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Original Article

A Systematic Review of Medial and Lateral Entry Pinning Versus Lateral Entry Pinning for Supracondylar Fractures of the Humerus

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Abstract

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Background: Some authors propose lateral entrance pins alone after closed reduction, while others recommend medial/lateral pins that include one medial and one lateral.

Aim of the study: This study aims to detect association between iatrogenic nerve injury and surgical treatment of types II and III supracondylar fractures with medial/lateral or lateral entry pins.

Patients and Methods: A search strategy was formulated firstly then we used it on different databases such as PubMed, Web of Science, Cochrane Library, and Scopus to reach the studies compared the Medial and Lateral Entry Pinning and Lateral Entry Pinning. Screening was done followed by data extraction and statistical analysis of the outcomes.

Results: Success rate was reported in only four studies counting for 232 [84.9%] of 273 in the crossed pinning entry compared to 399 [84.8%] of 470 in the lateral pinning entry. The pooled odds OR showed no significant difference [OR = 1.04, 95% CI [0.82 to 1.31], P= 0.77]. Iatrogenic ulnar nerve injury was the most common problem reported in 20 studies of the 27 studies included in this meta-analysis. The data were pooled across all 20 studies, and the pooled OR revealed a significant higher incidence of the crossed pinning entry occurring in 37 [4.36%] of 849 children allocated whereas the iatrogenic ulnar nerve injury was occurred in 10 [1.03%] of 967 children allocated to the lateral pinning entry [OR= 2.07, 95% CI [1.07 to 3.98], P=0.03].

Conclusion*:* The most reliable method is to use medial/lateral entry pins, while being cautious to prevent any nerve damage caused by medical intervention, regardless of the chosen treatment methodology.

Keywords: Medial; Lateral Entry; Pinning; Supracondylar Fractures; Humerus.

INTRODUCTION

Young children under 15 often suffer elbow injuries. [1] The supracondylar fracture of the distal humerus accounts for 75% of pediatric elbow injuries in the region. Due to thin supracondylar bone architecture and ligamentous laxity, children aged 5–10 usually suffer the injury [2,3]. It is believed that 95% to 98% of supracondylar fractures occur while the hand is extended, while less than 5% occur when the elbow is flexed [4]. Supracondylar fractures are often classified based on Gartland's system, which consists of three types: type I [non-displaced], type II [angulated with intact posterior cortex], and type III [totally displaced] [5]. In the past, these injuries have been linked to considerable morbidity caused by malunion [6-8].

A long arm cast is typically used to treat type I fractures, while closed reduction and casting alone can be used to treat type II fractures. However, percutaneous pinning is typically the preferable method [9].

Some propose lateral entrance pins alone after closed reduction, while others recommend medial/lateral pins that include one medial and one lateral. Lateral pins avoid the medial entry site, preventing ulnar nerve damage, however they impair mechanical stability [10, 11].

Medial/lateral entrance pins improve mechanical stability, but they may injure the ulnar nerve [12]. This study aims to detect association between iatrogenic nerve injury and surgical treatment of types II and III supracondylar fractures with medial/lateral or lateral entry pins.

PATIENTS AND METHODS

Upon the PRISMA guidelines we performed our systematic review.

Literature search strategy: Three authors act independently to search on network databases including PubMed, Cochrane Library, Web of Science, EMBASE and Scopus to identify randomized controlled trials [RCTs], retrospective studies and prospective studies on Medial and Lateral Entry Pinning and Lateral Entry Pinning published to September 2023. A search strategy was [[supracondylar fracture humerus] OR [humeral fracture] OR [distal humerus]] AND [[pinning] OR [pins] OR [fixation]] AND [k-wire] OR [wires]] AND [[medial entry] or lateral entry]]

Eligibility criteria

We included all RCTs, retrospective and prospective studies match with the following inclusion criteria:

(1) **Population:** Patients aged 3–13 with type II or III supracondylar humeral fracture and iatrogenic ulnar nerve damage or loss of reduction.

(2) **Intervention:** Medial and Lateral Entry Pinning

(3) **Comparator**: Lateral Entry Pinning

(4) **Outcomes:** Success rate, and iatrogenic nerve injury.

Our exclusion criteria were:

(1) Reviews, and book chapters

(2) Age above 13 years.

Screening

Firstly title/abstract screening was done followed by full-text screening. Searching databases in a total of 2100 studies. 2000 studies were excluded since they did not meet our inclusion criteria. After conducting a thorough analysis of the complete text of the remaining 100 articles, using specific criteria to determine which research to include and exclude, and 27 papers were chosen to be included in the current review.

