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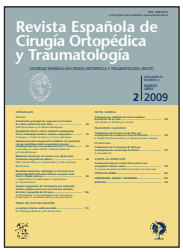

ORIGINAL PAPERS

Functional and radiological outcomes in distal radius fractures treated with a volar plate vs. an external fixator

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KEYWORDS
Distal radius fracture;
Volar buttress plate;
External fixator

Abstract
Purpose: To compare the functional and radiological results obtained in distal radius intraarticular fractures treated by means of internal fixation with a volar buttress plate vs. those treated with an external fixator.
Materials and methods: We performed a comparative retrospective study of two patient series: 36 distal radius fractures treated with a volar AO T 2.4/2.7 buttress plate and 40 fractures treated with Pennig's dynamic external fixator. We used Müller's AO-ASIF classification following the anteroposterior and lateral x-ray study. We collected data about patient characteristics, mechanism of injury and postoperative complications. Minimum follow-up was 10 months. We performed clinical and radiographic evaluations at the beginning, at 3 months and at the end of follow-up. We used Lidström's scale for the functional assessment.
Results: In the group treated with a volar buttress plate better results were obtained for ulnar inclination of the radius and volar inclination on the sagittal plane. In this group only one case was left with an intraarticular step-off greater than or equal to 3 mm, as compared with 6 cases in the group treated with external fixation. 80 % of patients treated with a volar plate obtained excellent or good results on the Lidström scale, as compared with 72.5% in the external fixation group, there being no statistically significant differences between the two groups. 30% of patients treated with an external fixator developed complications during follow-up, as compared with 22.2% in the volar plate group. OR time in the volar plate group was 74 minutes on average, whereas in the external fixation group it was 42 minutes. Mean time to postoperative mobilization was 12 days in the volar plate group. In patients treated with external fixation, the fixator was dynamized at 40 days on average and withdrawn at 62 days on average.

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Conclusions: Our study shows that both kinds of treatment seem to afford similar radiological and functional results. Direct reduction followed by volar buttress plate fixation seems to provide for a more stable sort of anatomical reduction. Nevertheless, such difference does not lead to better functional outcomes. Both methods of treatment present with an acceptable postoperative complications rate.

PALABRAS CLAVE
Fractura de radio distal;
Placa volar de soporte;
Fijador externo

Resultado funcional y radiológico en fracturas de la extremidad distal del radio tratadas con placa volar frente a fijador externo

Resumen
Objetivo: comparar los resultados funcionales y radiológicos obtenidos en las fracturas intraarticulares de la extremidad distal del radio tratadas mediante fijación interna con placa volar de soporte frente a las tratadas con fijación externa.
Material y método: se realiza un estudio retrospectivo comparativo entre dos series de pacientes: 36 fracturas de radio distal tratadas con placa volar de soporte en T de AO de 2,4/2,7 y 40 fracturas tratadas con el fijador externo dinámico de Pennig. Se utilizó la clasificación AO-ASIF de Müller tras estudio radiográfico anteroposterior y lateral. Se recogieron datos demográficos, sobre mecanismo causal y complicaciones postoperatorias. El seguimiento mínimo fue de 10 meses. Se realizaron evaluaciones clínicas y radiográficas al inicio, postoperatorias, a los 3 meses y al final del seguimiento. En la evaluación funcional se utilizó la escala de Lidström.
Resultados: en el grupo de las fracturas tratadas con placa volar de soporte se obtuvieron mejores resultados radiológicos. En sólo un caso persistió un escalón intraarticular X 3 mm, frente a 6 casos en el grupo tratado mediante fijación externa. El 80% de los pacientes tratados con placa volar obtuvieron resultados excelentes y buenos valorados mediante la escala de Lidström, frente al 72,5% obtenido mediante fijación externa; no hubo diferencias estadísticamente significativas entre los dos grupos. El 30% de los pacientes tratados con fijador externo presentaron complicaciones durante el seguimiento, frente al 22,2% en el grupo de las placas. El tiempo quirúrgico en el grupo de las placas fue de 74 min de media, frente a 42 min en el grupo de la fijación externa. El inicio de la movilidad durante el postoperatorio se realizó a los 12 días de media en el grupo de las placas. En los pacientes tratados con fijación externa, se realizó dinamización del fijador a los 40 días de media, y se procedió a su retirada a los 62 días de media.
Conclusiones: en nuestro seguimiento ambos métodos de tratamiento parecen tener resultados radiológicos y funcionales similares. La reducción directa y fijación mediante placa volar de soporte parece obtener una reducción anatómica más exacta. Sin embargo, dicha diferencia no se traduce en resultados funcionales mejores. Ambos métodos de tratamiento presentan tasas de complicaciones postoperatorias aceptables.

