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Radial bow- its importance in return of rotation after fixation of fracture both bones forearm in adult

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Abstract
Rotations of the forearm are very essential for activities of daily living. Diaphyseal fractures of Both Bones of the Forearm often lead to loss of rotations of the forearm. So an essential aspect of management of such fractures is achieving near normal rotations of the forearm as this affects patient's perception of their functional outcome. Plate fixation is the treatment of choice of fracture Both Bones Forearm in adults as it restores length, apposition, axial and rotational alignment and gives good functional outcome.
Previous studies have shown the importance of restoration of Radial bow in achieving maximal rotational movement of forearm. But some of the recent studies have been unable to find a significant association between restoration of Radial bow and the return of rotations of the forearm.
So this study was done to determine the relation between the Radial bow and rotations of forearm after plate fixation of fracture Both Bones of Forearm.

Keywords: amount of radial bow, location of radial bow, rotation measuring device, restoration of rotations, both bones forearm fracture fixation

Introduction
The forearm serves an important role in the upper extremity function, facilitating positioning of hand in space thus helping to provide upper extremity with mobility. The both bones forearm fractures are commonly encountered in trauma setup.
Fractures of Both Bones Forearm are relatively common injuries which can challenge the treating surgeon [2]. Malunion and Non-union occur more frequently because of difficulty in reducing and maintaining reduction of two parallel bones in presence of supinating and pronating muscles that have angulating and rotational influences. Restoration of length, opposition, axial and rotational alignment must be achieved if a good range of pronation and supination is to be restored [3].
Radius is a bone with complex angle and curve. The lateral curve is also called the Radial bow. It is the most important curve. The Radial bow plays an important role in supination and pronation [5] of the forearm where the Radius rotates around the fixed Ulna. Previous studies have shown the importance of restoration of Radial bow in achieving maximal rotational movement of forearm after plate fixation of fractures Both Bones Forearm. But some of the studies have been unable of find a significant association between restoration of Radial bow and the return of rotation. The unique surgical anatomy of forearm creates problems in the treatment of fractures of the forearm. These difficult problems are obtaining primary osseous union and restoring normal function.
Restoring the Radial curvature after surgical fixation of fractures of Both Bones Forearm in adults and its impact on the rotational movement is studied in Indian setup.
The purpose of this study was to correlate clinically the rotations of forearm with the radiological restoration of radial bow after surgical fixation of both bones forearm fracture in adults. Specific Objectives was to study relation between the range of supination & pronation after surgery with Amount of Radial Bow and Location of the Radial bow.

Materials and Methods
1. Type of study: In Vivo Prospective, Observational study.

2. **Duration of study**: Dec 2011 to Oct 2013.
3. **Study Location:** Govt. Wenlock Hospital & Kasturba Medical College Associated Hospital.
4. **Sample Size:** 54 patients.

Inclusion criterion
- All patients of age >18 years treated with open reduction internal fixation for fracture of both bones forearm.

Exclusion Criterion
- Open fractures
- Multiple injuries (i.e. Polytrauma cases)
- Age < 18 years
- Previous contralateral forearm fracture

Methodology
All the patients with Both Bones forearm fracture fulfilling the inclusion criterion underwent detailed clinical evaluation. All the subjects underwent the following x-ray examination preoperatively.
- X-ray of affected forearm
- X-ray of normal contralateral forearm (control for measuring Radial Bow)

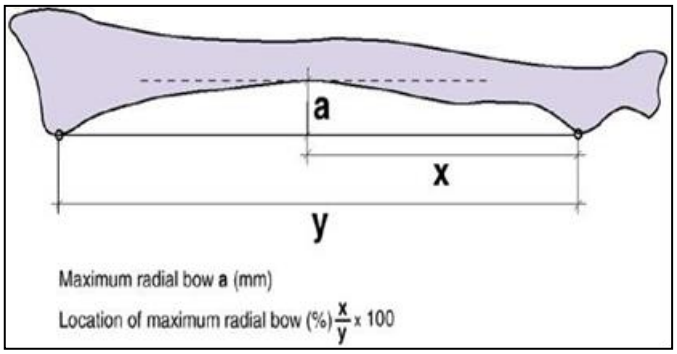
Importance of admission and surgical management explained to the patient and his relatives. All patients were managed according to Basic Trauma Life Support Protocol. All patients who received injections of Tetanus Toxoid, analgesics were monitored closely for development of any complications. In all patients routine blood and urine examinations were done. Pre anesthetic evaluation was done by the anesthetist. Pre-operative consent for surgery was taken from the patient and his relative.

