

Predictors of Cubitus Varus After Paediatric Supracondylar Humerus Fracture: A Structured Review of The Evidence

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Abstract

Background: Cubitus varus is the commonest late complication of paediatric supracondylar humerus fracture (SCHF) and can cause late instability and ulnar neuropathy. Which factors predict it remains uncertain.

Methods: A structured review was conducted under PRISMA 2020 reporting principles. The Crossref and Europe PMC databases and the open web were searched for clinical studies and meta-analyses reporting cubitus varus, or its intermediate step, loss of reduction, by patient, fracture or treatment factor. Data were extracted from the abstracts and open-access full texts that could be retrieved. Odds ratios (OR) were calculated from 2 × 2 data where available. Findings were synthesised narratively by predictor following the SWiM guideline, and certainty was rated with GRADE for prognostic factors.

Results: Fifteen sources were included: twelve primary studies (three randomised trials and nine cohort studies; 985 children) and three meta-analyses of pin configuration. Reported incidence of cubitus varus ranged from 2.5% (2 of 79, mean follow-up more than 6 years) to 8.8% (3 of 34), and was about 2% in pooled pinning series. Severity of injury (Gartland grade), posteromedial (medial) displacement and medial column comminution were the most consistent fracture-related predictors. Posteromedial displacement was associated with greater carrying-angle loss (15° vs 8.8°, P = 0.019), and medial comminution with change in Baumann angle (adjusted OR 4.15, 95% CI 1.25–13.80). For Gartland type II fractures, casting rather than pinning was associated with more loss of reduction (OR 4.28, 95% CI 1.20–15.22), and in a matched cohort cubitus varus occurred only after casting (2 of 41 vs 0 of 38), although a larger cohort with short follow-up found similar rates of Baumann-angle malunion (13.5% vs 15.2%). In fractures with medial column impaction, casting left a smaller carrying angle than pinning (3.3° vs 11.9°). Pin configuration did not clearly affect cubitus varus (about 2% with either lateral or crossed pins), although crossed pins reduced loss of reduction in randomised trials (RR 0.70, 95% CI 0.52–0.94). Evidence for age, sex and side was sparse and inconsistent. Certainty was low to very low for every predictor.

Conclusion: Cubitus varus after SCHF appears to be driven mainly by fracture instability on the medial side and by failure to achieve or hold reduction, rather than by patient characteristics. Medial displacement and medial comminution should prompt stable fixation and careful checking of the Baumann angle. A definitive, registered meta-analysis of individual-level data using a standard definition of cubitus varus is needed.

Keywords: supracondylar humerus fracture; cubitus varus; children; prognostic factors; malunion; percutaneous pinning.

Introduction

Supracondylar humerus fractures (SCHF) are the most common elbow fractures of childhood, accounting for over half of paediatric elbow injuries, with a peak incidence between 5 and 7 years of age (Houshian et al., 2001). More than 95% are extension-type injuries produced by a fall on the outstretched hand. They are graded by displacement using the Gartland classification and its later modifications (Gartland, 1959; Wilkins, 1984). Treatment has moved steadily over five decades from traction and closed reduction with casting towards closed reduction and percutaneous pinning (CRPP) for displaced fractures. This shift was driven largely by the wish to prevent malunion.

Cubitus varus, the "gunstock" deformity, is the commonest late complication of SCHF. It is defined as a reversal or loss of the normal carrying angle relative to the uninjured side. It results mainly from malunion rather than growth disturbance: the distal fragment heals in medial (coronal) tilt, often combined with internal rotation and extension. The deformity was long regarded as cosmetic. It is now known to cause tardy posterolateral rotatory instability, tardy ulnar nerve palsy, snapping triceps and an increased risk of later lateral condyle fractures (O'Driscoll et al., 2001; Davids et al., 1994). Correction usually requires supracondylar osteotomy, which carries its own risks of nerve injury, lateral prominence and recurrence.

A number of factors have been proposed to predict cubitus varus. These include patient age and sex, fracture severity (Gartland grade, medial column comminution, the direction of displacement), the treatment chosen (casting versus pinning), the pin configuration (lateral-entry versus crossed medial-lateral), the timing of surgery and, above all, the quality of the reduction as judged by the Baumann angle and the integrity of the medial and lateral columns (De Boeck et al., 1995; Skaggs et al., 2004). The evidence is fragmented. Most data come from single-centre retrospective series, definitions of cubitus varus vary (for example, any loss of carrying angle, a threshold of 5° or 10°, or clinically evident varus), and earlier meta-analyses have focused on pin configuration and iatrogenic ulnar nerve injury, treating deformity only as a secondary outcome (Brauer et al., 2007).

