Supracondylar Humerus Fracture Treatment in Children: A Comparison Between Supine and Prone Positions

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ABSTRACT
Introduction: Supracondylar humeral fractures are common injuries in pediatric patients, accounting for approximately 60-70% of all elbow fractures in this population. The aim of this study was to describe the clinical and radiological outcomes of osteodesis for supracondylar humeral fractures in pediatric patients and to evaluate the impact of patient positioning (prone vs. supine). **Materials and Methods:** A retrospective study was conducted, including all patients under 16 years of age with Grade II and III Gartland supracondylar humeral fractures who underwent humerus reduction and osteodesis between 2002 and 2022, with a minimum follow-up of 6 months. **Results:** The study included 265 patients, of whom 127 underwent surgery in the supine position and 138 in the prone position. The most significant finding of our study was that osteodesis achieves excellent clinical and radiological outcomes, and the patient's position does not have a significant impact on the surgery. **Conclusions:** Reduction and osteodesis of the humerus provide excellent clinical and radiological outcomes for the treatment of supracondylar fractures. The patient's position (prone or supine) does not appear to affect the consolidation rate or limb function.
Keywords: Distal humeral fractures; supracondylar humerus fracture; prone position; supine position.
Level of Evidence: III

Tratamiento de las fracturas supracondíleas de húmero en niños. Comparación entre decúbito supino y prono

RESUMEN
Introducción: Las fracturas supracondíleas de húmero son lesiones comunes en pacientes pediátricos, representan aproximadamente el 60-70% de todas las fracturas de codo en esta población. El propósito de este estudio fue describir los resultados clínico-radiológicos del tratamiento con osteodesis de fracturas supracondíleas de húmero en pacientes pediátricos y evaluar el impacto de la posición (decúbito prono o supino). **Materiales y Métodos:** Se realizó un estudio retrospectivo que incluyó a todos los pacientes <16 años con diagnóstico de fractura supracondílea de húmero grado II y III de Gartland, que fueron sometidos a reducción y osteodesis de húmero, entre 2002 y 2022, con un seguimiento mínimo de 6 meses. **Resultados:** La serie estaba formada por 265 pacientes, 127 fueron operados en decúbito supino y 138, en decúbito prono. El hallazgo más importante de nuestro estudio fue que la osteodesis permite alcanzar excelentes resultados clínicos y radiológicos, y que la posición del paciente no tiene un impacto significativo en la cirugía. **Conclusiones:** La reducción y osteodesis de húmero logra excelentes resultados clínico-radiológicos para el tratamiento de las fracturas supracondíleas. La posición del paciente (decúbito ventral o prono) no parece tener un impacto en la tasa de consolidación ni en la función del miembro.
Palabras clave: Fracturas humerales distales; fractura supracondílea del húmero distal; posición prona; posición supina.
Nivel de Evidencia: III

INTRODUCTION

Supracondylar humerus fractures are common injuries in pediatric patients, accounting for approximately 60-70% of all elbow fractures in this population.[1] They occur mainly in school-age children, with a peak incidence around six years of age.[1] The most common mechanism of injury is a fall onto an outstretched hand

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with the elbow in full extension,[2-4] leading to a fracture proximal to the condyles and dorsal displacement of the distal fragment.[5,6] This pattern is observed in 98% of cases.[7] Proper treatment is crucial to restore elbow function and prevent long-term complications such as cubitus varus, neuropraxia, vascular injuries, or compartment syndrome.[8]

Over the years, various surgical techniques have been developed for managing these fractures. One of the most common is osteosynthesis, which involves fracture reduction and fixation using K-wires to promote bone healing and restore anatomical alignment of the elbow.[9] Traditionally, surgery has been performed with patients in the supine or dorsal decubitus position.[10] However, in recent years, different authors have described performing the procedure in the prone or ventral decubitus position.

The supine position has traditionally been preferred because it allows good visualization and access to the surgical site, provides stability during osteosynthesis, and facilitates better control of fracture reduction.[11]

Conversely, the prone position offers greater surgeon comfort and is associated with a lower incidence of neurological complications.[12] However, its main drawback is the patient positioning process, which may increase operative time and require a more experienced anesthesiologist.[13]

Despite the widespread use of both techniques, there is limited scientific evidence directly comparing osteosynthesis in the prone versus supine position for treating supracondylar humerus fractures in pediatric patients.[14]

Therefore, this study aimed to describe the clinical and radiological outcomes of osteosynthesis for supracondylar humerus fractures in pediatric patients and evaluate the impact of patient positioning (prone or supine) on these outcomes.

MATERIALS AND METHODS

A retrospective study was conducted, including all patients under 16 years of age diagnosed with a supracondylar humerus fracture (Gartland grade II or III)[15] who underwent fracture reduction and osteosynthesis between 2002 and 2022, with a minimum follow-up of six months.

Patients with open fractures, other ipsilateral upper limb injuries, polytrauma, pathological fractures, or incomplete clinical records were excluded.