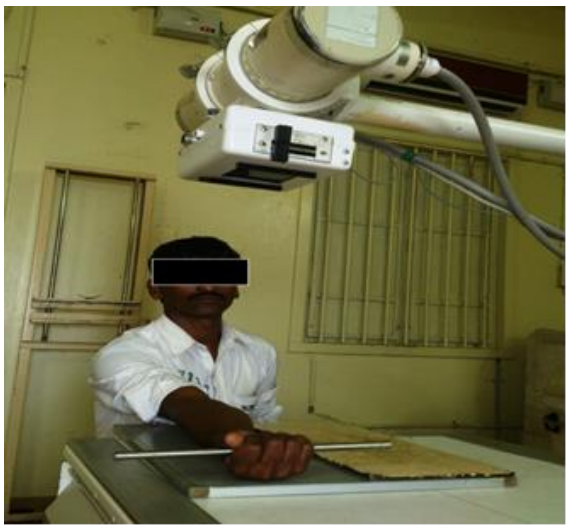
Operative procedure
All the surgeries were done with the patients in supine position and under general anesthesia or brachial block. Tourniquet was used in all the cases. The proximal Radius was approached through Henry's approach or Thompson's approach depending on the surgeon's choice. The middle and distal third Radius was approached through Henry's approach. Ulna was approached through the posterior approach.
The Radius was fixed with 3.5 mm DCP or LCP, the length of which depended on the fracture pattern and plates less than 5 holes were not used in any of the cases. The Ulna was fixed with DCP or a Semi Tubular plate.
After fixation, hemostasis was achieved and the subcutaneous and skin layer was sutured. Compression bandage was applied and the tourniquet was released.

Post-operative management
Two doses of intravenous antibiotics were administered for closed fractures.
The limb was elevated for 24 to 48 hours depending on the swelling. Active finger movements were encouraged. Range of motion exercises of the forearm was started before discharging the patient. After surgical fixation of affected forearm, post-op x-ray was taken to measure Radial Bow. Radiological measurement of Radial bow of the injured and the uninjured side was done according to the method of Schemitsch and Richards. Patient was assessed clinically after surgical fixation and effect of surgery on return of supination and pronation was studied.

Measurement of radial bow [5]
To measure the Radial Bow, a line is drawn from the Bicipital Tuberosity to the most ulnar aspect of the Radius at the wrist. A perpendicular line is drawn from the point of Maximal Radial bow to this line. The height of the Radial Bow is measured in millimeters.

This measurement is as termed Maximal Radial Bow (MRB).
The distance from the Bicipital Tuberosity to previously measured perpendicular line at the point of Maximal Radial Bow is then measured and recorded as a percentage of the length of the entire Radius. This measurement is termed as the Location of the Maximum Radial Bow (LMRB).





The method of taking radiograph was standardized in all the patients. While taking x-ray, patient forearm was positioned over a x-ray cassette such that they held a tubular rod in their hand which was kept parallel to ground.

Evaluation
A Grace and Eversmann [6] criterion was used for evaluation of functional results.
An Excellent rating consists of union of the fracture and at least 90 % of the normal rotation arc of the forearm.
A Good rating requires union of the fracture and at least 80% of the normal rotation arc of the forearm.
An Acceptable result is union of the fracture and at least 60% of the normal rotation arc of the forearm.
An Unacceptable results means that either there is nonunion of the fracture or less than 60% of the normal rotation arc of the forearm.

Rotation measuring device
Custom made rotation measuring device was made such that it accurately measures the supination and pronation of the forearm thereby elimination any pseudo movement occurring

at the shoulder joint. The device consists of two stands. Static stand supports and secures the arm and elbow, while the rotating stand support and secures the forearm over a rotating pivot. Arm is adducted and strapped to the vertical arm of the instrument to prevent any rotation occurring at shoulder joint. Hence supination and pronation that occur only at forearm, is measured. The rotation is read accurately in degrees from reading on the scale.

Considering the normal rotation arc between 130-150 degree

The following values have been considered (Using Grace and Eversmann[34] criterion) in this study

- Excellent outcome- 120-135 degree arc of rotation with united fracture
- Good outcome– 105-120 degree arc of rotation with united fracture
- Acceptable- 78—90 degree arc of rotation with united fracture
- Unacceptable <75 degree arc of rotation and/or fracture non union.

