

## LATERAL ENTRY PINNING AND CROSSED ENTRY PINNING IN PEDIATRIC SUPRACONDYLAR HUMERAL FRACTURES GARTLAND TYPE III

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### ABSTRACT:

**Background:** *Supracondylar humeral fracture is a very common pediatric trauma disorder. It is very common between four and eleven years, more in boys than girls and left side affected more than right one. Major cases are extension type, which is sub classified according to Gartland classification by severity diagnosed radiologically through plain x-rays. Displaced fractures usually need fixation to avoid functional and cosmetic complications.*

**Aim of the Work:** *This systematic review of literature and meta-analysis is conducted to compare between two methods of closed pinning of Gartland's III supra-condylar humeral fractures comparing lateral entry wires and crossed wires according to ulnar nerve injury and post-operative clinical and radiological outcomes.*

**Patient and Method:** *Recent after 2000 clinical trials or cluster trials, prospective and retrospective comparative cohort studies. Search results will be uploaded to systematic review management software and manually screened for eligibility to be included. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart will be introduced on the search results.*

**Data Sources:** *Medline databases (PubMed, Medscape, Science Direct, EMF-Portal) and all materials available in the Internet till 2020.*

**Results:** *Closed reduction and per-cutaneous pinning, of supracondylar humeral fractures in children by lateral only and crossed medial and lateral wires result in similar construct stability and functional outcome, and there was significant difference between the two managements as for the complications of ulnar nerve injury which is higher in crossed pinning.*

**Conclusion:** *Lateral pinning with proper technique for sake of safety and to minimize risk of ulnar nerve injury in addition to adequate stability if proper pin fixation principles are used.*

**Keywords:** *Supracondylar humeral fractures, closed reduction, crossed pinning*

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### INTRODUCTION:

Supracondylar fracture of distal humerus (SCHF) is one of the common pediatric fractures that are encountered in orthopedics practice. Eighty-five percent of children are

between 4-11 years of age. It accounts for around 3-7 % of all pediatrics fractures.<sup>(1)</sup>

Untreated type III supracondylar fractures are the common cause for cubitus varus deformity<sup>(2)</sup>. The main aim of treatment in

supracondylar fracture is to prevent such varus, and rotational deformity. There are various modalities of treatments that range from conservative to operative. Undisplaced fractures are treated conservatively. Gartland type III supracondylar fractures are very unstable fractures. They require proper reduction and stable fixation to prevent such deformity.<sup>(3)</sup>

The standard method of fixation of displaced fractures is closed reduction and per-cutaneous pinning. The aim of this study is to compare between lateral entry pinning and crossed pinning techniques according to safety and efficacy (functional and radiological).<sup>(4)</sup>

Crossed pinning provides increased biomechanical stability, but it carries the risk of iatrogenic ulnar nerve injury from the placement of the medial pin. On the other hand lateral pinning provides less biomechanical stability but less risk of ulnar nerve injury.<sup>(5)</sup>

Some authors believe that (two ‘divergent’ lateral pins or three lateral pins are equivalent in terms of rotational stability to crossed pins) and without having the risk of iatrogenic ulnar nerve injury.<sup>(6)</sup>

The literature is still lacking consensus about a certain number and configuration of pins. this study is conducted to compare between the crossed and lateral-only pins regarding the provided stability and the risk of ulnar nerve injury.

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## AIM OF THE STUDY

This systematic review of literature and meta-analysis is conducted to compare between two methods of closed pinning of Gartland’s III supra-condylar humeral fractures comparing lateral entry wires and crossed wires according to ulnar nerve injury and post-operative clinical and radiological outcomes.

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## METHODS:

**Types of studies:** Recent after 2000 clinical trials or cluster trials, prospective and retrospective comparative cohort studies. Search results will be uploaded to systematic review management software and manually screened for eligibility to be included. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart will be introduced on the search results.

**Types of participants:** Only human subjects aged (2-10 years old) with a recent fracture supracondylar humerus.

**Types of interventions:** Treatment by closed reduction and pinning either lateral pinning or crossed pinning by k-wires

Types of outcome measures: Neurologic (ulnar nerve injury) and vascular examination of the extremity. Flynn’s criteria,<sup>(7)</sup> which are based on the carrying angle and elbow motion,(table 5).