Data extraction and Risk of Bias assessment: We extracted the characteristics of each study as following: first author, study design, year of publication, duration of study, country, population number, Operation procedures. The Newcastle-Ottawa Scale tool was used for the quality assessment of the studies [Table 1].

Outcomes: Outcomes of the study were Success rate, iatrogenic nerve injury, iatrogenic ulnar nerve injury, deformity and/or loss of reduction. Continuous variables were expressed as mean ± standard deviation, and dichotomous variables are expressed by event number and total number.

Statistical analysis: Using the Mantel-Haenszel [M-H] random-effects model for dichotomous data outcomes, the risk ratio between the two groups was calculated by combining the frequency. All statistical analyses were done by Stata/MP version 17 for Microsoft Windows. Statistical heterogeneity among studies was evaluated by the Chi-square test [Cochrane Q test]. Then, the chi-square statistic, Cochrane Q, was used to calculate the I-squared according to the equation: $I2=\left(\frac{Q-df}{Q}\right)x100\%$. A Chi-square P value less than 0.1 was considered as significant heterogeneity. I-square values ≥50% were indicative of high heterogeneity.

RESULTS

A total number of 39 women were included in our study.

Success rate: Success rate was reported in only four studies counting for 232 [84.9%] of 273 in the crossed pinning entry compared to 399 [84.8%] of 470 in the lateral pinning entry. The pooled odds OR showed no significant difference [OR = 1.04, 95% CI [0.82 to 1.31], P= 0.77]; the pooled results were homogenous [I^2= 0.00%, P= 0.98] as shown in Figure 1.

Iatrogenic ulnar nerve injury: Iatrogenic ulnar nerve injury was the most common problem reported in 20 studies of the 27 studies included in this meta-analysis. The data were pooled across all 20 studies, and the pooled OR revealed a significant higher incidence of the crossed pinning entry occurring in 37 [4.36%] of 849 children allocated whereas the iatrogenic ulnar nerve injury was occurred in 10 [1.03%] of 967 children allocated to the lateral pinning entry [OR= 2.07, 95% CI [1.07 to 3.98], P=0.03]. The pooled results were homogenous [I^2= 0.00%, P= 0.92] as shown in Figure 2.

We used funnel plot to detect for any publication bias, and by inspection, the plot revealed minor asymmetry indicating a possible publication bias, as shown in figure 3. We used the trim and fill method, five studies were imputed to achieve stability, as shown in figure 4. Our finding may be explained by insufficient literature and clinical heterogeneity. We further tested the heterogeneity using Galbraith plot, and there were no studies outside the regression area of the 95% CI, indicating no significant heterogeneity found, as shown in figure 5.

Other evaluated measure such as incidence of radial nerve injury or median nerve injury, showed no significant difference between crossed pinning entry and lateral pinning entry. The pooled OR was 1.03 [95% CI [0.39 to 2.73], P= 0.95] for radial nerve injury and 0.91 [95% CI [0.43 to 1.9], P= 0.79] for median nerve injury, as shown in figures 6 and 7. The pooled studies were homogenous for the two outcomes [I2= 0.00%, P= 0.84; and I2= 0.00%, P= 0.66] for radial nerve injury and median nerve injury, respectively.

Radiological outcomes: Loss of reduction or deformity was reported in eight studies included in this meta-analysis. The incidence of loss of reduction in the crossed pinning entry was 15.33% [48 of 313] of children included whereas the incidence of the lateral pinning entry was 22.78% [72 of 316] of children included. The pooled OR showed no significant difference with 0.7 [95% CI [0.46 to 1.06], P= 0.09]; the pooled results were homogenous [I^2= 0.00%, P= 0.74], as shown in Figure 8.

We used the funnel plot to detect for any publication bias, and by inspection, there was a minor asymmetry in the plot indicating a possible publication bias, as shown in figure 9. We used the trim and fill method to achieve stability, and four studied were imputed to achieve the stability, as shown in figure 10. We also tested the heterogeneity using Galbraith plot, and all studies were in the 95% precision area indicating no significant heterogeneity found.

Other reported outcomes of radiological outcomes, such as the Bauman angel, loss in the Bauman angle, the carrying angle, and loss of the carrying angle, also showed no significant difference between the crossed pinning entry and the lateral pinning entry configurations.

The pooled studies were homogenous for loss in the Bauman angle and loss of the carrying angle [I^2= 0.00%, P= 0.64; and I^2= 0.00%, P= 0.88], respectively. The pooled studies were not homogenous for the Bauman angel and the carrying angle [I^2= 77.28%, P= 0.01; and I^2= 94.94%, P= 0.01], respectively.