For statistical analysis functional outcome

- Excellent and Good were categorized in Group 1 and
- Acceptable and Unacceptable outcomes were categorized in Group 2.

Statistical Method

Statistical analysis was carried out by obtaining frequency, percentage, mean S.D. Also ANOVA Paired t test and Chi Square Test were used to find the significance between the groups.

Results

The age of patients ranged from 18 years to 70 years and mean age was 41 years.

Age in years	Frequency	Percent
18 - 25	14	25.9
26 - 40	14	25.9
41 - 60	17	31.5
Above 60	9	16.7
Total	54	100.0

In the study there were 36 males and 18 females. 66.7% cases were males.

Sex	Frequency		Percent
F		18	33.3
M		36	66.7
Total		54	100.0

Excellent outcome **Unacceptable outcome**

(N) Contralateral Xray
A=12.04
Y/x % = 57.10%

Post OP Xray
A=912.19
y/x%= 56.96%

(N) Contralateral Xray
A=14.71
Y/x % = 56.20%

Post OP Xray
A=16.56
y/x%= 49.04%

Supination 100º **Pronation 60º** **Supination 45º** **Pronation 25º**

The mean duration of follow up in our study was 11.9 months, which ranged from minimum of 6 month to maximum of 24 months.

The mean duration to the time of surgery from the date of admission was 4.26 days with minimum of 0 day to maximum of 16th day.

Fall was the most common accounting for 28 cases and Road Traffic Accident was 2nd common accounting for 22 cases. There was 1 case of Heavy Object fall over forearm leading to Both Bones Forearm fracture.

	Results		
	Group 1	**Group 2**	**Total**
Mode Of Injury	2	1	3
	4.5%	10.0%	5.6%
Assault			
Fall From Height	24	4	28
	54.5%	40.0%	51.9%
Fall Of Heavy Object	1	0	1
	2.3%	.0%	1.9%
Road traffic accident	17	5	22
	38.6%	50.0%	40.7%
Total	44	10	54
	100.0%	100.0%	100.0%

Most common fracture pattern for Radius and Ulna was Oblique, accounting for 42.6% and 44.4% each.
Middle 3rd was the most common injured location in both Radius and Ulna with 32 and 34 cases each, accounting for 59.3 and 63.0% respectively.

MRB- maximum radial bow
The mean MRB of control was 11.75 mm while that of injured forearm was 11.79 mm.

Group	N	Mean	Std. Deviation	t value	p value
Injured	54	11.79	1.82	.158	.875
Control	54	11.75	1.48		NS

LMRB- location of maximum radial bow
The LMRB of control was 58.73% while that of injured was 58.85%.

Group	N	Mean	Std Deviation	t value	P value
Injured	54	58.46	3.06		
Control	54	58.73	3.04	1.401	0.167

Arc of rotation
Group 1 – Arc of rotation more than 80 %
(Patients with Excellent and Good functional outcome)
Group 2- Arc of rotation less than 80%
(Patients with Acceptable and Unacceptable functional outcome)

	No. of patients	Percent
Group 1	44	81.5
Group 2	10	18.5
Total	54	100.0

Functional outcome
There was EXCELLENT outcome in 33 cases and 11 cases with GOOD outcome. This group was accounting for 81.5% of cases.
Unacceptable result in 5 patients and Acceptable in 5 patients. It constituted remaining 18.5% of cases.

	Frequency	Percent
Acceptable	5	9.3
Excellent	33	61.1
Good	11	20.4
Unacceptable	5	9.3
Total	54	100.0

Relationship between MRB and rotation of forearm
Patients with forearm rotations of more than 80% were compared with patients with forearm rotations of less than 80% with respect to MRB. The mean MRB for the two groups was 11.92 mm and 11.18 mm respectively. The difference between the mean MRB of the injured forearm from the uninjured forearm in patients with more than 80% rotations of the forearm was 0.17 mm. This value in patients with less than 80 % was 0.57 mm.

The two groups were analyzed. The 'p' value was 0.445. The relation between the MRB and rotations of the forearm was not significant.

	Rotation	N	Mean MRB	Std Deviation
Uninjured	Normal	54	11.75	1.47
Injured	>80 %	44	11.92	1.51
Injured	<80%	10	11.18	2.83
ANOVA F	0.815	P- Value		0.445

Relationship between LMRB and rotation of forearm
Patients with forearm rotations of more than 80% were compared with patients with forearm rotations of less than 80% with respect to LMRB. The mean LMRB for the two groups was 58.32% and 59.05% respectively. The difference between the mean LMRB of the injured forearm from the uninjured forearm in patients with more than 80% rotations of the forearm was 0.41%. This value in patients with less than 80 % was 0.32%.