Table 1. Flynn crieteria<sup>(8)</sup>

Results	Rating	Cosmetic loss of carrying angle (deg.)	Functional loss of motion (deg.)
Satisfactory	Excellent	0-5	0-5
	Good	5-10	5-10
	Fair	10-15	10-15
Unsatisfactory	Poor	>15	>15

**Selection criteria for studies:**

**Inclusion criteria:** Prospective and retrospective comparative studies discussing the results of various techniques as surgical management of supracondylar humerus fracture in pediatric patients. Reporting functional outcomes following each technique. Studies conducted in English. Gartland type III supracondylar fracture. In period of 2000-2019. Human studies. Journal articles. Exclusion criteria. Studies conducted in other languages than English. Animal studies studies before 2000. Gartland type I and II supracondylar fractures

Search strategy for identification of study:

**The search will be conducted by using the databases:** Without restrictions on location or publication types: PubMed, EMBASE, the Cochrane Library, and the Google Scholar database . The Mesh terms and their combinations used in the search were as follows: “supracondylar humeral fractures” OR “SCHF” AND “closed reduction” AND “crossed pinning”, “lateral pinning”. The reference lists of related reviews and original articles were searched for any relevant studies.

**Methods of the review:**

**Locating and selecting studies:** Abstracts of articles identified using the search strategy above will be viewed, and articles that appear to fulfill the inclusion criteria will be retrieved in full. When there is doubt, a second reviewed will assess the article and consensus will be reached.

**Data extraction:** Data will be independently extracted by two reviewers and cross-checked.

**Statistical considerations:**

Outcomes from included trials will be combined using the systematic review manager software and manually screened for eligibility to be included. PRISMA flow-chart will be produced based on the search results and the inclusion/exclusion criteria .to facilitate the assessment of possible risk of bias of each study, information will be collected using the (Cochrane collaboration tool for assessing the risk of bias). After pooling of the collected data from the desired search studies. The relative risk of each of the intended outcome measures of interest will be calculated.

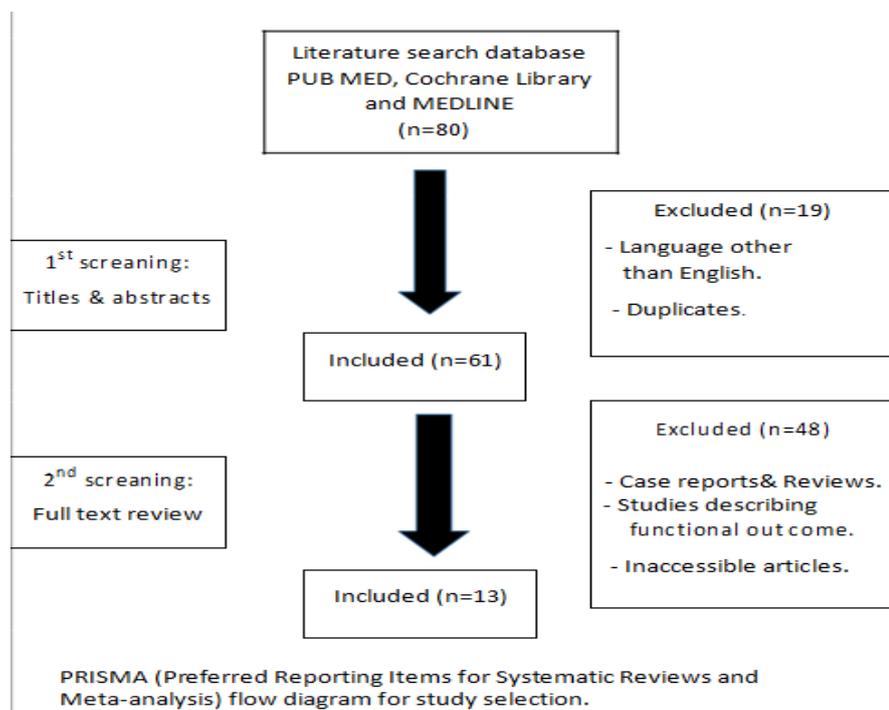


Diagram 1. PRISMA chart

**Statistical methods**

Statistical analysis was done using the jamovi project (2019) [jamovi Version 1.0 Computer Software. [Retrieved from <https://www.jamovi.org>]

