ORIGINAL CLINICAL ARTICLE

Surgical approaches for open reduction and pinning in severely displaced supracondylar humerus fractures in children: a systematic review

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Abstract

Purpose There is no clear evidence in the actual literature regarding which of the surgical approaches could bring about the best functional, cosmetic, and radiological outcomes, as well as fewer complications, when an open reduction and pinning of a severely displaced supracondylar humerus fracture is performed. We, therefore, performed a systematic review of the English literature to investigate the existing evidence regarding this issue.

Methods A MEDLINE and EMBASE databases search was performed to identify articles that focused on the functional, cosmetic, and radiological outcomes, as well as post-surgical complications, regarding different surgical approaches used for open reduction and pinning in severely displaced supracondylar humerus fractures in children. One hundred and ninety-four articles were identified, of which seven were included for review. Data analysis included weighted means for all contingency tables and the Chi-square test. Standardized residues were studied when the Chi-square test was statistically significant. Statistical analyses were conducted using Stata 9.1/SE (StataCorp.,

College Station, TX) and *P*-values lower than 0.05 were considered to be statistically significant for all analyses.

Results For functional outcome, a high frequency of excellent results was found within the lateral and medial approaches, and a high frequency of good results within the anterior approach. A high frequency of poor results was found within the posterior approach. For cosmetic outcome, there was a high frequency of fair results within the posterior and lateral approaches, and a high frequency of poor results within the posterior approach. No statistically significant difference regarding time to union, as well as complications, was found.

Conclusion Our results suggest that a combined antero-medial approach could be the method which allows the achievement of better functional and cosmetic outcome according to Flynn's criteria. Time to union, as well as post-surgical complications, should not be an issue regarding surgical approaches used for open reduction and pinning in these fractures.

Keywords Open reduction and pinning · Surgical approaches · Supracondylar humerus fracture · Outcome · Post-surgical complications

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Introduction

Supracondylar humerus fractures (SCHF) are common pediatric injuries [1–4], representing about 3% of all fractures [5, 6], are the second most common fractures [7, 8], the most frequent fractures in children under 8 years of age [1, 7–10], and the most common elbow fractures [9, 11, 12]. Two-thirds of children hospitalized because of an elbow injury have an SCHF [11]. Boys have had a higher incidence of this type of fracture, but the difference in comparison with

girls seems to be equalizing, and higher rates in girls have actually been reported in some series [9, 11, 13].

These fractures are classified using the modified Gartland classification [14], and most of them are of extension type [10]. Type III and type IV (described by Leitch et al. [15] as being like fractures with multidirectional instability) are considered to be totally displaced with an incidence of 16.7% [16, 17].

Severely displaced SCHF are challenging injuries to treat [16, 18–20] and entail technically difficult procedures for orthopedic surgeons [7, 10]. There remains controversy in the literature with regards to the definitive management of these type of fractures [16, 21, 22]. The differences among authors relate mainly to the choice between treatment by closed reduction and percutaneous K-wire fixation [7, 23, 24] or open reduction and wiring under direct vision [21, 25, 26].

The literature supports closed reduction and percutaneous pinning as the treatment of choice for these fractures [12, 18, 27–29]; however, they could be associated with various complications, such as neurovascular compromise ranging from 5 to 30% [27, 30, 31], skin problems, compartment syndrome, Volkmann's ischemia, and cubitus varus with an incidence as high as 60% [16, 23, 32, 33]. Although irreducible fractures are uncommon (mostly due to interposition of the brachialis muscle, median nerve, and brachial artery [20]), 2–12% require open reduction [27, 34]. Surgical exposure can be accomplished by a variety of approaches [21, 35–37]. A surgical approach should permit a safe and rapid reduction, with full anatomic alignment, obtaining adequate functional and cosmetic outcomes, as well as few complications.

