Original article

Risk factors for redisplacement in pediatric distal radius fractures after closed reduction and cast immobilisation

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Abstract

Introducation: Pediatric distal radius fractures are one of the most common fractures that we see in our practice. The primary modality of treatment of the displaced fractures of distal radius in children is closed reduction and immobilization in cast. Loss of alignment in cast after an acceptable reduction is common. Twenty one to fifty percent rates of redisplacement in cast after acceptable initial reduction have been reported in literature.

Methods: This prospective study included 58 fractures of distal radius and distal third shaft of radius in 57 children with radiologically open physis. Age, gender, initial displacement, associated fracture of the ulna, adequacy of reduction, cast index and gap index were evaluated as possible risk factors for redisplacement in cast.

Results: A redisplacement rate of 34.48%was found in distal radius fractures of children after acceptable initial closed reduction and immobilization in cast. Initial complete displacement, degree of initial translation in coronal and sagittal plane, degree of initial angulation in the coronal plane, associated fracture of the ulna, non anatomical initial reduction and cast index were found to be significant risk factors for redisplacement. Age, gender, initial angulation in the sagittal plane and gap index were insignificant risk factors.

Conclusion: Distal radius fractures in children have high rate of redisplacement in cast. Fractures with initial complete displacement, fractures with associated fracture of ulna and non-anatomically reduced fractures should either be treated by primary closed reduction and percutaneous pinning or must be followed very carefully in cast treatment. Cast index rather than gap index is a better predictor of loss of reduction in cast.

Keywords: Pediatrc, Distal radius fracture, Close reduction, Redisplacement

Introduction

Distal radius is the most common site of fracture in children involving up to 27% of all fractures.[1] These fractures are defined by the anatomical relationship of fracture line with the physis as metaphyseal fractures, physeal injuries and pediatric equivalent of Galleazzi fracture dislocation.[2]

Like other forms of forearm fractures in children, the primary modality of treatment of the displaced fractures of distal radius is closed reduction and immobilization in cast. Torus fractures, undisplaced or minimally displaced fractures can be managed by removable splint or cast application without reduction.[3,4] Other modalities of treatment are closed reduction and percutaneous pinning and open reduction.[2]

Loss of alignment in cast after an acceptable closed reduction is common. Bowmann et al found 22.9% redisplacement of fractures of distal 1/3 rd of the shaft of radius treated by closed reduction and immobilization.[5] The rates of redisplacement in cast in other studies have ranged from 21% to 50% after acceptable initial reduction.[6-8] Factors implicated in the loss of reduction are numerous and different studies undertaken to define their roles have not been able to give uniform results. Mazzini et al[9] have classified the risk factors implicated for the loss of reduction as:

Fracture related:

Initial displacement
Location of the fracture
Distance from the physis
Isolated distal radius fracture
Associated ulna fracture at the same level
Obliquity of the fracture

Patient related:

Muscle atrophy
Resolution of initial soft tissue swelling while in cast

Surgeon related:

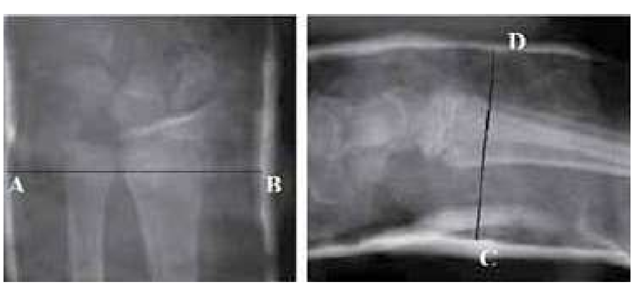
Inadequate initial reduction
Poor casting technique

The role of casting technique has been historically described subjectively. In the meantime different authors developed different indices. Cast index was proposed by Chess et al.[10] They found that re-displacement in distal forearm fractures were related to poor cast molding, reflected by a high cast index. Malviya et al[11] defined the gap index and compared the gap index and the cast index. They found that significant difference was observed in both the cast index and the gap index and gap index was more sensitive than the cast index in predicting failure of cast treatment.

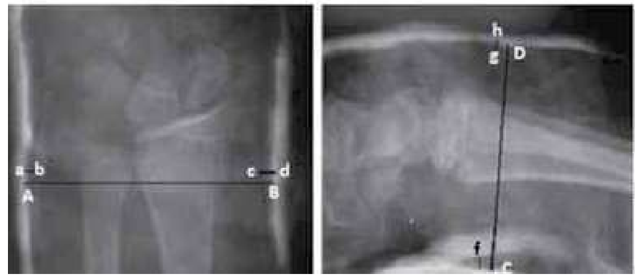
This study was done to analyze the role of different factors which led to redisplacement of distal radius fractures in children after initial acceptable closed reduction and immobilization in cast.

