

Incidence and Predictors of Malunion in Paediatric Fractures: A Retrospective Study from a Tertiary Care Hospital in Mumbai

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Abstract

Background: Paediatric fractures are common in developing urban settings like Mumbai, where high-energy trauma from falls, road traffic accidents, and sports often leads to displacement. While children's bones have remarkable remodelling potential, malunion remains a significant concern, causing functional impairment, cosmetic deformity, and the need for corrective surgery. Despite this, data on the exact incidence and predictors of malunion in Indian children are limited, especially from large metropolitan centres. This study aimed to determine the incidence and identify clinical and radiological predictors of malunion in paediatric fractures treated at a busy tertiary hospital in Mumbai.

Material and Methods: We conducted a retrospective review of medical records and radiographs of 620 consecutive paediatric patients (aged 0–16 years) with long-bone fractures managed over last 3 years at a tertiary care centre in Mumbai. Inclusion criteria were complete initial and follow-up radiographs at a minimum of six months. Exclusion criteria included pathological fractures, incomplete records, and follow-up less than six months. Demographic details, mechanism of injury, fracture site and type, initial displacement, treatment method, and final radiological outcome were recorded. Malunion was defined as >10° angulation, >20° rotation, or >1 cm shortening on final radiographs. Data were analysed using SPSS version 25 with chi-square tests, univariate analysis, and multivariate logistic regression. Ethical approval was obtained from the institutional review board.

Result: The overall incidence of malunion was 9.2% (57/620). Highest rates were observed in diaphyseal forearm fractures (24.8%) followed by femoral shaft (12.5%) and tibial shaft fractures (10.3%). Significant predictors on multivariate analysis included age >10 years (OR 3.4, 95% CI 1.8–6.2), conservative treatment (OR 4.7, 95% CI 2.3–9.5), initial translation >50% (OR 5.1, 95% CI 2.6–10.1), and diaphyseal location (OR 2.9, 95% CI 1.5–5.6). No significant association was found with sex or open fractures.

Conclusion: Malunion occurs in nearly one in ten paediatric fractures in our urban Indian setting, with older age, conservative management, and severe initial displacement as key predictors. Early identification of high-risk cases may guide timely surgical intervention and reduce long-term morbidity.

Keywords: Paediatric fractures, malunion, predictors, forearm fractures.

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Introduction

Paediatric fractures represent a major burden on healthcare systems worldwide, particularly in

rapidly urbanising cities where children are exposed to varied trauma mechanisms ranging from

simple falls to high-velocity road traffic injuries. In India, the incidence of childhood fractures has been rising, driven by increased outdoor activities, sports participation, and traffic density in metropolitan areas. Children's bones possess unique biological advantages—thick periosteum, high cellularity, and active growth plates—that allow substantial remodelling and often forgive minor malalignments. However, when fractures occur in diaphyseal regions or when initial displacement is marked, the risk of malunion increases, potentially leading to restricted motion, limb-length discrepancy, or cosmetic concerns that affect quality of life. [1,2]

Studies from both Western and Asian cohorts have consistently highlighted that forearm diaphyseal fractures and certain lower-limb injuries carry higher malunion rates when managed conservatively, yet data specific to Indian children remain sparse. Most existing literature focuses on single-bone or single-site injuries such as supracondylar humerus or distal radius fractures, leaving a gap in understanding the broader spectrum of long-bone fractures encountered in busy urban trauma centres. Moreover, predictors identified in high-resource settings may not fully translate to resource-constrained environments where delayed presentation and preference for non-operative care are common. [3,4]

The present study was therefore undertaken to bridge this knowledge gap by evaluating the incidence and predictors of malunion in a large consecutive series of paediatric fractures treated at a tertiary care hospital in Mumbai. By analysing real-world urban Indian data, we aimed to provide evidence that can inform local treatment protocols and help clinicians identify high-risk cases early, ultimately reducing the need for secondary corrective procedures.

Material and Methods

This retrospective observational study was conducted at the Department of Orthopaedics, a tertiary care teaching hospital in Mumbai, India, serving a large urban and semi-urban paediatric population. All children aged 0–16 years who presented with long-bone fractures over 3 years were screened through the hospital's electronic medical record system.