There is no clear evidence in the literature regarding which of the surgical approaches could bring about the best functional and cosmetic outcomes, as well as less complications. We, therefore, performed a systematic review of the literature to investigate the existing evidence regarding functional and cosmetic outcomes, as well as post-surgical complications among the different surgical approaches described.

Materials and methods

We performed a systematic review of the literature to identify publications dealing with functional, cosmetic, and radiological outcomes, as well as post-surgical complications in patients with totally displaced SCHF managed with primary open reduction through different surgical approaches. An electronic search of the MEDLINE and EMBASE databases (from January 1990 to December 2009) was conducted, entering the following terms and Boolean operators: "open reduction" AND "supracondylar humeral fractures" AND "children"; "primary open reduction" AND "supracondylar humeral fractures" AND "children". Only papers in English were included.

Articles were considered eligible if they met the following inclusion criteria: (1) the target population consisted of children with totally displaced SCHF; (2) each study included cases with primary open reduction stabilized with K-wires; (3) different surgical approaches were included, such as: lateral, medial, anterior, posterior, and medial + lateral; (4) functional, cosmetic, and/or radiological outcomes; as well as (5) post-surgical complications, such as: nerve/arterial injury, compartment syndrome, infection, nonunion were described adequately.

Review articles, case reports, expert opinion articles, editorials, letters to the editor, publications on congress proceedings, manuscripts with incomplete documentation of outcomes mentioned above, details of applied procedures, or unpublished series were excluded (Fig. 1).

The quality of the reviewed manuscripts was evaluated by two assessors (JPM, JRM). They independently classified the reviewed studies for the level of evidence [38] (Table 1) and selected the appropriate studies based on the above criteria.

Data extracted from these articles were further analyzed for: (1) functional, cosmetic, and radiological outcomes, as well as (2) post-surgical complications according to the surgical approach used for open reduction.

Of the papers initially selected based on the search strategy of this study, seven met the inclusion criteria [1, 2, 7, 21, 26, 35, 39]. The levels of evidence of these studies were II (prospective comparative study) [2], III (retrospective comparative study) [1, 7], and IV (case series) [21, 26, 35, 39]. Two hundred and twenty-six patients were included for the final analysis. Patients were distributed into the different surgical approaches as follows: lateral (58) [2, 7, 21], medial (50) [21, 26, 39], posterior (47) [1, 21, 26], anterior (65) [35, 39], and medial + lateral (6) [21, 26, 39].

To assess the functional outcome, we used Flynn's criteria (loss of motion), as well as for the cosmetic outcome (carrying angle) [23]. To assess the radiological outcome, we included the time to union. Post-surgical complications described were: compartment syndrome, nonunion, nerve/vascular injury, pin tract infection, and wound issues.