Methods

This prospective study was undertaken in Department of Orthopaedics and Trauma Surgery, Institute of Medicine from March 1, 2013 to September 31, 2014. After obtaining ethical clearance from the Institute Review Board, we enrolled 76 displaced fractures of metaphysis and physis of distal radius and distal third diaphysis in 75 patients with radiologically open physis.
For the purpose of our study displaced fractures were defined as: Any amount of translation in frontal or sagittal plane or angulation of 20 degrees or more in sagittal plane or angulation of 5 degrees or more in the frontal plane.
They were reduced closed under hematoma block or brachial block or intravenous sedation or general anesthesia with or without the use of image intensifier as deemed appropriate by the surgeon.
Cast index was defined by: Inner diameter of cast on lateral radiograph at fracture site/inner diameter of cast on AP radiograph at fracture site



Cast Index= CD/AB
Gap index was defined by:[(Radial fracture-site gap + ulnar fracture-site gap)/inner diameter of cast in AP plane]+[(dorsal fracture-site gap + volar fracture-site gap)/inner diameter of cast in lateral plane]



Gap Index= [(ab+cd)/AB + (ef+gh)/CD]
The quality of initial reduction was categorized as anatomic, good or fair as described by Alemdaroglu et al12:

Anatomic: Complete anatomic fracture reduction without any translation or angulation
Good: <10 degrees of angulation in sagittal plane or <2mm of translation in any plane
Fair: With translation of between 2 and 5 mm in any plane or angulation of between 10 and 20 degrees in sagittal plane or any deviation of <5 degrees in coronal plane or a combination of 5 to 10 degrees of angulation in sagittal plane and <2 mm of translation.
In post reduction x-ray, displacement more than fair reduction was considered unacceptable and excluded from the study. The patient was discharged with appropriate advice and follow up was done the next day to detect any plaster complications. Subsequent follow ups were done on completion of 1 week, 2 week, 3 week and 6 week with AP and Lateral radiographs. For the purpose of our study redisplacement was defined as any displacement more than that in the criteria for fair reduction. Undisplaced fractures were followed for 6 weeks and after union, cast was removed and range of motion exercises was started.
Statistical analysis was done using the SPSS version 20.0. Categorical data were analyzed for significance by the Chi square test; numerical data were analyzed by Independent t test or Mann-Whitney test. The p value of less than 0.05 was considered to be significant.

Results

Out of the 76 fractures meeting the inclusion criteria, 5 patients had initial unacceptable reduction, 4 patients had the cast splitted due to excessive swelling the next day after reduction and 9 patients were lost in follow up and were excluded from the study.
Out of 58 fractures in 57 patients that completed the study, 20 (34.48%) fractures redisplaced and 38 (65.52%) fractures progressed to union without redisplacement. In the redisplaced group, 3 patients underwent dorsal wedging of the cast, 3 patients underwent remanipulation

and application of long arm cast, 4 underwent remanipulation and percutaneous pinning. In 10 patients the amount of malunion was accepted with expectation of spontaneous remodeling with growth. Of the 4 patients who underwent closed reduction and percutaneous pinning, 1 patient developed superficial pin track infection which was managed by dressing and oral antibiotics. Rest of the patients achieved union uneventfully. The patient characteristics of the fractures that went to redisplace in cast were compared with the fractures that proceeded to union without redisplacement.

Table 1. Risk factors for redisplacement of facture

Characteristics		Redisplaced	Undisplaced	p value
Mean age in years		10.4 ±3.24	10.68±3.11	0.717
Gender	Male	16	32	0.687
	Female	4	6	
Ulna	Fractured	16	17	0.009949
	Intact	4	21	
Initial translation in the sagittal plane	No	1	6	0.000135
	Partial	4	25	
	Complete	15	7	
Initial translation in the coronal plane	No	2	11	0.007825
	Partial	14	27	
	Complete	4	0	
Initial complete translation	Complete	7	17	<0.00001
	Incomplete	3	31	
Initial median angulation in degrees in the coronal plane		17	7.5	0.008
Initial median angulation in degrees in the sagittal plane		20	17	o.417
Adequacy of reduction	Anatomical	0	11	0.014
	Good	15	16	
	Fair	5	11	
Mean Cast Index		0.793(0.0932)	0.7408(0.0556)	0.01
Mean Gap Index		0.1222 (.0566)	0.1290 (0. 0583)	0.667

Initial complete displacement, degree of initial translation in coronal and sagittal plane, degree of initial angulation in the coronal plane, associated fracture of the ulna, non anatomical initial reduction and cast index were found to be significant risk factors for later redisplacement in cast after initial acceptable closed reduction.