We used the leave-one-out model to solve this heterogeneity, and we found that no single study had a disproportional effect on the pooled OR, which varied between 0.4 [95% CI [-0.44 to 1.24]] by excluding Kawk-lee et al., and -0.32 [95% CI [-1.61 to 0.97]] by excluding Abubeih et al. for the Bauman angle, as shown in figure 11.

Leave-one-out model for the carrying angle showed no disproportional effect on the pooled OR, by excluding Jain et al. with OR -0.31 [95% CI [-0.82 to 0.2]], and 0.82 [95% CI [-1.07 to 2.72]] with Kawk-lee et al. excluded, as shown in figure 12.

We further did a sensitivity analysis by removing studies with missing data for the Bauman angel, loss in the Bauman angle, the carrying angle, and loss of the carrying angle, and found no significant difference between the crossed pinning entry and lateral pinning entry configurations [P= 0.05, 0.91, 0.21, and 0.72], respectively.

Functional outcomes: Flynn criteria for the cosmetic and functional outcomes were reported in 17 studies included in this meta-analysis. Excellent and good outcomes were reported in 628 [91.28%] of 688 children treated with crossed pinning entry and 559 [87.48%] of 639 children treated with lateral pinning entry. According to the pooled OR for children reported excellent and good scores, there was no significant difference between crossed pinning and lateral pinning [OR= 1.04, 95% CI [0.89 to 1.22], P= 0.62]; the pooled studies were homogenous [I^2= 0.00%, P= 1.00], as shown in Figure 13.

Regarding other outcomes reported such as total range of elbow motion, loss of range of elbow motion, and deformity, there was no significant difference between the two fixations methods**.** The pooled studies for loss of range of elbow motion, and deformity were homogenous [I^2= 0.00%, P= 0.96; and I^2= 0.00%, P= 0.93], respectively.

The pooled studies for total range of elbow motion were not homogenous [I^2= 89.66%, P= 0.01]. We did a leave-one-out analysis to resolve the heterogeneity, and there was no single study had a disproportional effect on the pooled OR, varied between 0.33 [95% CI [-0.28 to 0.95]] with Kocher et al. excluded, and -0.90 [95% CI [-2.68 to 0.88]] with Maity et al. excluded. We performed a sensitivity analysis by excluding studies with missing data, and the pooled OR showed no significant difference between the two fixations methods.

Complications

The incidence of vascular complications occurred in 14 [4.25%] of 329 children treated with crossed pinning entry and in 18 [3.85%] of 468 children treated with lateral pinning entry. The pooled OR showed no significant difference between the two fixations methods [OR= 1.07, 95% CI [0.53 to 2.18], P= 0.85]; the pooled results were homogenous [I^2= 0.00%, P= 0.98], as shown in Figure 14.

Fourteen studies reported the incidence of pin infections. In the crossed pinning group, 28 [5.25%] of 533 children reported pin infections, whereas 31 [4.25%] of 730 children in the lateral pinning group reported pin infections. There was no significant difference between the two fixations methods [OR= 1.11, 95% CI [0.64 to 1.92], P= 0.71]; the pooled studies were homogenous [I^2= 0.00%, P= 0.96], as shown in Figure 15.

Five studies reported the incidence of pin loosening. There were seven [4.79%] of 146 children treated with crossed pinning entry reported pin loosening, while there were seven [4.82%] of 145 children treated with lateral pinning entry reported pin loosening. The pooled OR showed no significant difference between the two fixations methods [OR= 1.02, 95% CI [0.34 to 3.02], P= 0.98]; the pooled studies were homogenous [I^2= 0.00%, P= 0.87], as shown in Figure 16.

