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Original Research Article

To Evaluate the Role of Cast Index in Predicting Re-Displacement of Pediatric Both Bone Forearm Fractures

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Conflict of interest: Nil

Abstract:

Background: Fractures of the forearm constitute 35% and 45% of all pediatric long-bone fractures. Despite of increasing trend in operative treatment for pediatric forearm fractures, closed fractures of the forearm in children are often treated with closed reduction and immobilization in a well-fitting plaster cast and achieve a satisfactory outcome in a majority of patients, The goal of the treatment is to restore appropriate length, alignment & rotation which will allow normal function after remodeling and healing is completed.

Material and Methods: 30 patients with forearm fractures of the pediatric age group attending the OPD and emergency of the Department of Orthopedics, MGM MC, and MY hospital, Indore who met the inclusion criteria outlined below were recruited in the study. All children between 2 to 13 years of age, fractures undergoing closed reduction of radius and ulna fractures, no other associated fractures, and informed consent included in our study.

Results: In our study, we included 30 patients from age 2 to 13 years (Mean age – 7.38 years). Out of these patients, 12 were males and 18 were females. 10 patients who were lost in follow-up after close reduction and cast application were excluded from the study. The mean follow-up in our study was 6.4 weeks. The mean cast index is 0.858 with a range of 1.004 -0.65. In our study, we noticed complications of Re-displacement in 3 patients (cast index range of 0.75-0.97) and nonunion in one case (cast index -1.004).

Conclusion: CI is a simple, reliable, and objective radiological measurement to determine the quality of molding and padding of the plaster thereby predicting the Re-displacement of fractures in this group.

Keywords: Cast Index (CI), Re-Displacement, Pediatric Forearm Fracture.

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Introduction

One of the most common childhood fractures is forearm fractures after clavicular fractures [1]. Fractures of the forearm constitute 35% and 45% of all pediatric long-bone fractures [2-3]. The common age group is >5 years with direct trauma to the limb being the most common cause. Despite of increasing trend in operative treatment for pediatric forearm fractures, closed fractures of the forearm in children are often treated with closed reduction and immobilization in a well-fitting plaster cast and achieve a satisfactory outcome in a majority of patients [4], The goal of the treatment is to restore appropriate length, alignment & rotation which will allow normal function after remodeling and healing is completed.

Fixation is reserved for unstable fractures, failed reductions; complicated cases eg open fractures, and compartment syndrome. Distal radius fractures heal satisfactorily and mild to moderate displacement is acceptable as the remodeling potential is great but the same can't be said for children over 9 years of. Age where this potential decreases [5]. Re-displacement rates of as high as 25% are there and some recommend fixation of high-risk forearm fractures [6,7].

The most important risk factor for re-displacement of a forearm fracture is the initial displacement of the fracture [8]. A modifiable risk factor that can prevent the re-displacement of fracture is the quality of casting, which can be measured

objectively by casting indices. The first and simplest index to be described is the cast index (CI), described by Chess et al. [9] It is calculated by measuring the internal anteroposterior (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). The cast index (CI) is a simple and quick method of predicting the re-displacement after cast application in radius ulna fractures in pediatric patients, particularly distal radius fractures [10]. The ideal cast index is 0.7 or less for distal radius ulna fractures for reduced risk of re-displacement, whereas a cast index of 0.8-0.84 is associated with a significant risk of subsequent re-displacement [11-13]. Hence we conducted this study to predict the re-displacement in forearm fractures at all levels by calculating of cast index.

Materials and Method

A prospective study was conducted in the Department of Orthopedics, MGM MC and MY hospital, Indore from 01-09-2019 to 01-09-2021.

Data Collection: 30 patients with forearm fractures of the pediatric age group attending the OPD and emergency of the Department of Orthopedics, MGM MC, and MY hospital, Indore who met the inclusion criteria outlined below were recruited in the study. Inclusion criteria included all children between 2 to 13 years of age, fractures undergoing closed reduction of radius and ulna fractures, no other associated fractures, and informed consent. Exclusion criteria included patient refusing informed consent, open fractures, pathological fractures, distal neurovascular deficit positive, same limb with other fractures, pathological fractures, segmental fractures, intraarticular fractures, and incomplete follow-up.

To reduce edema, all cases included in the study received ice fomentation, slab, and limb elevation for three to five days. After the swelling decreased, the fracture was managed and closed reduced to anatomical position under C-arm guidance and short GA.

