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Re-displacement and cast index in distal forearm fractures in children

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Abstract
Introduction: Forearm fractures in children treated by closed reduction and immobilization with plaster cast provide satisfactory outcome. Prediction of re-displacement in conservative fracture treatment would be a gift for orthopaedic surgeon. Cast index (CI) is a simple and reliable marker to predict re-displacement of fracture. It is calculated by measuring the ratio of the internal antero-posterior and lateral diameter of the cast at the fracture site.
Materials and Methods: A hospital based prospective study was conducted in the Department of Orthopaedics, Silchar Medical College and Hospital on 113 patients below 13 years of age with forearm fractures. They were treated conservatively by closed reduction and above elbow casting. Cast index was measured from the post-manipulation radiographs and then followed up weekly to check for re-displacement. All fractures were divided as proximal and distal based on the location of the radius fracture. Open fractures, patient with distal neurovascular deficit or associated with other fractures are excluded.
Results: Maximum incidence of pediatric forearm fractures was found in 8-12 years age group. Out of 113 patients, incidence in males (68.14%) was higher than females (31.85%) and distal fractures (73.45%) are more than proximal (26.55%). Mean cast index in distal fractures which were displaced was 0.85. Out of 83 distal forearm fractures 9 were re-displaced. Re-displacement was the only complication.
Discussion: Cast Index of >0.8 correlates with increased risk of re-displacement. Cast index stays a clinically useful tool to predict re-displacement particularly in distal fractures.
Conclusion: Achieving <0.8 cast index in distal forearm fractures was easier and correlates well with the re-displacement assessment than proximal forearm fractures. Thus, cast index is useful to predict the re-displacement in distal forearm fractures and can also help prevent re-displacement by adhering to it.

Keywords: Closed forearm fracture, children, closed reduction, cast index, re-displacement

Introduction
In children, forearm fractures are the most encountered after clavicle fractures. Distal radius amounts for 20-30% and proximal forearm fractures accounts for about 16-42% of all limb fractures [1, 2]. In children closed forearm fractures can be managed by closed reduction and immobilization with plaster cast which can provide satisfactory outcome. The goal of treatment is to restore appropriate length, alignment and rotation for good functional outcome.
Mild to moderate degrees of displacement and deformity are acceptable in children due to high remodelling potential [3]. However, re-displacement is the main complication to about 25% caused mainly due to initial displacement [4, 5, 6]. Other factors contributing to re-displacement are inadequate fracture reduction, resolution of oedema in cast, poor cast quality, pattern of fractures etc. For decreasing the incidence of re-displacement, the most important modifiable risk factor is the quality of casting that can be assessed by casting indices. Cast Index (CI) described by Chess *et al*. is considered as the simplest one [7]. It is calculated by measuring the internal antero-posterior (AP) diameter of the cast (excluding padding) at the level of the fracture and dividing it by the internal lateral diameter of the cast (excluding padding). An ideal CI ratio was defined as 0.7 but several studies have concluded that a CI of > 0.8-0.84 signifies a poorly moulded cast and carries a significant risk of re-displacement. However, it is difficult to achieve a cast index <0.8 in proximal forearm fractures due to the bigger muscle bulk and more rounded shape when compared to distal forearm.

Materials and Methods

A hospital based prospective study was conducted in the Department of Orthopaedics, Silchar Medical College and Hospital, Assam over the period of 1(one) year from June 2019 to May 2020.

Data Collection

113 patients with forearm fractures of the pediatric age group attending the OPD and emergency of Department of Orthopaedics, Silchar Medical College and Hospital who met the inclusion criteria outlined below were recruited in the study. Inclusion criteria include all patients under the age of 13 years with closed forearm fracture (with or without ulna fractures), guardian/parents giving informed consent. Open fractures, positive distal neurovascular deficit, any other associated with other fractures, guardian/parents not giving informed consent or any pathological fractures are excluded from the study. An informed written consent was obtained from each patient prior to participation in the study.

Procedure

All fractures are examined clinically and radiographically before closed reduction and cast application. After taking consent and explaining the procedure, the patient is prepared for closed reduction. Traction and counter-traction was applied under sedation under C-arm. Integrity of the interosseous membrane is maintained by putting the pressure between the two bones. Soft cotton padding is applied uniformly. First below elbow cast was applied, and again interosseous membrane was maintained till the cast is set, then the cast is converted to above elbow with the elbow fixed at 90 degrees. In case if there is sufficient swelling, an above elbow slab was applied and then converted to cast after the swelling subsides.

Post manipulation x-ray of forearm is done in AP & lateral with a 4cm long radio-opaque scale as a reference to measure internal AP & lateral diameter and to rule out magnification error in the x-ray. The fracture fragment is also measured using the same method.

Follow-up is done every 1-2 weeks until union is confirmed radiologically.