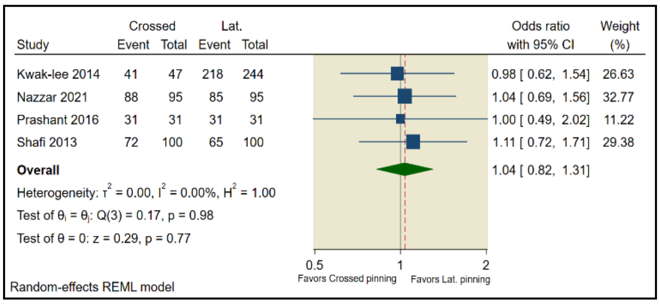

Figure [1]: Forest plot of the success rate

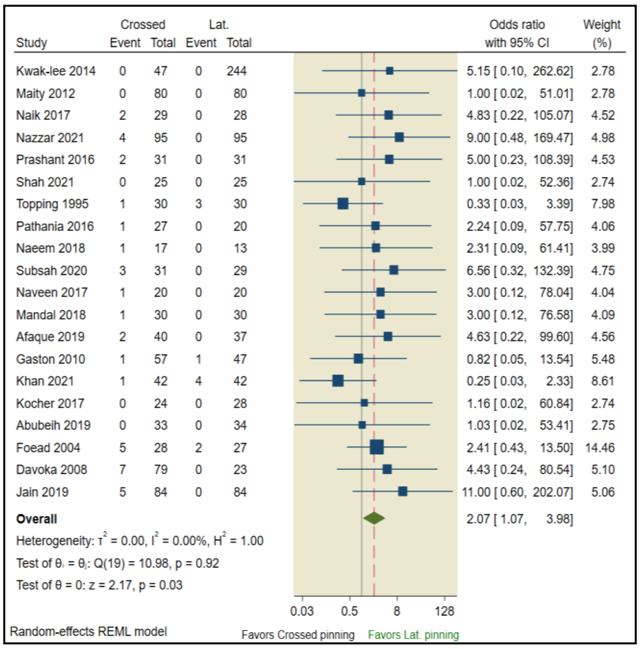

Figure [2]: Forest plot of iatrogenic ulnar nerve injury.

