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Clinico-Radiological Significance of Restoration of Radial Bow in Pediatric Forearm Fractures: An Indian Perspective

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Abstract

Background: The normal anatomical radial bow is of crucial importance to the normal range of motion of the forearm and to the strength generated by the muscles. The restoration of the normal amount and location of the radial bow is of crucial importance in functional outcome of forearm fractures. Few studies exist on characteristics of radial bow in Indians.

Materials and methods: In this prospective observational clinic-radiological study we aimed to establish the normal characteristics of the radial bow in the Indian population, and compare the radial bow of the injured limb with the normal contralateral side to establish a co-relation of the radial bow with rotational movements of forearm and to establish whether remodelling had any effect on the characteristics of radial bow. We used modified Schmetisch & Richards method to establish the characteristics of radial bow. The proposed sample size was 100 patients under the age of 14 years, but only 86 patients completed of the study.

Results: The mean of the site of maximum radial bow was at 61.68 % and that of the magnitude of radial bow was 7.62 % of the total radial length. The location and magnitude of radial bow have a significant correlation with forearm rotation .A negative correlation exists between the location of maximum radial bow and the magnitude of the radial bow but it is not statistically significant.

Conclusion: The characteristics of radial bow in our are comparable to that of the western literature. In forearm fractures every effort must be made to restore the radial bow close to the values of the normal limb for better functional outcome. Multicentric studies with larger sample size and a longer follow-up might add value to the available data.

Key Words: Radial bow, forearm, fracture, radius, ulna

Introduction

Forearm fractures are the very common fractures in children and account for about 40 percent of all pediatric fractures. [1,2] Despite their apparent simplicity they still continue to be a challenge to the treating orthopedician owing to the treatment complexity and the risk of complications.[3] Most patients in the pediatric age group need not be and should not be treated by open reduction and internal fixation.[4] The aim of the line of management, whether conservative or operative is to achieve optimal reduction of the fracture and to restore functionality to the injured limb. Despite enormous remodelling potential in the paediatric population, malunion is not uncommon and has a strong bearing on functional outcome. Pronation and supination movements add to the dexterity of the upper limb and are very important in the activities of daily living. These are complex movements influenced by numerous factors. Of the many factors the normal anatomical radial bow is of crucial importance to the normal range of motion of the forearm and to the strength generated by the muscles.[5] Alteration of the normal bowing may result from forearm fractures. While axial deformities are easily recognised, changes of bowing may be subtle and minor fractures which may influence it are frequently missed. Apart from appropriate reduction and rotational alignment, it is equally important to restore the radial bow comparable to the normal side for optimal treatment of forearm fractures. Studies show that restoration of the normal radial bow is related to the functional outcome. A good functional result is associated with restoration of the normal amount and location of the radial bow.[6] Estimation of the radial bow of the unaffected forearm and comparison of the injured limb with it can be useful for optimising reduction by non operative or operative management. To the best of our knowledge we did not find any literature delineating the characteristics of the radial bow in the Indian population. In our study we aimed to establish the characteristics of the radial bow with respect to the Indian population, compare the radial bow of the reduced injured limb with the normal side and follow it up to establish a co-relation with remodelling, to measure rotational movements of the forearm and establish a co-relation between the radial bow and rotational movements. We also wanted to evaluate the effect of remodelling of the isolated ulna fractures on the radial bow.

Materials and methods: The study was a prospective observational study with the intended sample size of 100 patients in the paediatric age group(0 – 14 yrs) with forearm fractures .The study was conducted at our institute and parents of the patients gave a formal consent and were free to withdraw their children from the study at any given point of time. Clearance from the institutional ethics committee was obtained before starting with the study. The first 100 Patients aged less than 14 years with radius or ulna or both forearm bones fractures with no

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Table 1: Mean, Median and Standard Deviation of Point of maximum radial bow, Maximum radial bow, Supination and Pronation. Point of maximum radial bow and the maximum radial bow are expressed as a percentage of the radial length

TABLE 1	N	Mean	Median	Std. Deviation
Point of Max Radial Bow	100	61.68	61.26	3.943
Max Radial Bow	100	7.62	7.8	1.09
Supination in degrees	100	93	90	3.83
Pronation in degrees	100	89.97	90	2.48

Table 2: showing statistically significant positive correlation between Maximum Radial Bow with Pronation among Fractured Side [FS] Group at 1, 3, and 9th month (M)

