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## INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/16174

DOI URL: <http://dx.doi.org/10.21474/IJAR01/16174>



### RESEARCH ARTICLE

#### EVALUATION OF RADIOLOGICAL REMODELING USING BAUMANN' S ANGLE IN SUPRACONDYLAR FRACTURES OF THE HUMERUS MANAGED WITH CLOSE OR OPEN REDUCTION AND INTERNAL FIXATION WITH K WIRES

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#### Manuscript Info

##### Manuscript History

Received: 29 November 2022

Final Accepted: 30 December 2022

Published: January 2023

#### Abstract

**Introduction:** Supracondylar fractures of the humerus are one of the most common fractures occurring in children. These fractures are difficult to treat because of the frequent occurrence of complications like neurovascular injury and elbow stiffness. The aim is to re-establish the anatomy of the distal humerus perfectly.

**Material and Methods:** Retrospective study of 50 patients with supracondylar fracture of humerus. 50 patients were operated with closed or open reduction internal fixation with k- wire. The study was conducted from September 2018 to August 2020 in a tertiary care center in the city of India. At the final follow up that is at 1 year patients underwent X-ray of Bilateral upper limbs full length to calculate Baumann's angle and Carrying angle of the affected side was compared to the normal side.

**Result:** The mean carrying angle of the unaffected side was  $11.27 \pm 1.860$  and that of the affected side was  $9.67 \pm 1.920$ . The difference was found to be statistically significant ( $p=0.001$ ), showing a significant decrease in the carrying angle of the affected side in comparison to the unaffected side at the final follow-up.

**Conclusion:** supracondylar humerus fracture although remodels well in children by either close or open reduction and internal fixation good to excellent functional outcome can be achieved in Gartland type II and type III fractures.

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#### Introduction:-

Supracondylar Fractures of the humerus are one of the most common fractures occurring in children<sup>1,2,3,4</sup>. They are categorized as extension or flexion injuries. The extension type is more common, accounting for 90% to 98% of cases. Supracondylar fractures of the humerus in children are also one of the most challenging fractures to treat because of the frequent occurrence of complications like neurovascular injury, cubitus varus and valgus, elbow stiffness, and myositis ossificans. Although there is a general accord regarding the treatment of Gartland type 1 and type 3 supracondylar fracture of the humerus, treatment of Gartland type 2 supracondylar fracture of the humerus is still a point of debate. Closed reduction and percutaneous pinning promises to be the paramount method of management at present. but closed reduction is not achievable at all times because of severe soft tissue swelling and the intrinsically unstable nature of the supracondylar fracture of the humerus. In such cases open reduction becomes essential. The aim in treating these fractures is to re-establish the anatomy of the distal humerus perfectly with adequate stability to permit early painless, functional elbow range of motion and restore coronal and sagittal plane

alignment while also evading neuropraxia and vascular injury<sup>5</sup>. Much interest has been paid to the problem of malunion of supracondylar fractures of humerus by obtaining as anatomical reduction as possible either by closed or open method because it is no longer acceptable to hear: —Acceptable for a supracondylar fracture of Humerus”<sup>6</sup>. The rotation or medial tilting of the distal fragment are responsible for the angular deformity pathogenesis whereas some believe that growth disorders of the cartilaginous complex of the distal end of the humerus induced by the fracture itself may cause it<sup>7</sup>. Our aim was to assess the remodeling potential of distal humerus following supracondylar humerus fracture, clinical outcome by assessing carrying angle and elbow range of motion. Baumann’s angle has been validated as one of the most reliable parameters in radiologic monitoring of displaced supracondylar fractures of the humerus in children. Baumann angle is created by the intersection of a line drawn down the humeral axis and a line drawn along the growth plate of the lateral condyle of the elbow<sup>8,9</sup>.