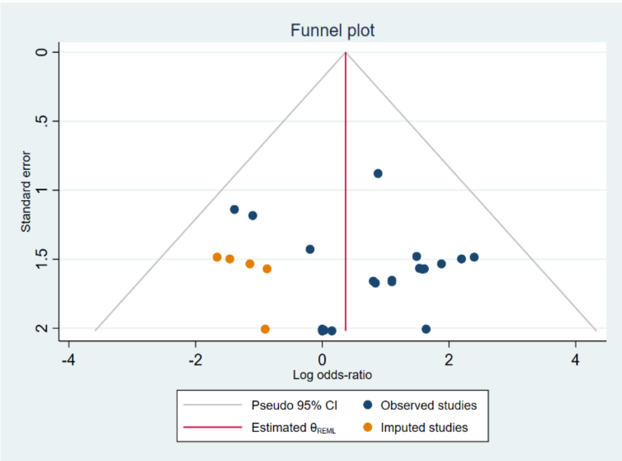

Figure [3]: Funnel Plot of iatrogenic ulnar nerve injury

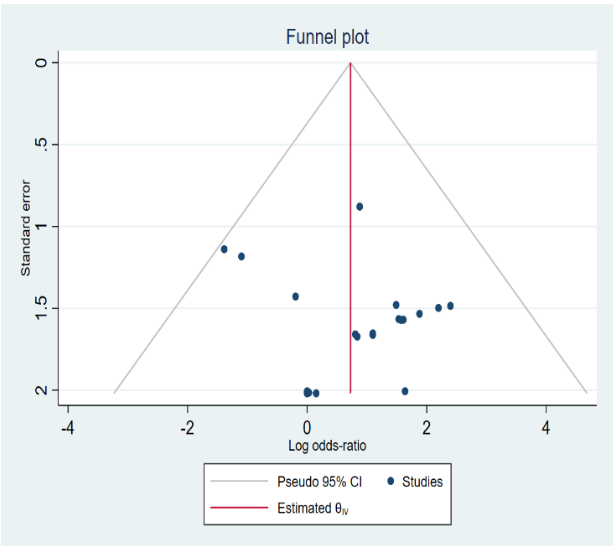

Figure [4]: Trim and fill plot of Iatrogenic Ulnar Nerve Injury

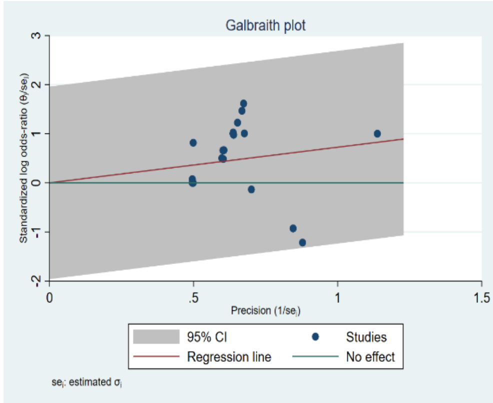

Figure [5]: Galbraith plot of Iatrogenic Ulnar Nerve Injury

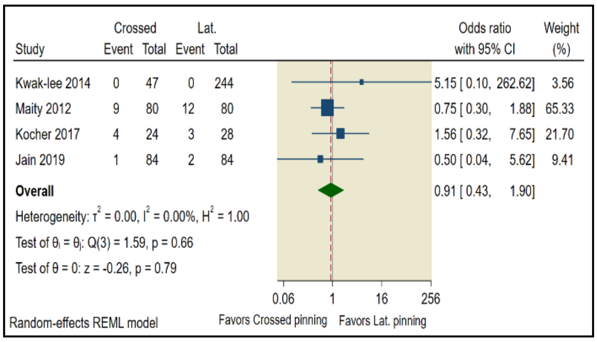

Figure [6]: Forest plot of Radial Nerve Injury

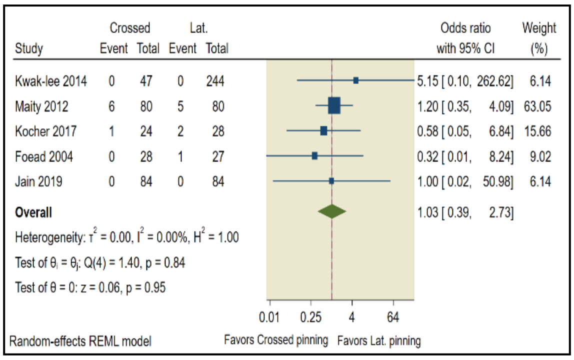

Figure [7]: Forest plot of Median Nerve Injury

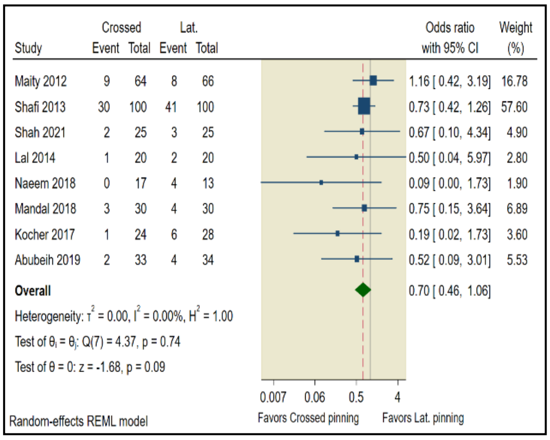

Figure [8]: Forest plot of Radiological outcomes

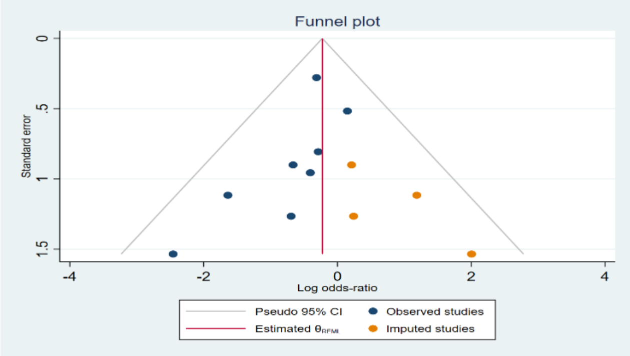

Figure [9]: Funnel plot of Loss of reduction or deformity assessing publication bias

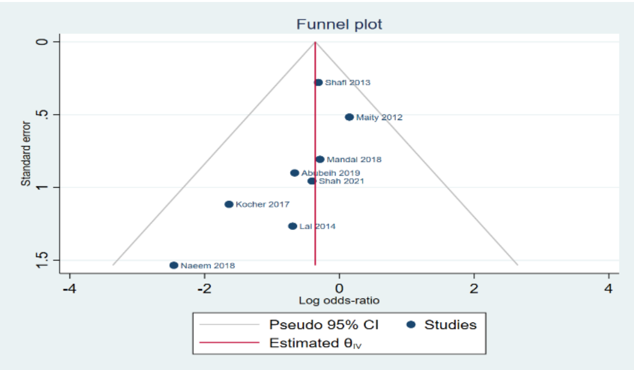

Figure [10]: Trim and fill plot of Loss of reduction or deformity assessing publication bias.