The two groups were analyzed. The 'p' value was 0.718. The relation between the LMRB and rotations of the forearm was not significant.

	Rotation	N	Mean LMRB	Std Deviation
Uninjured	Normal	54	58.73%	3.035
Injured	>80 %	44	58.32%	2.925
Injured	<80%	10	58.05%	3.709
ANOVA F	0.332	P- Value	0.718	

Discussion
Functions of the forearm and hand are dependent on the combination of stability and mobility. In the fractures of the forearm return of function depends on the union of fracture and rotations of the forearm. So the two reasons for performing open reduction and plate fixation of the fractures of both bones forearm are to achieve union and restore good function.
Compression plating gives high rates of union and low rates of complication. Rigid fixation and early active mobilization are the keys to good functional outcome. Restoration of length, apposition, normal axial and rotational alignment must also be achieved if good range of supination and pronation is to be restored [7]. The patients who had an unacceptable result in our series had many associated factors, such as an injury to a nerve, an artery, or a tendon, a segmental fracture; or a complication. The greatest number of neurovascular injuries involved the Radial Nerve.
Our results are comparable to the previous studies done on fracture of Both Bones Forearm. We compared our results with the results of the studies done by Schemitsch *et. al*. and Goldfarb *et.al*.
The number of patients in our study was 54. It was 55 in the study by Schemitsch *et. al*. and 23 in the study by Goldfarb *et. al*.
The mean age of patients in our study was 41 years, in study

by Schemitsch *et. al*, it was 32 years and in the study by Goldfarb *et. al* [8], it was 40 years. Like in the other two studies males were more commonly involved than females in our study.

The mean MRB of normal side by Schemitsch *et.al*. was 15.3 mm and LMRB was 59.9%, however in this study mean MRB of normal side was 11.75 mm and LMRB was 58.73%.

Schemitsch *et al*. compared the Radial Bow in patients with forearm rotations of more than or equal to 80% of the normal range with patients who had less than 80% normal forearm rotations. They found a significant correlation between MRB and rotation of the forearm ('p'< 0.05). They also found a significant correlation between LMRB and rotation of the forearm ('p'< 0.05).

Goldfarb *et.al*. compared the Radial Bow in patients with forearm rotations of more than or equal to 80% of the normal range with patients who had less than 80% normal forearm rotations. They were unable to demonstrate significant correlation between either MRB and rotation of the forearm ('p'=0.53) or between LMRB and rotation of the forearm ('p'=0.19)

In our study we compared Radial bow in 44 patients with forearm rotation of more than 80% with 10 patients with forearm rotation of less than 80%. We did not find significant correlation between either MRB and rotation of the forearm ('p'=0.44) or between LMRB and rotation of the forearm ('p'=0.71)

While arc of movement of injured side was definitely reduced than control side, significant correlation between arc of movement and MRB, LMRB was not established. Hence the results produced by Schemitsch and Richards were not reproducible in this study of patients of Indian subcontinent.

Limitation of the study: The mean follow up period by Schemitsch and Richards was 6 years while it was 12 months in this study. Also there was variation in different surgeons of different hospital operating the patients with Both Bones of Forearm. The Strength of our study was that we have standardized the procedure of measuring the forearm rotations and also the technique of taking x-rays for accurate measurement of MRB and LMRB.

Accurate anatomical reduction and stable internal fixation should continue to be the standard method of treatment for fractures of Both Bones of the Forearm in adults. If Radial bowing is obtained close to the normal side, forearm rotation limitations due to differences of Radial bowing can be prevented.

Conclusions

In our study the Radial bow of the injured forearm after plating was restored to the near normal value and the functional outcome was excellent or good in majority of the patients. When the magnitude and location of the Maximum Radial bow were close to what they were in the non-injured extremity, range of rotation of the forearm was improved. However, there was no significant correlation either between MRB and rotations of the forearm or between LMRB and rotations of the forearm in patients with more than 80% or less than 80% of the normal rotations of the forearm.

Our data does not minimize the importance of an anatomical reduction during fixation by a compression plate, but do suggest that other factors may also be important for restoration of the arc of movements of the forearm.

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