Randomized controlled trial comparing above- and below-elbow plaster casts for distal forearm fractures in children

S. R. Paneru · Raju Rijal · B. P. Shrestha ·
P. Nepal · G. P. Khanal · N. K. Karn ·
M. P. Singh · P. Rai

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Abstract

Purpose Long arm cast is the method of immobilization after closed reduction of the fracture of the distal third of the forearm, although short arm cast has been used to immobilize the forearm by some orthopedic surgeons. We conducted this study to evaluate the rate of displacement, union time, complication, and cost of treatment between the above-elbow and below-elbow plaster cast groups.

Methods We designed a prospective randomized controlled trial to compare above- and below-elbow casts for patients of distal forearm fracture aged 4–12 years. One hundred and one patients were presented to our institution during the period from 1st June 2007 to 31st May 2008. Twelve patients were excluded from the study. Eighty-nine patients were randomized into two groups. Four patients were lost to follow up. Hence, 85 patients, 42 in the above-elbow group and 43 in the below-elbow group, were

analyzed. Informed consent was obtained prior to participation in the trial. The parameters to be studied were defined before treatment and noted in the pilot-tested pro forma and follow up was done.

Results Among the 85 patients analyzed, randomization was successful. Pain and swelling on the next day and at one week following cast application was significantly higher ($P = 0.000$) in the above-elbow group. Three cases in the above-elbow group needed slitting of the plaster cast. Remanipulation was needed more often in the above-elbow group (9.5%). Although the cast index was not statistically significant ($P = 0.054$) between the groups, those who needed remanipulation had a larger cast index (0.80). The total cost of the treatment and the number of school days lost was significantly higher ($P = 0.000$) in the above-elbow group.

Conclusion Below-elbow cast treatment was comparable in terms of redisplacement, union time, and movement of the wrist to the above-elbow treatment. The complications rate and total cost was higher in the above-elbow plaster group, which could be a cost benefit if a below-elbow cast is used.

Keywords Fracture · Both bones · Distal third · Forearm · Children

S. R. Paneru · R. Rijal (✉) · B. P. Shrestha ·
G. P. Khanal · N. K. Karn
Department of Orthopedics, B.P. Koirala
Institute of Health Sciences, Ghopa, Dharan, Nepal
e-mail: rijalraju@yahoo.com

P. Nepal
Department of Orthopedics, Civil Service Hospital,
Kathmandu, Nepal

M. P. Singh
Department of Orthopedics,
University College of Medical Sciences (UCMS),
New Delhi, India

P. Rai
School of Public Health and Community Medicine,
B.P. Koirala Institute of Health Sciences, Dharan, Nepal

Introduction

Forearm fractures are common injuries in childhood. Approximately 75–84% of forearm fractures occur in the distal third, 15–18% in the middle third, and 1–7% in the proximal third [1]. The treatment of forearm fracture in children is nonoperative with closed reduction and cast application because of the rapid healing of these fractures

and the potential for considerable remodeling of residual deformity. Above-elbow plaster cast has been used historically to immobilize the elbow joint to neutralize the deforming forces of muscles that originate above the elbow to prevent redisplacement of fracture fragments [2–8]. Short arm plaster cast has been used by some orthopedic surgeons, who claimed equally beneficial results [9–11]. Well molded short arm cast can reduce supination and pronation movement at the wrist, thereby, decreasing the redisplacement [11]. Hence, controversy still persists regarding the length of the plaster cast for the treatment of distal third forearm fracture. We have designed this randomized controlled trial to evaluate the effectiveness of short arm cast over long arm cast for the treatment of pediatric distal third forearm fracture.