Analyzed Variables

Clinical history and institutional records were reviewed to collect data on age, sex, and laterality. Fractures were classified according to the Gartland criteria[15] using anteroposterior and lateral radiographs of the elbow.

Data were recorded on patient positioning, type of reduction (open or closed), and K-wire configuration (crossed vs. laterally divergent) during definitive osteosynthesis. The surgeon determined patient positioning at the time of the procedure. Range of motion was measured with a goniometer at the six-month postoperative follow-up.

Anteroposterior and lateral elbow radiographs were analyzed. The Baumann angle (formed by a line along the humeral axis and another crossing the epiphyseal plate of the capitellum, normal range: 64°-81°) (Figure 1)[16] and the carrying angle of the elbow (formed between the radially deviated forearm axis and the anatomical humeral axis, normal values: 14° in girls, 11° in boys) (Figure 2) were measured. Both angles were used to assess postoperative reduction adequacy.

Fracture consolidation was defined as radiological union in at least three of the four cortices, along with clinical examination confirming mechanical stability of the affected limb and absence of patient-reported symptoms.[17]

The Flynn criteria were applied for clinical and functional assessment, evaluating both functional capacity (range of motion) and cosmetic outcome (loss of the normal carrying angle on radiographs).[18]

Surgical complications were also documented, including superficial and deep infections (defined as signs of localized inflammation at the K-wire entry site), loss of initial reduction >5° on follow-up radiographs based on Baumann and carrying angle values, heterotopic ossification, malunion, chronic pain, and complex regional pain syndrome.

Figure 1. Anteroposterior radiograph of the right elbow. Measurement of Baumann angle.

Figure 2. Anteroposterior radiograph of the right elbow. Measurement of the elbow carrying angle.

All procedures were performed by two surgeons from the same pediatric orthopedic team at a high-complexity private hospital.

In prone-positioned patients, the shoulder was abducted 90° with the elbow flexed at 90°, leaving the distal humerus free. In supine-positioned patients, fracture reduction was achieved by applying traction to the proximal humerus and counter-traction to the forearm, elevating the distal fragment from posterior to anterior. Once adequate reduction was confirmed via fluoroscopy, the fracture was stabilized with either crossed or divergent K-wires at the surgeon's discretion.

Postoperatively, patients were immobilized with a long arm cast until the third week, when K-wires were removed. A closed long arm cast was then applied for an additional three weeks. Thereafter, active and passive range-of-motion exercises were initiated and explained to the patient and caregivers.

Statistical Analysis

Quantitative variables are expressed as means and standard deviation or median and interquartile range, depending on distribution. Qualitative variables are presented as frequencies and percentages. Continuous data were compared using Student's t-test, while categorical variables were analyzed using the χ^2 test (or Fisher's exact test). A p-value <0.05 was considered statistically significant.

All data were recorded in an Excel spreadsheet (Microsoft, Redmond, USA), and statistical analyses were performed using GraphPad Prism 9.0.

RESULTS

During the study period, 273 osteodeses for supracondylar humerus fractures were performed at our institution. Three open fractures, one pathological fracture, and four polytraumatized patients were excluded.

The final series included 265 patients: 127 operated on in the supine position and 138 in the prone position. The overall follow-up period was 9.2 ± 2.6 months. Table 1 provides a global description of the patients and surgical positioning, as well as a comparative analysis between those operated on in the supine and prone positions.

Table 1. Global characteristics and according to surgical technique

Variables	Global	Supine	Prone	p
No. of patients	265	127	138	
Age, years (mean, SD)	6 ± 0.9	6.5 ± 1.4	5.9 ± 1.6	0.44
Sex (n, %)				0.50
Male	153 (57.7)	76 (60)	77 (56)	
Female	112 (42.3)	51 (40)	61 (44)	
Side (n, %)				0.61
Left	171 (64.5)	80 (63)	91 (66)	
Right	94 (35.4)	47 (37)	47 (34)	
Gartland (n, %)				0.74
Type II	78 (29.4)	44 (35)	34 (25)	
Type III	187 (70.6)	83 (65)	104 (75)	
Reduction (n, %)				0.13
Closed	253 (95.5)	123 (98)	128 (93)	
Open	12 (4.5)	4 (2)	10 (7)	
Pin configuration (n, %)				<0.0001
Two lateral	129 (48.7)	118 (93)	11 (8)	
Two crossed	136 (51.3)	9 (7)	127 (92)	

There was a statistically significant difference regarding K-wire placement. The proportion of lateral K-wires was significantly higher in the supine group (92.9%) compared to the prone group (8.0%) ($p < 0.0001$).

In the supine group, Gartland type III fractures were the most frequent (83 cases; 65.3%), while the remaining 44 cases (34.6%) were type II. None of the patients had vascular injuries at the time of the fracture. There were four nerve injuries: two anterior interosseous nerve palsies, one posterior interosseous nerve palsy, and one ulnar neuropraxia. In the prone group, 104 patients (75%) had a type III fracture, and 34 (25%) had a type II fracture, with no vascular or nerve injuries reported.