Introduction

Distal radius fractures make up 70% of the fractures of the forearm[1] and may constitute a sixth part of the total number of fractures that are treated in emergency services.[2]

External fixation and open reduction with internal fixation are the two classical surgical techniques used in the treatment of unstable distal radius fractures. Internal fixation open reduction with volar plates obtains stabilization of the joint fragments and enables early wrist mobility at post-op.[3] However, many surgeons prefer external fixation due to its easy application and its low rate of complications.[1]

The purpose of this study is to compare the radiological and clinical results obtained in the treatment of unstable distal radius fractures by means of internal fixation with volar buttress plates vis a vis those obtained by means of external fixation.

Materials and methods

We carried out a retrospective study comparing two series of patients: 40 distal radius fractures treated by means of Pennig's dynamic external fixator[4] and 36 distal radius fractures treated with internal fixation using a volar AO T

2.4/2.7 buttress plate. Minimum follow-up time was 10 months (range: 10-14).

The mean age of the patients treated with external fixation was 45 (range: 17-77), whereas in the volar plate group it was 48 (range: 18-78). In the latter group, 61.1 % were women and 38.8%were men. In the external fixation series, 47.5%were women and 52.5%were men.

21 (58,33%) of the cases treated with the buttress volar plate were left wrists, while 15 (41.66%) were right wrists. In the external fixation group there were 25 (62.5%) left wrists and 15 (37.5%) right wrists. There were no bilateral cases.

In both series the most frequent mechanism of injury were simple falls (27 in the plate group and 23 in the external fixator group); there were also traffic accidents (3 in the plate group and 14 in the external fixator group), falls from heights (5 in the plate group and 2 in the external fixation group) and attacks (1 in the plates and two in the external fixators).

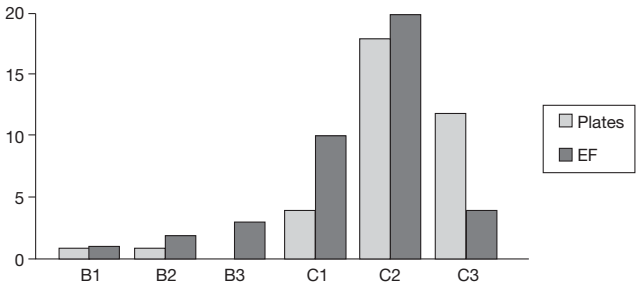

Figure 1 Muller's AO-ASIF classification of distal radius fractures in the two groups under study. EF: external fixator.

We used Muller's AO-ASIF classification,[5] once we had obtained the anteroposterior and lateral x-ray images (Fig. 1). 89% of the fractures treated with external fixation corresponded to types C (1 case of B1, 1 case of B2, 4 C1 cases, 18 C2 cases and 12 C3 cases), whereas 94%of those treated with the buttress plates corresponded to that type (1 case of B1, 2 B2 cases, 3 B3 cases, 10 C1 cases, 20 C2 cases and 4 C3 cases).

75%of the fractures treated with the volar buttress plate corresponded to types VII and VIII in Frykman's classification,[6] while 70% of the external fixation group corresponded to these types. 20% of the fractures treated with external fixation were open fractures (2 type I, 2 type II, 2 type IIIA and 2 type IIIB according to Gustilo and Tscherne's open fracture classification),[7] whereas there were only 2 cases of open fractures in the volar buttress plate group.