### Material And Methods:-

This Retrospective study was conducted from September 2018 to August 2020 in Orthopaedic department of a tertiary care center of the metropolitan city of India. Overall 50 patients with supracondylar fracture of humerus were operated with closed or open reduction internal fixation with k- wire out of which 30 patients were able to come for complete follow up. Duration of the study was 2 years. All patients of age between 3-15 years with Gartland type II /III fractures supracondylar humerus who have undergone surgical intervention either by closed or open reduction with internal fixation with k wire between period September 2018 to August 2020 with no concomitant fracture or other injuries in the same limb were included in the study. Patients with Gartland type I fractures, those who were conservatively managed and patients with past fractures of contralateral upper limb were excluded from the study.

Preoperatively digital X-ray of the affected elbow was taken in AP and lateral views and fracture was classified according to Gartland classification<sup>10</sup>. All the patients were operated either by closed reduction with internal fixation with k wire or open reduction with internal fixation with k wires, whenever an attempt of closed reduction failed (2 consecutive attempts) to achieve near anatomical reduction. Post operatively limb was immobilised with above elbow slab in 90° flexion, hence post operative Baumann’s angle was not measured. Patient was followed up at 4 weeks, during which pin tract was inspected, K wires were removed and range of motion of the elbow were started. Patient was further followed up at 3 months, 6 months and 1 year. During subsequent visit patient was assessed clinically and Digital radiograph was obtained in AP and lateral views and compared.

At the final follow up that is at 1 year patients underwent X-ray of Bilateral upper limbs full length to calculate Baumann’s angle and Carrying angle of the affected side was compared to the normal side.

### Observation And Result:-

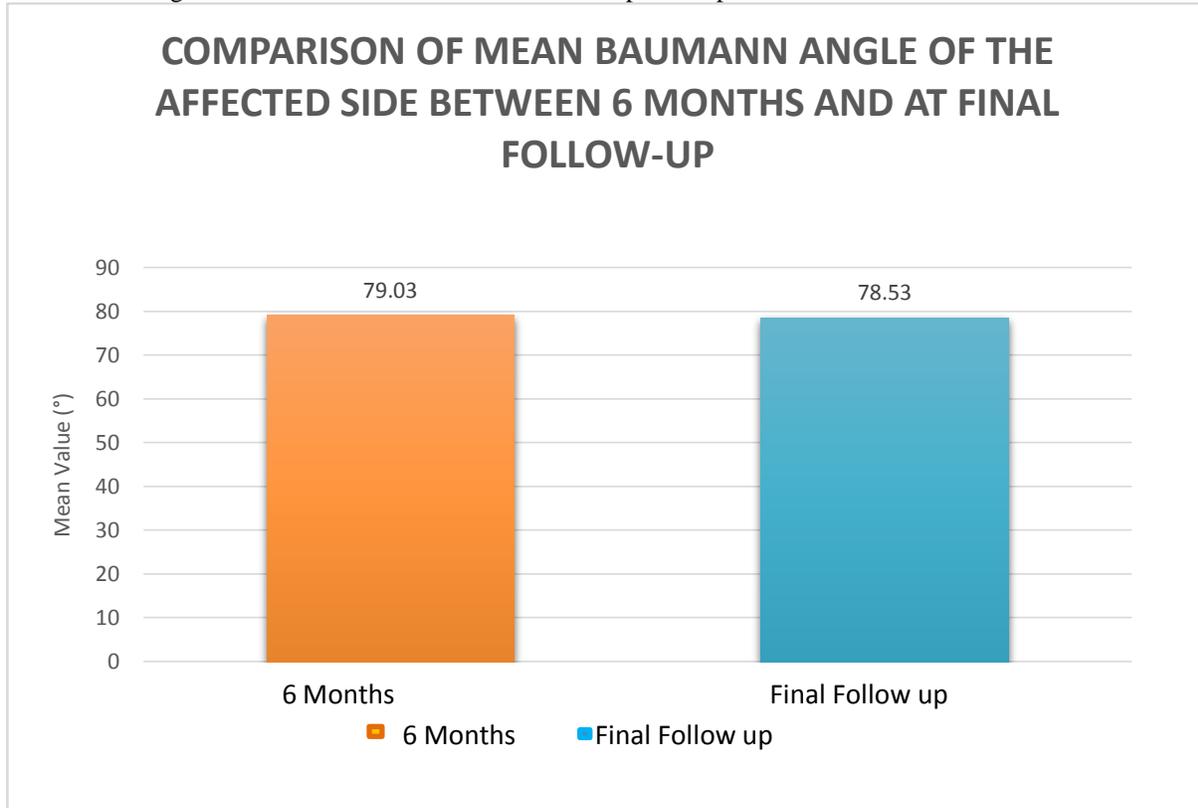
In our study there were 26 (86.7%) patients in the age group 5-9 years and 4 (13.3%) patients in the age group 10-13 years. 10 (33.3%) patients were females and 20 (66.7%) patients were males, showing a male preponderance. 14 (46.7%) patients there was right side involvement and in 16 (53.3%) patients there was left side involvement. 24 (80.0%) patients sustained an injury due to fall on outstretched hand and 6 (20.0%) patients sustained an injury due to fall from height. 7 (23.3%) patients had Gartland Type II fractures, 18 (60.0%) patients had Gartland Type IIIA fractures and 5 (16.7%) patients had Gartland Type IIIB fractures. The incidence of Gartland Type IIIA fracture was higher among those who were surgically treated. Of the 30 patients in our study closed reduction was achieved in 29(96.66%) while after failed closed reduction attempt, open reduction was done in 1(3.33%). The majority of the patients did not have any complications but K-wire migration was seen in 1 (3.3%) patient and superficial infection were seen in 3 (10%) patients.