After adequate homogeneous padding and the elbow bent to 90 degrees with a forearm, an above elbow plaster of Paris cast was put once a proper, acceptable reduction was reached.

Table 1: Acceptable criteria for forearm fracture reduction

Age (years)	Saggital plane (in degree)	Frontal plane (in degree)
4-9	20	15
9-11	15	5
11-13	10	0
>13	5	0

For the proximal third fracture in supination and all other fractures in the mid-prone position. True anteroposterior and true lateral radiographs were collected after the plaster had dried, and the cast index was computed using the "IMAGEJ" program.

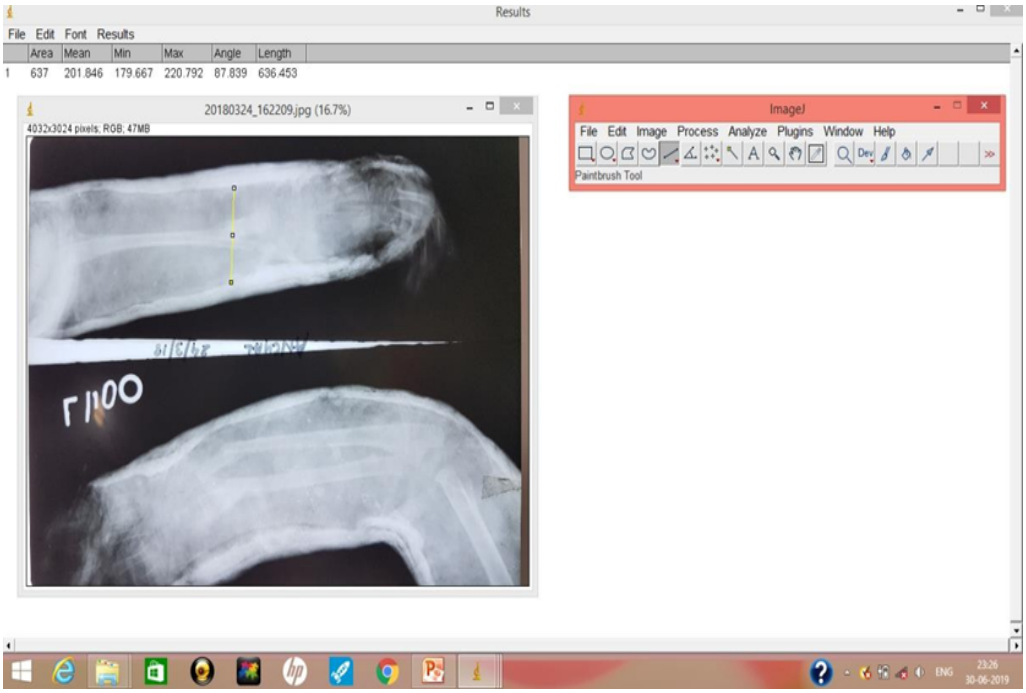

Fig 1: Screenshot of software 'IMAGEJ' used for calculating Cast index

The Cast index is calculated by measuring the internal anterior-posterior (AP). diameter of the cast (excluding padding) at the level of the fracture taken on the lateral view and dividing it by the internal mediolateral diameter of the cast (excluding padding) taken on the AP view

$$\text{Cast Index} = \frac{\text{Lateral Diameter of Internal Cast}}{\text{Anteroposterior Diameter of Internal Cast}}$$

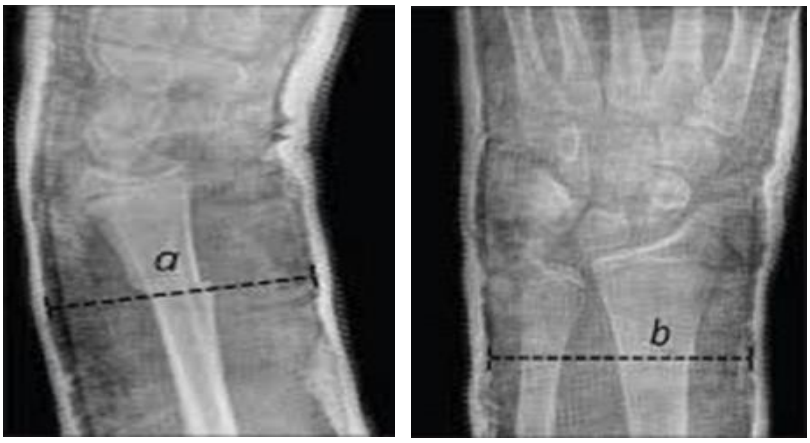

Fig 2: Cast index

Following closed reduction, the first appropriate radiograph is used to take both measurements.