Owing to the instability of the fracture, surgical treatment was indicated (metaphyseal comminution, intra-articular fragmentation, >20° dorsal angulation, >10 mm radius shortening, fracture of ulnar styloid base with distal radioulnar instability) in the cases of open fractures or with unsatisfactory reduction.

In the cases treated with the volar plate, we used AO 2.4/2.7 buttress plates (Figs. 2 and 3). In all the cases we used Henry's volar approach,[8] direct reduction of fragments and plate fixation on the volar surface of the distal radius. 12 cases required additional osteosynthesis: 7 cases were treated with Kirschner wire, 3 cases required

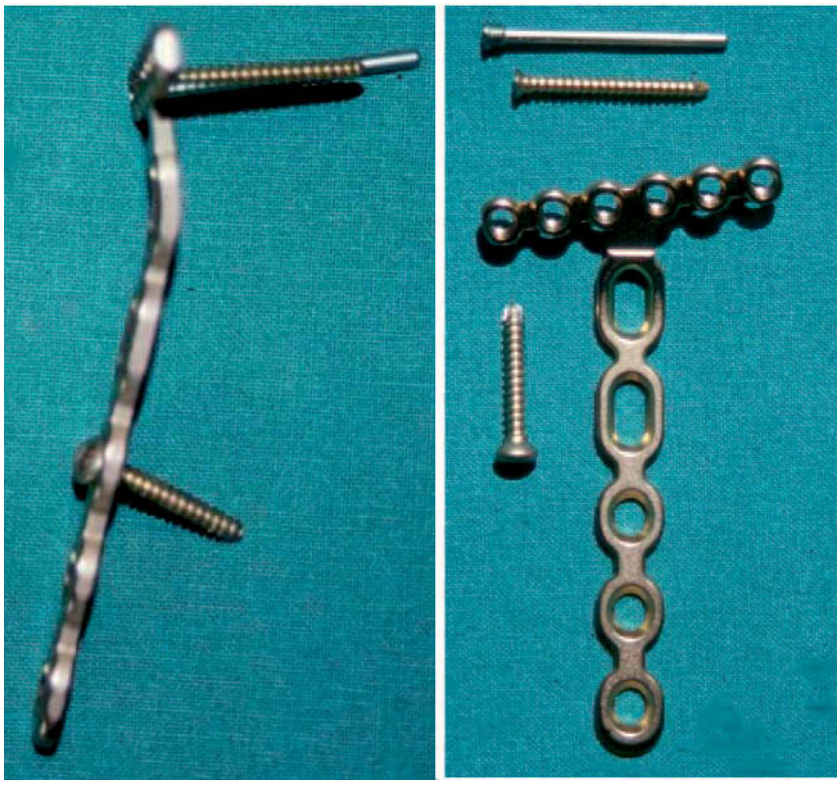

Figure 2 The AO T 2.4/2.7 plate used in this study.

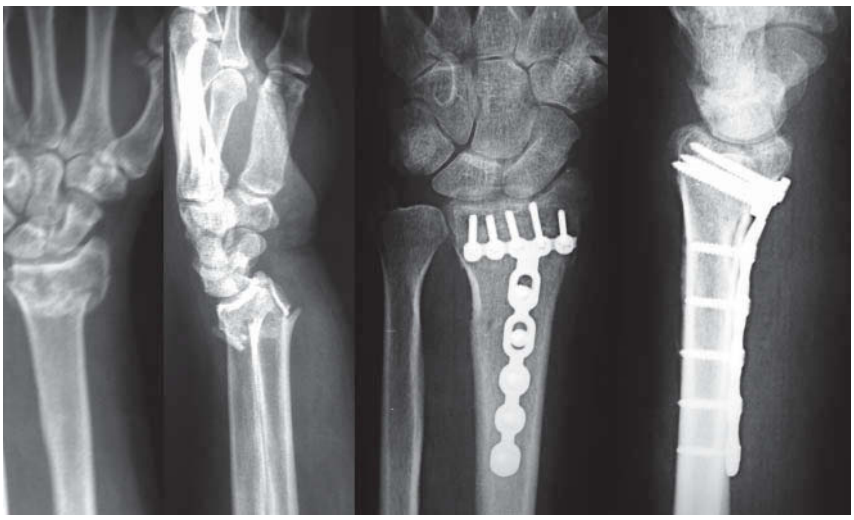

Figure 3 Pre-op and post-op radiologic controls of a case treated with volar buttress plate.

