

Which immobilization is better for distal radius fracture? A prospective randomized trial

Carlo Gamba¹ · Felipe Andrés Mingo Fernandez¹ · Marta Cuenca Llavall¹ · Xavier Lizano Diez¹ · Fernando Santana Perez¹

Received: 18 January 2017 / Accepted: 14 May 2017 / Published online: 3 June 2017
© SICOT aisbl 2017

Abstract

Introduction The aim of this study was to determine whether an above-elbow cast (AEC) is better than a below-elbow cast (BEC) at maintaining the initial reduction in the orthopaedic management of a distal radius fracture (DRF).

Methods It is a prospective randomized study carried out in a single emergency trauma department. There were 72 patients older than 55 years of age (55–96) with a distal radius fracture treated orthopaedically. They were randomized into two groups: group B (AEC 32 patients) and group A (BEC 40 patients). Randomization was done by a computer program. Four subgroups were constituted according to the instability criteria: subgroup 4 the most unstable fractures. Main outcome was reduction loss from initial reduction to cast removal: it was measured using the volar tilt, radial tilt and radial length on plain radiographs.

Results No differences were observed between group A and B when analysed globally (volar tilt loss $p = 0.89$ radial tilt loss $p = 0.08$ ulnar variance $p = 0.19$). Subgroups analysis revealed less radial tilt reduction loss in group A in patients within subgroup 3 ($p = 0.02$) and 4 ($p = 0.003$).

Discussion Results are in contrast to what was expected. Limiting prono-supination AEC is supposed to better maintain initial fracture reduction. Effect of pronation and supination as well as distraction of brachioradialis muscle could have been overestimated until now.

Conclusion The above-elbow cast is not better than the below-elbow cast in terms of loss reduction. However, the

below-elbow cast more efficiently controls radial tilt reduction.

Keywords Distal radius fracture · Cast · Conservative treatment · Immobilization

Introduction

Fractures of the distal radius (DRF) are one of the most common among skeletal injuries. With an annual incidence >600,000 cases in the United States, they suppose an important issue in fracture management that represent about 16% of all fractures. Despite their frequency, there is still a lack of evidence relative to classification, treatment, needs for reduction, type of splinting/immobilization and the surgical technique used [1].

Conservative treatment has been shown to be safe and effective when correctly applied. Good results can be achieved with closed reduction and immobilization, especially in elderly patients [2].

Many studies have described and compared different types of immobilization like the sugar tong plaster, radial plaster cast and cast bracing. To date, there is not enough evidence to suggest which is best at immobilizing the DRF. Moreover, it is not possible to find a study comparing below and above-elbow immobilization when a circular Paris cast is used [3–6]. The purpose of the present study is to compare the above-elbow and below-elbow cast for DRF conservative treatment in terms of the different capacities to maintain the initial reduction achieved in the emergency room. The null hypothesis is that there are no differences between these two types of cast.

✉ Carlo Gamba
CGamba@parcdesalutmar.cat

¹ Hospital del Mar, Barcelona, Spain

Materials and methods

A prospective randomized study was conducted. Permission from the local institutional board was given (N° CEIC 2013/5457/I). Power analysis with an alpha error less than 0.05 was fixed. In order to decide the size of the sample, data from the first ten patients were obtained and a final sample size of about 55–60 patients was calculated. Anticipating a possible loss of 10% to follow-up, a final sample size of 75 patients was estimated. Patients were enrolled in the emergency room when the distal radius fracture was diagnosed. Recruitment started on October 2013 and lasted until August 2014. Full study information was given and informed consent was signed by every patient. Patients older than 55 with a DRF were consecutively recruited. The radiological inclusion criteria were volar tilt greater than or equal to 0°, radial tilt greater than or equal to 20° and an articular step off less than 2 mm after reduction. The exclusion criteria were volar displacement, metaphyseal extension, open fractures, bone dysplasia, previous fractures, severe cognitive impairment and surgical fractures. Reduction was performed with mechanical traction with finger traps and manipulation after blocking with bupivacaine. Time between anaesthetic injection and reduction manoeuvre was at least ten minutes. Traction was maintained until deformity was corrected and surgeon felt good alignment was achieved to start reduction. Immobilization in a three-point fixation cast with 15° of volar flexion and 10° of ulnar deviation with mild pronation was achieved [7]. Reduction was made by a resident supervised by a senior trauma team member. Two practice training sessions were carried out in order to perform reduction and immobilization in the same manner. Patients were randomized to group A (below-elbow cast) or group B (above-elbow cast) according to a random-order table generated by a computer program (SPSS v22) (Figs. 1 and 2). Clinical and radiological follow



Fig. 1 Group A (below-elbow cast)



Fig. 2 Group B (above-elbow cast)

up with antero-posterior and lateral views were done at week one, three and six. The cast was removed after six weeks of immobilization. Patients within group B followed the same treatment protocol except that they were converted to a below-elbow cast at the third week to avoid elbow stiffness.