The results according to patient positioning are detailed in Table 2. A statistically significant difference was found in the Flynn criteria in the supine group ($p < 0.001$).

The mean Baumann angle was 17.11°, and the mean carrying angle was 15.75°. A global flexion deficit of 4.05° and an extension deficit of 0.59° were observed, both statistically significant ($p < 0.001$). According to the Flynn criteria, 7% of patients had a fair outcome, 14% had a good outcome, and 79% achieved excellent outcomes (Table 2).

Table 2. Global and comparative outcomes according to patient position.

Variables	Global (265 patients)	Supine (127 patients)	Prone (138 patients)	p
Complications (n, %)	17 (6.3)	6 (4.8)	11 (8.0)	0.21
Superficial infections	8 (3)	2 (1.6)	6 (4.3)	
Deep infections	1 (0.3)	1 (0.8)	0 (0.0)	
Loss of initial reduction	7 (2.7)	3 (2.4)	4 (2.9)	
Heterotopic calcification	1 (0.3)	0 (0)	1 (0.7)	
Baumann angle (mean)	17.1° ± 2.3º	17.5°	16.72°	0.12
Carrying angle (mean)	15.8° ± 1.8°	16.2°	15.3°	0.07
Flexion deficit (mean)	4.1° ± 1.7°	3.4°	4.7°	<0.001
Extension deficit (mean)	0.6°	0.5°	0.68º	<0.001
Flynn criteria (n, %)				<0.001
Fair	18 (7)	5 (3.9)	13 (9.4)	
Good	38 (14)	10 (7.9)	28 (20.2)	
Excellent	209 (79)	112 (88)	97 (70.3)	

There were 17 complications: 8 superficial infections requiring antibiotics, 1 deep infection requiring surgical debridement, 7 cases of loss of initial reduction requiring reoperation, and 1 case of heterotopic ossification.

Complete fracture healing was observed in all patients. The prone position was associated with a higher complication rate than the supine position (8.7% vs. 4.7%), although this difference was not statistically significant ($p = 0.21$).

DISCUSSION

The most important finding of our study was that osteodesis achieves excellent clinical and radiological outcomes and that patient positioning does not significantly impact surgical success.

To evaluate functional and aesthetic outcomes, we used the Flynn classification,[18] as we consider it the most rigorous. In our study, 79% of patients achieved excellent outcomes. These findings are consistent with those of Mazda et al.,[19] who reported a 91.6% success rate in 116 patients treated with reduction and osteodesis. Based on these results, we believe that the quality of the reduction is far more critical for achieving good outcomes than the patient's positioning.

We agree with Fowler and Marsh[20] that the prone position offers several advantages over the conventional supine technique. The primary benefit is avoiding excessive hyperflexion (>90°) of the elbow. When the patient is positioned prone, reduction is smoother, aided by gravity due to the weight of the forearm. Additionally, maneuvering the upper limb in the prone position improves intraoperative fluoroscopic visualization. In the supine position, maintaining the reduction while inserting K-wires and positioning the C-arm for anteroposterior imaging is challenging, and extreme external rotation of the arm may result in loss of reduction.[21] Conversely, in the prone position, slight forearm extension allows for a proper anteroposterior view of the elbow. Furthermore, without moving the limb, simply rotating the fluoroscopic C-arm provides an optimal lateral view of the joint.

In our study, the mean Baumann angle in the supine group was 17.5°, while in the prone group, it was 16.72°. The carrying angle was 16.2° in the supine group and 15.3° in the prone group. These results align with those reported by Venkatadass et al.,[22] who found a Baumann angle of 18.14° in the supine group and 18.46° in the prone group.

Mapes and Hennrikus[23] observed that elbow flexion beyond 90° reduces radial artery flow and increases intracompartmental pressure in the forearm, potentially leading to elevated pressure in the deep volar compartment and ischemia at the fracture site.[24] In the prone position, the elbow does not need to be flexed beyond 90°, thereby reducing the risk of neurovascular complications.[20] Consequently, in addition to avoiding postoperative immobilization in hyperflexion, we recommend minimizing prolonged hyperflexion during the surgical procedure. In our study, no neurovascular complications of this nature were observed, suggesting that both prone and supine positions provide safe exposure and treatment.

The prone position also reduces the risk of ulnar nerve injury, both during reduction maneuvers and during K-wire placement, as excessive elbow flexion narrows the ulnar tunnel.[25] Additionally, in children, the ulnar nerve is highly mobile and can easily dislocate when the elbow is hyperflexed, as required in the supine technique.[25]

The main limitation of our study is its retrospective design.

CONCLUSIONS

Reduction and osteodesis of the humerus provide excellent clinical and radiological outcomes in the treatment of supracondylar fractures. Patient positioning (supine or prone) does not appear to impact the consolidation rate or functional outcomes, although in our series, the prone position was associated with nearly twice the complication rate.

Conflict of interest: The authors declare no conflicts of interest.

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