**Assessment of heterogeneity:** Studies included in meta-analysis were tested for heterogeneity of the estimates using the following tests: Cochran Q chi square test: A statistically significant test (P-value <0.1) denoted heterogeneity among the studies. I-square (I<sup>2</sup>) index which is interpreted as follows: I<sup>2</sup> = 0% to 40%: unimportant heterogeneity. I<sup>2</sup> = 30% to 60%: moderate heterogeneity. I<sup>2</sup> = 50% to 90%: substantial heterogeneity. I<sup>2</sup> = 75% to 100%: considerable heterogeneity.

**Assessment of publication bias:**

Publication bias was assessed by: Examination of funnel plots of the estimated effect size on the horizontal axis versus a measure of study size (standard error for the effect size) on the vertical axis. In the presence of publication bias, the plots are asymmetrical. Begg and Mazumdar rank correlation analysis for asymmetry of funnel plot. Egger regression analysis for asymmetry of funnel plot.

**Pooling of estimates:** Binary outcomes are presented as log odds ratio with 95% confidence limits (95% CI). Estimates from included studies were pooled using restricted maximum likelihood (REML) random-effects model. P-value <0.05 is considered statistically significant.

**RESULTS:**

Table 2. Summary of included studies, comparing crossed versus lateral pinning.

Authors	Year	Journal	Type
Hossam et al. <sup>(9)</sup>	2019	The Egyptian Orthopaedic Journal	Prospective randomized study
Pavone et al. <sup>(10)</sup>	2016	J. Funct. Morphol. Kinesiol.	Retrospective study
Pesenti et al. <sup>(11)</sup>	2017	Orthopedics& traumatology surgery& research	Retrospective study
Sapkota et al. <sup>(12)</sup>	2018	Asian Journal of Medical Sciences	Prospective non randomized study
Kocher et al. <sup>(13)</sup>	2007	THE JOURNAL OF BONE AND JOINT SURGERY	Prospective randomized study
Prashant et al. <sup>(14)</sup>	2016	J OrthopaedTraumatol	Prospective randomized study
Palange et al. <sup>(15)</sup>	2019	International Journal of Orthopaedics Sciences	Prospective randomized study
Solak et al. <sup>(16)</sup>	2003	Journal of Pediatric Orthopaedics B	Retrospective study
Govindasamy et al. <sup>(17)</sup>	2016	International Journal of Research in Orthopaedics	Retrospective study
Naik et al. <sup>(18)</sup>	2017	Journal of Clinical and Diagnostic Research.	Prospective randomized study
Baharti et al. <sup>(19)</sup>	2018	International Journal of Biomedical Research	Prospective randomized study
Vaidya et al. <sup>(20)</sup>	2009	UNIVERSITY OF SEYCHELLES American Institute of medicine	Prospective randomized study
Patil et al. <sup>(21)</sup>	2017	International Journal of Orthopaedics Sciences	Prospective randomized study

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Table 3. Number, sex ,side, age, follow up period of included studies.

Study	Number of patients	Mean age	Crossed pins	Lateral only pins	Mean follow-up	Females	Males	Rt side	Lt side
Hossam <sup>(9)</sup>	67	5.4 vs 4.9	33	34	12 weeks	22	45	15	42
Pavone <sup>(10)</sup>	35	6.26 vs 5.69	22	13	12 months	10	25	13	24
Pesenti <sup>(11)</sup>	235	6.5 vs 6.3	177	58	4.7 months	106	129		
Sapkota <sup>(12)</sup>	34	7.59 vs 7.53	17	17	6 months	13	21		
Kocher <sup>(13)</sup>	52	5.7 vs 6.1	24	28	3 months	29	23		
Prashant <sup>(14)</sup>	62	8.55 vs 8.25	31	31	6 months	17	45	14	48
Palange <sup>(15)</sup>	30	6.52 vs 7.41	15	15	6 months	19	11	12	18
Solak <sup>(16)</sup>	59	5	35	24	6 months	43	16		
Govindasamy <sup>(17)</sup>	55	6.75	28	27	6 months	22	33		
Naik <sup>(18)</sup>	57	6.28 vs 7.25	29	28	12 months	21	36	25	32
baharti <sup>(19)</sup>	45	6.7	28	17	12 month	32	13	14	31
VAIDYA <sup>(20)</sup>	60	5.8 vs 6.2	31	29	6 months	22	38	26	34
Patil <sup>(21)</sup>	30	8	15	15	6 months	11	19	8	22
Total/mean	821		485	336		367	454		

Table 4. Pooled outcome measures.