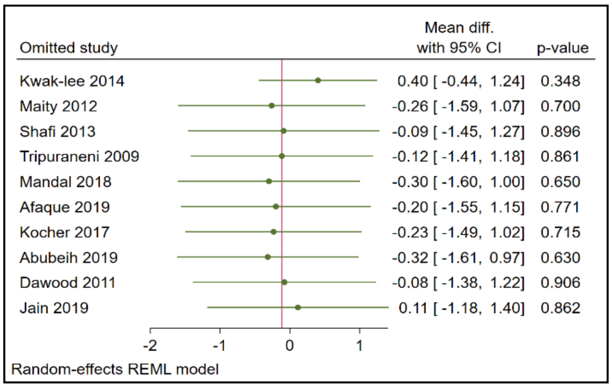

Figure [11]: Leave-one out of final Baumann angle

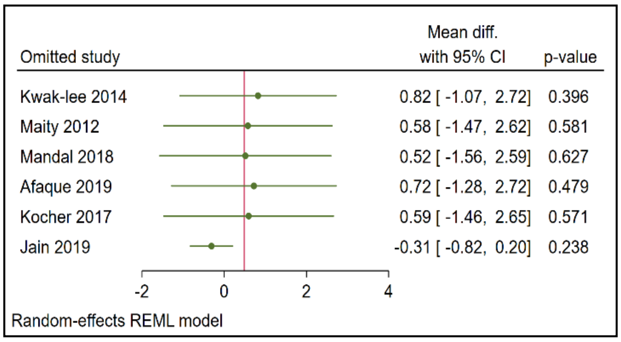

Figure [12]: Leaveoneout of Final Carrying angle

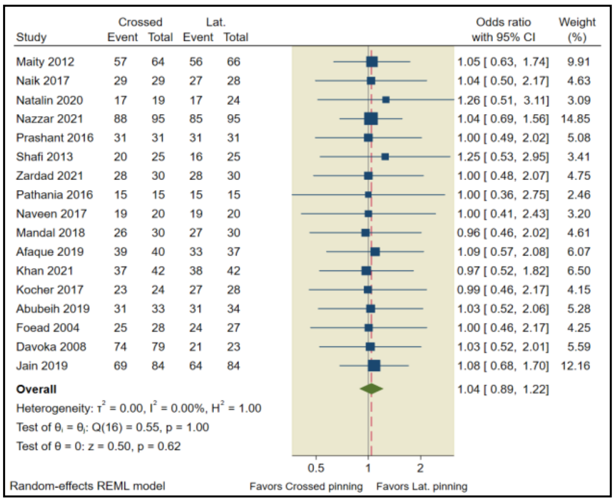

Figure [13]: Forest plot of Functional outcomes

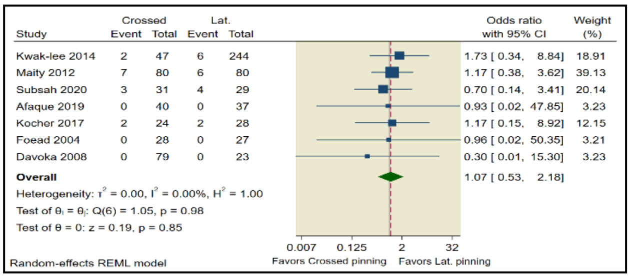

Figure [14]: Forest plot of vascular complications

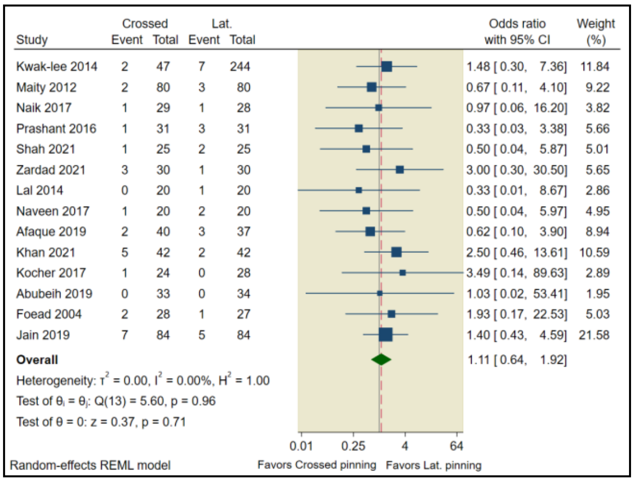

Figure [15]: Forest plot of infections

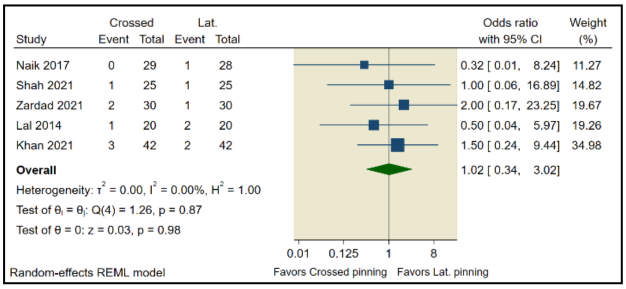

Figure [16]: Forest plot of pin loosening

Table [1a]: Summary table of the included studies.