In order to prevent confounding factors, fractures were classified following the instability criteria previously described (LaFontaine) [8, 9].

A fracture of the ulnar styloid, dorsal comminution, an initial dorsal tilt greater than 20°, an initial shortening of the radius and an articular fracture, if present, were noticed and registered as instability criteria. Four subgroups were made following these criteria. Subgroup 1 had no instability criteria, subgroup 2 had one criteria, subgroup 3 had two criteria and subgroup 4 had three or more criteria. Radial tilt, volar tilt and ulnar variance were measured as described by Medoff in every x-ray from post-reduction to cast removal using Picture Archiving Communication System (PACS) software [10]. Measurements were performed by four different observers independently. Each measurement was repeated twice by each observer with a four week interval in between. The mean value was used as the final result. Differences between radiological parameters after reduction and at last visit were recorded. Data analysis was carried out using the Student's t-test. The demographic analysis (age and sex distribution, type of cast, distribution of instability criteria) of the sample was performed using the Fisher exact test and Pearson χ^2 test as well as t-test. All data have been analysed with SPSS v22.

Results

A total of 76 patients finally matched the inclusion criteria. Two patients were excluded because surgical correction was needed after severe displacement at the first week after reduction and cast immobilization. Those two patients belonged to a

Table 1 Demographic characteristic of sample

	Group A (n = 40)	Group B (n = 32)	
Female/male	38/2	31/1	$p = 1$
Age (years)	75.9 10.8	78.5 8.3	$p = 0.25$
Laterality (right/left)	15/25	16/16	$p = 0.1$
Dorsal tilt >20°	25	17	$p = 0.42$
Dorsal comminution	19	12	$p = 0.39$
Articular fracture	14	9	$p = 0.53$
Shortening	18	6	$p = 0.02$
Ulnar styloid	14	9	$p = 0.22$

different group. Two more patients, each coming from different groups, were lost to follow up.

In the end, 72 were analysed. Group A had 40 patients, group B comprised 32 patients. The mean age was 77 years (55–96). There were 69 (95.8%) female patients and three males. The right side was affected in 31 (43%) and the left in 41 (57%). Some 97% of the patients were right-handed. Group A and B were comparable in terms of sex and age distribution. There were no differences between the two groups with regard to the fracture instability parameters ($p > 0.05$).

There was only one exception with initial shortening. Group A had a greater incidence of initial shortening ($p = 0.02$). As far as parameters after reduction a lower ulnar variance was also registered in group A ($P = 0.01$) (Tables 1 and 2).

No differences were found in the loss of reduction parameters: volar tilt loss ($p = 0.89$ 95% CI [-2.4–2.1]) was $10.8^\circ \pm 8.1$ for group A and $10.6^\circ \pm 10.3$ for group B, radial tilt loss ($p = 0.08$ 95% CI [-0.1–1.9]) was $4.6^\circ \pm 4$ for group A and $5.6^\circ \pm 4.6^\circ$ for group B, ulnar variance loss ($p = 0.19$ 95% CI [-1.7–0.3]) was $1.4 \text{ mm} \pm 1.7$ for group A and 0.7 ± 6 for group B.

All results were analysed for each instability subgroup (1–4). Subgroup 1 was too small ($n = 6$) and was not statistically relevant. Subgroup 2 showed no differences between the two cast types for all measured parameters. Group 3 and group 4 showed a less loss of radial tilt with cast type A. Within subgroup 3, A-cast type patients had a $3.9^\circ \pm 4.5$ radial tilt loss while the B-cast type had $6.5^\circ \pm 5.5$ ($p = 0.02$ 95% CI [0.4–

4.9]). Within group 4, A-cast type patients showed a $5.2^\circ \pm 3.5$ radial tilt loss while the B-cast type had $7.9^\circ \pm 3.3$ ($p = 0.003$ 95% CI [1.2–5.4]). Within both groups, the most important reduction loss was observed in the first three weeks. This was specially so in patients belonging to subgroups 3 and 4 (Tables 2 and 3).

