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# Study of cast index in middle third fractures of both bones of forearm in children

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**Abstract**
**Introduction**: Forearm fractures are one of the most common orthopaedic injuries in paediatric age group. Normal function is often achieved with closed reduction and casting. Loss of fracture reduction is the most commonly reported complication of forearm fractures. An important modifiable risk factor for fracture redisplacement is the quality of casting, which can be measured objectively by the use of casting indices. An attempt is made to validate the role of cast index in middle third fractures of both bones of forearm in children.
**Materials and methods**: Patients in the age group of 2 to 12 years with fracture of both bones of forearm involving the middle third treated by closed manipulation and cast application were included in the study. An above elbow cast was applied in the emergency room after closed reduction in all patients. Cast Index, defined as ratio of inner diameter of the cast in lateral view to that in anteroposterior view was measured at the fracture site in all the radiographs.The mean Cast Index in nondisplaced and displaced groups were calculated and compared.
**Results**: Thirty children with middle third fractures of radius and ulna were included in the study. At 1 and 2 week follow-up, all but 5 cases maintained acceptable reduction. The mean cast index in 25 cases which maintained reduction was 0.75 whereas that in the group with significant displacement was 0.84.
**Conclusion**: Majority of paediatric forearm fractures are amenable to conservative treatment. Quality of casting as expressed by indices such as cast index is one of the indicators of satisfactory outcome following middle third forearm fractures when used as a measure of risk of redisplacement.

**Keywords**: Forearm fractures, Redisplacement, Cast index

## Introduction
Forearm fractures are one of the most common orthopaedic injuries in paediatric age group. Ulna is relatively straight whereas radius has a bow and rotates over ulna during supination and pronation. Much of the growth occurs at the lower end of both bones of forearm.
Most forearm injuries are the result of indirect trauma. A fall on an outstretched hand coupled with a rotational component to produce fracture is common. The goal of forearm fracture treatment is to restore appropriate length, alignment, and rotation to allow normal function after completion of remodelling and healing [1].
Normal function is often achieved with closed reduction and casting. Because of children's ability to remodel, especially if more than two years of growth is left, some amount of angulation and translation is acceptable. Most authors concur with the recommendations from Noonan and Price with angulation of 10-15 degrees and malrotation of 30 degrees [2]. Historically, most of these fractures in children have been treated by a good closed anatomical reduction and immobilisation in a cast [3]. Conservative methods still play a major role in treatment and 85% of these patients achieve satisfactory results with these methods [4, 5]. Loss of fracture reduction is the most commonly reported complication of manipulated distal forearm fractures and, up to one third of cases will demonstrate late displacement.[6] Maintaining acceptable reduction inside the cast is difficult in some cases and re-displacement may occur. Exact and repeated radiological checks are necessary because early identification allows additional treatment, which will prevent further complications[6, 7].
Failure of conservative treatement is due to multiple factors; important among them are initial displacement, obliquity of fracture lines, initial soft tissue swelling, inadequate closed reduction and poor casting technique. An important modifiable risk factor for fracture

redisplacement is the quality of casting, which can be measured objectively by the use of casting indices [8].

Various objective indices have been proposed for assessing quality of the cast. The most well known is the Cast Index which was proposed by Chess *et al*. and is calculated on the basis of the cast geometry at the fracture site [9].

Mazzini *et al* stressed on the fact that there are not many studies about role of casting indices in redisplacement of paediatric forearm fractures and there is no homogeneity among them [10]. Our study tries to validate the role of cast index in middle third fractures of both bones of forearm in children.

## Materials and Methods

Patients in the age group of 2 to 12 years with fracture of both bones of forearm involving the middle third, who were treated by closed manipulation and cast application, were included in the study.

The inclusion criteria were patient age between 2 to 12 years (skeletally immature patients), closed injuries, fractures that did not require fixation (nails/wiring), patients who attended the follow-up, and displaced fractures that involved the middle third forearm. Patients with open fractures, unsatisfactory initial reduction and incomplete followup were excluded from the study.

An above elbow cast was applied in the emergency room after closed reduction in all patients. A thin soft cotton roll was used as a padding. Particular attention was given to maintainance of interosseous space while molding the cast thereby increasing the lateral diameter of the cast compared to anteroposterior diameter.