Study	Ulnar n. injury in crossed group		Technique of medial pin insertion	Flynn score				Other complications
		Study participants		Excellent	Good	fair	Poor	
Hossam et al. <sup>(9)</sup>	0	33	Small incision 1.5–3.0 cm	27	4	1	1	
Pavone et al <sup>(10)</sup>	2	22	a landmark on the medial epicondyle	21	1	0	0	
Pesenti et al. <sup>(11)</sup>	7	177	A minimally invasive 2-cm Approach				4	
Sapotka et al <sup>(12)</sup>	1	17	Not mentioned	11	5	1	0	2 radial palsy 5 pin tract infection
Kocher et al. <sup>(13)</sup>	0	24	A small medial incision of 1.5 to 3.0 cm over the medial epicondyle.	19	4	1	0	
Prashant et al. <sup>(14)</sup>	2	31	extended elbow and the ulnar nerve rolled back with the opposite thumb	26	5	0	0	4 pin tract infection
Palange et al. <sup>(15)</sup>	3	15	small incision was taken	10	4	1	0	
Solak et al. <sup>(16)</sup>	2	35	Not mentioned	21	8	6	0	1 median nerve 4 anterior inter osseus n inj
Govindasamy et al. <sup>(17)</sup>	3	28	Elbow extension	22	6	0	0	
Naik et al. <sup>(18)</sup>	2	29	small incision was	23	0	6	0	

			taken					
Baharti et al. <sup>(19)</sup>	2	28	Elbow extension	23	5	0	0	3 pin tract infection
VAIDYA et al. <sup>(20)</sup>	3	31	2-3 cm medial incision	24	5	2	0	3 pin tract infection
Patil et al. <sup>(21)</sup>	1	15	Rolling , elbow extension	10	5	0	0	

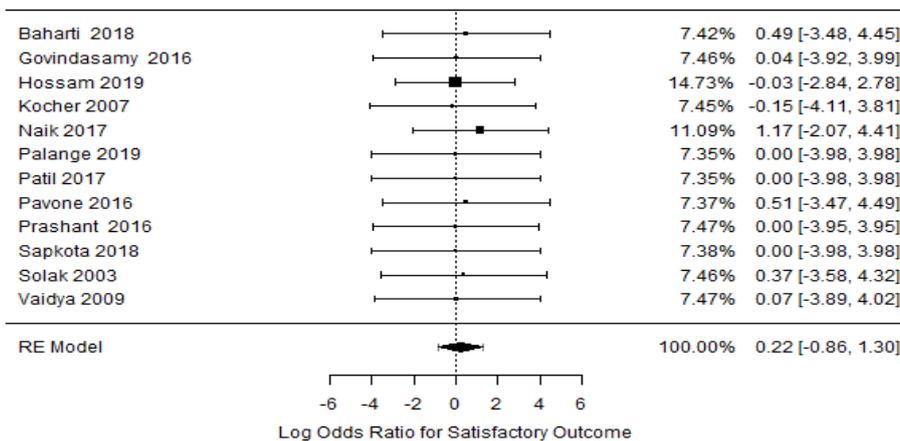


Diagram 2. Forest plot for achievement of satisfactory (fair to excellent) outcome as per Flynn's criteria

