

Comparison of Pin Tract Infection Rate in Buried Versus Unburied Kirshner Wires Fixation in the Management of Gartland Type III Supracondylar Fracture of Humerus in Children

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Each author of this article fulfilled ALL 04 Criteria of Authorship:

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ABSTRACT

Objective: To evaluate the results of pin tract infection rate in buried versus unburied Kirshner wires fixation in the management of Gartland type III supracondylar fracture of humerus in children.

Methods: This randomized control trials study was conducted in the Department of Orthopedics and Trauma, Medical Teaching Institute Lady Reading Hospital, Peshawar Pakistan from December 2020 to June 2021 on 62 (31 in each groups) patient having age range of less than 12 years of either gender having closed fracture of less than two days old with no neurovascular injury. All the patients were observed to compare pin tract infection rate in buried versus unburied Kirshner wires fixation in the management of Gartland type III supracondylar fracture of humerus in children. Sampling technique was non-probability consecutive sampling.

Results: In this study age distribution among 62 patients was analyzed as n= 2 -4 Years 17(27.4%) 4-6 Years 14(22.6%) 6- 9 Years 11(17.7%) 9-12 Years 20(32.3%). Mean age was 7.1 Years with SD ± 2.87 (Gender wise Distribution among 62 Patients were analyzed as Male were 31(50.0%) and female were 31(50.0%) Distribution of duration of disease among 62 patients were analyzed as n= 1-2 weeks was 47(75.8%) and 3-4 weeks was 15(24.2%) BMI classification among 2 patients were analyzed as n= Below 18.5 Underweight was 25(40.3%) 18.5–24.9 Normal weight was 10(16.1%) 25.0–29.9 Pre-obesity was 17(27.4%) and 30.0–34.9 Obesity class was 9(14.5%) Distribution Pin tract Infection after 4 weeks among the groups were analyzed as n= Infection rate among Group A (K-Wires buried) was 4(12.9%) and Group B (K-Wires Unburied) 9(29.%)

Conclusion: We believe that closed reduction and buried percutaneous lateral pinning is an efficient, reliable and safe method.

Keywords: Buried wires, Fracture, Gartland Type III, Pin tract infection, Supracondylar

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INTRODUCTION

The second most frequent fracture in children during their first ten years of life is a supracondylar fracture¹. Compared to females, males experience it more frequently. Supracondylar fractures are most frequently caused by falls onto outstretched hands². Extension and flexion type injuries are two categories

for supracondylar fractures. The kind of extension is more prevalent, accounting for almost 90% of all cases³. Type I un-displaced fractures, Type II displaced fractures with posterior cortical contact, and Type III totally displaced fractures are further classifications for extension types.^{2,3} Restoring normal functioning and a cosmetically acceptable

limb with full range of motion is the aim of therapy for this fracture.⁴ Although there are several ways to treat supracondylar fractures, the majority of studies indicate that Kirshner wires, or K-Wires, fixation is the most effective technique. K-wires can be left exposed or buried.⁴ K-wires are widely utilized in the treatment of fractures in pediatric patients due to their low risk of complications and cost-effectiveness. Despite the fact that K-wires can cause a variety of issues and have detrimental effects.⁵ It is debatable whether buried or unburied K-wires should be utilized, based on evidence that has been published. The measurement of post-procedural complications serves as the scale for choosing the optimal method.⁶ "Pin tract infection is the most frequent complication associated with supracondylar fracture therapy using k-wires. Severe complications such as septic arthritis, osteomyelitis, flexor sheath infection, toxic shock syndrome, early physal closure, and nonunion might arise from an untreated pin tract infection.⁷ A research was out in the United Kingdom revealed that three patients with unburied K-wires had microbiologically proven infections⁸. Two of them had antibiotic treatment that was effective. For the third patient, two surgical debridements were performed. Two individuals with buried K-wires who did not have skin erosions had infections that were verified microbiologically. While the other had surgical debridement, the first was treated with antibiotics. According to an Indian research, two patients out of twenty (10%) in the buried K-Wires group and eight out of twenty (36.4%) in the percutaneous group experienced pin site infections.⁵ The purpose of this research is to compare the incidence of pin tract infections in children with buried vs unburied K-wires used in the treatment of Gartland type III supracondylar humeral fractures. There aren't many research on this subject, and the ones that are available are out of date. The findings of this study will give orthopedic surgeons information on the use of buried or unburied K-Wires in the treatment of pediatric supracondylar humeral fractures. K-wire removal was simple and could be done as a day case without anesthesia if it turns out that unburied K-wires are linked to a lower risk of infection.