Immediate check X-ray was done and angulation of <10 degreees in anteroposterior (AP) and lateral views and more than 50% contact at fracture surface was considered as satisfactory. The patient was discharged with instructions for limb elevation and warning signs of compartment syndrome.

Patients were followed up at weekly intervals for first three weeks and then at 6 and 9 weeks with clinical examination and AP and lateral X-rays.

Cast Index (CI), defined as ratio of inner diameter of the cast in lateral view to that in AP view was measured at the fracture site in all the radiographs.

Failure of reduction was defined as >15 degrees angulation in AP or Lateral radiographs or displacement of fracture fragments leading to <25% contact between the fracture ends.

The mean Cast Index in nondisplaced and displaced groups were calculated and compared.

**Fig 1:** Measurement of cast index in anteroposterior and lateral views

## Results

Thirty children with middle third fractures of radius and ulna were included in the study. 22 were males and 8 were females. Average age was 9 years. All patients were applied above elbow casts after closed manipulations and check X-rays showed satisfactory reduction.

At 1 and 2 week follow-up, all but 5 cases maintained acceptable reduction. 5 casts had to be removed and remanipulated as angulation and/or translation was above acceptable criteria.

The mean CI in 25 cases which maintained reduction was 0.75 whereas that in the group with significant displacement was 0.84. The cast index in group with failure of reduction was significantly higher than in the patients who maintained the initial reduction.

The CI was the only factor which was significantly higher in the redisplacement group. No significant differences were seen for age and sex. No significant difference was noted in initial angular deformity, initial displacement, and seniority of the surgeon between displaced and nondisplaced groups.

## Discussion

Majority of paediatric forearm fractures are amenable to closed traeatment. Many papers suggested closed reduction of paediatric forearm fractures followed by long arm plaster to be the accepted standard and the technique of pins and plaster should be considered a reliable alternative for the unstable injuries when acceptable alignment after manipulation cannot be achieved or maintained.[11] But, optimal management of pediatric and adolescent forearm fractures remains controversial [1].

Most common complication of the closed method of treating these paediatric forearm fractures is redisplacement within the cast. Rates of redisplacement have been measured in various studies of between 12% and 34% [3, 12, 13]. The redisplacement is due to multiple factors, both fracture and surgeon related. One important modifiable risk factor is the quality of manipulation and cast application. To achieve a high quality casting (decreasing surgeon related factors), an adequate reduction is required as well as a good plaster application technique. The second point is obtained by application of a well moulded cast with three-point bending or appropriate interosseous mould [10].

Though qualities of adequate casting are well appreciated, including maintaining the interosseous space and thereby, the radial bow, they are largely subjective. Objective criteria for measuring the quality of cast include Cast index, Gap index, Padding index and Canterbury index.

It has previously been shown that poor moulding techniques lead to redisplacement of fractures [10, 11]. Although several studies have been done in recent years, overall the literature is sparse [10]. Initial articles focussed on fracture/surgeon related factors of re-displacement [3, 12, 14]. A high quality cast application in children's forearm and distal radius fractures has always been a goal; however, an objective assessment was not directly done until Chess *et al*. defined the "cast index" [9]. After this, other "casting indices" appeared with the aim to provide the best measurement for this issue [10].

The first indices used was the cast index suggested by Chess *et al*. who conducted a study in which all distal one third fractures requiring reduction were included if the distal radial physis was open, a short-arm cast was used and pre-reduction, post-reduction and three week follow-up radiographs were available for review. The cast index is measured as the ratio of sagittal to coronal width from the inside edges of the

plaster cast at the fracture site. Cast index values averaged 0.72 and the change in angulation was less than 5° in 90% of cases. In this study the cast index was applied to distal forearm fractures and the re-displacement in supination–extension type injuries were most related to an abnormal cast index value. This original paper describing the CI recommended a CI of 0.7 [9].

