Acta Ortopédica Mexicana 2010; 24(4): Jul.-Aug: 220-228

Original article

Functional result in distal radius fractures. Comparison among the severity of the fracture, the treatment of choice and the baseline X-Ray parameters

Farías EC,*,[i] Gil FO,**,[i] Trueba CD,***,[i] Jaspeado RR,[ii]

Hospital Español de México

ABSTRACT. ***Background:*** **the AO classification has a prognostic value and assists physicians in the planning of fracture management. The X-ray data and the DASH questionnaire are used to assess the outcome of radial fractures. A trend towards open treatment, opposite to closed or percutaneous approaches, has been observed in the past ten years.** ***Methods:*** **descriptive study evaluating the functional outcome, with a follow-up from 6-months to one year, using the DASH questionnaire and correlating the outcomes with the treatment used, the type of fracture, the AO and Frykman classifications, and the baseline X-ray parameters. The fracture stability and the treatment of choice were recorded. Patients were grouped according to the treatment used.** ***Results:*** **a DASH score ≤ 20 was considered as good, and > 20 as poor. The questionnaires were applied at the 6- and 12-month follow-up visits, the mean score was 14.46. No statistical difference was found between the good or bad outcomes and the type of treatment. A correlation was found between both the type of fracture and the X-ray parameters and the functional outcome.** ***Conclusions:*** **regardless of the treatment of choice of distal radius fractures, the major goal is to restore the normal X-ray parameters to improve the functional outcome and decrease the complications. No difference was found in the functional outcome among the treatment options used to treat the distal radius fractures. The AO classification is**

RESUMEN. ***Antecedentes:*** **La clasificación AO tiene valor pronóstico, ayudando a los médicos en planificar el manejo de fracturas. Los datos radiológicos y el cuestionario DASH se usan para evaluar el resultado de las fracturas radiales. En los últimos diez años se ha observado una tendencia hacia el tratamiento abierto, opuesto a los métodos de tratamiento cerrados o percutáneos.** ***Métodos:*** **Estudio descriptivo que evalúa el resultado funcional con seguimiento de 6 meses a 1 año con el cuestionario DASH, correlacionando los resultados con el tratamiento empleado, tipo de fractura, clasificaciones AO y Frykman y los parámetros radiológicos iniciales. Se registraron estabilidad de la fractura y tratamiento de elección. Los pacientes se agruparon de acuerdo al tratamiento empleado.** ***Resultados:*** **Se tomó un resultado DASH ≤ 20 como bueno, y > 20 como pobre. A los 6 a 12 meses de seguimiento se aplicaron los cuestionarios, el resultado promedio fue 14.46. No se encontró diferencia estadística entre un resultado bueno o malo de acuerdo al tipo de tratamiento. Se encontró correlación entre el tipo de fractura y los parámetros radiológicos con el resultado funcional.** ***Conclusiones:*** **Sin importar el tratamiento de elección para las fracturas del radio distal, el objetivo más importante es restaurar las mediciones radiológicas normales para mejorar el resultado funcional y reducir las complicaciones. No se encontró diferencia en el resultado funcional entre**

Level of evidence: IV (Act Ortop Mex, 2010)

* Head, Orthopedics Residents.
**Head, Orthopedics and Traumatology Service.
*** Titular Professor of the Orthopedics Course, National Autonomous University of Mexico.
[i] Hospital Español de México.
[ii] Medical school undergraduate doing Social Service, Universidad La Salle.

Please address all correspondence to:
Dr. Efraín Farías Cisneros. Jefe de Residentes de Ortopedia. Hospital Español de México
San Raúl 89. Pedregal de Santa Úrsula Coapa. CP 04600. México, D. F. Tel/Fax: 5618 6927
E-mail: dr.efrain.farias@gmail.com

valid as a prognostic indicator and useful to make therapeutic decisions.

Key words: fracture, radiology, radius, comparative study, treatment, evaluation.

las opciones terapéuticas empleadas para las fracturas del radio distal. La clasificación AO es válida como indicador pronóstico y útil para tomar decisiones terapéuticas.

Palabras clave: fractura, radiología, radio, estudio comparativo, tratamiento, evaluación.

Introduction

Distal radius fractures have been analyzed for more than 200 years. The initial descriptions of the fracture mechanisms and their treatment were made before the radiography was available. Colles, Poteau, Smith and Barton,[1,2] among many others, described the distal radius fractures before the advent of radiography. Around 1930, the authors started describing other treatments, besides the standard casts and splints, for distal radius fractures. Anderson and O'Neil[3] described the use of an external bar that was fixed to the bone with pins placed proximal and distal to the fracture. Around that same time, Cole and Obletz[4] described an alternative method using pins and a cast. These methods were used for around 30 years, until direct reduction and fixation were commonly accepted for the treatment of displaced and unstable distal radius fractures. In 1965, Ellis[5] described the placement of a volar buttress plate for fractures previously known as Barton's fractures. These fractures were found to shift after closed reduction due to their intraarticular location, as well as the instability at the fracture site, which was difficult to control using a cast and/or external fixation. The buttress plate could stand the straining forces of this fracture and thus its superiority for achieving stabilization was rapidly accepted. However, the role of internal fixation for the most common and complex distal radius fractures, including those originally described by Colles, was recognized only later. The papers written in the late 1980's and early 1990's describing the usefulness of open fixation with and without external neutralization started clarifying how a combination of treatments could provide stability and improved results in some of the most unstable distal radius fractures.[2]