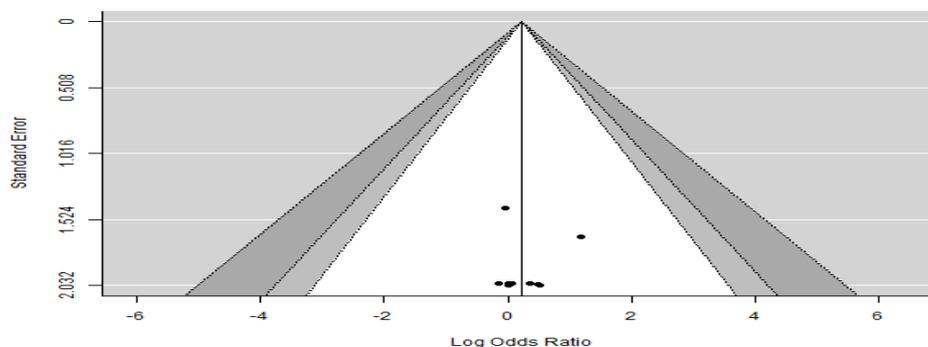


Diagram 3. Funnel plot for achievement of satisfactory (fair to excellent) outcome as per Flynn's criteria.

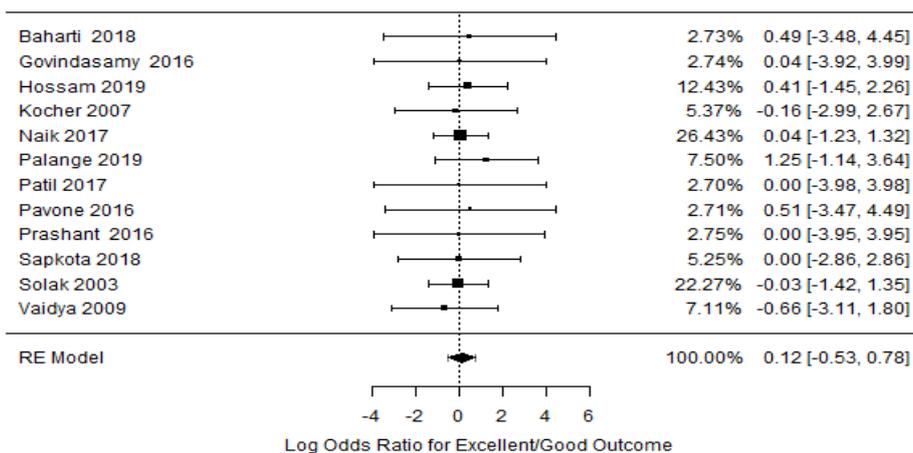


Diagram 4. Forest plot for achievement of excellent/good outcome as per Flynn's criteria

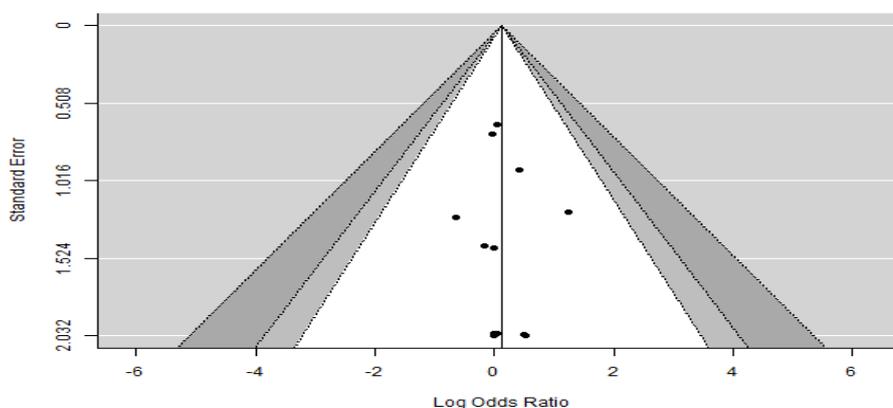


Diagram 5. Funnel plot for achievement of excellent/good outcome as per Flynn's criteria