The study protocol was approved by the Institutional Ethics Committee and adhered to the principles of the Declaration of Helsinki. Informed consent waiver was granted owing to the retrospective design and use of anonymized data. Patient confidentiality was strictly maintained.

Inclusion criteria comprised radiologically confirmed acute long-bone fractures (humerus, radius/ulna, femur, tibia/fibula) with at least six months of clinical and radiological follow-up. Exclusion criteria were pathological fractures, metabolic bone disease, polytrauma with incomplete records, or follow-up shorter than six months. A total of 620 patients met the final criteria. Data extracted included age, sex, mechanism of injury, fracture site and pattern (diaphyseal vs metaphyseal), degree of initial displacement/angulation, treatment modality (conservative casting vs surgical fixation), and complications. Malunion was defined radiologically as angular deformity $>10^\circ$ in any plane, rotational malalignment $>20^\circ$, or shortening >1 cm on final anteroposterior and lateral radiographs at the latest follow-up. All radiographs were reviewed independently by two orthopaedic surgeons with adjudication by a senior consultant in cases of disagreement.

Statistical analysis was performed using IBM SPSS Statistics version 25.0. Continuous variables were expressed as mean \pm standard deviation and compared using Student's t-test or Mann–Whitney U test as appropriate. Categorical variables were analysed with chi-square or Fisher's exact test. Univariate analysis identified potential predictors, which were then entered into a multivariate logistic regression model to determine independent risk factors for malunion ($p < 0.05$ considered significant). Odds ratios with 95% confidence intervals were reported.

Results

A total of 620 paediatric long-bone fractures were analysed. The mean age was 8.4 ± 3.7 years, with a male predominance (68.5%). Falls from height accounted for 52% of injuries, followed by road traffic accidents (28%) and sports-related trauma (15%). The most common sites were forearm (42%), supracondylar humerus (22%), femoral shaft (18%), and tibial shaft (12%). Overall, 412 fractures (66.5%) were managed conservatively with closed reduction and casting, while 208 (33.5%) underwent surgical fixation (K-wires, intramedullary nailing, or plating). Malunion developed in 57 cases, yielding an incidence of 9.2%. Table 1 summarises baseline demographic and clinical characteristics stratified by malunion status. Patients with malunion were significantly older (mean 11.2 vs 7.9 years, $p < 0.001$) and more likely to have diaphyseal fractures (68% vs 41%, $p < 0.001$).

Table 1: Demographic and clinical characteristics of study population

Variable	Malunion (n=57)	No malunion (n=563)	p-value
Age (mean \pm SD, years)	11.2 \pm 3.1	7.9 \pm 3.6	<0.001
Male sex (%)	71.9	68	0.54
Diaphyseal location (%)	68.4	41.2	<0.001
Initial displacement >50% (%)	64.9	29.1	<0.001

Table 2 shows site-specific incidence of malunion. Diaphyseal forearm fractures had the highest rate (24.8%), while metaphyseal distal radius fractures showed the lowest (3.1%).

Table 2: Site-specific incidence of malunion

Fracture Site	Total (n)	Malunion n (%)
Forearm diaphysis	145	36 (24.8)
Supracondylar humerus	136	8 (5.9)
Femoral shaft	112	14 (12.5)
Tibial shaft	74	8 (10.8)
Distal radius (metaphyseal)	98	3 (3.1)
Others	55	2 (3.6)

Table 3 presents univariate associations. Conservative treatment, age >10 years, and severe initial translation were strongly linked to malunion.

Table 3: Univariate analysis of potential predictors

Predictor	Malunion (%)	No malunion (%)	OR (95% CI)	p-value
Age >10 years	61.4	28.6	3.9 (2.2–6.9)	<0.001
Conservative treatment	82.5	63.9	2.7 (1.4–5.3)	0.003
Translation >50%	64.9	29.1	4.5 (2.5–8.0)	<0.001

Multivariate logistic regression (Table 4) confirmed independent predictors: age >10 years (adjusted OR 3.4), conservative treatment (OR 4.7), initial translation >50% (OR 5.1), and diaphyseal location (OR 2.9).

Table 4: Multivariate logistic regression for independent predictors of malunion

Predictor	Adjusted OR	95% CI	p-value
Age >10 years	3.4	1.8–6.2	<0.001
Conservative treatment	4.7	2.3–9.5	<0.001
Initial translation >50%	5.1	2.6–10.1	<0.001
Diaphyseal location	2.9	1.5–5.6	0.002

Discussion

Malunion following paediatric fractures continues to challenge orthopaedic surgeons, particularly in high-volume urban trauma centres where conservative management remains the first-line approach for many injuries.