This structured review therefore set out to (1) summarise the reported incidence of cubitus varus after paediatric SCHF, and (2) bring together the evidence on patient, fracture, treatment and radiographic factors associated with its development, rate the certainty of that evidence, and identify modifiable targets for prevention and the gaps a definitive meta-analysis must fill.

Methods

Design and reporting

This structured review follows the PRISMA 2020 reporting items that apply to it (Page et al., 2021) and the Synthesis Without Meta-analysis (SWiM) guideline (Campbell et al., 2020). It was not prospectively registered.

Eligibility criteria

Element	Criterion
Population	Children and adolescents (≤ 16 years) treated for an acute supracondylar humerus fracture
Candidate predictors	Age, sex, side, Gartland grade, direction of displacement, medial comminution, treatment method, pin configuration and number, reduction quality
Outcome	Cubitus varus at final follow-up as defined by the authors (primary); loss of carrying angle, change in Baumann angle and loss of reduction as intermediate outcomes (secondary)
Design	Randomised trials, cohort or case-control studies with outcome data by at least one predictor, and meta-analyses reporting these outcomes

We excluded case reports, studies of corrective osteotomy for established deformity, studies of lateral condyle or other distal humeral fractures, and biomechanical studies.

Search

The Crossref metadata database was searched on 1 October 2026 using the terms "supracondylar", "cubitus varus", "children" and "risk factors" (records from 1990 onwards). Web searches were run on the same day for pin configuration, Gartland type II treatment, medial comminution and displacement direction combined with cubitus varus. The search was updated on 2 October 2026 in Europe PMC ("cubitus varus", "supracondylar" and "children"), with targeted searches for the potentially eligible records that could not be retrieved at first and for comparative studies of casting versus pinning. Reference lists of three meta-analyses of pin configuration were screened. PubMed and Embase could not be searched directly in this review, although Europe PMC indexes MEDLINE records; this is addressed under Limitations.

Selection and data extraction

Records were screened on title and abstract, and the abstracts or open-access full texts of potentially eligible studies were read. For each study we recorded the design, sample size, fracture grade, treatment, follow-up, outcome definition and, for each predictor, the number of children with the outcome in each group or the published effect estimate. Data were extracted by one reviewer and checked against the source text.

Risk of bias and synthesis

The risk of bias of primary studies was judged across the six QUIPS domains (Hayden et al., 2013). Odds ratios (OR) with 95% confidence intervals were calculated from 2×2 data where reported, with a 0.5 correction for zero cells. Pooling was not undertaken because no predictor had two or more studies reporting the same effect measure for cubitus varus. Results were therefore grouped by predictor and summarised by the direction and size of reported effects, following SWiM. The certainty of evidence for each predictor was rated with GRADE adapted for prognostic factors (Foroutan et al., 2020).

Results

Study selection

The Crossref search returned 40 records, most of them reports of corrective osteotomy or case reports; the Europe PMC search, web searches and reference screening added further records. Nineteen abstracts or full texts were assessed. Four were excluded: one comparative study that did not report outcomes by pin configuration (Paramasivam et al., 2022), two narrative reviews without study-level cubitus varus data, and one cohort restricted to children with established cubitus varus whose abstract compared ulnar and humeral deformity by age group without extractable data (Cha et al., 2016). Three potentially eligible records could not be retrieved in full or in abstract: Shin et al. (2010), Moraleda et al. (2013) and a Chinese-language study of risk factors after conservative treatment (PubMed 29417774). Fifteen sources were included: twelve primary studies with 985 children and three meta-analyses of pin configuration. Two of the randomised trials (Kocher et al., 2007; Prashant et al., 2016) may also contribute to the pooled estimates of Peng et al. (2021) and Xing et al. (2023); they are reported here for their study-level data and were not combined with those estimates.

Characteristics of included primary studies

Study	Country	Design	n	Population and treatment	Outcome reported	Follow-up	Risk of bias (QUIPS)
Takagi et al., 2025	Japan	Retrospective cohort	173	58 conservative, 115 operative	Cubitus varus measures (linear regression)	NR	Moderate
Yuan et al., 2025	China	Retrospective cohort	46	Medial column impaction; K-wires 20, casting 26	Carrying and Baumann angles	Mean 5.4 months	High (short follow-up; non-random allocation)
Jain & Mohan, 2024	India	Retrospective cohort	61	Gartland II; casting 32, K-wires 29	Loss of reduction	NR	Moderate
Soo et al., 2024	Singapore	Retrospective cohort	142	Gartland II; casting 108, operative 34	Malunion by Baumann angle	2 months	Moderate
Iorio et al., 2019	Italy	Retrospective matched cohort	79	Gartland II; casting 41, CRPP 38	Cubitus varus; Baumann angle	Mean > 6 years	Moderate
Kwak et al., 2018	Korea	Retrospective cohort	67	Gartland III, lateral-only pins	Change in Baumann angle	NR	Moderate