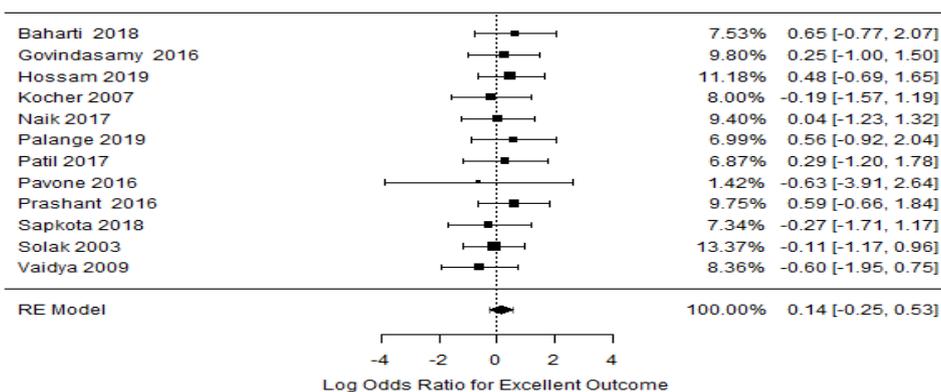


Diagram 6. Forest plot for achievement of excellent outcome as per Flynn's criteria

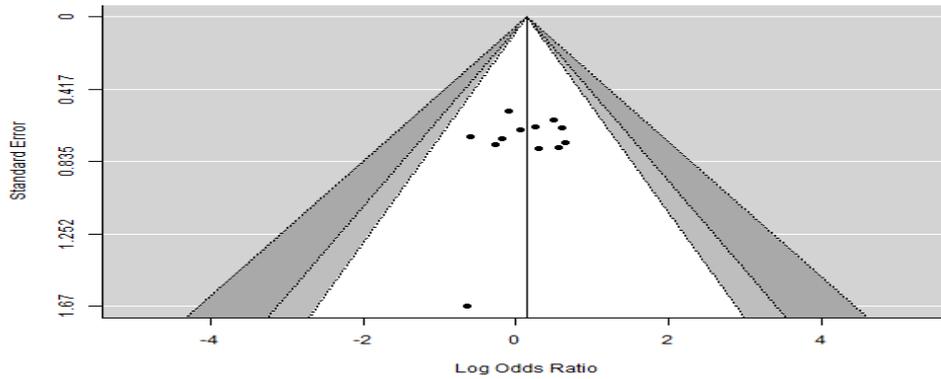


Diagram 7 Funnel plot for achievement of excellent outcome as per Flynn’s criteria

**Table 5.** Incidence of iatrogenic ulnar nerve injury

Technique	Ulnar nerve injury	Total	Incidence
Crossed pinning	28	485	5.7%

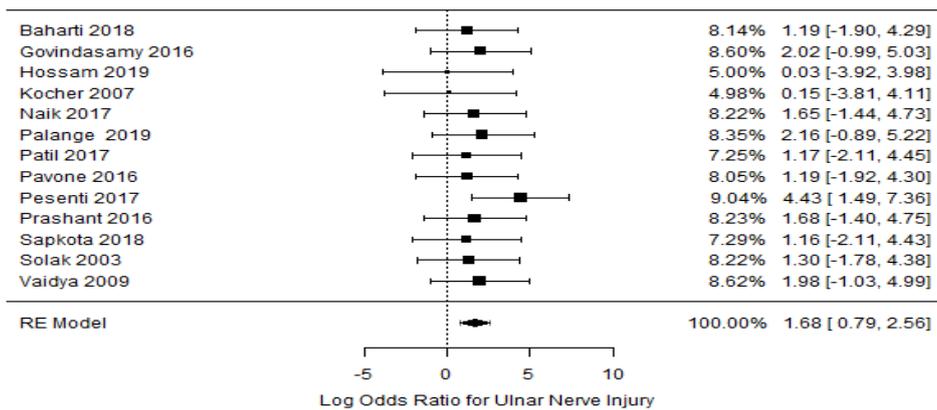


Diagram 8 Forest plot for risk of ulnar nerve injury. Crossed-entry pinning is associated with higher risk for ulnar nerve injury which is statistically significant (log odds ratio = 1.68, 95% CI = 0.79 to 2.56). There is unimportant heterogeneity across studies (I-squared = 0%, Cochran Q test P-value = 0.950).