Data analysis

Study participants' characteristics were summarized according to the result of the systematic review. In order to find differences in associated injuries, functional, cosmetic, and radiological outcomes among different approaches used for open reduction and post-surgical complications, we have calculated weighted means for all contingency tables and the Chi-squared test was performed, studying the
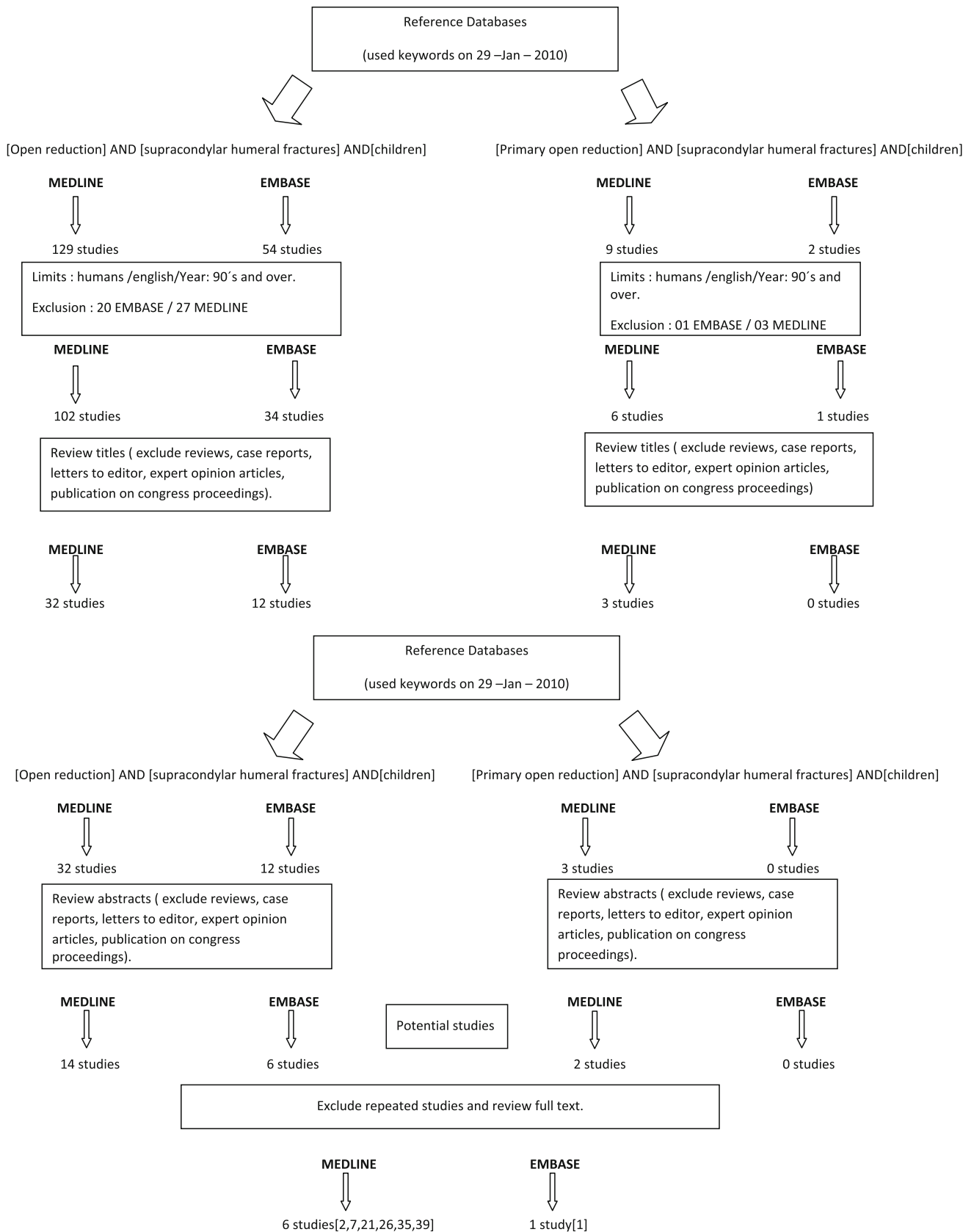
Reference Databases

(used keywords on 29 –Jan – 2010)

[Open reduction] AND [supracondylar humeral fractures] AND[children]

MEDLINE   **EMBASE**

129 studies   54 studies

Limits : humans /english/Year: 90´s and over.

Exclusion : 20 EMBASE / 27 MEDLINE

MEDLINE   **EMBASE**

102 studies   34 studies

Review titles (exclude reviews, case reports, letters to editor, expert opinion articles, publication on congress proceedings).

MEDLINE   **EMBASE**

32 studies   12 studies

[Primary open reduction] AND [supracondylar humeral fractures] AND[children]

MEDLINE   **EMBASE**

9 studies   2 studies

Limits : humans /english/Year: 90´s and over.