Variable	Pronation 1 M (FS)		Pronation 3 M (FS)		Pronation 9 M (FS)	
	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value
Max Radial Bow 1 M (FS)	0.489	0	0.477	0	0.522	-
Max Radial Bow 3 M (FS)	0.51	0	0.52	0	0.571	-
Max Radial Bow 9 M (FS)	0.48	0	0.515	0	0.569	-

previous history of fractures in either forearm bones were included in the study. Patients aged more than 14 years, history of fracture of either bones of either forearm, patients with pre-existing deformity and co-existing elbow and wrist injuries, with neurological deficit affecting the forearms were primarily excluded from the study. The primary line of management was closed reduction and casting. The patients were followed up clinico-radiologically on weekly basis in the first one month to assess for loss of reduction and cast related complications. Since eight patients showed loss of reduction beyond the acceptable criteria, requiring surgical intervention they were secondarily excluded from the study to negate the effect of the possible stiffness arising of surgery. Six patients were lost to follow up over the period of time. The remaining Eighty six patients were followed up clinico-radiologically at 1, 3, 9 monthly intervals. At every visit a standardised anteroposterior view of the forearm was obtained. The point of maximum radial bow and maximum radial bow were measured as percentage of the total radial length for comparability using the modified Schemitsch and Richards method.[6] Two measurements were taken independently by two observers and a mean of the values were taken to avoid inter observer bias. The pronation–supination movements and deformity were also assessed clinically at follow up. The data was tabulated and analysed using SPSS13.0 software.

Results: We had 71 % male and 29 % female patients with 24% of the fractures occurring in the age group of four to six years. Fall on outstretched hand was the mode of trauma in majority of the patients (91 %). The characteristics of the radial bow and the pronation and supination movements in our study are enlisted in Table 1. There is a statistically significant positive co-relation between the maximum radial bow and the prono-supination movements (Table 2 & 3). There is a statistically significant negative co-relation between the point of the maximum radial bow and the prono-supination movements (Table 4). We found a negative co-relation between the maximum radial bow

Figure 1: a & b) Antero-posterior and lateral view radiographs of the right forearm showing fracture of the radius and ulna shaft in a nine year old girl.
c & d) Antero-posterior views of the bilateral forearm showing comparable radial bow of the injured side post union with that of the normal side.
e & f) Functionality. Note full pronation and supination on the right side as compared with the uninjured left side.

Table 3: showing statistically significant positive correlation between Maximum Radial Bow with Supination among Fractured Side [FS] Group at 1, 3, and 9th month(M)

Variable	Supination 1 M (FS)		Supination 3 M (FS)		Supination 9 M (FS)	
	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)
Max Radial Bow 1 M (FS)	0.28	0.009	0.329	0.002	0.342	**0.00**
Max Radial Bow 3 M (FS)	0.304	0.004	0.367	0	0.365	**0.00**
Max Radial Bow 9 M (FS)	0.249	0.021	0.292	0.006	0.276	**0.01**

and the point of the maximum radial bow but it was statistically insignificant.(Table 5)

Discussion: In our study the male to female ratio was 2.448 to 1 with a significant male preponderance. The increased male preponderance in our study could be associated with increased outdoor and sports activity in male children in our subcontinent and hence increased risk and vulnerability for the fractures. 24 % of the fractures occurred in the age group of 4-6 years with no significant predilection to fracture in any specific age group in the rest of the study group. Forearm shaft fractures have been shown to occur most commonly in the 12 to 16 year old age group which are a challenging group to treat.[1] The difference in the distribution of the fractures when compared to other studies could be attributed to the low sample size and the sampling method of including the first hundred patients as the study group. In our study the predominant mode of trauma was fall on outstretched hands (91 %) while the rest were due to direct impact. This is in acceptance with the published data on the mechanism of injury in forearm fractures where the indirect transmitted force is implicated in most of the forearm fractures. The primary mechanism of injury associated with radial and ulnar shaft fractures is a fall on outstretched hand that transmits indirect force to the bones of the forearm.[7]With respect to the location and magnitude of the radial bow, our results are comparable with the results of M Firl[8] and Schemitsch.[6] The minor differences in values could be due to the differences in the study group. The study group of M Firl although had pediatric population they didn't represent a normal population as they had suspected injury to forearm. The other contributing factor could be the difference in the race. Both the papers analysed Western population. We couldn't find any published data on normal radial bow in the Indian population. We used the modified method of Schemitsch & Richards[6, 8] to measure the radial bow as we could express it as a percentage of the total radial length and the results could be compared. Measurement of the radial bow in a singular plane, although representing a simplification, gives clinically significant information[8] and can be applied in the clinical scenario owing to the simplicity and reproducibility. Measurement of the bow on the normal side and comparing it with the affected side can help to diagnose plastic deformation of the radius in the absence of obvious fracture of the radius and serve as a guide for optimum reduction in the treatment of the fractures of the forearm.(Figure 1 and 2) The mean supination in our study was 93 degrees and the mean pronation was 89.97 degrees. The mean values of pronation and supination is not comparable in various studies. The average arc of normal forearm motion for the Mayo[9] group was 68 degrees of pronation to 74 degrees of supination. In a study by Rickert et al[10] the arc of motion was from 75 degrees of pronation to about 100 degrees of supination. In yet another study by Boone and Azen[11] it ranged from 77 degrees of pronation to 83 degrees of supination. Though it has been traditionally taught that 50 degrees of pronation and supination represent adequate forearm motion [9], it has been observed that losing 20 to 30 degrees of either pronation or supination carries the potential for significant functional impact upon important activities of daily living [12]. Prono-supination movements assume even greater importance in the Indian scenario. An "all or none" phenomenon exists whereby a small deviation from the norm of the radial bow, a good functional result could be expected in terms of rotational movements of the forearm, but once a certain point was reached there was a rapid decline in the outcome.[6] Statistical analysis has shown that a change in the location of the maximum radial bow is of greater functional significance than a change in the value of the maximum radial bow.[7] We opine that both the location and magnitude of the radial bow have a significant correlation with forearm rotation and hence has a significant effect on functional outcome. We compared isolated ulna fractures with radius-ulna & radius fractures to evaluate the

