

Original Research Article

Radiographic evaluation of Baumann angle in North Indian paediatric population: a cross-sectional study

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ABSTRACT

Background: Baumann angle is an essential radiographic parameter used for assessing coronal alignment of the distal humerus in pediatric elbow injuries. It plays a critical role in evaluating fracture reduction, particularly in supracondylar fractures. However, normative values vary across populations and require regional validation. To determine the normative values of Baumann angle in North Indian pediatric population and analyze its variation with age, sex and side.

Methods: A cross-sectional observational study was conducted in the Department of Orthopaedics at GSVM Medical College. A total of 289 children aged 3–13 years with normal elbow radiographs were included. Baumann angle was measured on standardized anteroposterior radiographs. Statistical analysis was performed using descriptive statistics and unpaired t-test.

Results: The mean Baumann angle was $70.42^\circ \pm 5.28^\circ$. Males had significantly higher values ($72.26^\circ \pm 5.25^\circ$) compared to females ($68.05^\circ \pm 4.29^\circ$) ($p < 0.05$). Age-wise analysis showed minimal variation, indicating stability across growth. Side-to-side differences were not clinically significant.

Conclusions: Baumann angle is a reliable and consistent parameter in pediatric elbow assessment with significant sex-based variation but minimal age dependency. Establishing population-specific reference values enhances diagnostic accuracy in pediatric elbow trauma.

Keywords: Anthropometry, Baumann angle, Pediatric elbow, Radiographic analysis, Supracondylar fracture

INTRODUCTION

The pediatric elbow is a complex anatomical region characterized by multiple ossification centers and evolving skeletal morphology, making radiographic evaluation challenging.¹ Accurate interpretation is essential in trauma settings, particularly in supracondylar fractures, which are among the most common pediatric elbow injuries.² Among various radiological parameters, the Baumann angle is widely used to assess coronal alignment of the distal humerus.³ It is defined as the angle between the longitudinal axis of the humeral shaft and the physeal line of the lateral condyle on an anteroposterior radiograph.⁴ This angle is critical for assessing adequacy of fracture reduction and predicting deformities such as cubitus

varus.⁵ Previous studies have reported variability in Baumann angle due to differences in age, sex and radiographic positioning.⁶ Most normative data are derived from Western populations, limiting their applicability to Indian children.⁷ Therefore, establishing region-specific reference values is essential for accurate clinical decision-making.⁸ The objective of the present study was to determine the normative values of Baumann angle in the North Indian pediatric population and to analyze its variation with age, sex and side.

METHODS

This was a cross-sectional observational study conducted in the Department of Orthopaedics, GSVM Medical

College. The study period was from August-2023 to March 2025. A total of 289 children between 3 and 13 years of age with normal elbow radiographs were included in the study. Children were selected on the basis of the predefined eligibility criteria and the availability of standardized anteroposterior elbow radiographs suitable for Baumann angle measurement. Children with normal elbow radiographs and no history of trauma or deformity were included. Children with a previous fracture or surgery around the elbow, congenital deformity or metabolic bone disorders were excluded. Standardized anteroposterior radiographs of the elbow were obtained with the elbow fully extended and the forearm supinated.

Appropriate positioning was maintained to minimize rotational error, because variation in humeral rotation can influence the measured Baumann angle. Radiographs were assessed for normal elbow anatomy and suitability for measurement before inclusion in the analysis. Baumann angle was measured digitally on the standardized anteroposterior radiograph. The first reference line was drawn along the longitudinal axis of the humeral shaft. The second reference line was drawn along the physal line of the lateral condyle. The angle formed between these two lines was recorded as the Baumann angle. Measurements were recorded for the available right and left elbow radiographs and subsequently analyzed according to age and sex. Ethical approval was obtained from the institutional ethics committee (Approval No. EC/BMHR/2025/134, dated 22 December 2025).

Statistical analysis

Descriptive statistics were used to calculate the mean, standard deviation and range of Baumann angle measurements. Differences between male and female participants were assessed using an unpaired t-test. A p value of <0.05 was considered statistically significant.

RESULTS

The study included 289 children aged 3–13 years with normal elbow radiographs. The overall mean Baumann angle was $70.42^\circ \pm 5.28^\circ$, with a range of 49.4° to 83.3° . Sex-wise analysis demonstrated a higher mean Baumann angle among males ($72.26^\circ \pm 5.25^\circ$) than females ($68.05^\circ \pm 4.29^\circ$). This difference was statistically significant ($p < 0.05$), as shown in Table 1.