Exclusion : 01 EMBASE / 03 MEDLINE

MEDLINE   **EMBASE**

6 studies   1 studies

Review titles (exclude reviews, case reports, letters to editor, expert opinion articles, publication on congress proceedings)

MEDLINE   **EMBASE**

3 studies   0 studies

Reference Databases

(used keywords on 29 –Jan – 2010)

[Open reduction] AND [supracondylar humeral fractures] AND[children]

MEDLINE   **EMBASE**

32 studies   12 studies

Review abstracts (exclude reviews, case reports, letters to editor, expert opinion articles, publication on congress proceedings).

MEDLINE   **EMBASE**

14 studies   6 studies

[Primary open reduction] AND [supracondylar humeral fractures] AND[children]

MEDLINE   **EMBASE**

3 studies   0 studies

Review abstracts (exclude reviews, case reports, letters to editor, expert opinion articles, publication on congress proceedings).

Potential studies

MEDLINE   **EMBASE**

2 studies   0 studies

Exclude repeated studies and review full text.

MEDLINE   **EMBASE**

6 studies[2,7,21,26,35,39]   1 study[1]

Fig. 1 Flowchart showing the literature search strategy followed by the authors. Medline and EMBASE databases were used

Table 1 Demographics of patients in the seven reviewed articles

Study	Journal	Year	Level of evidence [38]	No. of patients	Surgical approach[a]	Gender (M/F)[b]	Age (years)[c]	Follow-up (months)[c]
Kazimoglu et al. [7]	Int Orthop	2009	III	37	Lateral	M/F:26/11	5.9 years (2–12)	29.5 months (19–62)
Kaewpornsawan [2]	J Pediatr Orthop B	2001	II	14	Lateral	M/F:11/3	6.8 years (4.2–9.4)	5 months (2.5–7.5)
Ozkoc et al. [1]	Arch Orthop Trauma Surg	2004	III	44	Posterior	M/F:25/19	10.7 years (3–15)	35 months (27–46)
Ay et al. [35]	J Pediatr Orthop	2005	IV	61	Anterior	M/F:35/26	8.7 years (3–13)	42 months (12–72)
Mulhall et al. [21]	Int Orthop	2000	IV	16	L:7; M:6; P:1; M + L:2	M/F:8/8	5.9 years (3–10)	31 months (24–65)
Mohammed and Rymaszewski [26]	Injury	1995	IV	10	M:6; P:2; M + L; 2	N/A	7.5 years (4–14)[d]	12 months (at least)
Kumar et al. [39]	Injury	2002	IV	44	M:38; A:4; M + L:2	M/F:34/10	8 years (2–14)	14 months (6–36)

[a] Surgical approaches: L lateral, M medial, P posterior, M + L medial and lateral, A anterior

[b] Gender: M male, F female

[c] Values expressed as means, with ranges in parentheses

[d] Age and follow-up: mean of the whole study group (32 patients)

standardized residues when the test was statistically significant. When two qualitative variables are analyzed using contingency tables, the Chi-square test is usually used. This test is based on the comparison between the observed frequency and the expected frequency if there was no relationship between both variables. The difference between both values is the "standardized residue"; it has a normal distribution $N(0, 1)$, so if we obtain a value greater than 1.96, we can consider it as being significant with a high frequency ($P < 0.05$).

Statistical analyses were conducted using Stata 9.1/SE (StataCorp., College Station, TX) and P-values lower than 0.05 were considered to be statistically significant for all analyses.

Results

We identified after our searches, 194 articles (Fig. 1); after applying our eligibility criteria, we had seven papers for systematic review and data synthesis [1, 2, 7, 21, 26, 35, 39].

The patient groups were well matched at baseline for the available demographic data (Table 1). Associated injuries such as nerve/arterial injuries, open fractures, and ipsilateral fractures were described and compared among surgical approaches. There were 23 nerve injuries (10.1%), with radial nerve injury being the most common (11), followed by the anterior interosseous nerve (7), ulnar nerve (2), and diffuse paresthesias (3). Arterial injury (brachial artery) was seen in 15 cases (6.63%). Four open fractures [40, 41] were reported (1.76%; two grade II, one grade I, and one not specified) and ten cases with an ipsilateral fracture (4.42%) were found (Table 2). Weighted means were used for the distribution of these associated injuries into the different groups of surgical approaches, and no statistically significant differences were found (Table 3). A total of 226 patients were included in the analysis.