Besides the development of rigid fixation, the limited pin fixation of distal radius fractures has been advocated by many. Since the late 1940's and until recently, the role of pin fixation, as compared with internal or external fixation, has not been clear. A continuously evolving view is that pin fixation is effective in some fractures with minimal communication with the volar cortex, so that the latter may act as a buttress point around which the pins may assist in rotating the fracture and maintaining reduction after fixation.[2]

In the past ten years[6] a marked trend towards internal fixation with plates and screws has been observed in the management of distal radius fractures.[7-17] This has been influenced, in part, by the development of anatomical implants with a stable angular fixation providing a more predictable fixation of the osteoporotic cancellous bone.[7,18-21] There has been little level I or II evidence to justify this approach.[13,22-24] The Cochrane review, which limits its reviews to the randomized controlled trials, has emphasized that the literature related with the treatment of distal radius fractures is inappropriate.[25-27] Most of the trials are too small and do not have appropriate statistical power; most of them are methodologically flawed; and many case series are weak due to lack of standardization and the use of measurement instruments without a validated functional result.[27]

The DASH (Disabilities of Arm, Shoulder and Hand) questionnaire is one of the properly validated instruments. This questionnaire was developed by the American Academy of Orthopedic Surgeons (AAOS) in collaboration with the Council of Musculoskeletal Specialty Societies (COMSS) and the Institute for Work and Health (IWH) in 1996.[28] The DASH is a 30-item questionnaire designed to measure topics related with thoracic limb function; 21 of them assess difficulty with specific tasks, 5 assess symptoms (2 pain, 1 hypoesthesia, 1 stiffness and 1 weakness), and each of the remaining ones assesses the social and work function, sleep and confidence. This questionnaire was designed to measure the physical inability and symptoms in a heterogeneous population that includes both males and females; individuals with high, medium or low demands on their thoracic limbs during the activities of daily living (work, self-care, recreation), and people with a variety of thoracic limb disorders. For the proper use of the questionnaire, patients are asked to answer all the sections based on their ability to perform activities in the past week. At least 27 of the 30 items should be completed for a proper estimate. The assigned values are added and divided by the number of questions answered. This value is transformed into a scale ranging from 0 to 100, then 1 is subtracted from this number and the resulting number is multiplied by 25, according to the following formula:

DASH = {(sum of *n* answers) - 1} x 25/ *n* = total number of questions answered by the patients.

The highest scores indicate a worse upper limb function.

It has been established that the AO classification[29] has a prognostic value for patient outcome, besides helping the

surgeon in planning the treatment of fractures. Within the setting of stable extraarticular distal radius fractures, it is commonly accepted to manage them with closed reduction and immobilization with a sugar-tong splint or a circular brachiopalmar brace based on the biologic principle of ligamentotaxis; however, loss of reduction has been observed in many cases.[30] On the other hand, the most effective method to fix a distal radius intraarticular fracture has not been established yet. Two commonly used methods include external fixation combined with nail fixation, and plate fixation.

The treatment of distal radius fractures is entering a new stage. As the trial results become more prevalent, it will be possible to compare several fixation methods provided the classification scheme they use is highly reliable. Moreover, there is an increasing demand for better functional treatment results on behalf of the affected population.

In any surgical approach to the wrist, whether open, percutaneous or arthroscopic, the surgeon should be aware of the anatomical location of the neurovascular structures. The superficial branch of the radial nerve, the lateral antebrachial cutaneous nerve, the dorsal sensory branch of the ulnar nerve and the volar cutaneous branch of the median nerve are particularly at risk of injury during the surgical procedures of the wrist.[31]

Biomechanically, the healthy wrist behaves as three columns supporting the bones of the carpus and the hand, composed as follows: first, a radial column encompassing the lateral aspect of the radius including the radial styloid and the scaphoid fossa; then an intermediate column composed of the ulnar side of the radius, including the lunar fossa and the sigmoid rim; and, finally, an ulnar column composed of the ulnar head, including the triangular fibrocartilaginous complex and the ulnar aspect of the distal radioulnar joint.[32] The loss of continuity of two of these columns produces instability, which is defined as the inability of a fracture to resist displacement after the manipulation of an anatomical position.[33]

We conducted a descriptive study during a period of six months to one year, in distal radius fractures, designed to assess the functional results of these fractures treated with different methods. The specific objective of the study included the assessment of the various treatments documenting the results, as well as the usefulness of the AO classification for the prognosis and treatment, with the use of time-validated measurements.

Material and methods.

This is a descriptive study assessing the functional outcome of the hospital-based treatment of distal radius fractures with a follow-up of 6 months to one year. The study was approved by the Ethics Committee of the hospital.

The inclusion criteria were the presence of a unilateral acute fracture of the distal radius, with anteroposterior (AP) and lateral X-rays, and skeletal maturity. No informed consent was required, as this was a merely observational study. The treatment of choice was decided by the treating physician and in all cases the patient's informed consent was obtained.

The exclusion criteria were the inability to answer the questionnaire, the presence of medical disorders with an impact on bone physiology and another ipsilateral fracture.

All the distal radius fractures that occurred in adults and that were diagnosed and treated in the emergency room for one year were reviewed.

Initial Assessment: The demographic characteristics at the time of injury were documented, including sex, dominance and the associated medical conditions. The initial characteristics of the injury were also recorded, including the type of accident, the energy level, the type of fracture according to the AO[32] and Frykman[34] classifications, and the associated soft tissue injuries at the fracture site. AP and lateral X-rays were obtained of each patient at the time of admission, immediately after the treatment provided and during the follow-up visits. The baseline radiologic parameters were measured, and the fracture stability, according to the Altissimi[35] and Fernández[36] criteria (Table 1), and the treatment provided were recorded.