Figure 4 Additional xation to volar buttress plate: interfragmentary screws, a temporary external xator, a Kirschner wire, a Muller-type tension band.

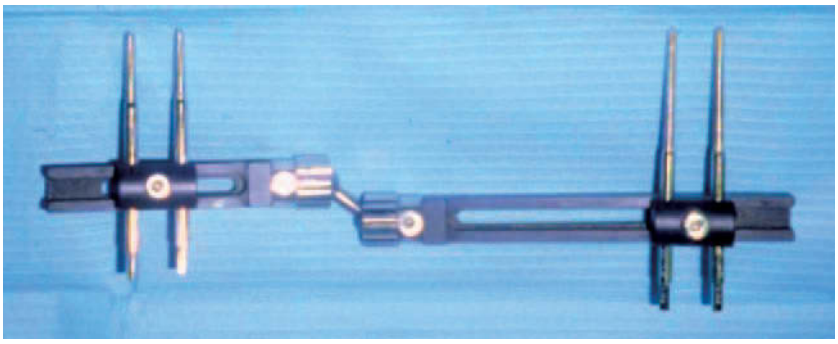

Figure 5 Pennig type dynamic external xator.

interfragmentary screws, 4 cases were temporarily treated with an external xator and 1 case was treated with Muller-type tension band osteosynthesis in the distal ulna (g. 4). An opening of the carpal tunnel was associated in 7 cases—2 by clinical compression of the median nerve and 5 were performed prophylactically. Six cases required structural support (4 cases with autologous iliac crest bone graft, 1 case with autologous olecranon grafting, and 1 case with bone substitute for calcium phosphate). In 20 cases the wrist was immobilized during immediate post-op by means

Figure 6 Pin insertions, indirect reduction and stabilization by means of Pennig external fixator.

of a dorsal forearm splint, with the aim of accelerating the recovery of the soft tissue, and it was maintained for 22.72 days on average (range: 10-60 days). We obtained intraoperative x-ray images with the aim of monitoring reduction as well as the adequate application and size of the implants.

In the first 20 cases treated with external fixation reduction was obtained, once we had applied the Pennig fixator[9] (Pennig, Ortho fix®), by using the traction lever. A continuous digital traction device was used in the rest of the cases. In all the cases a simple unilateral assembly maneuver was performed with four 3.3mm conical groove nails (fig. 5). Proximal nails, with 35mm grooves, were placed at 5-10cm from the radiocarpal joint. The distal nails, with 20mm grooves, were placed with radiographic control on the radial surface of the base of the second metacarpal. We carried out the identification and protection of the superficial branch of the radius nerve in all the cases. Once reduction had been obtained by means of traction with x-ray control, the connection bar was placed in and stabilization in the adequate position was achieved (fig. 6). In 27 cases only the dynamic Pennig external fixator was used, while in the 13 remaining cases percutaneous Kirschner wire was needed as additional synthesis. Neither open reduction nor additional structural grafting were required.

Mean surgery time was 74 min. for the cases with volar plates and 42 min. for those with external fixator.

External fixators were dynamized at 40 days on average (range: 35-64 days) and withdrawn at 62 days on average (range: 49-98 days). In the volar plate group, active mobility was initiated at 12.5 days on average (range: 5-60 days).