**Table No. 1:-** Comparison of Baumann’s angle of the affected side between 6 months and final follow-up.

Baumann Angle of Affected Side	No.	Mean ± SD	‘t’ value	P value
At 6 months	30	79.03 ± 3.32 <sup>0</sup>	2.408, df=29	0.023*
At Final Follow-up	30	78.53 ± 2.89 <sup>0</sup>		

Unpaired ‘t’ test applied. P value = 0.023, Significant

The mean Baumann’s angle of the affected side at 6 months was  $79.03 \pm 3.320$  and that at the final follow-up was  $78.53 \pm 2.890$ . The difference was found to be statistically significant ( $p=0.023$ ), showing a significant decrease in the Baumann angle of the affected side at the final follow-up in comparison to 6 months results.



**Figure 1:-** Bar diagram showing comparison of mean Baumann angle of affected side between 6 months and final follow-up.

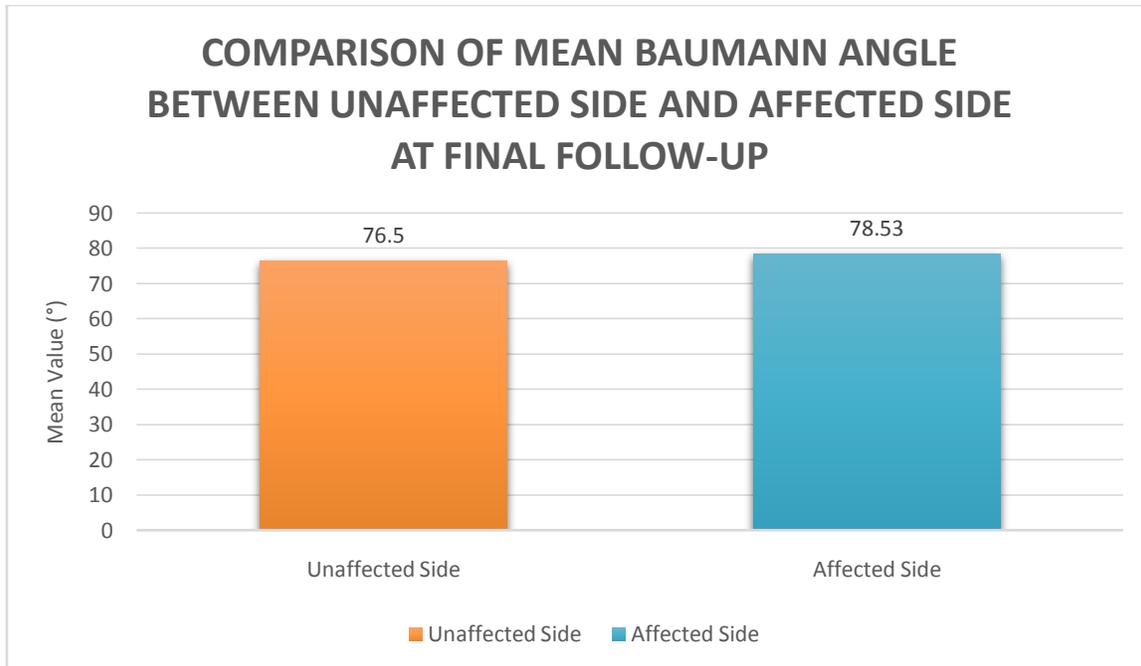
**Table No. 2:-** Comparison of Baumann angle between the unaffected side and affected side at final follow-up.

