ORIGINAL ARTICLE

Diagnostic Accuracy of Three Point Index for Prediction of Displacement of Fractured Bone after Cast Manipulation in Diaphyseal Forearm Fractures in Children

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ABSTRACT

Background: Diaphyseal forearm fractures accounts for 13-40% of all pediatric fractures often occurring between the ages of 5 to 14 years. Close reduction and long arm cast immobilization is the treatment of choice in majority of cases. Re-displacement is the most commonly reported complication that may require re-manipulation. Cast indices have been described to access cast application quality.
Aim: To apply three point index (TPI) to predict displacement after cast manipulation in diaphyseal forearm fractures in children.
Method: 175 children with diaphyseal forearm fractures of either side were selected in the study from Oct 2015 - March 2016 in the accident and emergency department of Children's Hospital & Institute of Child Health, Lahore. Clinical assessments were done and under sedation closed reduction with an above elbow plaster of Paris casts were applied. Post manipulation radiographs of the forearm were taken and three point index (TPI) was calculated. Patients were labeled as positive or negative for displacement on the basis of TPI value. These patients were then followed at 2nd week in the OPD where X-rays were done for the assessment of displacement.
Results: The mean age of 175 children presented with diaphyseal forearm fracture was 9.49±2.95 (mean ± SD) years with range from 4 – 12 years. Male to Female ratio was 1.43:1. Displacement of fractured bone after cast manipulation in Diaphyseal forearm fractures on X rays was recorded as 21.14 %(n=37). Diagnostic accuracy of three point index for prediction of displacement after cast manipulation in diaphyseal forearm fractures in children , where sensitivity, specificity, Positive predictive value and negative predictive value was calculated as 78.38%, 92.02%, 72.5% and 94.07% respectively.
Conclusion: The diagnostic accuracy of three point index for prediction of displacement after cast manipulation in diaphyseal forearm fractures in children taking x-ray findings as gold standard is higher but being primary data it needs some other trials for validation.
Keywords: Diaphyseal forearm fractures, children, cast immobilization, diagnostic accuracy, three point index, re-displacement

INTRODUCTION

The 3rd most common long bone fractures, following distal radius and humeral supracondylar fractures are the diaphyseal forearm fractures accounting for 13-40% of all pediatric fractures[1,2] The mechanism commonly involved is a fall (83%) followed by direct trauma (10%) and the typical scene of injury is likely a playground area[1,2].

Due to their treatment complexity and risk of complications, these fractures are among the most challenging to orthopedics[1,2]. Closed reduction with long arm cast immobilization is still viable treatment choice particularly in children who are under 10 years of age.[1, 3]These fractures have an excellent remodeling capacity to correct axial deformities during the growing years and healing is quick.[3] The most commonly reported complication is re-displacement after initial fracture reduction that may require re-manipulation[1,3,4,5].

Most Studies have highlighted the importance of surgeon-related factors that includes the surgeon hands on experience, inadequate initial reduction, poor cast moulding, a wobbly cast and loss of three-point index (TPI).[3]Three point index (TPI) is unique from other radiological indices in that it not only takes the gaps at the fracture site, it also uses the gaps proximal and distal to fracture sites, which are important determinants to maintain reduction against common displacement forces[6,7].

The current aim of this study is to evaluate the diagnostic accuracy of three point index for prediction of displacement of fractured bone after surgery in diaphyseal forearm fractures in children taking x-ray findings as gold standard.

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MATERIAL AND METHODS

This cross sectional study had approval from the ethical review committee and non-probability, consecutive sampling was done. Between Oct 2015 and March 2016, 175 children with diaphyseal forearm fractures who fulfill selection criteria were selected in the study from the Accidental and Emergency department of Children's Hospital & Institute of Child Health, Lahore. Our Selection criteria included children between 4 and 14 years having initial acceptable reduction angulation of < 20° [9] in the

immediate post manipulation radiographs (Antero-posterior and lateral views). All patients having either open diaphyseal fractures, unsatisfactory initial acceptable reduction (angulation of > 20^o), patients presented with multiple fractures (poly trauma), floating elbow, patients with diaphyseal forearm fractures along with neurovascular injury were excluded from the study.