Post-reduction, all patients were recommended to perform light finger grasp and finger extension activities, as well as taking painkillers. Patients were followed up regularly basis at 2, 4, and 6 weeks following cast application, and radiographs were taken in true anteroposterior and true lateral views at each visit. Re-displacement was measured, and the cast index was determined. Patients who showed re-displacement were re-manipulated under image intensifier supervision but did not achieve sufficient reduction and were evaluated for intramedullary nailing.

Cast removal occurred at 6 weeks when a radiological callus bridging three cortexes was found.

Rehabilitation protocol: Physiotherapy started after cast removal. The early rehabilitation phase focuses on restoring the range of motion, strength, and function of the affected forearm. Passive range of motion exercises for the wrist, elbow, and shoulder joints are initiated, followed by gradual progression to active-assisted after 2-3 weeks of cast removal. Strengthening exercises for the muscles surrounding the forearm are introduced, starting with gentle isometric exercises and progressing to isotonic exercises as tolerated after 4-6 weeks. Focusing on activities of daily living and age-appropriate functional tasks. Functional activities such as gripping objects, and picking up small items, functional training include activities specific to the child's interests and recreational pursuits to enhance engagement and motivation.

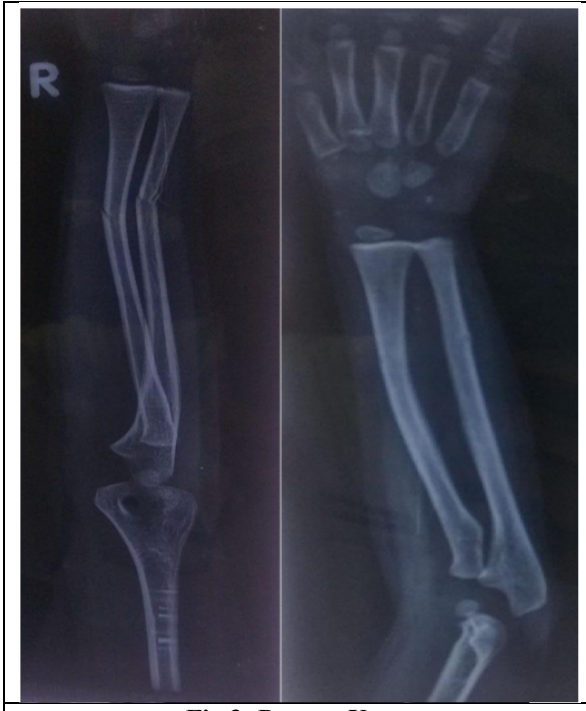

Fig 3: Precast X-ray

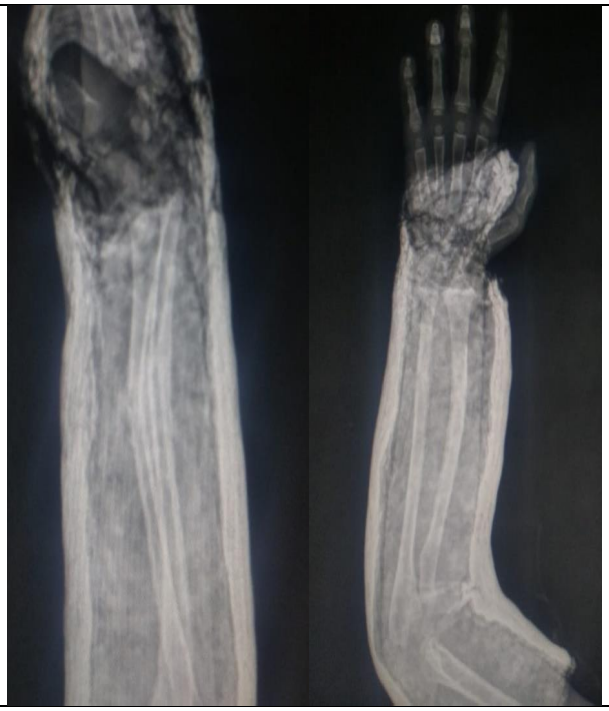

Fig 4: Post-cast x-ray of the same patient with CAST INDEX= 0.77