Follow-up Interview: The study protocol was implemented with the application of a questionnaire 6 months to one year after treatment was provided; one of the research team members applied the questionnaire during the follow-up visit or by telephone. The functional result was calculated using the DASH questionnaire. All adverse effects were documented throughout the duration of the study. The X-rays were evaluated and measured by orthopedists. The radial angle, the radial height, the ulnar variance, and the presence of a step-off or articular gaps were evaluated in the AP X-rays. The volar tilt angle, and the presence of a step-off or articular gaps were evaluated in the lateral X-rays. These measuremente were made according to the criteria by Kreder et al[37] *(Figure 1).*

Demographic and Baseline Patient Characteristics: The study was started in January 2008 and a total of 113 patients with acute distal radius fractures were enrolled. Mean age of the group was 59.8 years (range 15-90, median 63, mode 83). Four patients were lost during the follow-up. The final population was composed of 109 patients; 29 males and 80 females; 59 injuries involved the right wrist, and 50 the left. Most patients (91%) were right-handed. Eighty-eight (81%) of the fractures occurred due to a fall from a standing height, 10 (9%) due to a fall from a height, 4 (3.6%) due to motor vehicle accidents, 3 due to a fall from a bicycle, and the cause of 4 of them was not documented. Almost half of the sports and motor vehicle-related injuries were considered as high-energy injuries. According to the AO classification, 48 (44%) were type A, 22 (20%) were type B, and 39 (36%) were type C *(Chart 1).* The ulnar styloid was involved in 54 (49%) fractures *(Chart 2).* All fractures were closed. Forty-three (39%) were classified as stable and 67 (61%) as unstable (*Chart 3 and 4*).

Surgical Data: Patients were grouped according to the treatment of choice, which included: 1) Closed reduction

(CR) and immobilization with a splint or cast, 2) CR and internal fixation (IF) with percutaneous nails and immobilization with a splint or cast, 3) CR and external fixation (EF) either alone or combined with percutaneous nails, 4) Open reduction (OR) and IF with volar or dorsal plates. The fractures were treated as soon as the patient arrived in the emergency room; those that required surgery were treated within 48 hours of the injury; in no case was it necessary to further delay surgery. The treatment of choice was selected by the treating physician, as well as the surgical approaches and the implants.

Seventy-nine (72%) patients were treated non-surgically: 47 (43%) of the fractures were treated with closed reduction plus immobilization with a splint or a closed brace, 32 (29%) were treated with a splint or a closed brace only. Thirty-two patients (28%) were treated surgically: 14 (13%) were treated with closed reduction and internal fixation with percutaneous Kirschner nails, 7 (7%) with open reduction and internal fixation, 7 (7%) with closed reduction and external fixation, and 2 (2%) with closed reduction and hybrid fixation with percutaneous Kirschner nails and external fixators *(Chart 5)*. No grafts or bone substitutes were used in any of the fractures. Most of the fractures were treated by experienced surgeons or by supervised residents of Orthopedics.

Table 1. Radiologic signs indicative of possible failure of the orthopedic treatment with a splint or cast after closed reduction. [35,36]

Dorsal comminution >50% of the radius height
Volar metaphyseal comminution
Initial dorsal angular deviation > 20°
Initial displacement > 1cm (translation of the fragment)
Initial shortening > 5mm
Intraarticular involvement
Associated ulnar fracture
Major osteoporosis

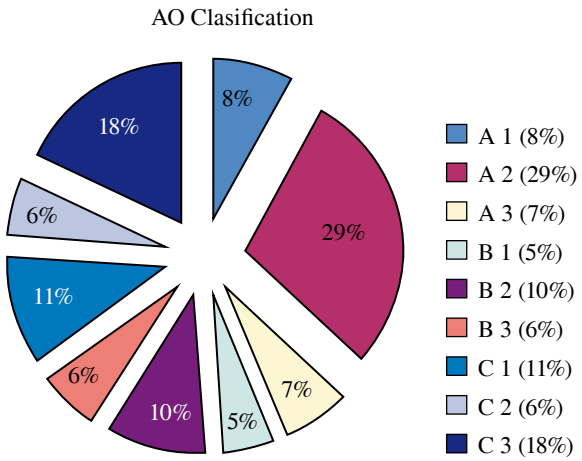

Chart 1. Distribution of the AO classification, distal metaphysoepiphyseal segment of the radius and ulna, corresponding to number 23, among the 109 fractures studied.