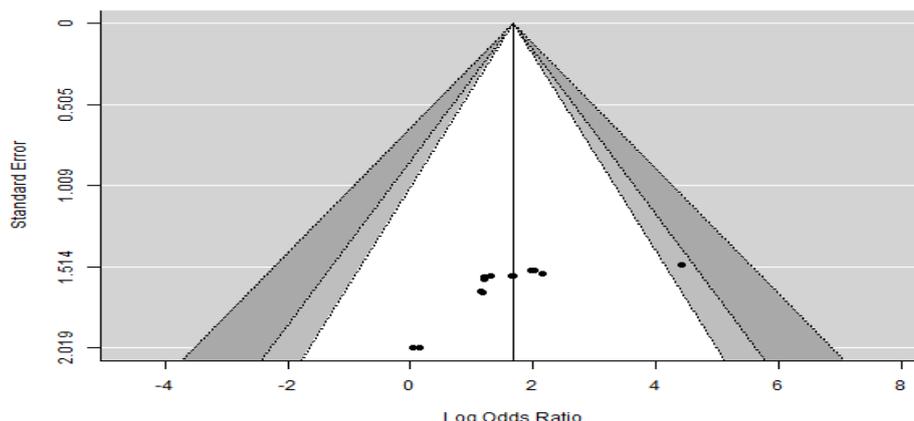


Diagram 9 Funnel plot for risk of ulnar nerve injury

Table 6. A summary of the results of similar meta-analysis.

Authors	Date	No of studies included	Stability	Iatrogenic ulnar nerve injury
O L Carrazone <sup>(22)</sup>	2020	12 ( 930 patient)	Crossed pinning more stable	higher risk in Crossed
Y Na <sup>(23)</sup>	2018	24 (2222 patient )	Crossed pinning more stable	higher risk in Crossed
A E Dekker <sup>(24)</sup>	2016	13 (1158 patient)	No difference	higher risk in Crossed
P Woratanart <sup>(25)</sup>	2012	18 (1615 patient)	No difference	higher risk in Crossed
T Yousri <sup>(26)</sup>	2012	2	No difference	higher risk in Crossed
C A Brauer <sup>(27)</sup>	2007	35(2054 patient)	Crossed pinning more stable	higher risk in Crossed

**DISCUSSION:**

The ideal treatment for displaced supracondylar humeral fractures, according to many authors, is closed reduction and percutaneous pinning. A debate between the two fixation techniques by K-wires; lateral pins only and crossed (lateral and medial) pins still exists with ne consensus considering biomechanical stability and the risk of iatrogenic nerve injury. Although iatrogenic ulnar nerve injuries usually resolve, several permanent iatrogenic ulnar nerve injuries have been described.<sup>(28)</sup>

In the current study, we found that closed reduction and percutaneous pinning utilizing both techniques has comparable clinical outcomes according to the Flynn’s criteria, with a significantly higher risk of iatrogenic ulnar nerve injury in the crossed group.

The selection of the appropriate surgical technique is important for the maintenance of reduction and to avoid iatrogenic ulnar nerve injury. The positioning of the fracture within acceptable radiographic parameters and the stabilization and proper positioning of the wires are crucial points for good outcomes.<sup>(29)</sup>

Crossed pinning was considered more biomechanically stable compared to lateral only pins as reported by Zions et al<sup>(30)</sup>, while other authors as Skaggs et al.<sup>(31)</sup> believed that no stability difference when considering technical points like maximizing separation of the pins at the fracture site, engaging the medial and lateral columns proximal to the fracture, engaging sufficient bone in both the proximal segment and the distal fragment and pin diameter and torsional stability intra operative advised by Bloom et al.<sup>(32)</sup> with addition of third lateral pin if not stable after two give same stability as medial pin without risk of ulnar nerve injury. Arino et al.<sup>(33)</sup> recommended the use of two lateral pins to

avoid injury to the ulnar nerve, and two recent meta-analyses<sup>(34,35)</sup> support this recommendation.

The reviewed articles have concluded that medial-entry pinning, may have a higher risk of ulnar nerve injury with no significant difference regarding stability and post-operative outcomes according to Flynn criteria.

Other systematic reviews were conducted comparing both techniques of fixation have reported similar results.<sup>(24)(25)(26)</sup> However, Carrazone et al.<sup>(22)</sup>, Y Na et al.<sup>(23)</sup> and Brauer et al.<sup>(27)</sup> reported that crossed pinning as more stable with less post-operative displacement, but with a higher risk of ulnar nerve injury compared to lateral group.

There are a number of limitations in the current study, some inherent to all systematic reviews, and some particular to our review.

