.

ployees). These results may be due to more active patient-participation during rehabilitation and the fact that self-employed workers have no income when not working. Time to surgery has a negative influence on outcome; for each day of delay there is a 20% decrease in the probability of achieving an excellent functional result. It was not possible to demonstrate statistically that the surgical technique used (volar plate or external fixator) had any influence on the final functional result. Neither did Wright et al²⁸, in their study, find any functional differences between both groups; the comparison they published differs from this one in terms of the size of the population studied (25 volar plates and 11 external fixators) and the use of a DASH questionnaire as a functional assessment scale.

The factors that had greatest influence on the achievement of excellent radiological results (according to Castaing's scale) were the type of fracture (according to the Fernández Classification) and the surgical technique employed. Type III, IV and V fractures have worse radiological results than type I and II. Possibly the Fernández Classification is the most comprehensive and updated scale available. It takes into account the bone injury, the soft tissue lesion and the mechanism that caused the fracture. As is seen in Wright's study²⁸, open reduction and internal fixation make it possible to perform a more anatomical reduction, whereas the alignment provided by external fixators is not always capable of re-establishing joint anatomy completely; especially in fractures with comminution caused by high-energy trauma. However there is not always clinical-radiological agreement, as was proved in this study.

The results of this study may have been affected by the loss of patients during follow-up and the refusal of others to take part in the study because they were referred to other hospitals or health-care facilities for their follow-up.

Therefore, the study should be enlarged with the inclusion of a larger sample of patients, both in the group treated with plates and in that treated with external fixators, to see if the conclusions are the same.

ACKNOWLEDGEMENTS

The authors would like to thank Vicente Ibáñez Pradas, M.D. for his help with statistics and his comments on the manuscript.

REFERENCES

- Clancey GJ. Percutaneous Kirschner-wire fixation of Colles fractures. A prospective study of thirty cases. *J Bone Joint Surg Am.* 1984;66A:1008-14.
- Cooney WP 3rd, Linscheid RL, Dobyns JH. External pin fixation for unstable Colles' fractures. *J Bone Joint Surg Am.* 1979;61A:840-5.
- Hove LM, Nilsen PT, Furnes O, Oulie HE, Solheim E, Molsater AO. Open reduction and internal fixation of displaced intra-articular fractures of the distal radius. 31 patients followed for 3-7 years. *Acta Orthop Scand.* 1997;68:59-63.
- Greatting MD, Bishop AT. Intrafocal (Kapandji) pinning of unstable fractures of the distal radius. *Orthop Clin North Am.* 1993;24:301-7.
- Jupiter JB. Fractures of the distal end of the radius. *J Bone Joint Surg Am.* 1991;73A:461-9.
- Nana AD, Joshi A, Lichtman DM. Placas de osteosíntesis en radio distal. *J Am Acad Orthop Surg* (ed. española). 2005;4:231-43.
- Jakob M, Rikli DA, Regazzoni P. Fractures of the distal radius treated by internal fixation and early function. A prospective study of 73 consecutive patients. *J Bone Joint Surg Br.* 2000;82B:340-4.
- Kamano M, Honda Y, Kazuki K, Yasuda M. Palmar plating for dorsally displaced fractures of the distal radius. *Clin Orthop Relat Res.* 2002;397:403-8.
- Orbay JL, Fernández DL. Volar fixation for dorsally displaced fractures of the distal radius: a preliminary report. *J Hand Surg Am.* 2002;27A:205-15.
- Orbay JL, Fernández DL. Volar fixed-angle plate fixation for unstable distal radius fractures in the elderly patient. *J Hand Surg Am.* 2004;29A:96-102.
- Weber SC, Szabo RM. Severely comminuted distal radial fracture as an unsolved problem: complications associated with external fixation and pins and plaster techniques. *J Hand Surg Am.* 1986;11A:157-65.
- Muller ME, Nazarian S, Koch P, Schatzker J. The comprehensive classification of fractures. New York: Springer-Verlag; 1990.
- Amadio PC, Berquist TH, Smith DK, Ilstrup DM, Cooney WP 3rd, Linscheid RL. Scaphoid malunion. *J Hand Surg Am.* 1989;14A:679-87.
- Sarmiento A, Pratt GW, Berry NC, Sinclair WF. Colles' fractures: functional bracing in supination. *J Bone Joint Surg Am.* 1975;57A:311-7.
- Castaing J. Fractures récentes de l'extrémité inférieure du radius. *Rev Chir Orthop.* 1964;50:581-696.
- Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (Disabilities of the Arm, Shoulder and Hand). The Upper Extremity Collaborative Group (UECG). *Am J Ind Med.* 1996;29:602-8.
- Atroshi I, Ekdahl C. The Disabilities of the Arm, Shoulder and Hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. *BMC Musculoskelet Disord.* 2003;16:11-3.
- Moser VL, Pommersberger KJ, Pessenlehner C, Meier M, Krimmer H. Fijación de las fracturas inestables del radio con placas volares de ángulo fijo. *Tec Quir Ortop Traumatol* (ed esp). 2005;14:99-112.
- Gausepohl T, Pennig D, Mader K. Principles of external fixation and supplementary techniques in distal radius fractures. *Injury.* 2003;31:56-70.
- Fernández DL. Fractures of the distal radius: operative treatment. *Instr Course Lect.* 1993;42:73-88.
- Knirk JL, Jupiter JB. Intra-articular fractures of the distal end of the radius in young adults. *J Bone Joint Surg Am.* 1986;68A:647-59.
- Boyd LG, Horne JG. The outcome of fractures of the distal radius in young adults. *Injury.* 1988;19:97-100.
- McQueen M, Caspers J. Colles fracture: does the anatomical result affect the final function? *J Bone Joint Surg Br.* 1988;70B:649-51.

24. Haddad N, Chebil M, Khorbi A. Fractures marginal antérieures de l'extrémité inférieure du radius traitées par plaque antérieure. *Rev Chir Orthop.* 2004;90:329-36.
25. Bartosh RA, Saldana MJ. Intraarticular fractures of the distal radius: a cadaveric study to determine if ligamentotaxis restores radiopalmar tilt. *J Hand Surg Am.* 1990;15A:18-21.
26. Jupiter JB, Lipton H. The operative treatment of intraarticular fractures of the distal radius. *Clin Orthop Relat Res.* 1993; 292:48-61.
27. Bradway JK, Amadio PC, Cooney WP. Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. *J Bone Joint Surg Am.* 1989;71A:839-47.
28. Wright TW, Horodyski M, Smith DW. Functional outcome of unstable distal radius: ORIF with a volar fixed-angle titanium plate versus external fixation. *J Hand Surg Am.* 2005;30A: 289-99.

Conflict of interests

The authors have declared that they have no conflict of interests.