Authour	Year	Population	Total participants	Follow up duration	Study Period [year to year]	Country	Design
Kwak-lee [57]	2014	children < 12	291	7.5	2007 - 2012	USA	Prospective nonrandomized
Maity [2]	2012	children < 15	160	3	2007 - 2010	India	prospective, randomized controlled clinical trial
Naik [59]	2017	children < 13	57	5.67	2013 - 2015	India	prospective, randomized controlled clinical trial
Natalin [4]	2020	children of any age	43	6	2015 - 2018	Brazil	prospective, randomized controlled clinical trial
Nazzar [5]	2021	children < 10	190	6	2019 - 2020	Pakistan	prospective, randomized controlled clinical trial
Prashant [6]	2016	children < 12	62	8.5	2014 - 2015	India	prospective, randomized controlled clinical trial
Shafi [7]	2013	children < 10	200	3	2011 - 2012	Egypt	prospective, randomized controlled clinical trial
Shah [8]	2021	children < 14	50	6	2021	Pakistan	prospective, randomized controlled clinical trial
Tripuraneni [9]	2009	children < 11	40	2	2004 - 2006	USA	prospective, randomized controlled clinical trial
Zardad [10]	2021	children < 14	60	-	2019 - 2020	Pakistan	prospective, randomized controlled clinical trial
Topping [11]	1995	children < 12	47	-	1988 - 1993	USA	-
Pathania [12]	2016	-	30	4	2014-2015		-
Solak [13]	2003	-	59	-	-		-
Lal [14]	2014				2010 - 2012	Pakistan	-
AM El-Ngehy [15]	2018	children < 9	30				-
Subsah [16]	2020	-	60	-	2012 - 2015	India	prospective, randomized controlled clinical trial
Naveen [17]	2017	children < 13	40	6	2016 - 2017	India	prospective, randomized controlled clinical trial
Mandal [18]	2018	children < 12	60	6	2015 - 2016	India	prospective, randomized controlled clinical trial
Afaque [19]	2019	children < 12	77	-	2014-2015	India	prospective, randomized controlled clinical trial
Gaston [20]	2010	-	104	-	2005-2006	USA	prospective, randomized controlled clinical trial
Khan [21]	2021	children < 14	84	-	2020-2021	Pakistan	prospective, randomized controlled clinical trial
Kocher [22]	2017	children < 10	52	3	2003-2005	USA	prospective, randomized controlled clinical trial
Abubeih [23]	2019	children < 9	67	-	2013-2015	Egypt	prospective, randomized controlled clinical trial
Foead [24]	2004	children < 12	55	9	2000-2001	Malaysia	prospective, randomized controlled clinical trial
Dawood [25]	2011	children < 10	21	4	2010-2011	Iraq	prospective, randomized controlled clinical trial
Davoka [26]	2008	children < 13	102	3.5	2004-2005	Nepal	prospective, randomized controlled clinical trial
Jain [27]	2019	children < 15	168	6	2012-2015	India	prospective, randomized controlled clinical trial

Table [1b]: Continuation of the summary table

Authors	Fracture type [Gartland] [%]		mean Time of injury to surgery [D]		No. patients		Type of displacement [%]			Mode of injury [%]		
	Type II	Type III	Crossed pinning	Lat. Pinning	Crossed pinning	Lat. Pinning	post-med	post-lat	post	RTA	FTG	FFH
Kwak-lee [1]	67.3	32.7	1.9	4.1	1 med & 2 lat	1 lat	-	-	-	-	-	-
Maity [2]	44	56	1.1	1.2	1 med & 1 lat	2	32.5	44.4	23			
Naik [3]	0	100	-	-	1 med & 1 lat	2	-	-	-	12.3	80.7	7
Natalin [4]	0	100	-	-	-	-	-	-	-	-	-	-
Nazzar [5]	0	100	6.88	7.04	1 med & 1 lat	-	-	-	-	-	-	-
Prashant [6]	0	100	2.35	2.25	1 med & 1 lat	2	77.4	22.6				
Shafi [7]	-	-	-	-	-	-	-	-	-	-	-	-
Shah [8]			-	-	-	-	66	34		24	54	22
Tripuraneni [9]	12.5	87.5	-	-	1 med & 2 lat	2	-	-	-	-	-	-
Zardad [10]	-	-	-	-	1 med & 2 lat	2	-	-	-	16.7	75	8.3
Topping [11]	-	-	-	-	1 med & 1 lat	2	49	34	-	-	-	-
Pathania [12]	-	-	-	-	-	-	-	-	-	-	-	-
Solak [13]	-	-	-	-	-	-	-	-	-	-	-	-
Lal [14]	-	-	-	-	-	-	65	35		27.5	52.5	20
AM El-Ngehy [15]	13.4	86.6	-	-	-	-	-	-	-	-	-	-
Subsah [16]			-	-	1 med & 1 lat	2	78.3	21.6	-	-	-	-
Naveen [17]	37.5	62.5	22	23	1 med & 1 lat	2	69.56	30.43	-	-	-	-
Mandal [18]	11.67	88.33	-	-	1 med & 1 lat	2			-	-	-	-
Afaque [19]	-	-	-	-	1 med & 1 lat	2	52	25	0	0	38	39
Gaston [20]	0	100	-	-	1 med & 1 lat	2	37	29	28	-	-	-
Khan [21]			-	-	1 med & 1 lat	2	20	21	11	17	60	7
Kocher [22]			-	-	1 med & 1 lat	2	-	-	-	-	-	-
Abubeih [23]	0	100	-	-	1 med & 1 lat	2	-	-	-	-	-	-
Foead [24]	-	-	-	-	1 med & 1 lat	2	-	-	-	-	-	-
Dawood [25]	0	100	-	-	1 med & 1 lat	2	-	-	-	-	-	-
Davoka [26]	-	-	-	-	1 med & 1 lat	2	-	-	-	-	-	-
Jain [27]			-	-	-	-	-	-	-	-	-	-