MATERIAL AND METHODS

From December 2020 to June 2021, 62 patients (31 in each group) with ages ranging from less than 12 years old and either gender who had closed fractures less than two days old without neurovascular injury were included in this randomized controlled trial study at the Medical Teaching Institute Lady Reading

Hospital in Peshawar, Pakistan. In order to examine the rate of pin tract infection between buried and unburied Kirshner wire fixation for the treatment of children with Gartland type III supracondylar fractures of the humerus, all patients were monitored. Non-probability sequential sampling was the method used for sampling After receiving approval from the hospital's ethical committee, all patients who presented to the accident and emergency department of Lady Reading Hospital Peshawar with a history of elbow trauma and a supracondylar fracture of the humerus—after confirming the condition radiographically—were included in the study. Once the patient was informed of the results of both operations, signed informed permission was obtained. These individuals were admitted to our facility following their first course of care. These patients were evaluated in our unit using a thorough history and physical, as well as the mechanism and kind of injury. These patients were operated on as soon as possible after undergoing preoperative examination and were deemed fit for anesthesia. By means of blocked randomization, half of the patients were randomized to have percutaneous K-wire fixation—half for burial, and the other half for unburying. After one week, two weeks, and four weeks following surgery, patients were evaluated in the outpatient department using the Modified Open him Classification for pin tract infection. On every visit, the proforma checklist was adhered to. Using SPSS 20.0, data were examined. Frequencies and percentages were used to calculate the outcomes for categorical variables, such as gender. Age and other quantitative data were expressed as mean + SD. The outcome variable, or infection, was divided into age and gender groups. Chi square tests after stratification were performed at the 5% significance level.

RESULTS

In this study age distribution among 62 patients was analyzed as n= 2 -4 Years 17(27.4%) 4-6 Years 14(22.6%) 6- 9 Years 11(17.7%) 9-12 Years 20(32.3%). Mean age was 7.1 Years with SD \pm 2.87.

Gender wise Distribution among 62 Patients was analyzed as Male were 31(50.0%) and female were 31(50.0%)

Distribution of duration of disease among 62 patients were analyzed as n= 1- 2 weeks was 47(75.8%) and 3-4 weeks was 15(24.2%).

BMI classification among 2 patients were analyzed as n= Below 18.5 Underweight was 25(40.3%) 18.5–24.9 Normal weight was 10(16.1%)

Table 1: Pin Tract Infection After 4 Weeks

Pin tract Infection after 4 weeks			Group wise Distribution		Total
			Group A (K- Wires buried)	Group B (K- Wires Unburied)	
	Yes	Count	4	9	13
		% within Pin tract Infection after 4 weeks	30.8%	69.2%	100.0%
		% within Group wise Distribution	12.9%	29.0%	21.0%
	No	Count	27	22	49
		% within Pin tract Infection after 4 weeks	55.1%	44.9%	100.0%
		% within Group wise Distribution	87.1%	71.0%	79.0%
Total	Count	31	31	62	
	% within Pin tract Infection after 4 weeks	50.0%	50.0%	100.0%	
	% within Group wise Distribution	100.0%	100.0%	100.0%	

* Group Wise Distribution Crosstabulation (n=62)

Table 2: Stratification of Age Wise Distribution

Age wise Distribution			Group wise Distribution		Total
			Group A (K- Wires buried)	Group B (K- Wires Unburied)	
	2 -4 Years	Count	15	2	17
		% within Age wise Distribution	88.2%	11.8%	100.0%
		% within Group wise Distribution	48.4%	6.5%	27.4%
	4-6 Years	Count	14	0	14
		% within Age wise Distribution	100.0%	.0%	100.0%
		% within Group wise Distribution	45.2%	.0%	22.6%
	6- 9 Years	Count	0	11	11
		% within Age wise Distribution	.0%	100.0%	100.0%
		% within Group wise Distribution	.0%	35.5%	17.7%
	9-12 Years	Count	2	18	20
		% within Age wise Distribution	10.0%	90.0%	100.0%
		% within Group wise Distribution	6.5%	58.1%	32.3%
Total	Count	31	31	62	
	% within Age wise Distribution	50.0%	50.0%	100.0%	
	% within Group wise Distribution	100.0%	100.0%	100.0%	

*Group Wise Distribution (n=62)