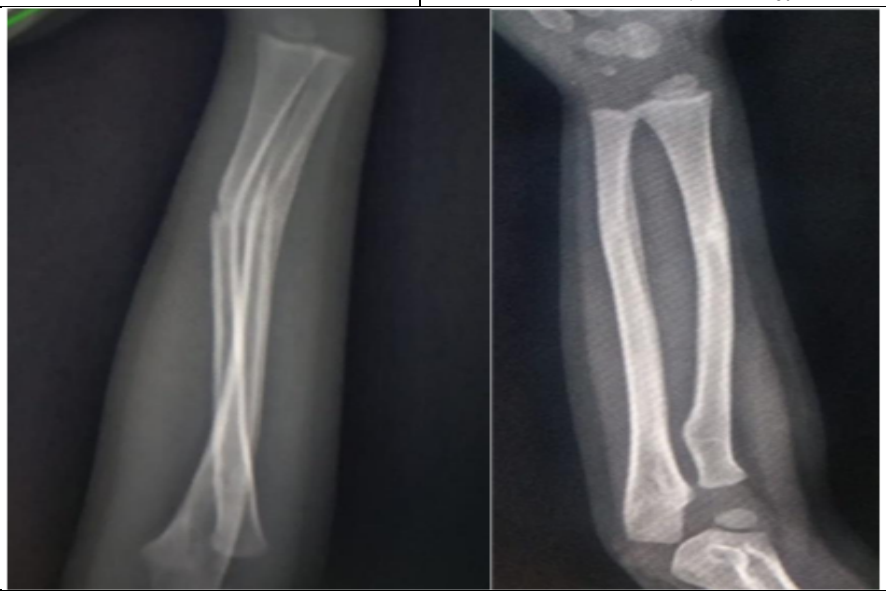

Figure 5: X-ray of the same patient on cast removal at 6 weeks

Results

Table 2: Level of Fractures with their corresponding mean cast index

Site of Fracture	No. of Cases	Cast Index	Re Displacement	Non-Union
Proximal third	6 (20%)	0.92 (1.004-0.82)	-	1
Middle third	15 (50%)	0.86 (1.0-0.7)	2	-
Distal third	9 (30%)	0.806 (0.91-0.65)	1	-

Table 3: Age Distribution

S. No.	Age Group	No.	Percentage
1	02-04	03	10
2	05-07	10	33.34
3	08-10	12	40
4	11-12	05	16.66

Table 4: Gender Distribution

S. No.	Gender	No.	Percentage
1	Male	12	40
2	Female	18	60

Table 5: Cast Index After Immediately Cast

S. No.	Cast Index	No.	Percentage
1	0.5-0.7	03	10
2	0.71-0.99	25	83.34
3	1.0 or More than 1.0	02	6.66

Table 6: Cast Index Two Weeks

S. No.	Cast Index Two Weeks	No.	Percentage
1	0.5-0.7	02	6.67
2	0.71-0.99	19	63.33
3	1.0 or More than 1.0	01	3.33
4	Nil	08	26.67

Table 7: Cast Index4 Weeks

S. No.	Cast Index 4 Weeks	No.	Percentage
1	0.5-0.7	01	3.33
2	0.71-0.99	19	60.33
3	1.0 or More than 1.0	01	3.333
4	Nil	10	33.33

Table 8: Cast Index6 Weeks

S. No.	Cast Index6 Weeks	No.	Percentage
1	0.5-0.7	03	10
2	0.71-0.99	16	53.33
3	1.0 or More than 1.0	00	0.0
4	Nil	11	36.67

Table 9: Complications

S. No.	Complication	No.	Percentage
1	Re-displacement	03	10
2	Ulna Non Union	01	3.33
3	Nil	26	86.67

Discussion

Forearm fractures are one of the most common orthopedic injuries in the pediatric age group. Normal function is often achieved with closed reduction and casting. Although anatomical reduction is desirable for all fractures, some degree of angulation is acceptable in these fractures largely due to the inherent ability of pediatric bone to remodel.