Baumann Angle	No.	Mean $\pm$ SD	‘t’ value	P value
Unaffected side	30	$76.50 \pm 2.21^0$	3.064, df=58	0.003*
Affected side	30	$78.53 \pm 2.89^0$		

**Unpaired ‘t’ test applied. P value = 0.003, Significant**

The above table shows the comparison of Baumann’s angle between the unaffected side and the affected side at the final follow-up.

The mean Baumann’s angle of the unaffected side was  $76.50 \pm 2.21^0$  and that of the affected side was  $78.53 \pm 2.89^0$ . The difference was found to be statistically significant ( $p=0.003$ ), showing a significant increase in Baumann’s angle of the affected side at follow-up in comparison to the unaffected side at the final follow-up.



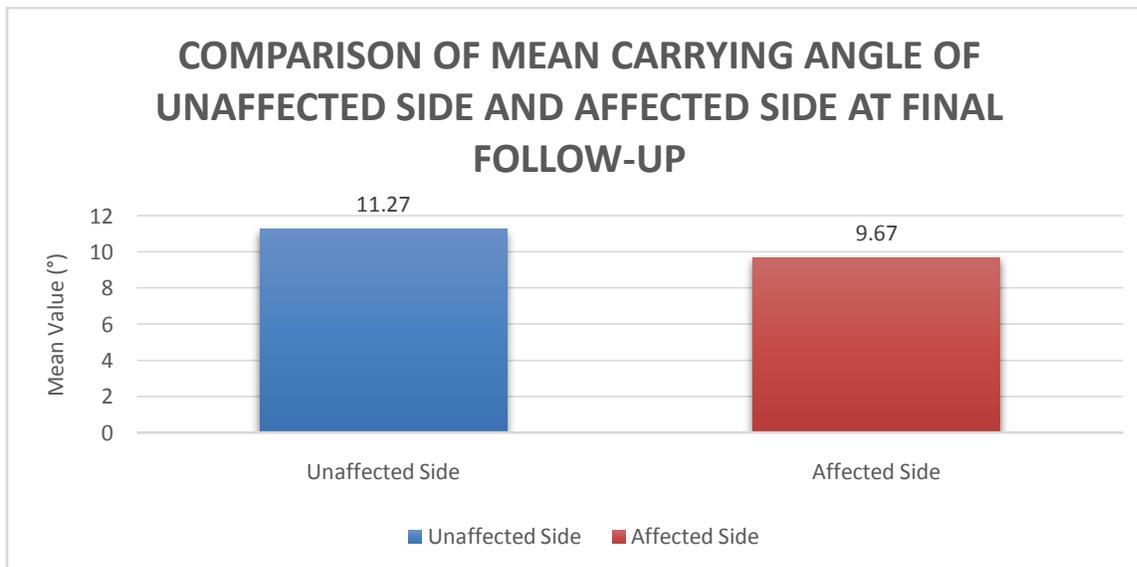
**Figure 2:-** Bar diagram showing comparison of mean Baumann angle of unaffected and affected side at final follow-up.