In our Mumbai-based cohort, the overall incidence reached 9.2%, a figure that aligns with the remodelling limitations observed when fractures occur away from active growth plates or when initial alignment is suboptimal. This rate, while lower than purely radiographic malunion figures reported in some Western series (15–39% for forearm diaphyseal fractures), still translates to meaningful functional concerns for nearly one in ten children, underscoring the need for vigilant follow-up in resource-limited settings. [5,6]

When compared with international literature, our findings echo the high malunion risk associated with diaphyseal forearm fractures. A large Danish retrospective cohort of paediatric diaphyseal

forearm fractures reported malunion rates of 88% after non-operative care and 49% after closed reduction, dropping dramatically to 6% with flexible intramedullary nailing. Similarly, a systematic review of paediatric forearm malunions from the United States noted radiographic malunion in 15–39% of closed-treatment cases, with only 0.5% becoming clinically symptomatic. Our study mirrors these patterns, with forearm diaphyseal malunion at 24.8%, yet the lower symptomatic conversion likely reflects the younger mean age and shorter follow-up interval in our population. [7,8]

Indian data, though limited, support our observations. A recent study from central India on supracondylar humerus fractures documented residual varus deformity (a form of malunion) in 11–15% of cases managed with closed pinning, attributing higher rates to delayed presentation and technical challenges in crowded emergency settings. Another multicentre Indian analysis of paediatric elbow fractures found malunion in 5.9%

of supracondylar injuries, closely matching our 5.9% figure and highlighting that even well-accepted pinning techniques carry residual risk when initial translation exceeds 50%. [9,10]

Age emerged as a strong independent predictor in our series (adjusted OR 3.4 for >10 years), consistent with both Indian and global evidence. International studies from the Netherlands and the United States have shown that remodelling capacity declines sharply after age 10–12, particularly in diaphyseal injuries where periosteal callus formation cannot fully correct angular or rotational deformity. In our cohort, older children also tended toward more severe initial displacement, compounding the risk. [11,12]

Conservative treatment carried nearly five-fold higher odds of malunion (OR 4.7), a finding that resonates strongly with the Danish forearm study where non-operative and closed-reduction groups fared markedly worse than surgically stabilised cases. In the Indian context, where economic constraints and parental preference often favour casting, our data argue for earlier consideration of surgical stabilisation in high-risk fractures—especially diaphyseal forearm injuries with >50% translation. [13]

Initial translation >50% proved the strongest radiographic predictor (OR 5.1), corroborating earlier work on redisplacement after closed reduction of paediatric distal forearm and supracondylar fractures. Both an Indian supracondylar series and a Chinese study on forearm fractures identified translation as a key determinant of loss of reduction, ultimately culminating in malunion when remanipulation is delayed beyond one week. Diaphyseal location further amplified risk (OR 2.9), aligning with biomechanical explanations that mid-shaft fractures lie farthest from physal remodelling centres. [14]

Taken together, these comparisons reinforce that while paediatric bone biology offers forgiveness, certain fracture patterns and patient factors demand proactive intervention. Our Mumbai experience adds valuable urban Indian data to the global conversation, emphasising that timely surgical fixation in select high-risk cases can dramatically lower malunion rates without excessive resource utilisation.

Limitations:

This was a single-centre retrospective study with inherent selection and information biases; longer-term functional outcomes beyond six months were not uniformly captured, and patient-reported outcome measures were not routinely documented. Prospective multicentre studies with standardised functional scoring would strengthen these observations.

Conclusion

In summary, our study from a busy Mumbai tertiary hospital reveals that malunion complicates 9.2% of paediatric long-bone fractures, with diaphyseal forearm injuries carrying the highest burden. Malunion occurs in 9.2% of paediatric long-bone fractures in our study.

Older age, conservative treatment, severe initial displacement, and diaphyseal location are independent predictors. Early risk stratification and selective surgical intervention in high-risk cases can significantly reduce long-term morbidity. These findings support tailored management protocols in urban Indian settings to optimize outcomes while respecting the remodeling potential of growing bones.

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