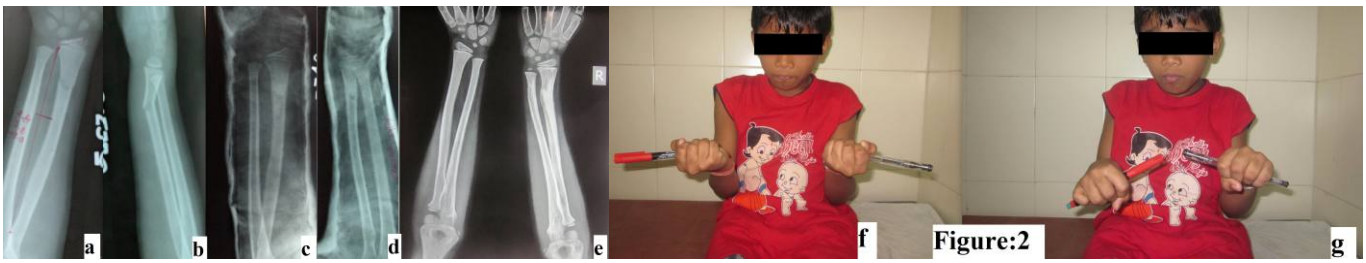

Figure 2: a & b) Antero-posterior and lateral view radiographs of the right forearm showing fracture of the radius shaft in a eight year old boy.
c & d) On cast antero-posterior and lateral view radiographs of the right forearm post reduction of the fracture.
e) Antero-posterior views of the bilateral forearm showed alteration of the radial bow characteristics on the injured side post union when compared with that of the normal side.
f & g) Comparison of the rotational movements of the forearm. Note restricted pronation on the injured right side as compared to the left side.

Table 4: showing negative correlation between Point of Maximum Radial Bow with Supination & Pronation among Fractured Side [FS] Group:

		Diff Max & Point of Max Radial Bow 1 months	Diff Max & Point of Max Radial Bow 3 months	Diff Max & Point of Max Radial Bow 9 months
Supination 1 Months (FS)	Pearson Correlation	-0.26	-0.259	-0.24
	P value	0.016	0.016	0.026
	Correlation is	Significant	Significant	Significant
Supination 3 Months (FS)	Pearson Correlation	-0.278	-0.301	-0.296
	P value	0.01	0.005	0.006
	Correlation is	Significant	Significant	Significant
Supination 9 Months (FS)	Pearson Correlation	-0.273	-0.329	-0.341
	P value	0.011	0.002	0.001
	Correlation is	Significant	Significant	Significant
Supination 1 Months (FS)	Pearson Correlation	-0.078	-0.112	-0.121
	P value	0.474	0.304	0.268
	Correlation is	Not significant	Not significant	Not significant
Supination 3 Months (FS)	Pearson Correlation	-0.184	-0.223	-0.249
	P value	0.09	0.039	0.021
	Correlation is	Not significant	Significant	Significant
Supination 9 Months (FS)	Pearson Correlation	-0.267	-0.298	-0.317
	P value	0.013	0.005	0.003
	Correlation is	Significant	Significant	Significant

Table 5: showing negative Co-relation between Max Radial Bow and Point of Max Radial bow among Fractured Side [FS] Group but it was statistically insignificant