First, the studies included in our analysis did not describe the same in technique of medial pin insertion. A small incision or palpation of nerve with elbow extension are believed to be a big concern on iatrogenic ulnar nerve injury, as risk of injury could be minimized up to 0% when minimal incision as done by Kocher et al.<sup>(13)</sup> and Hossam et al.<sup>(9)</sup>. But reported cases of ulnar nerve injury are still in range for previous reports and did not have major effect on iatrogenic nerve injury.

A second limitation is including lower number of studies with Gartland III fractures only despite there are many studies on displaced SCHF Gartland type II and III.

Another limitation is that some studies conducted lateral pins either by two or three K-wires which may account for difference in torsional stability as highlighted by Gordon et al.<sup>(36)</sup> however this did not affect instability compared to other studies using 3 k-wires only. Despite these concerns, the results presented in this review are the most up to date and can be useful in the clinical appraisal of supracondylar humeral fractures.

With regard to general recommendations for clinical practice, the closed reduction and percutaneous fixation of displaced SCFH has satisfactory results, regardless of the technique employed. This review suggests that the lateral wire technique should be used whenever possible, due to the increased risk of neurological lesions with crossed wire fixation. However, for unstable fractures, such as type III with medial comminution, for which a medial wire is found to be necessary, we suggest the use of the crossed wire technique, with special care taken to prevent injury to the ulnar nerve. The use of a mini-medial incision to identify the ideal entry point for the wire in the epicondyle is recommended.

Lastly we recommend larger prospective randomized controlled studies to be done including a larger number of patients done comparing lateral three pins with medial and lateral pins. With comparison of results including iatrogenic injury of all nerves including radial and median nerves which are at risk during reduction and fixation in both techniques. Revise sentence

### **Conclusion:**

Closed reduction and per-cutaneous pinning, of supracondylar humeral fractures in children by lateral only and crossed medial and lateral wires result in similar construct stability and functional outcome. And there was significant difference between the two managements as for the complications of ulnar nerve injury which is higher in crossed pinning, so we recommend lateral pinning with proper technique for sake of safety and to minimize risk of ulnar nerve injury in addition to adequate stability if proper pin fixation principles are used.

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**مراجعة منهجية و تحليل بعدي لما تم نشره من ابحاث عن كسور فوق اللقمتين بعظمة العضد الدرجة الثالثة عند الاطفال مقارنة التثبيت باسلاك متقاطعة التثبيت مع التثبيت باسلاك من الناحية الوحشية فقط**

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**المقدمة:** تمثل كسور فوق اللقمتين لعظمة العضد نسبة كبيرة من كسور الأطفال بالطوارئ ما بين عمر ٤ و ١١ عام ويمثل نسبة ٩٨% من هذه الكسور كسور إزاحة للخلف وعادة ما يستخدم تصنيف جارتلند لتقييم تحرك الكسر وشكله كسور الدرجة الثالثة جارتلند عادة ما تحتاج إلى التثبيت بواسطة أسلاك معدنية.

**الهدف من البحث:** مراجعة منهجية وتحليل بعدي لما تم نشره من أبحاث عن كسور فوق اللقمتين بعظمة العضد الدرجة الثالثة عند الأطفال مقارنة التثبيت بأسلاك متقاطعة التثبيت مع التثبيت بأسلاك من الناحية الوحشية فقط.

**المرضى وطرق البحث:** تضمنت الدراسة مقارنة النتائج العملية في دراسات سابقة منذ سنة ٢٠٠٠ بطريقتين تثبيت الكسر والتي كانت تشتمل مقارنة نتائج تثبيت حالات بواسطة أسلاك معدنية من الناحية الوحشية فقط وأسلاك بطريقة متقاطعة.

**النتائج:** لا يوجد اختلاف في النتائج بين طريقتي التثبيت من ناحية خصائص فلاين من حيث الشكل ومعدل الحركة في حين احتمالية حدوث إصابة العصب الزندي أكثر في طريقة التثبيت بواسطة أسلاك متقاطعة.

**الاستنتاج:** يوصى بتثبيت من الناحية الوحشية فقط مع مراعاة الإجراءات الصحيحة لتأكيد ثبات الكسر وتقادي الإصابة للعصب الزندي.