**Table No. 3:-** Comparison of carrying angle between the unaffected side and affected side at final follow-up.

Carrying Angle	No.	Mean ± SD	't' value	P value
Unaffected Side	30	11.27 ± 1.86 <sup>0</sup>	3.283, df=58	0.001*
Affected Side	30	9.67 ± 1.92 <sup>0</sup>		

Unpaired 't' test applied. P value = 0.001, Significant

The mean carrying angle of the unaffected side was 11.27 ± 1.86<sup>0</sup> and that of the affected side was 9.67 ± 1.92<sup>0</sup>. The difference was found to be statistically significant (p=0.001), showing a significant decrease in the carrying angle of the affected side in comparison to the unaffected side at the final follow-up.



**Figure 3:-** Bar diagram showing comparison of mean carrying angle of unaffected side and affected side at final follow-up.

**Representative Cases**  
**Pre-op x-ray**



**Immediate post-op x-ray**



1 month follow up xray



3 month follow up xray



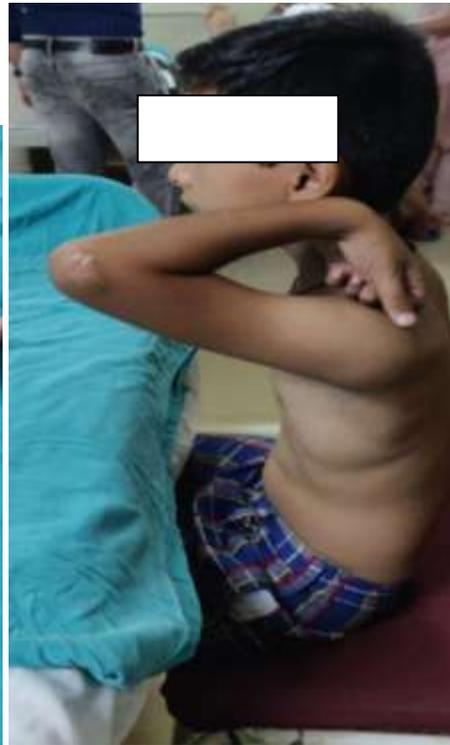
6 month follow up xray



1 year follow up xray



Clinical images



Representative Complication



**K wire migration****Superficial infection****Discussion:-**

Supracondylar fracture of the humerus is one of the most common fractures in the first decade of life accounting for 50% to 70% of all elbow fractures in children. This type of fracture occurs at the supracondylar area or the metaphysis of the distal humerus and accounts for 65.4% of upper extremity fractures in children according to Boyd and Altenberg 1944<sup>1,2,3,4</sup>. Initial treatment as well as the definitive treatment of this fracture is of utmost importance. This is quite often complicated in developing countries like India due to lack of awareness, poverty, and the presence of traditional bonesetters. The aim of the treatment of the supracondylar fracture is to achieve functionally and cosmetically satisfactory results and to avoid complications. Assuring a low cost and decreasing the hospitalization period is very important for the surgeon and parent's point of view. Thirty children with displaced type II and III supracondylar fractures of the humerus were managed with closed/open reduction with k wires during the period between September 2018 to August 2020 at Orthopaedic department of a tertiary care center of the metropolitan city of India. The data collected in this study is assessed, analyzed, compared with other series, and results were evaluated. The average age in our study is 7.43 which is comparable to CARVALHO et al<sup>11</sup>, NEDIM SMAJIC et al<sup>12</sup>, GUVEN et al<sup>13</sup>.