Materials and methods

Patients of age 4–12 years with displaced fracture of the distal third of the forearm reporting to the emergency or outpatient departments of our hospital from 1st June 2007 to 31st May 2008 were enrolled in the study. One hundred and one patients were presented to our hospital during the mentioned period. Twelve patients were excluded from the study: five patients due to open fractures, three having previous manipulations, and four patients did not give consent. Hence, 89 patients were randomized into two groups. Two patients from the above-elbow group and two patients from the below-elbow group were lost to follow up. Eighty-five patients, 42 in the above-elbow group and 43 in the below-elbow group remained for analysis. Ethical clearance was obtained from the institutional ethics committee and informed consent was granted from the parents. Patients were assessed prior to cast treatment. The fractures were manipulated and reduced under appropriate analgesia and sedation. Patients were assessed immediately after cast treatment and check radiographs were done, and on the next day, the swelling of fingers, hand, and distal neurovascular assessment were done. Swelling was categorized into whether there was no swelling, associated with pain, limitation of movement, and needed slitting of the cast. Radiographs were analyzed for displacement; angulation and overriding at the time of presentation, after reduction, and subsequent follow up intervals. The quality of molding of the cast was assessed by the cast index (which is calculated by dividing the inner sagittal width of the cast by the inner coronal width of the cast at the level of the fracture) on the postreduction radiograph. Loss of reduction and criteria for remanipulation was defined as an increase of $>10^\circ$ angulation and $>20\%$ of displacement compared with the postreduction values. Fracture union was defined as the presence of bridging callus at three out

of four cortices in anteroposterior and lateral radiographs and the presence of transmitted movement across the fracture site. Plaster of Paris was used as the cast material in our study. For above-elbow casts, we first applied the below-elbow component, molded it, and then extended it to above the elbow. Detailed instructions were provided to the patient and family regarding strict elevation of the arm for the first 24–48 h. In addition, warning signs that would necessitate an immediate consultation in the emergency department were explained to them.

Follow up

Follow up was done on the next day of plaster application and at 1, 2, 4, 6, 8, and 12 weeks, and 6 months. Redisplacement, plaster condition, and any complications were observed. Mobility of the wrist and elbow was measured using a goniometer.

Statistical methods

Random allocation of the patients was done on the basis of a computer-based random number generation technique. All data were collected in a Microsoft Excel 2007 worksheet. The data were analyzed using SPSS (version 10.0) software program. The χ^2 test was used for comparing two or more parameters (i.e., gender, dominant limb, injured limb, remanipulation rate, swelling before, after, and at 1 week following cast application, and intactness of the plaster). The significant difference of the means of continuous variables (i.e., age, time since injury, cast index, pain, angulation [$^\circ$], displacement [%], mobility of the wrist and elbow, school days lost, and the total cost of treatment) in the two cast groups were compared using Student's *t* test. The significance level of the *P* value was set at <0.05 .

Results

The mean ages of the children were 8.76 ± 2.31 years in the above-elbow group and 8.05 ± 2.27 years in the below-elbow group. The gender distribution was not different among the two groups (*P* value 0.52), although the boys:girls ratio was 3:1.

The right side was the dominant limb in both groups, but both sides were equally involved in nearly the same number. There was no difference in the time from injury to manipulation, swelling prior, or swelling the next day following casting, but swelling at 1 week after cast application was statistically significant ($P < 0.0000$) and it was more common in the above-elbow group. The plaster cast needed to be repaired more often in the above-elbow group. About 9.5%

of children in the above-elbow group required remanipulation as compared to 2.3% in the below-elbow group. More than 97% of patients in both groups had fracture in the process of union at 6 weeks follow up (Table 1).