Study	Country	Design	n	Population and treatment	Outcome reported	Follow-up	Risk of bias (QUIPS)
Prashant et al., 2016	India	Randomised trial	76 (62 analysed)	Gartland III; lateral 31, crossed 31	Loss of reduction; Baumann and carrying angles	Mean 35 weeks	Some concerns (18% lost to follow-up)
Maity et al., 2012	India	Randomised trial	160 (130 analysed)	Displaced extension type; crossed 80, lateral 80	Loss of reduction	3 months	Some concerns (19% lost to follow-up)
Krusche-Mandl et al., 2012	Austria	Retrospective cohort	78	Crossed pinning	Cubitus varus	Mean 8.1 years	Moderate
Eren et al., 2008	Turkey	Retrospective series	17	Gartland III with cubitus varus; open reduction, crossed pins	Loss of carrying angle	Mean 3.7 years	High (only children with deformity)
Kocher et al., 2007	USA	Randomised trial	52	Gartland III; lateral 28, crossed 24	Loss of reduction	NR	Some concerns (data from abstract)
Castañeda et al., 2007	Mexico	Retrospective cohort	34	Crossed 26, lateral 8	Cubitus varus	Mean 2.3 years	High (small sample)

NR = not reported in the accessible text. The three meta-analyses were Na et al. (2018), 24 studies; Peng et al. (2021), 12 randomised trials; and Xing et al. (2023), 19 randomised trials.

Incidence of cubitus varus

Cubitus varus occurred in 2 of 78 children (2.6%) a mean 8.1 years after crossed pinning (Krusche-Mandl et al., 2012) and in 3 of 34 (8.8%) in a mixed cohort, where the mean carrying angle fell from 14.88° to 12.26° relative to the uninjured side ($P = 0.045$; Castañeda et al., 2007). Across the six comparative studies pooled by Na et al. (2018), cubitus varus occurred in 2.3% of children with lateral pins and 2.1% with crossed pins. In a matched cohort of Gartland type II fractures followed for a mean of more than six years, cubitus varus occurred in 2 of 79 children (2.5%), both after casting (2 of 41, 4.9%) and none after pinning (0 of 38; Iorio et al., 2019). Using a radiographic definition, malunion by Baumann angle two months after treatment was found in 19 of 137 type II fractures (13.9%; Soo et al., 2024).

Predictors

No predictor had two or more studies reporting the same effect measure for cubitus varus, so results are summarised by predictor below (SWiM).

Predictor	Sources	Outcome	Reported effect	Direction	Certainty (GRADE)
Posteromedial (medial) displacement	Takagi 2025; Eren 2008	Cubitus varus; carrying-angle loss	Significant in conservative and operative	Increases risk, consistent	Low

Predictor	Sources	Outcome	Reported effect	Direction	Certainty (GRADE)
			groups (Takagi); carrying-angle loss 15° (range 6–29°) posteromedial vs 8.8° (6–10°) posterolateral, P = 0.019 (Eren)		
Gartland grade (higher)	Takagi 2025; Castañeda 2007	Cubitus varus	Significant in conservative cases (Takagi); higher risk with type III (Castañeda, counts not given)	Increases risk, consistent	Low
Medial column comminution	Kwak 2018; Takagi 2025; Yuan 2025	Baumann change; cubitus varus; carrying angle	Adjusted OR 4.15 (95% CI 1.25–13.80) for Baumann change (Kwak); significant in operative cases but not conservative ones (Takagi); with medial impaction, carrying angle 3.3° after casting vs 11.9° after K-wires, P < 0.05 (Yuan)	Increases risk, partly inconsistent	Low
Casting vs pinning (Gartland II; medial impaction)	Jain & Mohan 2024; Iorio 2019; Soo 2024; Yuan 2025	Loss of reduction; cubitus varus; Baumann malunion; carrying angle	Loss of reduction 13/32 (40.6%) vs 4/29 (13.8%), OR 4.28 (1.20–15.22) (Jain); cubitus varus 2/41 vs 0/38, OR 4.87 (0.23–104.9) (Iorio); Baumann malunion 14/104 (13.5%) vs 5/33 (15.2%), OR 0.87 (0.29–2.63) (Soo); smaller carrying	Casting increases risk in three of four studies	Low (mostly surrogate outcomes; imprecise)