All articles reported functional, cosmetic, and radiological outcomes, as well as post-surgical complications according to different surgical approaches. Three articles reported results regarding the lateral approach [2, 7, 21], three articles regarding the medial approach [21, 26, 39], three articles regarding the posterior approach [1, 21, 26], two articles regarding the anterior approach [35, 39], and three articles regarding the combined approach (medial + lateral) [21, 26, 39].

In all cases of the studies used for the analysis of the cosmetic, functional, and radiological outcomes, as well as for the post-surgical complications, a primary open reduction was done and no statistically significant difference was found among the different surgical approaches used regarding the associated injuries. The functional and cosmetic outcomes were divided into their subcategories

Table 2 Associated injuries before open reduction was performed in the seven reviewed articles

Author	Journal	Year	No. of patients	Nerve injury	Arterial injury	Open fracture[a]	Ipsilateral fracture
Kazimoglu et al. [7]	Int Orthop	2009	37	3 (1 ulnar/2 radial)	0	1 (I)	2
Kaewpornsawan [2]	J Pediatr Orthop B	2001	14	2 (anterior interosseous)	0	0	0
Ozkoc [1]	Arch Orthop Trauma Surg	2004	44	0	0	0	2
Ay et al. [35]	J Pediatr Orthop	2005	61	9 (3 anterior interosseous/6 radial)	7 (brachial artery)	2 (II)	5
Mulhall et al. [21]	Int Orthop	2000	16	4 (2 median/1 ulnar/1 radial)	4 (brachial artery)	0	0
Mohammed and Rymaszewski [26]	Injury	1995	10	3 (general paresthesia)	0	1 (not specified)	0
Kumar et al. [39]	Injury	2002	44	2 (radial nerve)	4 (brachial artery)	0	1

[a] Open fractures: classified according to Gustilo classification [40, 41]

for analysis according to Flynn's criteria [23] (excellent, good, fair, and poor).

Functional outcome

Four subcategories were evaluated (excellent, good, fair, and poor). Weighted means for the distribution of patients into each subcategory were used and the Chi-square test was used for the assessment of statistical difference. There were three subcategories into which a statistically significant difference was found (excellent, good, poor; Table 4). Standardized residues were used to evaluate the difference among the different surgical approaches within these subcategories. There was a high frequency of excellent results within the lateral and medial approaches ($P < 0.05$), high frequency of good results ($P < 0.05$) within the anterior approach, and a high frequency of poor results within the posterior approach ($P < 0.05$).

Cosmetic outcome

As it was done with the functional outcome, weighted means for the distribution of patients into each subcategory were used and the Chi-square test was used for the assessment of statistical difference. There were two subcategories into which a statistically significant difference was found (fair, poor; Table 5). Standardized residues were used to evaluate the difference among the different surgical approaches within these subcategories. There was a high frequency of fair results within the posterior and lateral approaches ($P < 0.05$) and a high frequency of poor results within the posterior approach ($P < 0.05$).

Radiological outcome assessment included time to union. Weighted means were also used and the Chi-square test was utilized to assess for statistical difference among the surgical approaches. The results were as follows: lateral (4.46 weeks), medial (4.70 weeks), posterior (4.02 weeks), anterior (4 weeks), and medial + lateral (4.70 weeks); there was no statistically significant difference ($P = 0.985$).