Radiological and functional evaluation was carried out during a minimum follow-up time of 10 months. Simple x-rays of the anteroposterior and lateral wrist were obtained during immediate post-op, at 3 months and at end of follow-up. On the frontal plane, we measured radial inclination,

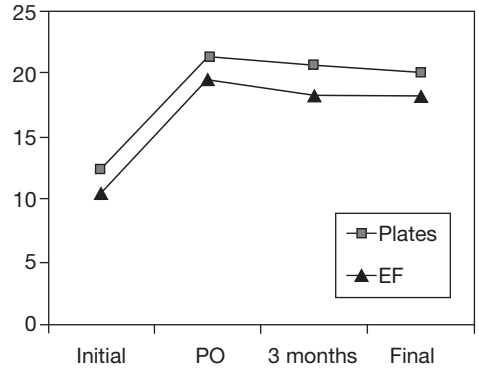

Figure 7 Radial inclination at beginning of follow-up, during post-op, at 3 months follow-up and at end of follow-up. EF: external fixator; PO: post-op.

the distal radioulnar index and the presence of intraarticular step-offs. On the sagittal plane, we measured the volar inclination of the radial facet joint.

Clinical evaluation was carried out using Lidström's scale[10]: function, symptoms, residual deformity and final mobility were assessed. We recorded all the complications of the two study groups during the follow-up period.

The information obtained was processed with the Windows SPSS 8,0 statistical software (SPSS Inc. Chicago, Illinois, USA) and the level of significance was established at $p<0.05$.

Results

As regards radiological evaluation, we obtained a greater correction ($p=0.023$) of the radial inclination in the group

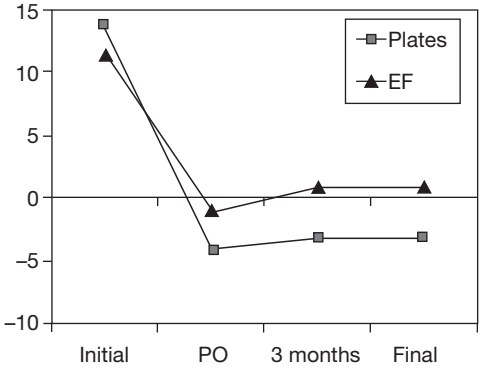

Figure 8 Volar inclination of radius, initially, postoperatively, at 3 months follow-up and at end of follow-up. EF: external fixator; PO: post-op. estudiada. DM: diabetes mellitus; GBA: glucosa basal alterada.

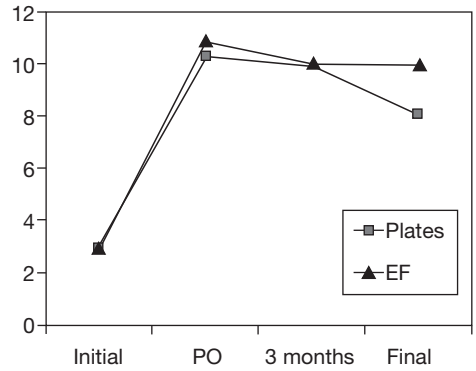

Figure 9 Distal radioulnar index in millimeters, initially, postoperatively, at 3 months follow-up and at end of follow-up. EF: external fixator; PO: post-op.

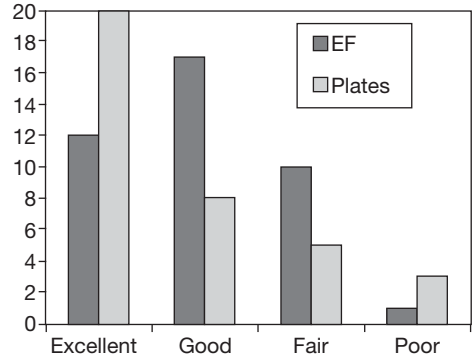

Figure 10 Functional evaluation in absolute numbers according to the Lidström scale. EF: external fixator; PO: post-op.

treated by means of direct reduction and volar plate fixation (Fig. 7).

The palmar inclination of the radial facet joint also obtained a better correction in the group treated with volar buttress plates (p= 0.001) (Fig. 8). The improvement of the distal radioulnar index, however, was better in the external fixation group ($p=5.61\times10^{-6}$) (Fig. 9).

In the external fixation group, 6 patients presented a ≥3 mm intraarticular step-off at end of follow-up, while there was only one case in the volar buttress plate group.