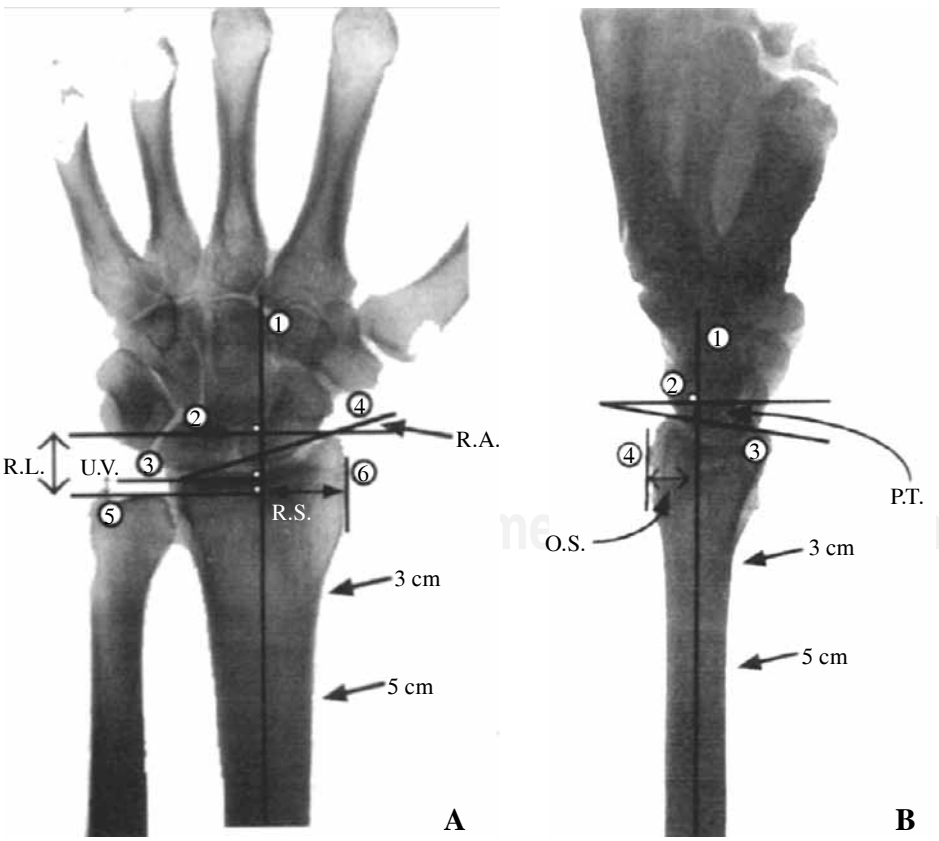

Figure 1. Anteroposterior (A) and lateral (B) measurement guidelines by Kreder et al. used in the study. (Taken from: Kreder HJ, Hanel DP, McKee M, Jupiter J, McGillivary G and Swiontkowski MF. X-ray Film Measurements for Healed Distal Radius Fractures. J Hand Surg 1996;21A:31-39.)

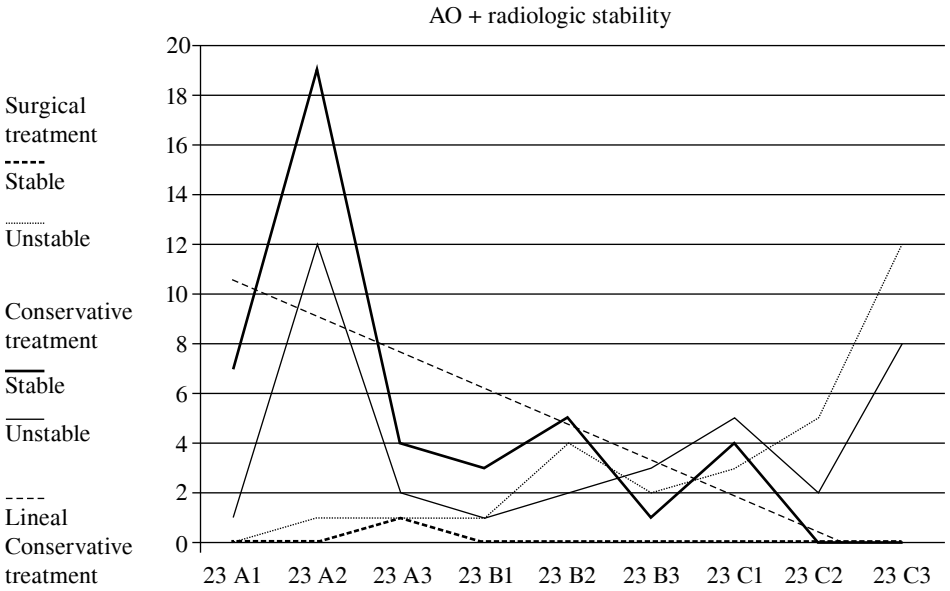

Chart 2. The distribution of the type of treatment according to the AO classification and the fracture stability are shown. The dotted line shows a trend towards surgical treatment as the severity and instability of the fracture increase.

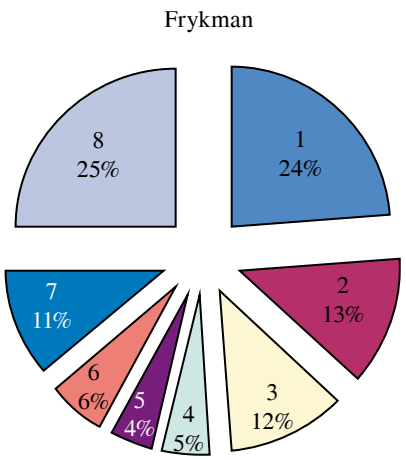

Chart 3. The distribution of the type of treatment according to the Frykman classification.

Forty-three fractures (38.6%) were classified as stable; one of them was treated surgically with ORIF using a volar plate. The remaining 67 fractures were classified as unstable (61.4%); 29 of them were treated surgically and 38 were managed conservatively *(Table 2)*.

Statistical methods: Patient lists were created with the data collected from the patients' medical records and the treatment records of the emergency room; all data were entered into a data base. Data inconsistencies were verified in the corresponding records and the necessary corrections were made in the data base.

All the baseline and follow-up parameters were described using standard descriptive statistics. The continuous variables were described by using means, standard deviations and ranges, while the categorical variables were tabulated as absolute and relative frequencies. The *One-Way ANOVA* tests were used, followed by a series of matched *t* tests if appropriate. The changes in the categorical results were analyzed using symmetry tests. P values ≤ 0.05 were considered as significant.