Predictor	Sources	Outcome	Reported effect	Direction	Certainty (GRADE)
			angle after casting (Yuan)		
Crossed vs lateral pins	Na 2018; Castañeda 2007; Peng 2021; Xing 2023; Maity 2012; Kocher 2007; Prashant 2016	Cubitus varus; loss of reduction	Cubitus varus 2.1% vs 2.3%, no significant difference (Na); 3/26 vs 0/8, OR 2.53 (0.12–54.3), $P = 0.115$ (Castañeda). Loss of reduction lower with crossed pins: RR 0.70 (0.52–0.94) (Xing); 9 vs 8 events (Maity); mild loss 1/24 vs 6/28, OR 0.16 (0.02–1.43), $P = 0.107$ (Kocher); 0/31 vs 2/31, OR 0.19 (0.01–4.07) (Prashant)	No clear effect on cubitus varus	Low
Number of pins	Takagi 2025	Cubitus varus	Significant in operative cases	Fewer pins, more risk	Very low
Age	Takagi 2025; Castañeda 2007	Cubitus varus	Not significant in conservative cases, significant in operative cases (Takagi); higher risk above 7 years (Castañeda, counts not given)	Inconsistent	Very low
Sex, side, anterior spike length	Takagi 2025	Cubitus varus	Not significant in conservative cases	No association	Very low

Certainty began at moderate for prognostic cohort evidence and was downgraded for risk of bias, imprecision (small samples, few events) and, for loss of reduction and Baumann change, indirectness. Peng et al. (2021) found that none of the 12 randomised trials of pin configuration reported cubitus varus as a separate outcome, so the cubitus varus data on pin configuration come from non-randomised studies. Casting versus pinning was rated low rather than very low because the evidence no longer rests on a single study and three of four studies point the same way; it remained downgraded for risk of bias, imprecision and the use of surrogate outcomes, with follow-up of only two to five months in two studies.

Discussion

Principal findings

The available evidence points to fracture mechanics, not patient characteristics, as the main driver of cubitus varus after paediatric SCHF. Three fracture-related factors were associated with deformity in the same direction in more than one study: higher Gartland grade, posteromedial (medial) displacement and medial column comminution. Treatment factors acted mainly through loss of reduction. Casting of Gartland type II fractures was associated with about four times the odds of loss of reduction compared with pinning, and in a matched cohort the only cases of cubitus varus followed casting; one larger cohort with short follow-up found no difference in Baumann-angle malunion. Crossed pins reduced loss of reduction in randomised trials, and two further trials showed the same trend without reaching significance, yet the rate of cubitus varus with either pin configuration was about 2%. Age, sex and side showed no consistent association. Certainty was low or very low for every predictor, and no estimate could be pooled.

Interpretation

Cubitus varus is a malunion of the coronal plane, with the distal fragment healed in medial tilt, usually combined with internal rotation and extension. Each consistent predictor fits that mechanism. In posteromedially displaced fractures, the medial periosteum stays intact and acts as a hinge, so the distal fragment tends to tip into varus during and after reduction. The doubling of carrying-angle loss with posteromedial displacement in Eren et al. (2008) is consistent with this. Comminution or impaction of the medial column removes the medial buttress. A reduction that looks acceptable on the lateral view can then collapse into varus, as De Boeck et al. (1995) described for impacted medial condyles, and as the fourfold odds of Baumann-angle change in Kwak et al. (2018) suggest. Higher Gartland grade marks greater periosteal disruption and instability, so it makes loss of the initial reduction more likely.

The treatment findings support the same pathway. Loss of reduction is the step between an unstable fracture and a malunion. Casting relies on an intact posterior hinge that may not be present, which is why loss of reduction was more common after casting of type II fractures. The same applies when the medial column is impacted: casting left a carrying angle of about 3°, against about 12° after K-wire fixation (Yuan et al., 2025), consistent with collapse of an unsupported medial column into varus. The difference between pin configurations in loss of reduction (RR 0.70 favouring crossed pins) did not translate into a measurable difference in cubitus varus. The likeliest reason is that most loss of reduction after pinning is small and stays within the range that remodelling and clinical tolerance absorb. Lateral-only constructs with two or three well-spread divergent pins achieve stability comparable to crossed pins (Skaggs et al., 2004), without the risk of iatrogenic ulnar nerve injury associated with a medial pin (Brauer et al., 2007).