The time from injury to manipulation was significantly higher in the above-elbow group ($P = 0.027$). There were no differences in the cast index ($P = 0.054$) or pain prior to manipulation ($P = 0.669$), but pain immediately following manipulation and after 1 week was significantly higher

($P = 0.0000$) in the above-elbow cast group. Mobility of the wrist was comparable after removal of the cast, but elbow mobility was higher in the below-elbow cast group ($P = 0.000$). In the below-elbow cast group, 4 days of school was lost as compared to 10 days in the above-elbow group. The treatment cost was nearly four times greater in the above-elbow cast group. Differences between radius and ulna translation in the anteroposterior and lateral views of the X-rays were not significant. Similarly, the difference

Table 1 Distribution of qualitative variables in the above-elbow and below-elbow cast groups

Variables	Group		Total	χ^2 test P value
	Above elbow (42)	Below elbow (43)		
Sex				
Male	33 (78.6)	33 (76.7)	66 (77.6)	0.523
Female	9 (21.4)	10 (23.3)	19 (22.4)	
Dominant limb				
Right	39 (92.9)	40 (93)	79 (92.9)	0.651
Left	3 (7.1)	3 (7.1)	6 (7.1)	
Injured limb				
Right	22 (51.2)	21 (48.8)	43 (50.5)	0.976
Left	20 (47.6)	22 (52.4)	42 (49.5)	
Time from injury to manipulation (h)				
<12	13 (31)	27 (62.8)	40 (47.1)	0.006
12–24	20 (47.6)	8 (18.6)	28 (32.9)	
24–48	9 (21.4)	8 (18.6)	17 (20)	
Swelling prior				
Nil	0 (0)	0 (0)	0 (0)	0.582
Pain	9 (21.4)	9 (21.4)	18 (21.2)	
Limitation of movement	33 (78.6)	34 (79.1)	67 (78.8)	
Swelling on the next day following casting				
Nil	0 (0)	0 (0)	0 (0)	0.008
Pain	1 (2.4)	9 (20.9)	10 (11.8)	
Limitation of movement	38 (90.5)	34 (79.1)	72 (84.7)	
Slitting of plaster	3 (7.1)	0 (0)	3 (5.8)	
Swelling at 1 week following casting				
Nil	9 (22.5)	34 (79.1)	43 (51.8)	0.000
Pain	27 (67.5)	9 (20.9)	36 (43.4)	
Limitation of movement	4 (10)	0 (0)	4 (4.8)	
Intactness of plaster				
Intact throughout	30 (71.4)	43 (100)	73 (85.9)	0.001
Reinforced	9 (21.4)	0 (0)	9 (10.6)	
Needed changing of cast	3 (7.1)	0 (0)	3 (3.5)	
Need for remanipulation				
Not required	38 (90.5)	42 (97.7)	80 (94.1)	0.173
Required	4 (9.5)	1 (2.3)	5 (5.9)	
Union time				
6 weeks	42 (100)	42 (97.7)	84 (98.8)	0.506
8 weeks	0 (0)	1 (2.3)	1 (1.2)	

Table 2 Association between independent variables and the two different cast groups