Results

Of the 113 patients enrolled in the study, 109 (96%) complied with the follow-up. The causes of loss to follow-up included one death, one patient who refused to answer the questionnaire and 2 patients from out-of-town who could not comply with the follow-up *(Table 3)*.

A DASH score ≤ 20 was considered as good, and >20 as poor. For this purpose, it was considered that patients had a function of 0 or close to this number prior to the injury, that the minimum detectable change in the scale considered as statistically significant with a 95% confidence interval was 12.7 points, and that the clinically relevant minimum difference considered as significant was 15 points.[38]

The questionnaires were applied at the 6- and 12-month follow-up visits, the mean DASH score was 14.46. The results according to the age (p=0.001) and the AO classification (p=0.003) were significant and correlated with a good functional outcome (DASH ≤ 20). The type of treatment (0.577) was not related with the functional outcome. Although not statistically significant (p=0.064), the radiologic instability criteria did show a trend towards a poor functional outcome. However, the AO classification was related with the age (p=0.035), the radiologic stability (p=0.000), the treatment of choice (p=0.000) and a good functional outcome (p=0.003). No statistical difference was found between the good or bad outcomes and the type of treatment used *(Table 4)*.

Discussion

Regardless of the treatment of choice of distal radius fractures, the major goal is to restore the normal X-ray pa-

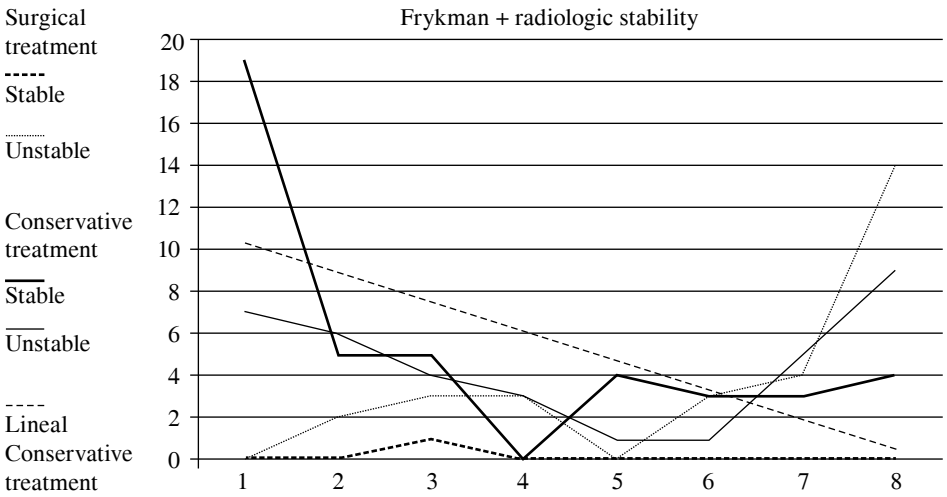

Chart 4. Distribution of the treatment of choice as percentages in the 109 fractures studied. Seventy-two percent of the fractures were treated conservatively, even though 61.4% of the fractures were considered as unstable.

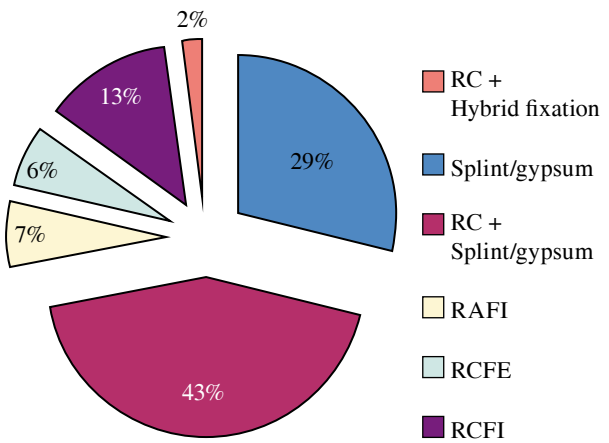

Chart 5. Treatment choice.

Table 2. Treatment provided according to fracture stability.

	Surgical	Conservative	Total
Stable	1	41	42
Unstable	29	38	67

rameters to improve the functional outcome and decrease the complications. It is essential to make a proper diagnosis and staging of the fracture to determine which is the best treatment, and to seek a good outcome according to the prognosis, based on the fracture characteristics, as well as on the presence or absence of stability. Once all of these requirements have been met, the best possible treatment should be offered according to the patient's features and expectations.

In a prospective trial of 87 fractures treated with volar locking implants, Chung et al.[39] reported an improvement in most functional parameters during a 12-month follow-up period. In a prospective study of 41 patients treated with volar locking implants, Rozental and Blazar[14] found a higher DASH score (14 points) during a mean of 17 postoperative months, with a mean DASH score of 12 in patients without complications and of 22 in those with complications.

Margaliot et al. did a meta-analysis of 46 papers consisting of 28 external fixation studies (917 patients) and 18 internal fixation studies (603 patients). No clinically or statistically significant differences were detected between both treatments in the grip strength, wrist ranges of motion, radiologic alignment, pain, and physician-assessed results. Higher rates of infection, implant failure and neuritis were seen with external fixation, and higher rates of tendon complications and early implant removal with internal fixation. A considerable heterogeneity was seen in all the trials, which adversely affected the precision of the meta-analysis. Westphal et al. did a comparative retrospective study of 166 of 237 patients treated surgically for distal radius fractures classified as AO A3 or C2. The fractures were treated with external fixation or ORIF using volar or dorsal plates. ORIF, particularly with volar plate fixation, showed the best radiologic and functional results.[40]

External fixation is not enough when used as the only treatment for displaced intraarticular fractures. In a study of 27 patients with comminuted, displaced intraarticular distal radius fractures treated only with external fixation, Arora et al.[41] concluded that, even though external fixation is reliable for maintaining the reduction in comminuted displaced intraarticular fractures, it does not restore the articular congruence in many cases. Kreder et al.[42] compared the results of ORIF versus external fixation plus percutaneous pins. A total of 179 adult patients with displaced intraarticular fractures of the distal radius were randomly distributed to undergo indirect percutaneous reduction and external fixation (88 patients) or ORIF (91 patients). There were no statistical differences in the radiologic restoration of the anatomical characteristics or the range of motion between both groups at two years. However, the patients who underwent indirect reduction and percutaneous fixation had a quicker functional recovery and a better functional outcome that those who underwent ORIF, provided that the step-off and the presence of an intraarticular gap were minimal.