All seven studies commented on *complications* [1, 2, 7, 21, 26, 35, 39], such as compartment syndrome, nerve/vascular injuries, infections (pin tract infection), and nonunion. Also, wound issues like wound infection and scar problems were commented upon. Weighted means for the distribution of complications into each surgical approach were used and the Chi-square test was used for the assessment of statistical difference. There were no compartment syndromes or nonunions reported; regarding nerve/vascular injuries ($P = 0.566$) and infections ($P = 0.249$), there was no statistically significant difference among surgical approaches (Table 6). No vascular injury was reported and the overall rate of nerve injury was 2.21%. The ulnar nerve was the one affected with a higher

Table 3 Associated injuries before open reduction was performed according to surgical approaches

Surgical approach	Associated injuries[a]			
	Nerve injury	Arterial injury	Open fracture	Ipsilateral fracture
Lateral	6.75	1.80	1.00	2.00
Medial	5.02	5.00	0.60	0.85
Posterior	0.85	0.30	0.20	2.00
Anterior	8.18	7.50	2.00	5.10
Medial + lateral	1.20	1.40	0.20	0.05
P-value	0.569	0.382	0.987	0.488

[a] Contingency table results expressed as weighted means

Table 4 Functional outcome according to surgical approach

Surgical approach	Functional outcome[a]			
	Excellent	Good	Fair	Poor
Lateral	48.69	5.88	3.44	0.00
Medial	40.77	1.61	4.69	2.93
Posterior	23.41	6.13	4.06	13.40
Anterior	47.27	17.09	0.45	0.18
Medial + lateral	4.86	0.30	0.35	0.49
P-value	0.000	0.002	0.159	0.005

Functional outcome according to Flynn's criteria [23]

[a] Contingency table results expressed as weighted means

Table 5 Cosmetic outcome according to surgical approach

Surgical approach	Cosmetic outcome[a]			
	Excellent	Good	Fair	Poor
Lateral	42.69	12.88	1.44	1.00
Medial	41.97	1.61	4.69	1.73
Posterior	33.81	6.13	5.06	2.00
Anterior	47.27	17.09	0.45	0.18
Medial + lateral	5.26	0.30	0.35	0.09
P-value	0.367	0.651	0.041	0.020

Cosmetic outcome according to Flynn's criteria [23]

[a] Contingency table results expressed as weighted means

tendency within the posterior and lateral approaches (cross K-wiring was the construct most often used). The overall pin tract infection rate was 7.96% (18 cases), with a higher tendency of cases within the medial approach. No scar issues were reported and only one case of a superficial wound infection was noted, which resolved with antibiotics.

Discussion

The main aim of the treatment of severely displaced supracondylar fractures is to gain a functional and cosmetically acceptable extremity [7], with no deformity or residual neurovascular deficits [21]. It is the means by which this can be reliably and safely achieved that has caused some controversy. Although closed reduction and percutaneous pinning has been suggested as the preferred treatment [21, 23, 35, 39, 42–44], the technique requires experience and carries risks such as neurovascular complications or incomplete success, which is, in that sense, a reason why open reduction and pinning gain a place within the treatment of these fractures.

Traditionally, open reduction and pinning has been reserved for cases with primary vascular or neural disruption, open fractures, signs of Volkmann's ischemia, failure of closed reduction, and severe swelling not allowing

Table 6 Post-surgical complications according to surgical approach

Surgical approach	Complications[a]			
	Nerve/ vascular injury	Compartment syndrome	Nonunion[b]	Infection[c]
Lateral	2.00	0	0	2.00
Medial	0.86	0	0	9.50
Posterior	2.00	0	0	3.00
Anterior	0.09	0	0	3.00
Medial + lateral	0.05	0	0	0.50
P-value	0.566	1.00	1.00	0.249

[a] Contingency table results expressed as weighted means

[b] No data mentioned in Kumar et al. [39] or Mohammed and Rymaszewski [26]

[c] Pin tract infection

acceptable reduction [1, 4, 19–21, 33, 45]. Regarding vascular compromise, there is a condition that should be known by surgeons taking care of this type of fracture, which is the "pulseless supracondylar humerus fracture". In this condition, knowing the status of perfusion of the hand is crucial for the outcome of the patient. In patients presenting with a well-perfused hand, fracture reduction alone is sufficient; however, in those with a poorly perfused hand, the risk for vascular repair is increased [46]. So, if vascular compromise is present, we could manage it with

closed reduction if the criterion mention previously are present; otherwise, if an open reduction is necessary, an anterior approach would be of great help because we could have excellent exposure of the structures involved [35].