DISCUSSION

The findings of this meta-analysis indicate that medial and lateral entry pinning, may carry a greater risk of nerve injury. However, it offers a more stable structure with a lower likelihood of deformity and clinically significant cubitus varus. Out of the 1816 patients treated, 47 of them [2.5%] experienced a nerve injury caused by medical treatment. There was a lack of documentation regarding the removal of pins and exploration of the injured nerve in the majority of the studies. People who enter from the medial or lateral side are more likely to suffer from ulnar nerve injuries caused by surgery.

It is intriguing that the lateral entry group has a 1.03 % probability of iatrogenic radial and median nerve injuries. This may be owing to the reduction or pins entering too far into the medial cortex or exiting anteriorly. The results cannot be used to determine the optimal nerve injury treatment.

Most research suggests removing the medial pin from medial and lateral entry pins because lateral entry pins are stable. Few details exist on when to remove lateral entry pins and do nerve exploration.

Deformity was reported in eight studies included in this meta-analysis as an outcome, The incidence of deformity in the crossed pinning entry was 15.33% [48 of 313] of children included whereas the incidence of the lateral pinning entry was 22.78% [72 of 316] of children included. The deformity manifested as cubitus varus with an angle exceeding 5 degrees or a reduction in the carrying angle over 10 degrees.

The studies did not indicate which patients needed additional surgery to fix the abnormality. The subsequent evaluation proved inadequate in determining which patients will continue to exhibit deformity upon reaching skeletal maturity, hence they may accept the outcome and refuse further treatment.

The success rate was similar in both techniques, with no significant difference between the two groups. The incidence of success rate in the crossed pining was 84.9% and 84.8% in the lateral pining. However, this percentage of success I limited by the smaller number of studies reported it which were four studies only. Flynn criteria for the cosmetic and functional outcomes were reported in 17 studies included in this meta-analysis. Excellent and good outcomes were reported in 628 [91.28%] of 688 children treated with crossed pinning entry and 559 [87.48%] of 639 children treated with lateral pinning entry.

In terms of the complication rate, it was similar in both groups with no significant difference between them. The incidence of vascular complications occurred in 14 [4.25%] of 329 children treated with crossed pinning entry and in 18 [3.85%] of 468 children treated with lateral pinning entry. Fourteen studies reported the incidence of pin infections. In the crossed pinning group, 28 [5.25%] of 533 children reported pin infections, whereas 31 [4.25%] of 730 children in the lateral pinning group reported pin infections. Five studies reported the incidence of pin loosening. There were seven [4.79%] of 146 children treated with crossed pinning entry reported pin loosening, while there were seven [4.82%] of 145 children treated with lateral pinning entry reported pin loosening.

This study has some limitations. First, most of the studies vary methodologically. Since these investigations were from different institutions and surgeons, the procedure of putting medial and lateral entry pins versus lateral pins only may vary. Our conclusions may be more generalizable, but the intervention impact may be diluted.

The majority of analyzed studies analyzed were of a retrospective design, which have a high risk of confounding bias and offer less robust empirical data compared to randomized trials or prospective investigations. Often, the investigations spanned multiple years, resulting in varying quality of data collected within each one study. The scarcity of prospective, case-controlled studies employing rigorous randomization methods had an adverse impact on the fraction of high-quality papers that were examined.

Conclusion: The most reliable method is to use medial/lateral entry pins, while being cautious to prevent any nerve damage caused by medical intervention, regardless of the chosen treatment methodology.

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