Variable	Cast group	Mean $\pm$ SD	<i>P</i> value
Age (years)	AE	8.76 $\pm$ 2.31	0.15
	BE	8.05 $\pm$ 2.27	
Time from injury to manipulation (h)	AE	14.15 $\pm$ 3.34	0.027
	BE	12.53 $\pm$ 3.30	
Cast index	AE	0.743 $\pm$ 0.080	0.054
	BE	0.712 $\pm$ 0.073	
Pain prior	AE	5.17 $\pm$ 0.99	0.669
	BE	5.26 $\pm$ 0.93	
Pain after	AE	7 $\pm$ 1.34	0.000
	BE	5.42 $\pm$ 1.10	
Pain after 1 week	AE	2.24 $\pm$ 1.99	0.000
	BE	0.33 $\pm$ 0.71	
Mobility of wrist (°)	AE	57.62 $\pm$ 13.94	0.057
	BE	64.42 $\pm$ 18.30	
Mobility of elbow (°)	AE	77.26 $\pm$ 21.25	0.000
	BE	126.98 $\pm$ 18.59	
School days lost	AE	10.43 $\pm$ 4.71	0.000
	BE	4.19 $\pm$ 7.59	
Treatment cost (rupees)	AE	1144 $\pm$ 308.26	0.000
	BE	358.14 $\pm$ 77.10	
*Radius translation (anteroposterior view)	AE	3.10 $\pm$ 7.73	0.25
	BE	1.40 $\pm$ 5.60	
*Radius translation (lateral view)	AE	4.05 $\pm$ 15.94	0.219
	BE	0.93 $\pm$ 2.94	
*Ulna translation (anteroposterior view)	AE	3.45 $\pm$ 9.91	0.094
	BE	0.70 $\pm$ 3.38	
*Ulna translation (lateral view)	AE	3.81 $\pm$ 11.25	0.087
	BE	0.70 $\pm$ 2.58	
*Angulation of radius (anteroposterior view)	AE	1.19 $\pm$ 5.50	0.21
	BE	0.12 $\pm$ 0.76	
*Angulation of radius (lateral view)	AE	3.93 $\pm$ 6.30	0.07
	BE	1.16 $\pm$ 3.75	
*Angulation of ulna (anteroposterior view)	AE	0.48 $\pm$ 1.85	0.51
	BE	0.23 $\pm$ 1.52	
*Angulation of ulna (lateral view)	AE	3.57 $\pm$ 6.65	0.018
	BE	1.28 $\pm$ 3.95	
**Overriding of radius	AE	0.52 $\pm$ 0.62	0.32
	BE	0.00 $\pm$ 0.00	
**Overriding of ulna	AE	0.19 $\pm$ 0.86	0.16
	BE	0.00 $\pm$ 0.00	

AE above-elbow cast group (42 patients); BE below-elbow cast group (43 patients)

* Difference in degree

** Difference in mm

in overriding of the radius and ulna was not statistically significant in both groups (Table 2).

Discussion

Forearm fractures are treated with closed reduction and cast immobilization because of the remodeling potential and some degrees of residual fixed angular deformity in the

distal third do not cause functional loss of forearm rotation [12]. In our study, the mean age of the patients was 8 years, which was similar to investigations by others [10, 11]. Male predominance in a ratio of 3:1 is similar to the reported age incidence elsewhere in the literature [13–15]. Our finding of the right side being dominant and no difference of injuries between the dominant limbs was contrary to the findings demonstrated by Borton et al. [16]. The below- and above-elbow cast groups were similar with

respect to age, gender, dominant limb, and injured limb, which indicated that the randomization had been effective. In our country, the time from injury to hospital admission and treatment is longer due to constrained facilities and economic status of the people. More than 50% patients were treated after 12 h following injury. There were no differences in swelling prior to cast immobilization between the two groups ($P = 0.58$); 7.1% of patients in the above-elbow cast group had to slit their plaster cast due to swelling on the next day following application, which was statistically significant ($P = 0.008$) between the two groups. Regarding pain at the fracture site, there were no significant differences between the groups prior to cast immobilization, whereas after cast application and 1 week following plaster cast, the difference was significant ($P = 0.000$). The cast index was 0.74 and 0.71 in the above-elbow and below-cast groups, respectively, which showed that adequate cast molding had been done during the application of the cast. Those patients who needed remanipulation has a cast index of 0.80, although there exist controversial results regarding the cast index [9, 10]. In our study, there was no statistically significant difference in the two cast groups with regard to change in translation and angulation of the radius in anteroposterior and lateral radiographs at the time of fracture union (6 weeks) compared to the postreduction radiograph. However, there was a statistically significant difference in the cast groups with regard to change in the angulation of the ulna on the lateral view ($P = 0.018$). The plaster cast had to be reinforced in 21.4% of patients and needed changing in 7.1% of casts in the above-elbow group, where none required changing in the below-elbow group, which was statistically significant ($P = 0.001$). Four (9.5%) patients required remanipulation and casting at 1 week due to loss of reduction in the above-elbow cast group, whereas only one (2.3%) patient needed remanipulation in the below-elbow group, which is similar to other studies [10, 11, 17]. There was no significant difference in the mobility of wrist movement after removal of the plaster ($P = 0.057$), although elbow movement was restricted more in the above-elbow group, which was statistically significant ($P = 0.000$). Due to elbow stiffness, two children needed physical therapy at 8 weeks of follow up, which was similar to other patients at the final follow up. Patients in the above-elbow group were absent from school for more than 1 week, whereas in the below-elbow group, it was less, which was statistically significantly ($P = 0.000$). The cost of treatment was three times higher in the above-elbow cast group as compared to the below-elbow group ($P = 0.000$). Although cost should not be a factor in deciding what should be the standard treatment,