Chi square test was applied in which P value was 0.000

Table 3: Stratification of Gender Wise Distribution

Gender wise Distribution			Group wise Distribution		Total
			Group A (K- Wires buried)	Group B (K- Wires Unburied)	
	Male	Count	9	22	31
		% within Gender wise Distribution	29.0%	71.0%	100.0%
		% within Group wise Distribution	29.0%	71.0%	50.0%
	Female	Count	22	9	31
		% within Gender wise Distribution	71.0%	29.0%	100.0%
		% within Group wise Distribution	71.0%	29.0%	50.0%
Total	Count	31	31	62	
	% within Gender wise Distribution	50.0%	50.0%	100.0%	
	% within Group wise Distribution	100.0%	100.0%	100.0%	

*Group Wise Distribution (n=79)

Chi square test was applied in which P value was 0.00

25.0–29.9 Pre-obesity was 17(27.4%) and 30.0–34.9 Obesity class was 9(14.5%).

Distribution Pin tract Infection after 4 weeks among the groups were analyzed as n= Infection rate among Group A (K-Wires buried) was 4(12.9%)

and Group B (K-Wires Unburied) 9(29.0%). (Table No 1).

Stratification of gender wise distribution, group wise distribution, infection wise distribution was presented in table 2-6.

Table 4: Stratification of BMI Classification *Group Wise Distribution (n=62)

BMI classification		Group wise Distribution		
		Group A (K- Wires buried)	Group B (K- Wires Unburied)	Total
Below 18.5 Underweight	Count	25	0	25
	% within BMI classification	100.0%	.0%	100.0%
	% within Group wise Distribution	80.6%	.0%	40.3%
18.5–24.9 Normal weight	Count	6	4	10
	% within BMI classification	60.0%	40.0%	100.0%
	% within Group wise Distribution	19.4%	12.9%	16.1%
25.0–29.9 Pre-obesity	Count	0	17	17
	% within BMI classification	.0%	100.0%	100.0%
	% within Group wise Distribution	.0%	54.8%	27.4%
30.0–34.9 Obesity class	Count	0	10	10
	% within BMI classification	.0%	100.0%	100.0%
	% within Group wise Distribution	.0%	32.3%	16.1%
Total	Count	31	31	62
	% within BMI classification	50.0%	50.0%	100.0%
	% within Group wise Distribution	100.0%	100.0%	100.0%

Chi square test was applied in which P value was 0.010

Table 6: Stratification of Pin Tract Infection After 4 Weeks

		Group wise Distribution			
		Group A (K- Wires buried)	Group B (K- Wires Unburied)	Total	
Duration of disease	1- 2 weeks	Count	25	22	47
		% within Duration of disease	53.2%	46.8%	100.0%
		% within Group wise Distribution	80.6%	71.0%	75.8%
	3-4 weeks	Count	6	9	15
		% within Duration of disease	40.0%	60.0%	100.0%
		% within Group wise Distribution	19.4%	29.0%	24.2%
Total	Count	31	31	62	
	% within Duration of disease	50.0%	50.0%	100.0%	
	% within Group wise Distribution	100.0%	100.0%	100.0%	

*Group Wise Distribution (n=62)

Chi square test was applied in which P value was 0.000

Table 5: Stratification of duration of Disease

		Group wise Distribution			
		Group A (K- Wires buried)	Group B (K- Wires Unburied)	Total	
Pin tract Infection after 4 weeks	Yes	Count	4	8	12
		% within Pin tract Infection after 4 weeks	33.3%	66.7%	100.0%
		% within Group wise Distribution	12.9%	25.8%	19.4%
	No	Count	27	23	50
		% within Pin tract Infection after 4 weeks	54.0%	46.0%	100.0%
		% within Group wise Distribution	87.1%	74.2%	80.6%
Total	Count	31	31	62	
	% within Pin tract Infection after 4 weeks	50.0%	50.0%	100.0%	
	% within Group wise Distribution	100.0%	100.0%	100.0%	