The differences in reduction loss are especially notable with the ulnar variance between subgroup 2 on the one hand and subgroups 3 and 4 on the other (Table 3).

No major complications (ulcerations, compartmental syndrome, etc.) were observed in the two groups. Window oedema was observed in a small number of patients despite being instructed to wear a sling and do finger mobilization exercises.

Discussion

The results from this study might confirm that similar radiological outcomes can be achieved with both the above-elbow cast and the below-elbow cast in DRF treatment. Loss of reduction in terms of the radial tilt, volar tilt and ulnar variance showed no differences between the two types of cast. An analysis considering instability criteria was performed to control the intrinsic risk of displacement after immobilization among different types of fractures even though a bias due to small subgroups might have been introduced.

The choice to compare these two types of casts implies verifying the role of prono-supination in the reduction loss risk as well as elbow flexion-extension and the effect of brachioradialis. Results are in contrast to what was expected. This underlines the possibility of overestimation of displacing effects produced by brachioradialis or prono-supination in DRF. Limited importance of elbow motion and forearm rotation in DRF is also underlined by Bong, comparing a radial gutter splint with sugar tong splint for initial immobilization. Pool also stated that an AEC had no advantages compared to BEC [3–5]. The fact that the below-elbow cast had a better capacity for maintaining the radial tilt correction in more unstable fractures may be difficult to explain but it is still a good reason to use below-elbow cast when treating DRF. The fact that group A had a lower initial ulnar variance could have

Table 2 Mean measurement of volar tilt, radial tilt and ulnar variance in both cast groups

	Post reduction		1st week		3rd week		6th week		Cumulative loss 1st week		Cumulative loss 3rd week		Cumulative loss 6th week	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Volar tilt	9.2	9.1	3.9	4.1	1	-0.2	-1.2	-1.2	5.3	4.9	8.3	9.4	10.8	10.6
Radial tilt	24.5	24.0	22.1	22.2	21.3	19.9	19.9	18.5	2.4	1.8	3.1	4.2	4.6	5.6
Ulnar variance (mm)	0.2	0.4	-0.2	0.3	-0.6	-0.6	-1.2	-0.3	0.4	0.4	0.7	1	1.4	0.7

A = group A, B = group B

Table 3 Mean reduction loss in radiographic parameters at the end of follow up within subgroup 2, 3 and 4

	Subgroup 2 (<i>n</i> = 27)		Subgroup 3 (<i>n</i> = 24)		Subgroup 4 (<i>n</i> = 15)	
	A	B	A	B	A	B
Volar tilt loss	10.2	12.8	10.5	9.7	10.9	9.3
Radial tilt loss	4.4	3.1	3.9	6.5	5.2	7.9
Ulnar variance loss (mm)	0.9	0.2	1.1	1.2	1.9	1.4

A = group A, B = group B

played a role in this result. Others uncontrolled factors may also influence reduction loss: bone quality, activity level of the patient and use of injured arm. Moreover, the point in which pressure is applied during casting process could determine the capacity to resist to precise deformation force, although Pretell Mazzini found that three point cast index is not a significant risk factor for loss of reduction in paediatric population. In the same work the importance of good reduction to avoid re-displacement is well evidenced with residual sagittal translation after reduction being the factor most importantly related to this complication [11].

Global findings by this study are in line with other published works even though there are no other studies, as far as we know, that have compared the differences between above and below elbow casts for DRF in adults.

In the Cochrane Review made by Handoll, the lack of evidence on conservative DRF treatment is well described. Most of the trials compared different kinds of immobilizations. They included the sugar tong cast compared to the below-elbow cast, the below-elbow dorsal slab to the full above-elbow plaster cast and short-arm to long-arm splinting. None is able to show a clear difference between these treatments. Pool, in a prospective study, compared five different immobilization techniques for DRF and found no radiological differences between them but a general 10° volar tilt loss of reduction was observed.

Stewart et al. compared the below-elbow plaster cast to above and below-elbow bracing. They found no differences in radiological outcomes and described a reduction loss comparable to what is described in this work: a volar tilt loss between 6.7° and 9.9°, a radial tilt loss between 1.7° and 2.2° and a radial length loss between 1.5 mm and 2.1 mm [3–5, 12].