Age-wise analysis showed only minimal variation in the mean Baumann angle. The mean angle was $69.73^\circ \pm 5.50^\circ$ in children aged 3–6 years, $70.99^\circ \pm 4.97^\circ$ in those aged 7–9 years and $70.57^\circ \pm 4.99^\circ$ in those aged 10–13 years, indicating relative stability across the assessed age groups (Table 2).

Side-wise analysis demonstrated a mean Baumann angle of $71.33^\circ \pm 5.60^\circ$ on the right side and $69.47^\circ \pm 4.78^\circ$ on the left side. The observed side-to-side difference was considered clinically insignificant (Table 3).

Table 1: Sex-wise distribution of Baumann angle.

Sex	Mean Baumann angle $\pm$ SD
Male	$72.26^\circ \pm 5.25^\circ$
Female	$68.05^\circ \pm 4.29^\circ$

Table 2: Age-wise distribution of Baumann angle.

Age groups	Mean Baumann angle $\pm$ SD
3–6 years	$69.73^\circ \pm 5.50^\circ$
7–9 years	$70.99^\circ \pm 4.97^\circ$
10–13 years	$70.57^\circ \pm 4.99^\circ$

Table 3: Side-wise distribution of Baumann angle.

Sides	Mean Baumann angle $\pm$ SD	Clinical interpretation
Right	$71.33^\circ \pm 5.60^\circ$	—
Left	$69.47^\circ \pm 4.78^\circ$	Side-to-side difference clinically insignificant

DISCUSSION

The present study establishes normative values of the Baumann angle in a North Indian pediatric population, with an overall mean value of 70.42° . This finding is consistent with previously published observations and supports the use of the Baumann angle as an important radiographic parameter for assessment of pediatric elbow

alignment.⁹ Establishing region-specific normative data is relevant because the interpretation of angular parameters may vary among populations and may be influenced by differences in skeletal morphology and radiographic technique. The significantly higher Baumann angle observed in males compared with females may reflect sex-related anatomical differences in distal humeral morphology.¹⁰ This finding is clinically relevant because a

single reference value may not completely represent the normal range across all children. Awareness of sex-related variation may therefore improve interpretation when evaluating radiographs for subtle coronal malalignment. The present study also demonstrated minimal variation in Baumann angle across the three age groups. The mean values remained relatively close to each other from early childhood through the 10–13 years age group. This relative stability during growth supports the reliability of the Baumann angle as a radiographic reference parameter and suggests that major age-specific adjustment may not be necessary within the studied age range.¹¹

Side-wise comparison showed only a small difference between the right and left elbows and the difference was considered clinically insignificant. This finding supports the practical use of the contralateral normal elbow as a useful reference when assessing alignment in a child with unilateral elbow trauma, provided that the contralateral limb is clinically and radiographically normal.¹² Despite its clinical utility, the Baumann angle is sensitive to radiographic technique. In particular, rotational malalignment of the humerus can alter the apparent angular measurement. Consequently, standardized positioning with the elbow appropriately extended and the forearm supinated is important when obtaining and interpreting radiographs.¹³

This technical consideration is especially important in the setting of supracondylar fractures, where decisions regarding adequacy of reduction and residual coronal deformity may depend on radiographic measurements. Taken together, the findings indicate that the Baumann angle remains a useful cornerstone of pediatric elbow radiographic assessment. The present study provides North Indian reference data and demonstrates significant sex-based variation with relatively little age- or side-related variation. These observations may assist clinicians in distinguishing normal anatomical variation from clinically important malalignment and may improve the assessment of reduction in pediatric elbow trauma.

Limitations

The study has several limitations. It was a cross-sectional study conducted at a single institution, which may limit the generalizability of the findings to other pediatric populations. The available manuscript also does not provide detailed information regarding participant recruitment, distribution of the sample across individual ages or interobserver and intraobserver reliability of the digital measurements. In addition, because the exact study period is not specified in the submitted manuscript, this information should be added before submission.

Further multicentric studies with larger and more evenly distributed samples, standardized measurement protocols and formal assessment of measurement reliability would strengthen the evidence for population-specific reference values.

CONCLUSION

Baumann angle is a reliable and reproducible radiographic parameter in pediatric elbow evaluation. It shows significant sex variation but minimal age dependency, making it clinically valuable across pediatric age groups. Establishing normative regional values enhances diagnostic precision and may improve assessment and management of pediatric elbow trauma.

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