The results of the functional evaluation of the external fixation group were excellent and good for 72.5% of the patients, according to the Lidström scale, whereas 80% of the patients in the volar buttress group obtained these results (Fig. 10).

There were complications in 8 cases in the volar plate group. One patient developed acute compartment syndrome, which was treated successfully with anterior fasciotomy. Three patients developed a complex regional pain syndrome, requiring treatment with gabapentin, calcitonin and physiotherapy. There was one case of surgical wound infection that received antibiotic treatment. Two cases of osteosynthesis failure were also recorded: one only required the withdrawal of the osteosynthesis material, and the other one needed, due to the presence of nonunion, the application of a new volar plate as well as the patient's own bone grafting from the iliac crest. One year after surgical treatment, six volar plates had been withdrawn, four of them on the patients' request and with no signs of deterioration or complications.

Within the external fixation group, there were 12 complications. Four of these developed a complex regional pain syndrome and were treated with physiotherapy, calcitonin and calcium. Four patients presented with osteitis around the grooved nails and were thus treated with oral antibiotic therapy, with no need of early withdrawal. There was one case of compartmental syndrome of the intrinsic hand muscles developing into a claw hand; one case of painful wound healing that was spontaneously solved; one case of transitory hypoesthesia of the superficial branch of the radius nerve; and one case of reduction loss due to loosening of the Pennig fixator.

Discussion

The ultimate objective of the treatment of distal radius fractures is to obtain a painless and functional wrist with a satisfactory degree of mobility.[4] Restoration of the intraarticular anatomy and of the metaphysio-epiphyseal axes are critical factors for the achievement of a satisfactory functional result.[11,12] Intraarticular step-offs greater than 2 mm produce radiocarpal and distal radioulnar osteoarthritis, even though this is not a load joint.[12,13] Radius shortening is the radiographic index that most radically alters carpal kinematics and produces a greater distortion of the triangular brocartilage.[11]

Among the options for treatment of these fractures[14] are: orthopedic reduction followed by immobilization in a cast,[15] stabilization of the fracture by means of percutaneous Kirschner wire, casts containing wire and functional casts;[16] external fixation; open reduction with internal fixation with plates and screws; closed intramedullary nailing; open reduction with bone graft or filling of the fracture site with remodeling bone cement[17,18] or other bone substitutes.[19]

External fixation is the classical treatment for distal radius fractures and is still a widely chosen therapeutic technique—whether on its own or in combination with other techniques.[20] Among its most important advantages are simplicity of application, minimum surgical trauma and exposition, and a greater efficiency for maintaining reduction than the bipolar cast.[21] On the other hand, this technique produces an indirect fragment reduction causing difficulty in the correction of volar radius angulation[16] and the reduction of sunken joint fragments; it requires a prolonged period of immobilization of the radiocarpal joint, and produces the loss of ligament integrity as well as complications around the pin insertions.[1]

The potential advantages of the plate fixation modality consist in a low rate of complications, stable subchondral fixation and the early initiation of active wrist mobility during post-op. The drawbacks are its higher cost and greater surgical complexity and exposition.[1,2]

Our study shows that both kinds of treatment afford good radiological results as far as correction is concerned, and similar functional results with an acceptable complications rate. Open reduction with internal fixation by means of volar buttress plates seems to provide for a better anatomical correction; however, the difference in degrees in our series was slight and it did not produce better functional outcomes than those of the external fixation group. On the other hand, reduction by means of volar buttress plates requires a more prolongued period of exposition than is required with the external fixation method, with an ensuing increase in complexity and surgical time.