Informed consent was taken from all patients guardians and demographic profile (name, age, sex, and contact) was obtained. Under sedation, close reduction was performed. Our method involved sustained traction and palm rotation in the direction of the angulation. Fracture alignment in traction was assessed under fluoroscopy. If alignment is adequate, then an above elbow Plaster of Paris cast was applied in the Emergency department. Casts was molded with anterior and posterior pressure applied. Care taken to protect the bony prominences at wrist and elbow joint. Fractures of the distal third of forearm were immobilized in pronation, of the middle third in neutral and that of the proximal third in supination. Post manipulation radiographs of the forearm in antero-posterior and lateral were taken and three point index (TPI) was calculated with cut of point of ≤0.8. (Fig. 1)

The three point index is calculated by the measurement of the distal radial gap (a), the fracture site ulnar gap (b) and the proximal radial gap (c), the sum of which was divided by the sum of the coronal reduced distance of the radius (x^1) and the ulna (x^2) on antero-posterior radiograph. Similarly, on lateral radiograph, the measurement of the distal dorsal gap (d), the fracture site volar gap (e) and the proximal radial gap (f), the sum of which was divided by the sum of the sagittal reduced distance of the radius (y^1) and the ulna (y^2). The results of the calculations of the AP and lateral radiographs are added to each other to find the TPI. The location of proximal and distal gap is to be taken at **≥**3 cm away from fracture site. A cut off value < 0.8 is to be taken[3]. (Fig. 1)

$$\text{Three point index} = [(a + b + c)/x^1 + x^2] + [(d + e + f)/y^1 + y^2]$$

Patients were labeled as positive (TPI>0.8) or negative (TPI ≤0.8) for displacement on the basis of TPI values. Patients were then kept in the emergency department with limb elevation and analgesia for 12 hours and discharged on medications if there was no evidence of swelling along with intact distal neurovascular status. Then patients were followed at 2nd week in the OPD where x-rays were done for confirmation of displacement (angulations of > 10^o in any direction i.e. dorsal or volar. True positives were identified when case was positive on both TPI and x-ray; true negatives were labeled when case was negative on both TPI and x-ray, false positive when case was positive on TPI but negative on x-ray and false negative when case was negative on TPI but positive on x-ray.

The data was recorded and analyzed through SPSS version 20. Quantitative variables like age (years) and TPI value was calculated as mean ± SD and qualitative variables like gender, location of fracture and displacement (on TPI and x-ray) was presented in form of frequency and percentage. A 2x2 table was created to determine sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy of TPI was calculated using x-ray findings. To address the effect modifier data was stratified for age and gender. Chi-square test was utilized to check the significance with p-value ≤0.05 as significant.

RESULTS

The study sample consisted of 175 children. No patient data was lost during the study period. Patients were distributed according to age of the patients, 107(61.14%) were between 4-10 years of age while 68(38.86%) were between 11-14 years of age, mean±sd was calculated as 9.49±2.95 years. Patients were divided according to gender, it shows that 103(58.86%) were male while 72(41.14%) were females with male to female ratio of 1.43:1 (Table 1). Our Mean Three Point Index (TPI) was recorded as 0.6±0.2 (Table 1).

Predicted Displacement after TPI value on post manipulation radiographs was labeled of which 37(21.14%) were positives and 78.86% (n=138) had been marked as negatives for displacement. At follow up X rays, degree of displacement (angulations of > 10^o in any direction i.e. dorsal or volar) was noted. 29 children were identified as true positives and 127 were true negatives. Similarly, 11 children were labeled as false positive and 8 were false negative. Finally, diagnostic accuracy of three point index for prediction of displacement after cast manipulation in diaphyseal forearm fractures in children taking TPI cut of value of ≤0.8 in the immediate post reduction radiographs where sensitivity, specificity, Positive predictive value and negative predictive value was calculated as 78.38%, 92.02%, 72.5% and 94.07% respectively (Table 2).

Table1. Distribution of frequency and percentages

Variables	**Frequency**	**%age**
Age		
4-10	107	61.14
11-14	68	38.86
Gender		
Male	103	58.86
Female	72	41.14
Mean TPI	0.6±0.2	
Predicted Displacement after cast manipulation		
Yes	37	21.14
No	138	78.86

Table 2: Diagnostic accuracy of three point index for prediction of displacement of fractured bone after cast manipulation in diaphyseal forearm fractures in children

TIP	**X-Ray findings at 2nd week**	
	Displacement (Positive)	Displacement (Negative)
Displacement (Yes)	True positive(a) 29	False positive(b) 11
Displacement (No)	False negative(c) 8	True negative(d) 127