In another study, Grewal et al. showed the superiority of external fixation augmented with Kirschner nails over the internal fixation with a Pi dorsal plate for displaced intraarticular distal radius fractures. The group that underwent plating also had more pain at one year compared with the group without external fixation; however, both were the same after implant removal. The external fixation group showed a mean grip strength of 97% when it was compared with the normal side versus 86% for the dorsal plate group.[43]

Leung et al.[6] conducted a randomized trial comparing external fixation augmented with nails and internal plate fixation for intraarticular distal radius fractures. Seventy-four (51%) of the fractures were treated with external fixation augmented with percutaneous nail fixation, and the rest were treated with volar, dorsal or combined plate fixation. At the time of the 24-month follow-up, the results for the plate fixation group were significantly better than for the augmented external fixation group, particularly in the AO C2 fractures.

In this study we did not find any differences in the functional outcome among the treatment modalities for distal radius fractures for several reasons which were not foreseen during the study design. These factors include the surgeon's skill to manage these fractures, as well as the trend to treat elderly patients conservatively regardless of the fracture characteristics. Although the mean DASH score between the 6-month and the one-year follow-ups in our study did not return to the presumed original baseline value, we must emphasize that the mean final score of 14 points reflects the satisfaction of patients with minimum symptoms, and this minimal residual difference is not clinically relevant.[38]

Another aspect to consider, even though for the time being it is a merely subjective interpretation, is the patients'

Table 3. Demographic and baseline characteristics of patients.

Categories		Variables		#		(%)
Age		≤ 25		5		(5)
		26-35		11		(10)
		36-45		8		(7)
		46-55		14		(13)
(mean 59.8,		56-65		24		(22)
median 63,		66-75		21		(19)
mode 83)		≥ 76		26		(24)
Sex		Female		80		(73)
		Male		29		(27)
Type of patients		Beneficiaries of SBE		17		(16)
		Private		92		(84)
Side involved		Right		59		(54)
		Left		50		(46)
Dominance		Right-handed		100		(91)
		Left-handed		9		(8)
Mechanism of injury		Fall from a standing height		88		(81)
		Fall from a height		10		(9)
		Motor vehicle accidents		4		(3.6)
		Fall from a bicycle		3		(2.7)
		Not documented		4		(3.6)
AO Clasification		A1		8		(8)
		A2		32		(29)
	Total A	A3	48	8	(44)	(7)
		B1		5		(5)
		B2		11		(10)
	Total B	B3	22	6	(20)	(6)
		C1		12		(11)
		C2		7		(6)
	Total C	C3	39	20	(36)	(18)
Ulnar injury	Present			54		(49)
	Absent			55		(51)
Radiologic stability	Present			42		(39)
	Absent			67		(61)

Table 4. Results according to the treatment of choice.

	Patients	(%)	Radiologic Stability		DASH
Nonsurgical Treatment	77	72	Yes	41	9.95
			No	38	19.52
Immobilization with splint or cast	30	29	Yes	27	9.30
			No	5	19.16
CR + Immobilization with splint or cast	47	43	Yes	14	11.07
			No	33	19.58
Surgical Treatment	32	28	Yes	1	16.70
			No	29	14.12
CREF	7	7	Yes	0	0.00
			No	7	14.45
Percutaneous CRIF	14	13	Yes	0	0.00
			No	14	12.64
CREF + Kirschner	4	2	Yes	0	0.00
			No	2	15.20
ORIF	7	7	Yes	1	16.70
			No	6	16.85
Total	109	100	Yes	42	10.11
			No	67	17.19

loyalty to their doctors, as in some cases their answers to the questionnaire were influenced by the patient-doctor relation, and the experience they had during the diagnosis, treatment and follow-up.

This study confirmed that the AO classification is valid as a prognostic indicator and useful to make therapeutic decisions, so we recommend its routine use in the initial assessment of patients with distal radius fractures, together with the baseline radiologic measurements and the search for radiologic signs of instability.

The use of closed methods, whether alone or combined with external or percutaneous external fixation methods, remains as a good treatment option, if performed properly, same as ORIF with plates. And, if a treatment modality is not going to be used properly, it is much better to use the method that the surgeon masters technically and one that assures the necessary stability so that the fracture can heal without complications. It is necessary to emphasize that, besides the above aspects, the so called *personality of the fracture* should be taken into account upon selecting the treatment, including the patient's age, dominance, presence of comorbid conditions, bone quality, ulnar involvement, radiologic and clinical stability, functionality prior to the injury, and patient expectations.[32]

With the advent of the implants designed specifically for the anatomical characteristics of the distal end of the radius and the availability of screws with a locking head, the surgical fixation of unstable distal radius fractures has become an increasingly widespread surgery.[44]