Medial-sided instability leads to cubitus varus through lost reduction

Predictors reported in included studies; certainty of evidence low to very low

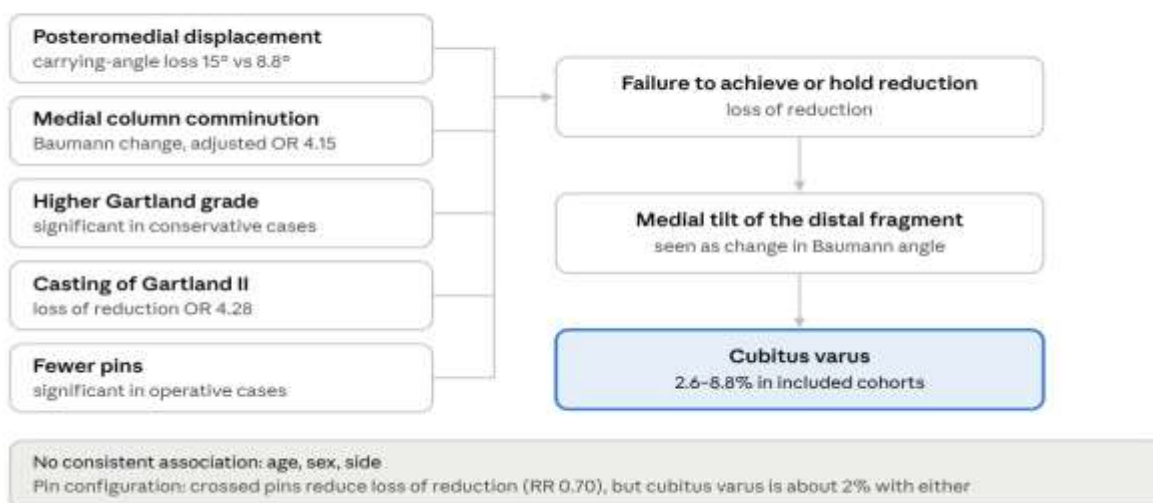


Figure 1. Proposed pathway from predictors to cubitus varus, drawn from the included studies

Fracture-related predictors and casting converge on a single step, failure to achieve or hold reduction, which leads to medial tilt and then cubitus varus.

Clinical implications

- Medial displacement and medial comminution on the injury films should be treated as markers of instability, with a lower threshold for operative fixation.
- Before final fixation, the Baumann angle should be checked on the intraoperative anteroposterior view and compared with the uninjured side, because it reflects coronal alignment and predicts the carrying angle (Worlock, 1986). Both medial and lateral columns should appear restored.
- Where the medial column is comminuted, pin spread at the fracture site should be maximised, and a third lateral pin, or a medial pin placed through a small incision, considered.
- Casting of Gartland type II fractures requires close radiographic follow-up in the first two weeks, with early pinning if the reduction is lost.

Strengths and limitations

This review brings together primary studies and meta-analyses on cubitus varus specifically, rather than treating it as a secondary outcome of pin-configuration trials, and grades the certainty of evidence for each predictor. Its limitations are substantial. PubMed and Embase could not be searched directly (Europe PMC, which indexes MEDLINE records, was searched instead), three potentially eligible studies could not be retrieved, and screening and extraction were done by one reviewer, so relevant studies may have been missed. Definitions of cubitus varus varied, and several studies reported only intermediate outcomes such as loss of reduction or Baumann-angle change. Two studies had follow-up of only two to five months, too short to capture remodelling or late deformity. Most studies were small, retrospective and single-centre, and some data came only from abstracts. These factors prevented pooling and lowered certainty. The findings should be regarded as hypothesis-generating.

Implications for research

A registered systematic review with full database searching and duplicate extraction is now needed, ideally pooling individual participant data so that predictors can be modelled together. Future cohorts should adopt a common definition of cubitus varus, for example a loss of 10° or more in carrying angle relative to the uninjured side at a fixed follow-up, and report the Baumann angle and column integrity at the end of surgery. Randomised trials of fixation methods should report cubitus varus as a prespecified outcome.

Conclusion

Cubitus varus after paediatric supracondylar humerus fracture is uncommon with modern operative care, at about 2–3% after pinning. The evidence, though limited in certainty, consistently links it to medial-sided instability: posteromedial displacement, medial column comminution and higher Gartland grade, acting through failure to achieve or maintain coronal alignment. Pin configuration has little effect on deformity once stable fixation is achieved. Accurate restoration and secure fixation of the medial column, checked against the Baumann angle of the uninjured side, is the most promising target for prevention.

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