Maintenance of reduction requires the application of a well-molded plaster cast with a thin uniform padding to achieve 3-point fixation. Loss of fracture reduction is the most commonly reported complication of forearm fractures. An important modifiable risk factor for fracture Re-displacement 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 fractures of both bones of the forearm in children. The CI is a valuable tool to assess the quality of molding of the cast following closed manipulation of forearm fractures in children. A high CI (≥0.84) in post-manipulation radiographs indicates an increased risk of re-displacement of the fracture in children, especially in those under the age of 5 years and over the age of 10 years.

In our study, we included 30 patients from age 2 to 13 years (Mean age – 7.38 years). Out of these patients, 12 were males and 18 were females. 10 patients who were lost in follow-up after close reduction and cast application were excluded from the study. The mean follow-up in our study was 6.4 weeks. The mean cast index is 0.858 with a range of 1.004 -0.65. In our study, we noticed complications of Re-displacement in 3 patients (cast index range of 0.75-0.97) and nonunion in one case (cast index -1.004) Hassaan Qaiser Sheikh et al 2018 [12] Study Many pediatric forearm fractures can be treated in plaster following closed reduction. The cast index is a simple, reliable

marker of the quality of molding, and a CI of >0.8 correlates with an increased risk of Re-displacement. Previously, CI has been applied to all forearm fractures. They hypothesized that an acceptable CI is more difficult to achieve and does not predict outcomes in fractures of the proximal forearm.

Seventy-nine cases of pediatric forearm fractures initially treated by manipulation alone over a year were included in this retrospective radiographic analysis.

The Cast index is useful in predicting the Re-displacement of manipulated distal forearm fractures. They found that in proximal half forearm fractures, it is difficult to achieve a CI of <0.8, but increased CI does not predict loss of position in these fractures. They therefore discourage the use of CI in proximal half forearm fractures.

Kamat AS et al 2012 [10] Study Case records and radiographs of 1001 children who underwent manipulation under anesthesia for a displaced fracture of the distal forearm were studied. Re-displacement was defined as > 15 degrees of angulation and/or > 80% of translational displacement on check radiographs at 2 weeks. From the 1001 patients who qualified for the study, fracture re-displacement was seen in 107 (10.6%) cases at the 2-week follow-up. A total of 752 (75%) patients had CIs of ≤ 0.8, whereas 249 (25%) had casting indices of ≥ 0.81. In patients with CIs of ≤ 0.8, the displacement rate was only 5.58%. However, in patients with CIs of ≥ 0.81, the displacement rate was 26%. A high CI was the sole factor that was significantly higher in the re-displacement group. No statistically significant difference was seen for age, sex, or surgeon seniority. Statistical differences were not noted in initial angular deformity or initial displacement.

Maneesh Bhatia et al 2006[14] Study Case records and radiographs of 142 children who underwent a manipulation for a displaced fracture of the forearm or wrist were studied. Angulation, translation displacement, Cast index, and Padding index were measured on radiographs. The sum of the Cast index and Padding index was termed the Canterbury index. Re-displacement was seen in 44 cases (32.3%).

Cast index, padding index, and Canterbury index were significantly greater in the re-displacement group as compared to the cases where no displacement was seen ($p < 0.005$). Improvement in plaster application skills as monitored by these indices reduced the re-displacement rate by 50%. We suggest that a high Cast index of more than 0.8, a Padding index of more than 0.3, and a combined Canterbury index of 1.1 are important risk factors for the re-displacement of these fractures. Ujjwal K Debnath et al 2019[11] Studied 174 consecutive cases treated during the study period, 156 patients (114 male and 42 female) with a mean age of 9.8 years (range: 2–15 years) were included in this retrospective radiographic analysis; 18 patients were excluded for various reasons. All patients were manipulated in the operation theatre under general anesthesia and a molded above-elbow cast was applied. The CI was measured on immediate post-manipulation radiographs. Children were divided into three groups according to age: group 1: <5 years, group 2: 5–10 years, and group 3: >10 years.

Angulation of the fracture within the original plaster cast occurred in 30 patients (19.2%): 22/114 males and 8/42 females. The mean CI in these 30 patients who required a second procedure was 0.92±0.08, which was significantly more than the mean CI in the other children (0.77±0.07) (P<.001). The mean CI in children who underwent re-manipulation in group 1 was 0.96, which was significantly higher than that of the other two groups, i.e., 0.90 in group 2 and 0.88 in group 3 (P<.05). A receiver operating characteristics (ROC) curve estimated the cut-off point for intraoperative CI of 0.84 when both the sensitivity and specificity of CI was high to predict re-manipulation for re-displaced fractures of the distal forearm in children in any age-group.