The main indication in the majority of cases is failure of closed reduction. This could be due to instability of the fracture or the interposition of anatomical structures such as the neurovascular bundle or the brachialis muscle (irreducible fracture) [20].

The overall rate of conversion from closed reduction to open reduction ranges from 3 to 46% [1, 5, 47, 48]. However, there are some authors that reported a rate of 1.3% [47]. Regarding irreducible fractures, some authors reported an open reduction rate ranging from 2 to 12%. We think that an acceptable rate will be the lowest one reported; however, we have to bear in mind that this is a multifactorial issue and rates could vary from one center to another.

Time from injury to surgery has been an issue of controversy regarding its effect on complication as well as open reduction rates. Conditions leading to delay in treatment mainly include severe swelling or skin problems around the elbow and health facility problems [49], such as: availability of a medical facility, surgeon, and anesthesiologist with pediatric capabilities [47]. Some authors advocated that delays in surgery of 6–21 h does not significantly alter complication rates or the need for open reduction in children undergoing surgical treatment of these fractures [47, 50–52]; however, this idea is not widely accepted by other authors, who maintained that there is no difference with regards to the complications rates, even though a significant swelling at presentation and delay in fracture reduction could be important warning signs for the development of a compartment syndrome [53]. Walmsley et al. [54] conducted a retrospective study that included 171 children and found that patients waiting for more than 8 h were more likely to undergo open reduction (33 vs. 11.2%; $P < 0.05$). And Yildirim et al. [45] concluded that the probability of switching to open reduction increased by a factor of 4 every 5 h beginning 15 h after injury; an open reduction was always necessary after 32 h. Based on these findings, a definitive conclusion is difficult to obtain, even though our recommendation is to treat this type of fracture as early as possible.

In cases in which an open reduction and pinning is justified, there is no clear evidence of which surgical approach could show better functional, cosmetic, and radiological outcome, as well as fewer complications. Trying to find this out, we focus our analysis onto the data extracted from articles based on primary open reduction and pinning with no statistically significant difference regarding the associated injuries. This provides a homogenous study group and the real behavior of the different surgical approaches regarding the outcomes mentioned above, as well as their post-surgical complications.

Our findings regarding the *functional outcome* show a high frequency of excellent results within the lateral and medial approaches and a high frequency of good results within the anterior approach. The most common reason for a failed reduction is the proximal fragment's buttonholing through the brachialis muscle [37, 55]. Another factor is the interposition of the joint capsule or periosteum between the fracture fragments [35, 37, 55, 56]; this could be managed through an anterior approach or combined with a lateral or medial method (posterolateral or posteromedial displacement), allowing an anatomical reduction. There is some evidence that fibrosis in the brachialis muscle is the principal obstruction to the restoration of extension [39], and through these approaches, this issue could be managed in an optimum fashion with direct access, producing less damage and a less intense inflammatory response with less scarring tissue formation. Some authors have demonstrated no correlation between stiffness and the type of surgical approach used, especially regarding the posterior approach [22, 39]. However, Gruber and Hudson [36] correlate motion restriction with posterior incisions. Our findings show a high frequency of poor results with this approach; this could be explained based on the fact that, through this approach, anterior structures such as the brachialis muscle as well as neurovascular structures could not be achieved and the effect of a retracted scar localized posteriorly could decrease the range of motion, as mentioned by Gruber and Hudson.