There are some limitations in our study. First, reduction manoeuvres were not always carried out by the same orthopaedic surgeon but every member team had been previously trained to use the same protocol. Additionally, the observers were not blinded during measurements. We might consider age not being a confounding factor as all the patients were older than 55. Nevertheless, it is obvious that bone quality is not the same in a 55-years-old patient as in a 96-year-old patient and this fact might have altered some results. Anyway, results from the study published by Makhni et al.

shows that incidence of secondary displacement in DRF are similar for patients above 45 years old [13]. The decision to use only three radiological parameters could have introduced some bias: other parameters like teardrop angle or radial height, used in other works, have been considered but the authors felt that the chosen measurements represent principal deformation forces in DRF [14, 15].

Conclusion

The treatment of DRF remains a controversial trauma topic for which there is still a lack of good quality studies to arrive at a consensus. When managing these fractures conservatively, an above-elbow cast is not better than a below-elbow cast. A short cast seems to maintain better radial tilt and have a similar capacity for immobilization despite freeing prono-supination. Therefore, we might conclude that a below-elbow cast is a good option, with good radiological outcomes and presents no risk of elbow stiffness. Clinical outcomes should be looked at along with these findings and this may be a worthwhile topic for future studies.

Compliance with ethical standards

Level of evidence Therapeutic level I.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interests On behalf of all authors, the corresponding author states that there is no conflict of interest.

Source of funding All authors declare no conflict of interests including financial, consultant or institutional.

References

1. Koval K, Haidukewych GJ, Service B, Zircgibel BJ (2014) Controversies in the management of distal radius fractures. *J Am Acad Orthop Surg* 2:566–575

2. Gehrmann SV, Windolf J, Kaufmann RA (2008) Distal radius fracture management in elderly patients: a literature review. *J Hand Surg [Am]* 33(3):421–429
3. Pool C (1973) Colles's fracture: a prospective study of treatment. *J Bone Joint Surg Br* 55(3):540–544
4. Stewart HD, Innes AR, Burke FD (1984) Functional cast-bracing for Colles' fractures: a comparison between cast-bracing and conventional plaster cast. *J Bone Joint Surg Br* 66(5):749–753
5. Bong MR, Egol KA, Leibman M, Koval KJ (2006) A comparison of immediate postreduction splinting construct for controlling initial displacement of fractures of the distal radius: a prospective randomized study of long-arm versus short-arm splinting. *J Hand Surg* 31A(5):766–770
6. Hendrickx RPM, Campo MM, Van Lieshout APW, Strijs PAA, Van Den Bekerom MPJ (2011) Above- or below-elbow casts for distal third forearm fractures in children? A meta-analysis of the literature. *Arch Orthop Trauma Surg* 131:1663–1671
7. Fernandez DL (2005) Closed manipulations and casting of distal radius fractures. *Hand Clin* 21:307–316
8. Leone J, Bhandari M, Adili A, McKenzie S, Moro JK, Dunlop RB (2004) Predictors of early and late instability following conservative treatment of extra-articular radius fractures. *Arch Orthop Trauma Surg* 124:38–41
9. Lafontaine M, Hardy D, Delince P (1989) Stability assessment of distal radius fractures. *Injury* 20:208–210
10. Medoff RJ (2005) Essential radiographic evaluation for distal radius fractures. *Hand Clin* 21:279–288
11. Pretell Mazzini J, Beck N, Brewer J, Baldwin K, Sankar W, Flynn J (2012) Distal metaphyseal radius fractures in children following closed reduction and casting: can loss of reduction be predicted? *Int Orthop* 36(7):1435–1440. doi:10.1007/s00264-012-1493-x
12. Handoll HHG, Madhok R (2003) Conservative interventions for treating distal radial fractures in adults. *Cochrane Database Syst Rev* 2:CD 000314
13. Makhni EC, Ewald TJ, Kelly S, Day CS (2008) Effect of patient age on the radiographic outcomes of distal radius fractures subject to nonoperative treatment. *J Hand Surg* 33A:1301–1308
14. Fujitani R, Omokawa S, Lida A, Santo S, Tanaka Y (2012) Reliability and clinical importance of teardrop angle measurement in intra-articular distal radius fracture. *J Hand Surg* 37A:454–459
15. Zhang B, Chang H, Yu K, Bai J, Tian D, Zhang G, Shao X, Zhang Y (2017) Intramedullary nail versus volar locking plate fixation for the treatment of extra-articular or simple intra-articular distal radius fractures: systematic review and meta-analysis. *Int Orthop*. doi:10.1007/s00264-017-3460-z