An axial view of the forearm will appear oval in shape and not round. It is therefore important to ensure that the cast is oval in shape and not circular. A circular cast would be demonstrated by a high CI, that is, one that was close to 1.0 [15]. Wedging is an option for fractures that have displaced early; however, this is recommended for midshaft and distal shaft fractures that are displaced only 5 to 10 degrees above acceptable limits without an unacceptable rotational component [1].

It is difficult to obtain a low cast index in chubby children as with fractures with large soft tissue edema, especially with delay in presentation to the hospital. Kamath *et al* in his study indicated in addition to obesity, excessive padding and soft tissue swelling could allow for fracture displacement as the swelling subsides within the confines of the applied plaster resulting in a looser fitting cast.[15] Malviya *et al* suggested that in young normally chubby children there is very little control over this otherwise useful tool [11].

Webb *et al*. included a total of 113 cases of distal third forearm fractures there was a significant relationship between cast index and loss of reduction. Webb and colleagues also suggested that the only variables that differed significantly between the patients who lost reduction and those who maintained reduction were the cast type and CI. The mean CI in their study was 0.79±0.07 for children who had lost reduction and required remanipulation [16].

Singh *et al*. assessed the reliability and practicality of the cast and padding index in plaster quality application for clinical decision making in forearm fractures. All selected cases were forearm fractures and no distal radius fractures were included. It showed the utility of both indices [17].

Malviya *et al*. defined the gap index. They noted a significant difference ($p<0.001$) in the cast index and the gap index of dispalced and nondisplaced groups. They concluded that the gap index was more sensitive than the cast index in predicting failure [11].

Edmonds *et al*. recently defined a measurement on AP view, the second metacarpal-radius angle and inferred there was no association between the treatment failure and cast index.[18]

A paper by Hang and colleagues stated that the CI was insignificant, but added that there was value in the padding, Canterbury, and 3-point indices [19].

Obtaining a low cast index near 0.7 is possible in distal forearm fractures but difficult in middle and proximal fractures as the soft tissue envelop increases as we go more proximally. Sheikh *et al* opined that due to the greater amount of soft tissue present in the proximal forearm as compared to the distal forearm, an ideal CI of <0.8 is more difficult to achieve for proximal forearm fractures following closed reduction. In other words, as the proximal forearm is more circular than elliptical in axial section than the distal forearm, it is more difficult to mould an elliptical cast at the proximal forearm, although this may not necessarily result in a loss of reduction. Traditionally, CI has been used for distal forearm fractures but there is little evidence to determine how effective CI is at judging the quality of cast molding in proximal forearm fractures [8].

An appropriate CI, however, seems to decrease the risk of redisplacement. The CI is a simple reliable radiographic measurement to predict and analyze the redisplacement of distal forearm fractures in children [9]. In the largest clinical study that directly correlates plaster moulding with radiologic outcome, Kamath *et al*. believed that the CI should be used to assist in judging adequate plaster cast moulding and a CI of <0.8 should be deemed the gold standard and that the CI is reliable and easy to learn and teach. They concluded that the CI has the advantage of being easy to perform, quick, and reproducible. The CI is accurate, with low interobserver and intraobserver error [15].

Malviya *et al* concluded that a quick assessment, especially by the less experienced surgeons, is a good practice before accepting any plaster following a manipulation of distal radial fractures. It has the potential of not only saving the patient a second anaesthesia but also complications of a more extensive second procedure and of course hospital resources [11].

Mazzini *et al* concluded that this is a very complex subject to be explained by a single factor; thus it is a multifactorial issue and should be considered on this basis. The casting indices should not be interpreted as a separate issue but in conjunction with fracture characteristics and patients factors [10]. It is clear that there are not many studies about this topic and there is no homogeneity among them [10]. In our study cast index was found to be a significant predictor of risk to redisplacement of middle third forearm bones fractures within the cast. It should be viewed in addition to other patient and fracture related factors in determining the outcome of the injury.

## Conclusion

Majority of paediatric forearm fractures are amenable to conservative treatment. Hence it is imperative that the surgeon is mindful of the factors affecting the outcome after cast treatment. Quality of casting as expressed by indices such as cast index is one of the indicators of satisfactory outcome following middle third forearm fractures when used as a measure of risk of redisplacement, in addition to other factors affecting the final functional result.

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