Fig 1: Lateral and AP x-ray views of forearm with wrist joint showing calculation of Cast Index (CI) = a/b (a=internal anteroposterior diameter, b=internal lateral diameter)

The Cast Index is calculated as a ratio of internal cast AP diameter and lateral diameter excluding the padding as described by Chess *et al*. Both measurements are taken at the level of the radius fracture site.

$$\text{Cast Index (CI)} = \frac{\text{Internal anteroposterior diameter (excluding the cast)}}{\text{Internal lateral diameter (excluding the cast)}}$$

All fractures can be categorized as proximal or distal by dividing the length of the distal radial fragment with that of the entire length of radius. The resultant values ranged from 0(distal) to 1(proximal). The fractures with a ratio of < 0.5 are grouped as distal and those with ratio of >0.5 as proximal. The measurements were made from wrist joint distally to proximal radio-ulnar joint.

Data were analysed using Microsoft Excel 2013 software (Redmond, WA 98052-7329, USA).

Results: In the study, the age of the group ranged from 0 to 13 years with mean age of 7.4 years. 8 to 12 years age group has the maximum incidence of forearm fracture among the paediatric age. Out of 113 patients, 77 patients (68.14%) were male and 36 patients (31.85%) were female.

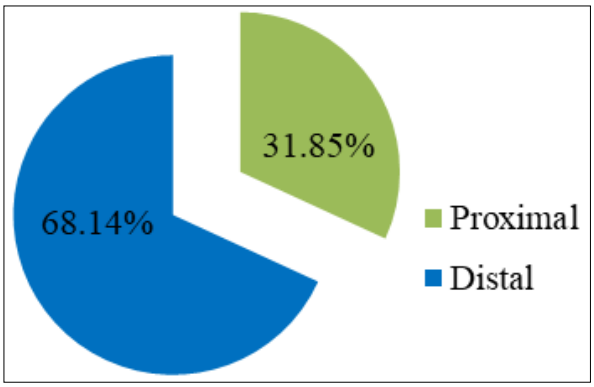

Fig 2: Distribution of proximal and distal fracture in forearm

Out of 113 patients, proximal and distal fractures were 30 (26.55%) and 83 (73.45%) respectively. 12(10.61%) had associated ulna fractures while rest of the majority are purely distal radius fractures. Mean initial displacement of fracture in distal forearm fractures was 22.1degrees. All the patients were followed up every 1-2 weeks until union is seen radiologically. Mean time for union was observed at 10 weeks.

Fig 3: Case 1, Anteroposterior and lateral view (Day 1) [CI=0.72]

Fig 4: Case 1, Anteroposterior and lateral view (4 week)

Fig 5: Case 2, Anteroposterior and lateral view (Day 1) [CI= 0.8]

Fig 6: Case 2, Anteroposterior and lateral view (4 weeks)

Table 1: Showing the mean cast index among the displaced and undisplaced distal forearm fractures

	Displaced Fracture	Undisplaced Fracture
Number of patients	9	104
Mean cast index	0.85	0.7
Re-manipulation	9	0
P value	<0.001	

Mean cast index was 0.72 for distal forearm fractures. Mean cast index in displaced distal fractures was calculated to be 0.85. Mean cast index for un-displaced distal fractures was 0.7. Out of 83 distal forearm fractures 9 were re-displaced and were re-manipulated while 4 (out of 9) had to undergo operative treatment. Re-displacement was observed commonly after 2 weeks with the resolution of edema and loosening of the cast. The only complication observed in the study was re-displacement following initial manipulation.

Discussion

In closed reduction of forearm fractures there is always a chance of re-displacement following cast application. Earlier the position of the elbow during casting was thought to be important in predicting the final outcome (8, 9). However, several studies have validated the use of cast indices as potent predictors of re-displacement. Uniform soft cotton padding and good moulding technique achieving three-point fixation is crucial in attaining a proper fracture reduction and thus avoiding re-displacement.

Cast Index of >0.8 correlates with increased risk of re-displacement. In the study the distal forearm fractures with cast index >0.8 were more likely to get re-displaced than with cast index <0.8 (10, 11) It is difficult to achieve a cast index <0.8 in proximal forearm fractures due to the bigger muscle bulk and more rounded shape, but cast index < or > 0.8 does not necessarily predict the risk of re-displacement and re-manipulation in this group. So, the Cast index stays a clinically useful tool to assess the quality of cast molding following closed reduction of pediatric forearm fractures and to predict re-displacement most importantly in distal forearm fractures.

Conclusion

It is easy to achieve <0.8 cast index in distal forearm fractures and predict the re-displacement accordingly unlike the proximal forearm fractures. Thus, cast index can be an essential clinical tool to predict the re-displacement in distal forearm fractures. Also, with strict application of this tool in cast molding it is possible to prevent the re-displacement of the fracture.

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