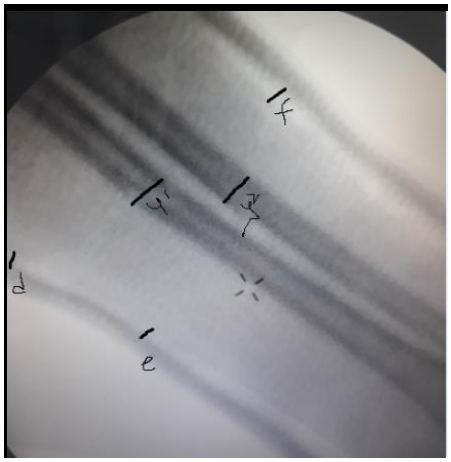
Sensitivity: TP/(TP+FN): 78.38%
Specificity: TN/ (TN+FP): 92.02%
PPV: TP/(TP+FP): 72.5%
NPV: TN/(TN+FN): 94.07%

Fig.1: Radiographs of a patient after adequate reduction of the fracture and casting, showing radiological assessment of the three-point index (TPI)

A: Initial radiograph of a 10 year old boy presented with diaphyseal fracture of radius and ulna

b) After Initial reduction TPI was calculated using the formula and was found to be 0.72. This was labeled as true positive

c)



d) Radiograph after 2 weeks showing no displacement of fracture segment and the treatment is continued

DISCUSSION

Diaphyseal forearm fractures are common in the paediatric population. According to several studies, these fractures occur mainly between the ages of 5 to 14 years with 18% of children do experience forearm fractures when they reach 9 years[1]. Surprisingly, there are some seasonal variations with 34.2% of them happen during the spring season with decreased rate in the winter[1]. They are managed conservatively under plaster of Paris cast or scotch cast. The most commonly reported complication is re displacement after cast manipulation is. The incidence of re-displacement of these fractures is high and various methods have been described to predict fracture re-displacement. One of these indices is the three-point index (TPI).

S. İltar *et al* reported that in diaphyseal forearm fractures TPI was far better to other radiological indices in predicting re displacement, with sensitivity of 84% and specificity of 97% when compared with other radiological indices and recommended it for routine use in the treatment plan (n=76)[3].

The current study was focused to evaluate the diagnostic accuracy of three point index for prediction of displacement of fractured bone after cast manipulation in diaphyseal forearm fractures in children taking x-ray findings as gold standard. Through literature, it has been known that TPI is beneficial in prediction of re-displacement. But most studies have been done retrospectively and on small sample sizes (n=43-76 cases).

In our study a large number of children (n=175) with diaphyseal forearm fractures were registered and has been followed prospectively. No patients were lost at follow up and as predicted by TPI, fewer displacements were recorded. Most of these displacements were related to poor cast moulding resulting in TPI value of >0.8 or resolution of swelling while in cast. We compared our results with previous studies, S. İltar *et al* and our findings are supported with the study by correlating specificity and sensitivity.

Another study showed high sensitivity and specificity of TPI for prediction of re-displacement i.e. 95.8% and 96.1%, respectively (n=75)[7]. These findings are showing better than our findings, on the other hand, a study showed that although the sensitivity of TPI is 84% for prediction of re-displacement but the specificity was 43(37%) only[8], these findings are in contrast with our results. Also inter observer calculation of TPI may likely to affect the results of the study[8]. Three later studies[9-11].confirmed the superiority of the TPI, not only over other indices, but also related to the risk factors involved for displacement. Marcheix *et al*[4] stated the only important risk factor for re displacement is the poor cast moulding, which is checked by TPI. He also stated that TPI reflects the quality of cast application that can predict re-displacement. Hang et al[10] concluded that a high TPI to be the most important risk factor for re-displacement, and Devalia *et al*[5] found TPI as an important indicator of re-displacement . He also concluded that TPI helps in determining the quality of reduction and recommended its use when assessing the method of cast moulding.

In absence of no local evidence our findings are helpful for us in implementing the use of TPI for better outcome and prognosis of such critical cases. However, being the primary data in our local population, it needs further trials for validation.

CONCLUSION

We concluded that the diagnostic accuracy of three point index for prediction of displacement of fractured bone after cast manipulation in diaphyseal forearm fractures in children taking x-ray findings as gold standard is higher but being primary data it needs some other trials for validation.

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