Discussion

Numerous authors have attempted to identify the risk factors involved in redisplacement after initial acceptable reduction and immobilization in cast so that the loss of reduction in cast could be fairly predicted. However, the results of these studies have not been uniform.

Our study failed to establish patient age and gender as risk factors for fracture redisplacement. Similarly Haddad et al[12], Devaliya et al,[13] Hang et al,[14] have reported that patient age and sex are not significant risk factors for redisplacement. However, the distal radial physis closes at an earlier age in female children. Female children, especially of older age, are the high risk groups of functional disability in treatment of these fractures, not because they are more likely to get displaced but because they have less potential for remodeling if redisplacement occurs.

The role of associated ulnar fracture in the stability of the fracture of the distal radius seems to be the most controversial among all proposed factors. Our study showed that intact ulna was significantly protective against redisplacement in cast. Similarly associated fracture of the ulna was also found to be associated with redisplacement in the studies of Hang et al[14], Alemdaroglu et al[15] and Zamzam et al.[16]

However Devaliya et al[13] and McQuinn et al[17] reported that the role of associated ulna fracture was not significant for fracture redisplacement. Fenton et al[18] reported a negative correlation of associated ulna fracture with fracture redisplacement. Proctor et al[19] inferred that a fracture of ulna by itself did not increase the risk of redisplacement but was closely related with completely displaced fracture of the distal radius which in turn increased the risk for redisplacement.

Fractures that were completely translated without any cortical contact between the fracture fragments in the sagittal or coronal plane or both had a significant risk of redisplacement compared with fractures that were incompletely translated. High rate of redisplacement in severely displaced fractures is probably due to the loss of stability given by the periosteum and surrounding soft tissue structures. In our study pre-reduction translation in both sagittal and coronal planes and pre- reduction angulation in the coronal plane were found to be significantly higher in the redisplaced groups. However, initial angulation in the sagittal plane was not found to be significantly associated with redisplacement in cast.

The role of initial complete displacement in redisplacement of fractures has been supported in studies by Proctor et al[19] Alemdaroglu et al, [15] Haddad et al[12] and Hang et al[14]. Zamzam et al[16] attributed initial complete displacement as the single most important predictor of redisplacement. Mani et al[20] reported a significant risk of redisplacement with distal radius fractures with higher degree of translation at the radial or ulnar fracture site. In the same study, when the translation was more than half of diameter of radius the risk of failure was 60%, whereas for less translation the risk of redisplacement was 8%.

In our study anatomical reduction gave significant stability to the fracture after immobilization in cast. Haddad et al[12] also reported that most favourable prognostic factor regarding maintenance of reduction in cast was perfect anatomical reduction on post-reduction radiograph. Similarly, Proctor et al[19] and Devaliya et al[13] also reported that failure to achieve perfect reduction was significantly associated with redisplacement. However, Zamzam et al[16] reported that imperfect reduction did not show a significant risk of redisplacement compared with perfect reduction, regardless of the type of initial displacement.

The role of quality of cast application in redisplacement is another matter of controversy. In our study, significantly higher value of cast index was found in those fractures which later redisplaced in cast whereas it failed to establish high gap index as a risk factor for later redisplacement in cast. Higher value of cast index was also found to be significantly associated with redisplacement in study by McQuinn et al.[17] The role of cast index in redisplacement of distal radius fracture has been refuted in studies by Devaliya et al[13] and Hang et al.[12] Malviya et al[11] observed that both the cast index and the gap index were significant risk factors for redisplacement and the gap index was more sensitive than the cast index in predicting failure of cast treatment. Alemdaroglu et al[15] also reported significant role of gap index in predicting the risk of redisplacement. The role of gap index was found not to be significant in the studies by Devaliya et al[13] and McQuinn et al.[17]

Conclusion

Distal radius fractures are characterized by high rates of redisplacement after closed reduction and immobilization in cast. Initial complete translation, associated ulnar fractures, non-anatomical initial reduction and poor casting technique reflected by high value of cast index are the significant risk factors that lead to loss of reduction of distal radius fractures in the cast.

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