We know that no treatment is innocuous, we should not believe that if a fracture site is not opened we will prevent complications, as the poorly performed closed reductions may cause anything from compressive neuropathies and malpositioned healing to pseudoarthrosis and compartmental syndrome. Neurovascular injuries occur due to the approaches, as well as osteomyelitis, tendon inflammation or rupture, and many other complications related with the osteosynthesis material. In the surgical treatment of unstable distal radius fractures the possible risks and failures should be anticipated to diminish them as much as possible with an appropriate preoperative planning.[45]

Although in this study we had an excellent follow-up rate, unfortunately the questionnaire could not be applied to all patients within the same period of time, because the research team could not schedule the follow-up visit in many patients. An important limitation of the study is the wide variety of therapeutic decisions and the poor compliance of treating physicians with the current recommendations concerning the treatment of this type of fractures. Another limitation is that the surgeries were performed by many surgeons, who used a gamut of implant forms and locations.

Despite these limitations, one of the achievements was that the data analysis and the application of questionnaires were both very homogeneous, since they were conducted only by the team members. We believe that the information generated by this study provides a reasonable view of the expected outcomes in the treatment of distal radius fractures if one considers the AO classification, the baseline radiologic parameters and the presence of instability, to provide a customized treatment that considers the best treatment option for each of our patients.

References

1. Colles A: Historical paper on the fracture of the carpal extremity of the radius [1814] *Injury* 1970; 2: 48-50.
2. Putnam MD, Seitz WH: Fracturas distales del radio. Cap 20, en: Bucholz RW. Rokwodds & Green's. Fracturas en el adulto. Tomo 2. Madrid, 2003.
3. Anderson R, O'Neil G: Comminuted fractures of the distal end of the radius. *Surg Gynecol Obstet* 1944; 78: 434-40.
4. Cole JM, Obletz BE: Comminuted fractures of the distal end of the radius treated by skeletal transfixion in plaster cast. An end-result study of thirty-three cases. *J Bone Joint Surg* 1966; 48A: 931-45.