Authors performing open reduction through the lateral and posterior approaches [6, 22, 36, 48, 57] have reported change in carrying angle (*cosmetic outcome*) as the most frequently encountered complication. These findings correlate with our results with a high frequency of fair results within the posterior and lateral approaches, as well as a high frequency of poor results within the posterior approach. Medial column comminution and internal rotation of the distal fragment predispose to the coronal tilt, which is the main cause of loss of carrying angle [39, 58, 59]; these facts could not be managed adequately through a lateral or posterior approach.

An important finding to highlight is that the time to union is not affected by the surgical approach used; we did not find a statistically significant difference among the surgical approaches.

No surgical approach showed a higher incidence of complications such as compartment syndrome, nonunion, or nerve/vascular injury. There was a higher tendency of ulnar nerve injury among the posterior and lateral approaches. This could be explained because, when using a cross K-wire construct through the approaches mention

previously, the ulnar nerve is not under direct vision and is prone to be damaged.

Even though our findings show that complications should not be an issue regarding surgical approaches, we feel that orthopedic surgeons should have some idea on how to solve them if they appear. With regard to vascular injury, 10–20% of patients with a type III supracondylar fracture present with an absent pulse [30, 31, 34]; this condition is called "pulseless supracondylar humerus fracture". There is controversy about treatment if the pulse does not return but the hand is well perfused. Omid et al. [11] recommend to admit the child to the hospital, elevate the limb slightly, and observe him or her for at least 48 h. Loss of perfusion can occur during this time and necessitate emergent treatment. As mentioned before, if an open reduction is performed, an anterior approach is indicated in order to allow the evaluation of all vital structures at risk for incarceration between fracture fragments [18]. Remember that early repair of the brachial artery is associated with a high rate of symptomatic reocclusion and residual stenosis [11]. Another possible issue could be neurologic injury, with a reported rate ranging from 10 to 20% [60]. The anterior interosseous nerve appears to be the most commonly injured nerve with extension type fractures [4, 11, 53]; this produces motor deficit without sensory changes. However, a complete median nerve transaction has also been reported with both motor and sensory changes [61]. Open reduction and exploration is not necessarily indicated when this injury is associated with a closed fracture because neural recovery generally occurs after 2–2.5 months, but it may take up to 6 months [62]. Compartment syndrome is a rare complication with a rate ranging from 0.1 to 0.3%, however, its consequences are devastating if an appropriate treatment is not performed. Some authors [53] suggested that ecchymosis and severe swelling, even in the presence of an intact radial pulse with good capillary refill, should alert to the possibility of a compartment syndrome; a fasciotomy should be done immediately. Finally, some words about pin tract infection; it could be presented in up to 6.6% of cases [63, 64]. In general, this problem could be solved with oral antibiotics with or without removing the pins [47, 50].

Limitations within our study must be acknowledged. That few studies selected for analysis was a consequence of the strict inclusion criteria used, this permits us to have a more valuable analysis of the effect of surgical approaches used for open reduction by themselves in the different parameters described. However, the number of patients for analysis decreased. There were few patients within the combined approach (medial + lateral); this did not allow us to make conclusions regarding this approach.

Conclusion

Supracondylar humerus fractures in children are very common and is the most common injury of the children's elbow. Sometimes, an open reduction and pinning is required to obtain an acceptable reduction of these fractures. There are different surgical approaches that can be used for this purpose; however, there is controversy regarding the effect on the functional as well cosmetic outcomes. Our results suggest that a combined anteromedial approach could be the method which allows the achievement of better functional and cosmetic outcomes according to Flynn's criteria. However, the final decision for performing a surgical approach will depend on the surgeon's experience, the anatomical structures involved, as well as the characteristics of the fracture.

The time to union as well as post-surgical complications should not be an issue regarding the surgical approaches used for open reduction and pinning in severely displaced supracondylar humerus fractures in children.

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