when the results are equally good, we should strive to reduce the overall cost.

Our randomized controlled trial concludes that below-elbow plaster cast is equally effective compared to above-elbow plaster cast for the immobilization of distal both bone fracture in children aged 4–12 years and is also cost-effective in the developing countries.

References

1. Armstrong PF, Joughlin VE, Clarke HM, Willis RB (1998) Pediatric fracture of the forearm, wrist and hand. In: Greene NE, Swiontkowski MF (eds) *Skeletal trauma in children*, 3rd edn. Saunders, Philadelphia, pp 166–255
2. Jones K, Weiner DS (1999) The management of forearm fractures in children: a plea for conservatism. *J Pediatr Orthop* 19:811–815
3. Noonan KJ, Price CT (1998) Forearm and distal radius fractures in children. *J Am Acad Orthop Surg* 6:146–156
4. Friberg KS (1979) Remodelling after distal forearm fractures in children. I. The effect of residual angulation on the spatial orientation of the epiphyseal plates. *Acta Orthop Scand* 50:537–546
5. Friberg KS (1979) Remodelling after distal forearm fractures in children. II. The final orientation of the distal and proximal epiphyseal plates of the radius. *Acta Orthop Scand* 50:731–739
6. Friberg KS (1979) Remodelling after distal forearm fractures in children. III. Correction of residual angulation in fractures of the radius. *Acta Orthop Scand* 50:741–749
7. Johari AN, Sinha M (1999) Remodeling of forearm fractures in children. *J Pediatr Orthop B* 8:84–87
8. Rodríguez-Merchán EC (2005) Pediatric fractures of the forearm. *Clin Orthop Relat Res* 432:65–72
9. Chess DG, Hyndman JC, Leahey JL, Brown DC, Sinclair AM (1994) Short arm plaster cast for distal pediatric forearm fractures. *J Pediatr Orthop* 14:211–213
10. Bohm ER, Bubbar V, Yong Hing K, Dzus A (2006) Above and below-the-elbow plaster casts for distal forearm fractures in children. A randomized controlled trial. *J Bone Joint Surg Am* 88:1–8
11. Webb GR, Galpin RD, Armstrong DG (2006) Comparison of short and long arm plaster casts for displaced fractures in the distal third of the forearm in children. *J Bone Joint Surg Am* 88:9–17
12. Price CT, Mencia GA (2001) Injuries to the shafts of the radius and ulna. In: Beaty JH, Kasser JR (eds) *Rockwood and Wilkins' fractures in children*, 5th edn. Lippincott Williams & Wilkins, Philadelphia, pp 443–482
13. Blount WP, Schaefer AA, Johnson JH (1942) Fractures of the forearm in children. *JAMA* 120:111–116
14. Davis DR, Green DP (1976) Forearm fractures in children: pitfalls and complications. *Clin Orthop Relat Res* 120:172–183
15. Roy DR (1989) Completely displaced distal radius fractures with intact ulnas in children. *Orthopedics* 12:1089–1092
16. Borton D, Masterson E, O'Brien T (1994) Distal forearm fractures in children: the role of hand dominance. *J Pediatr Orthop* 14(4):496–497
17. Voto SJ, Weiner DS, Leighley B (1990) Redisplacement after closed reduction of forearm fractures in children. *J Pediatr Orthop* 10:79–84