5. Ellis J: Smith's and Barton's fractures: a method of treatment. *J Bone Joint Surg* 1965; 47B: 724-7.
6. Leung F, Tu Y, Chew WYC, Chow SP: Comparison of External and Percutaneous Pin Fixation with Plate Fixation for Intra-articular Distal Radial Fractures. A Randomized Study. *J Bone Joint Surg Am* 2008; 90: 16-22.
7. Orbay JL, Fernandez DL: Volar fixation for dorsally displaced fractures of the distal radius: a preliminary report. *J Hand Surg [Am]* 2002; 27: 205-15.
8. Konrath GA, Bahler S: Open reduction and internal fixation of unstable distal radius fractures: results using the trimed fixation system. *J Orthop Trauma* 2002; 16: 578-85.
9. Orbay JL, Fernandez DL: Volar fixed-angle plate fixation for unstable distal radius fractures in the elderly patient. *J Hand Surg [Am]* 2004; 29: 96-102.
10. Jupiter JB: Plate fixation of fractures of the distal aspect of the radius: relative indications. *J Orthop Trauma* 1999; 13: 559-69.
11. Simic PM, Robison J, Gardner MJ, Gelberman RH, Weiland AJ, Boyer MI: Treatment of distal radius fractures with a low-profile dorsal plating system: an outcomes assessment. *J Hand Surg [Am]* 2006; 31: 382-6.
12. Jupiter JB, Ring D, Weitzel PP: Surgical treatment of redisplaced fractures of the distal radius in patients older than 60 years. *J Hand Surg [Am]* 2002; 27: 714-23.
13. Wright TW, Horodyski M, Smith DW: Functional outcome of unstable distal radius fractures: ORIF with a volar fixed-angle tine plate versus external fixation. *J Hand Surg [Am]* 2005; 30: 289-99. Erratum in: *J Hand Surg [Am]* 2005; 30: 629.
14. Rozental TD, Blazar PE: Functional outcome and complications after volar plating for dorsally displaced, unstable fractures of the distal radius. *J Hand Surg [Am]* 2006; 31: 359-65.
15. Kamath AF, Zurakowski D, Day CS: Low-profile dorsal plating for dorsally angulated distal radius fractures: an outcomes study. *J Hand Surg [Am]* 2006; 31: 1061-7.
16. Ring D, Prommersberger K, Jupiter JB: Combined dorsal and volar plate fixation of complex fractures of the distal part of the radius. *J Bone Joint Surg Am* 2004; 86: 1646-52.
17. Rikli DA, Regazzoni P: Fractures of the distal end of the radius treated by internal fixation and early function. A preliminary report of 20 cases. *J Bone Joint Surg Br* 1996; 78: 588-92.
18. Drobetz H, Bryant AL, Pokorny T, Spitaler R, Leixnering M, Jupiter JB: Volar fixed-angle plating of distal radius extension fractures: influence of plate position on secondary loss of reduction—a biomechanic study in a cadaveric model. *J Hand Surg [Am]* 2006; 31: 615-22.
19. Grindel SI, Wang M, Gerlach M, McGrady LM, Brown S: Biomechanical comparison of fixed-angle volar plate *versus* fixed-angle volar plate plus fragmentspecific fixation in a cadaveric distal radius fracture model. *J Hand Surg [Am]* 2007; 32: 194-9.
20. Taylor KF, Parks BG, Segalman KA: Biomechanical stability of a fixed-angle volar plate *versus* fragment-specific fixation system: cyclic testing in a C2-type distal radius cadaver fracture model. *J Hand Surg [Am]* 2006; 31: 373-81.
21. Osada D, Viegas SF, Shah MA, Morris RP, Patterson RM: Comparison of different distal radius dorsal and volar fracture fixation plates: a biomechanical study. *J Hand Surg [Am]* 2003; 28: 94-104.
22. Grewal R, Perey B, Wilmink M, Stothers K: A randomized prospective study on the treatment of intra-articular distal radius fractures: open reduction and internal fixation with dorsal plating versus mini open reduction, percutaneous fixation, and external fixation. *J Hand Surg [Am]* 2005; 30: 764-72.
23. Kreder HJ, Hanel DP, Agel J, McKee M, Schemitsch EH, Trumble TE, Stephen D: Indirect reduction and percutaneous fixation *versus* open reduction and internal fixation for displaced intra-articular fractures of the distal radius: a randomised, controlled trial. *J Bone Joint Surg Br* 2005; 87: 829-36.
24. Margaliot Z, Haase SC, Kotsis SV, Kim HM, Chung KC: A meta-analysis of outcomes of external fixation *versus* plate osteosynthesis for unstable distal radius fractures. *J Hand Surg [Am]* 2005; 30: 1185-99.
25. Handoll HHG, Madhok R: Closed reduction methods for treating distal radial fractures in adults. *Cochrane Database Syst Rev* 2003; 1: CD003763.
26. Handoll HHG, Madhok R: Conservative interventions for treating distal radial fractures in adults. *Cochrane Database of Syst Rev* 2003; 2:CD000314.
27. Handoll HHG, Madhok R: Surgical interventions for treating distal radial fractures in adults. *Cochrane Database of Syst Rev* 2003; 3: CD003209.
28. Hudak P, Amadio PC, Bombardier C, and the Upper Extremity Collaborative Group. Development of an Upper Extremity Outcome Measure: The DASH (Disabilities of the Arm, Shoulder, and Hand). *Am J Ind Med* 1996; 29: 602-8.
29. Kreder HJ, Hanel DP, McKee M, Jupiter J, McGillivary G, Swiontkowsi MF: Consistency of AO fracture classification for the distal radius. *J Bone Joint Surg Br* 1996; 78: 726-31.
30. Gausepohl T, Worner S, Pennig D, Koebke J: Extraarticular external fixation in distal radius fractures pin placement in osteoporotic bone. *Injury* 2001; 32(suppl 4): SD79-85.
31. Steinberg BD, Plancher KD: Clinical Anatomy of the Wrist and Elbow in The Athletic Elbow and Wrist: Diagnosis and Conservative Treatment. *Clin Sports Med* 1995; 14: 299-313.
32. Fernandez DL: "Distal Radius and Wrist," AO principles of fracture management, ed. T. P. Ruedi, W. M. Murphy, New York, Thieme, 2000.
33. Nesbitt KS, Failla JM, Les C: Assessment of Instability Factors in Adult Distal Radius Fractures. *J Hand Surg* 2004; 29A: 1128-38.
34. Goldfarb CA, Yin Y, Gilula LA, Fisher AJ, Boyer MI: Wrist Fractures: What the Clinician Wants to Know. *Radiology* 2001; 219: 11-28.
35. Altissimi M, Mancini GB, Azzara A, at al: Early and late displacement of fractures of the distal radius, the prediction of instability. *Int Orthop* 1994; 18(2): 61-5.
36. Fernandez DL, Jupiter JB: Fractures of the Distal Radius. Berlin Heidelberg New York: Springer-Verlag. 1995.
37. Kreder HJ, Hanel DP, McKee M, Jupiter J, McGillivary G, Swiontkowski MF: X-ray Film Measurements for Healed Distal Radius Fractures. *J Hand Surg* 1996; 21A: 31-39. Erratum in: *J Hand Surg [Am]* 1996; 21: 532.
38. Beaton DE, Davis AM, Hudak P, McConnell S: The DASH (Disabilities of the Arm, Shoulder, and Hand) outcome measure: What do we know about it now? *J Hand Ther Br* 2001; 6(4): 109-18.
39. Chung KC, Watt AJ, Kotsis SV, Margaliot Z, Haase SC, Kim HM: Treatment of unstable distal radial fractures with volar locking plating system. *J Bone Joint Surg Am* 2006; 88: 2687-94.
40. Westphal T, Piatek S, Schubert S, Winckler S: Outcome after surgery of distal radius fractures: no differences between external fixation and ORIF. *Arch Orthop Trauma Surg* 2005; 125: 507-14.
41. Arora J, Malik AC: External fixation in comminuted, displaced intra-articular fractures of the distal radius: is it sufficient? *Arch Orthop Trauma Surg* 2005; 125: 536-40.
42. Kreder HJ, Hanel DP, Agel J, et al: Indirect reduction and percutaneous fixation *versus* open reduction and internal fixation for displaced intra-articular fractures of the distal radius: a randomized, controlled trial. *J Bone Joint Surg* 2005; 87B: 829-36.
43. Grewal R, Perey B, Wilmink M, Stothers K: A randomized prospective study on the treatment of intra-articular distal radius fractures: open reduction and internal fixation with dorsal plating *versus* mini open reduction, percutaneous fixation, and external fixation. *J Hand Surg* 2005; 30A: 764-72.
44. Jupiter JB, Marent-Huber M and the LCP Study Group. Operative Management of Distal Radial Fractures with 2.4-Millimeter Locking Plates. A Multicenter Prospective Case Series. *Bone Joint Surg Am* 2009; 91: 55-65.
45. Friedman SL: Complicaciones en Ortopedia. Fracturas del Radio Distal. Jeffrey O. Anglen, AAOS. Barcelona, *Ars Medica*, 2008.