Variables		Max Radial Bow 1 Months (FS)	Max Radial Bow 3 Months (FS)	Max Radial Bow 9 Months (FS)
Point of Max Radial Bow 1 Month (FS)	Pearson Correlation	-0.022	-0.072	-0.068
	P value	0.842	0.51	0.535
	Correlation is	Not significant	Not significant	Not significant
Point of Max Radial Bow 3 Month (FS)	Pearson Correlation	-0.042	-0.082	-0.069
	P value	0.702	0.455	0.527
	Correlation is	Not significant	Not significant	Not significant
Point of Max Radial Bow 9 Month (FS)	Pearson Correlation	-0.053	-0.097	-0.07
	P value	0.631	0.375	0.519
	Correlation is	Not significant	Not significant	Not significant

effect of isolated ulna fractures on radial bow if any. In our study we observed that there is no statistically significant difference between both the groups. We conclude that isolated ulna fractures do not affect the magnitude and location of the radial bow in a statistically significant manner. We in our study also analysed the relation between the magnitude and location of the radial bow. We observed a negative correlation between the location of maximum radial bow and the magnitude of the radial bow but it was not statistically significant. Even earlier studies have failed to establish a significant correlation between the magnitude and location of the maximum radial bow. However it must be noted that they are related to functional outcome and to each other to differing degrees.[6] We followed up the maximum radial bow and the location of maximum radial bow for a period of nine months. We did not find any significant change in the value of maximum radial bow or its location during this observation period either on the fractured side or on the normal side. Despite our short follow up of nine months we opine it is important to achieve the normal radial bow on the fractured side at the initial setting itself as the remodelling process does not alter the location or the maximum value of the bow significantly. M Firl et al[8] state that the length of the radius and the value of maximum radial bow clearly increase with age but the location of maximum radial bow remained a constant. One of the reasons which could be responsible for this discrepancy between our study and the available literature could be the short follow up period of nine months in our study. We found a negative correlation between the location of the maximum radial bow and range of supination. The corelation was statistically significant throughout the duration of the study. We also established a negative co-relation between the location of maximum radial bow and pronation. The correlation was negative at every follow up, but it was statistically significant at three and nine months. In our study we found a positive co-relation between the maximum radial bow and rotational movements of the forearm. The co-relation was positive at one, three and nine monthly intervals and it was statistically significant. To evaluate the effect of radial bow in further detail on forearm rotation requires further follow up and linear regression analysis. But that was beyond the scope of our present study. But it has been found that the relation between the radial bow and rotational movements is not linear.[6] Although we have established a correlation between the radial bow and rotational movements of forearm it must be noted that radial bow is not the only factor rotational movements of the forearm are dependent on. There are many other contributory factors which are difficult to be excluded completely in clinical scenario. Small sample size and a short follow-up were among the drawbacks of the study. Further we evaluated patients in a particular subset of Indian patients. Large multicentric studies with a larger sample size and a longer follow up are necessary to further delineate the characteristics of radial bow in Indian population.

Conclusion:

The characteristics of the radial bow of the Indian population match that of the western population. Restoration of the radial bow characteristics is very important in the management of forearm fractures. Every effort must be made to restore the characteristics of radial bow in forearm fractures for a better functional outcome.

References

1. Cheng JC, Ng BK, Ying SY, et al. A 10 year study of the changes in the pattern and treatment of 6,493 fractures. J Pediatr Orthop 1999;19: 344-350.
2. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg Am 2001; 26:908-915.
3. Davis DR, Green DP. Forearm fractures in children: pitfalls and complications. Clin Orthop Relat Res 1976; 120: 172-184.
4. Canale ST. Fractures and Dislocations in Children:Canale ST, Beaty JH. Campbell's Operative Orthopaedics, vol 2, 11th edition, Mosby Elsevier;2008. p.1545-1556.
5. Richards RR. Chronic disorders of the forearm. J Bone Joint SurgAm. 1996; 78-A: 916-30.
6. Schemitsch EH, Richards RR. The effect of malunion on functional outcome after plate fixation of fractures of both bones of the forearm in adults. J Bone Joint SurgAm. 1992; 74-A:1068-78.
7. Atkas S, Saridogan K, Moralar U, et al. Patterns of single segment nonphyseal extremity fractures in children. Int Orthop 1999;23:345-347
8. Firl M, Wünsch L. Measurement of bowing of the radius. J Bone Joint SurgBr. 2004;86-B:1047-9.
9. Morrey BF, Askew LJ, Chao EY. A biomechanical study of normal elbow motion. J Bone Joint Surg Am 1981; 63: 872-877.
10. Rickert M, Burger A, Gunther CM, et al. Forearm rotation in healthy adults of all ages and both sexes. J Shoulder Elbow Surg 2008; 17: 271-275.
11. Boone DC, Azen SP. Normal range of motion of joints in male subjects. J Bone Joint Surg Am 1979; 61: 756-759.
12. Mehlman CT, Wall EJ. Injuries to the shafts of the radius and ulna: Beaty JH, Kasser JR et al. Rockwood and Wilkin' Fractures in Children, 7th edition, Lippincott Williams & Wilkins; 2010. p.347-404.

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