Anil Gupta et al 2015[15] Study Seventy-nine cases of pediatric forearm fractures initially treated by manipulation alone over a year were included in this study. The CI was calculated from the post-manipulation radiographs. All fractures were divided as either proximal or distal half forearm based on the location of the radius fracture. Subsequent radiographs were reviewed to assess re-displacement and reoperation. The mean CI was 0.77. Remanipulation was required in five cases (6%), all distal half fractures - mean CI 0.79. CI was higher in proximal half forearm fractures (0.83 vs. 0.76, P = 0.006), nonetheless, these fractures did not re-displace more than distal fractures.

Dr. Sunil Basavarajanna et al 2017[16] Study Thirty children with middle-third fractures of the radius and ulna were included in the study. At 1 and 2-week follow-ups, 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.

The majority of pediatric 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 the risk of re-displacement.

However, the delayed union has not been related to the cast index in any of the previous studies. In our

study another patient with cast index 1.0 in immediate post reduction x ray had satisfactory union in 6 weeks. Thus the delayed union is solely linked to the patient factor only.

Conclusion

A greater cast index is linked to a higher possibility of re-displacement in the cast, and it can be used to predict the outcome of pediatric forearm fractures as well as the likelihood of re-displacement. There is no correlation between the higher mean cast index and the greater frequency of re-displacement in proximal third fracture. This is likely due to the enhanced muscle in the proximal forearm.

References

1. Xian CJ. The Biologic Aspects of Children's Fracture. Rockwood & Wilkins' fractures in children, 2006.
2. Noonan KJ, Price CT. Forearm and distal radius fractures in children. JAm Acad Orthop Surg 1998; 6:146-56.
3. Tachdijan MO. Paediatric Orthopedics. Philadelphia: W.B. Saunders; 1972.
4. Herman MJ, Marshall ST. Forearm fractures in children and adolescents: a practical approach. Hand clinics. 2006; 22(1):55-67.
5. Hove LM, Brudvik C. Displaced pediatric fractures of the distal radius. Arch Orthop Trauma Surg 2008; 128:55-60.
6. Zamzam MM, Khoshhal KI. Displaced fracture of the distal radius in children: Factors responsible for re-displacement after closed reduction. J Bone Joint Surg Br 2005; 87:843
7. Garg NK, Ballal MS, Malek IA, Webster RA, Bruce CE. Use of elastic stable intramedullary nailing for treating unstable forearm fractures in children. J Trauma2008; 65:109-15.
8. Proctor MT, Moore DJ, and Paterson J. Redisplacement after manipulation of distal radial fractures in children. The Journal of bone and joint surgery. British volume. 1993; 75(3):453-4.
9. Chess DG, Hyndman JC, Leahey JL, Brown DC, and Sinclair AM. Short arm plaster cast for distal pediatric forearm fractures. Journal of Pediatric Orthopaedics. 1994; 14(2):211-3.
10. Kamat A, Mutimer J. The cast index: a simple radiological predictor of plaster cast failure in pediatric distal forearm fractures. Orthop Proceedings 2010; 92-B(suppl): 221-2.
11. Debnath UK, Guha AR, Das S. Distal forearm fractures in children: Cast index as a predictor of re-manipulation. Indian J Orthop 2011; 45:341-6.
12. Sheikh HQ, Malhotra K, Wright P. Cast index in predicting the outcome of proximal pediatric forearm fractures. Indian J Orthop 2015; 49:398-402
13. Boyer BA, Overton B, Schrader W, Riley P, Fleissner P. Position of immobilization for pediatric forearm fractures. J Pediatr Orthop 2002; 22:185-7.
14. Bhatia M, Housden PH. Re-displacement of pediatric forearm fractures: Role of plaster molding and padding.Injury 2006;37:259-68
15. Gupta A, Malhotra S, Padha K, Hilal Ahmed: Casting Index Predicting Outcome of Paediatric Forearm Fractures.JK Science 2015; vol. 17 no. 4.
16. Basavarajanna S, Sharath Kumar PV: Study of cast index in middle third fractures of both bones of the forearm in children. International Journal of Orthopaedics Sciences. 3. 673-676. 10.22271/ortho.2017.v3.i3j.103.