It is important to bear in mind that in our study we used only volar buttress plates and not volar, fixed-angle locked plates. The latter have afforded good results in recent studies, since they have the advantage of preventing the immediate post-op collapse of the fracture due to the fact that the momentum force is applied on the plate and not on the fracture site.[22]

In their study, Wright et al[3] compare 11 unstable distal radius fractures treated with external fixation with 21 fractures treated with volar fixed-angle plates. Mean follow-up time was 17 months. They obtained a wider exo-extension range for the volar plate group, there being no difference regarding pronosupination nor as regards the functional assessment scales. Grip strength, however, was greater at the end of treatment in the group treated with external fixation. This group obtained a higher complications rate (27%, as compared with 14% in the volar plate group). In the radiological evaluation, the volar plates group showed a better correction of radius and palmar inclination, and of the intraarticular steps or gaps. 75% of the volar plate patients presented no step-offs on the joint surface as compared to 25% in the external fixation group. There were no differences in consolidation time between the two groups.

Grewal et al[2] carry out a prospective randomized study to compare external fixation and open reduction, and internal fixation with dorsal plate. They compared 62 intraarticular fractures (29 plates and 33 external fixators) over a mean follow-up of 18 months. The results showed greater grip strength and a better correction of the ulnar variance in the external fixation group but there were no significant differences as regards mobility range, functional scales or the remaining postoperative parameters. They recorded a 58.6% complications rate in the dorsal plates group, including dorsal pain and tenosynovitis, as compared with a 24.2% rate in the external fixation group.

Kapoor et al[23] carry out a prospective randomized study of 90 intraarticular distal radius fractures randomly treated by means of closed reduction and immobilization with a cast, external fixation and open reduction, and internal fixation with Kirschner wire and T plates. Mean follow-up is 4 years. They conclude that internal fixation following open reduction obtains a more anatomic correction of the facet joint; however, they find better functional results in the fractures treated with external fixation, there being greater grip strength, a wider pronosupination range, and greater radius length and distal radioulnar congruence than in the other two study groups.

Kreder et al[12] publish an aleatory prospective study including 179 unstable intraarticular distal radius fractures treated with indirect reduction and external fixation (88 fractures) and with open reduction and internal fixation (91 fractures), with a minimum follow-up of 2 years. They registered no statistically significant differences between the functional and radiologic results of the two groups in the study; however, the patients treated with indirect reduction and external fixation showed an earlier functional and clinical improvement and thus went back to their normal activities earlier.

Margaliot et al[1] carry out a systematic review of published works on unstable distal radius fractures. They included 46 articles, 28 of these being about external fixation (917 patients) and 18 about open reduction and internal fixation (603 patients). This meta-analysis detected no statistically significant differences as regards functional results and pain, grip strength or radiographic alignment. They did record, however, a greater rate of neuritis, implant failure and infection in the external fixation group; and a higher rate of tendon complications and early material withdrawal in the open reduction internal fixation group.

Recently, Leung et al[24] publish a multi-center randomized prospective study including 144 intraarticular fractures (types C1, C2 and C3) treated with external fixation (74 fractures) or with T 3.5mm buttress plates (70 fractures). They carry out clinical and radiological evaluations with a minimum follow-up of 2 years. They find statistically significant differences in favor of the plates in the clinical results, but only in one of the systems (the Gartland and Werley Scoring System); on comparing results for type of fracture from the two groups, the significant differences remain only in the C2 type. Also, plate fixation shows better significant results for secondary osteoarthritis development than external fixation. However, the study includes heterogeneous fixation methods: 40 fractures were fixed with volar plates, 12 with dorsal plates and 18 with the two types, volar and dorsal; in 12 cases there was bone grafting and in 66 additional Kirschner wire; in the cases in which joint fragments could not be reduced by means of ligament repair, external fixation was combined with direct reduction by means of a limited dorsal approach.

In conclusion, both external fixation and open reduction with internal fixation by means of volar buttress plates

afford good results in the treatment of unstable fractures in the distal radius, having acceptable post-op complications rates. Nevertheless, new prospective well-designed randomized studies are needed to examine the differences between the classical external fixation method and the new internal fixation techniques, such as the use of volar fixed-angle plates.

Conflict of interests

The authors have not received any financial support in the preparation of this article. Nor have they signed any agreement entitling them to receive benefits or fees from any commercial entity. Furthermore, no commercial entity has paid or will pay any sum to any foundation, educational institution or other non-profit-making organization to which they may be affiliated.

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