The mean Baumann's angle of the unaffected side was  $76.50 \pm 2.210$  and that of the affected side at final follow up was  $78.53 \pm 2.890$ . The difference was found to be statistically significant ( $p=0.003$ ), showing a significant increase in the Baumann's angle of the affected side at follow-up in comparison to the unaffected side at the final follow-up. The mean Baumann's angle of the affected side at 6 months was  $79.03 \pm 3.320$  and that at the final follow-up was  $78.53 \pm 2.890$ . The difference was found to be statistically significant ( $p=0.023$ ), showing a significant decrease in the Baumann's angle of the affected side at the final follow-up in comparison to 6 months results. This suggests the potential for further remodeling in a longer follow up. Although the decreased Baumann's angle between 6 months and 1 year follow up has shown a trend towards normalization which signifies some remodeling potential in pediatric distal humerus, but a larger sample size and a longer follow up are required to ascertain this fact. Our results are comparable with other similar studies.

**Table 4:-** Comparison of Mean Baumann's angle with results of various studies.

Series	Year	MEAN BAUMANN ANGLE AFFECTED SIDE	CHANGE IN BAUMANN ANGLE AT FINAL
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			<b>FOLLOW UP</b>
REISOGLU et al <sup>14</sup>	2016	74.3 ± 5.1 <sup>0</sup>	0.02 ± 4.4 <sup>0</sup>
TOMORI et al <sup>15</sup>	2018	74.9±6.2 <sup>0</sup>	5.2±4.04 <sup>0</sup>
ZUSMAN et al <sup>16</sup>	2019	74.6± 5.6 <sup>0</sup>	-
<b>PRESENT study</b>	<b>2020</b>	<b>78.53 ± 2.89<sup>0</sup></b>	<b>2.93 ± 1.14<sup>0</sup></b>

The mean carrying angle of the unaffected side was  $11.27 \pm 1.86^0$  and that of the affected side was  $9.67 \pm 1.92^0$ . The difference was found to be statistically significant ( $p=0.001$ ), showing a significant decrease in the carrying angle of the affected side in comparison to the unaffected side at the final follow-up. In all 30 (100.0%) patients, there was a loss of carrying angle of 0-5° at follow-up. The mean carrying angle of the unaffected side was  $11.27 \pm 1.86^0$  and that of the affected side was  $9.67 \pm 1.92^0$ . The difference was found to be statistically significant ( $p=0.001$ ), showing a significant decrease in the carrying angle of the affected side in comparison to the unaffected side at the final follow-up. In all 30 (100.0%) patients, there was a loss of carrying angle of 0-5° at follow-up.

**Table 5:-** Comparison of Mean Carrying angle and change in carrying angle with results of various studies.

Series	Year	MEAN CARRYING ANGLE AFFECTED SIDE	CHANGE IN CARRYING ANGLE AT FINAL FOLLOW UP
BOJOVIĆ et al <sup>17</sup>	2012	7.3 ± 1.6 <sup>0</sup>	-
NEDIM SMAJIC et al <sup>18</sup>	2013	14 ± 1.36 <sup>0</sup>	4.30 ± 7.66 <sup>0</sup>
PRASHANT et al <sup>19</sup>	2016	10.1±2.63 <sup>0</sup>	3.80 ± 2.02 <sup>0</sup>
TOMORI et al <sup>20</sup>	2018	10.8±7.0 <sup>0</sup>	4.9±4.9 <sup>0</sup>
<b>PRESENT study</b>	<b>2020</b>	<b>9.67 ± 1.92<sup>0</sup></b>	<b>1.60 ± 1.04<sup>0</sup></b>

### Conclusion:-

Based on our experience in treating 30 cases of fracture supracondylar humerus in children by either close or open reduction and internal fixation we conclude that if a uniform standardized operative technique is followed and if an attempt is made to restore the distal humerus anatomy close to normal, good to excellent functional outcome can be achieved in Gartland type II and type III fractures. We have observed that supracondylar humerus fracture although remodels well and the change in Baumann's angle between 6 months and 1-year follow-ups is statically significant.

But, is the remodeling potential of distal humerus is dependent upon the near perfect anatomical reduction? To ascertain this fact, large sample size and a longer follow up are required.

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