*Group Wise Distribution

Chi square test was applied in which P value was 0.000

DISCUSSION

Handling type III displaced extension management When compared to other techniques, the treatment of a supracondylar fracture of the humerus with close reduction and percutaneous pinning had encouraging results⁸. Although it can result in ulnar damage, the medio-lateral crossing pinning technique has the benefit of improved fracture stability⁹. Although ulnar nerve damage can be prevented with lateral crossing pinning, this configuration is less stable than medio-lateral pinning¹⁰. According to Lee SS et al.¹¹ and Ziouts et al.¹², medial and lateral entrance offers more torsional stability than lateral pinning design. The divergence of the pins in various columns and the total number of pins are the primary factors that contribute to this construct's overall strength, rather than just pin entry. The position of the two pins' contact and the fact that their higher divergence allows for some purchase in the medial and lateral columns are what account for the increased strength observed in the divergence of the pins.^{11,12} Skaggs et al.¹³ discovered that 124 children treated with lateral-entry pins did not see any reduction in loss or ulnar nerve palsy. Of the 204 children who sustained a Gartland type-3 fracture in another trial by Skaggs et al., 51 received treatment with lateral pins only and 153 received treatment with crossing pins¹⁴. The Baumann's angle in Gartland type 3 fractures was unaffected by the pin arrangement. Iatrogenic ulnar nerve palsy caused by the use of a medial pin is the most frequent side effect following closed reduction and percutaneous pinning of displaced supracondylar fractures of the humerus.^{15,16} According to several research, the incidence of ulnar nerve injury ranges from 3% to 58%.¹⁷ It is discovered that postoperative nerve palsies following percutaneous pinning resulted from direct nerve damage rather than via closed reduction manipulation.¹¹ Because both groups had the identical treatment regimen, there was no incidence of ulnar nerve damage in the current research when pinning was done from the lateral side. Additionally, we did not observe significant differences in bone healing and stability between lateral-pin insertion and cross-pin insertion. Skaggs saw no iatrogenic ulnar nerve damage and no reduction was lost while using lateral-entry pins alone to treat even the most instability supracondylar humeral fractures.^{13,14} In the current investigation, eight patients (or 4.70%) who had cross pin insertions experienced iatrogenic nerve damage. Although the majority of ulnar nerve injuries heal on their own in four to six months, there have been

reports of lasting injury in the literature.¹⁷ Following the removal of the medial pin, Lyons et al.¹⁸ reported spontaneous functional recovery. Rasool et al.¹⁹, however, recommended early ulnar nerve investigation. Finger clawing is an uncommon side effect of ulnar nerve injury. The majority of ulnar nerve injuries may be identified using pathological nerve conduction studies in the early postoperative phase. In the current study, almost 70% of patients had good outcomes from the lateral and cross pin insertion groups at the eighth post-operative week. Roughly 90% of the patients showed these good results at the last follow-up. Patients with closed reductions or severe soft tissue injuries who had repeated attempts at treatment in nearby facilities had good or average outcomes. In one research, 88% of the participants had outstanding outcomes, 4% had good results, and 4% had bad results. In another study, 88% of the participants had satisfactory results when they examined children with late-presenting supracondylar fractures of the humerus.^{20,21} Our study is analogous to these two investigations. It has been estimated that the incidence of postoperative ulnar nerve damage varies between 5 and 19%.²² According to one study, if there is no clinical or electromyography confirmation of a return of neural function five months after the injury, exploration and neurolysis should be carried out. This is in addition to initial observation as well as supportive therapy for neural injury associated with a closed, displaced, supracondylar fracture of the humerus. The prognosis following neurolysis is quite good if the nerve is still intact.²³ Six (3.52%) of the patients in our research experienced superficial pin-tract infections, which resolved with the removal of the pins and oral antibiotic treatment. There was no sign of septic arthritis or profound infection.

In 2% of patients with no deep infection and septic arthritis, Pirone et al.²⁴ Discovered a superficial pin-tract infection.²⁴ In the current series, five patients (2.94%) had distal pin migration, while six patients (3.52%) experienced loss of reduction. These findings were not statistically significant, necessitating neither re-reduction nor re-pinning. In 6% of the instances, Lee and Gordon saw pin migration, and in 7% of the cases, they noted loss of reduction.¹² Based on available data, Lee et al.²⁵ reported that for children with supracondylar fractures of the humerus, the lateral pinning approach was shown to be more advantageous than the medial and lateral crossed pinning technique. But the outcomes depended on the information about

ulnar nerve damage. Even with delayed presentation, Dua et al.²⁶ suggested that closed reduction and crossed pinning of displaced supracondylar fractures of the humerus in children is a safe and successful procedure. According to Erpelding et al.²⁷ When distal humeral fractures are treated openly using an extensor mechanism-on approach, the elbows heal exceptionally well, their mean flexion-extension arc exceeds 100°, and 90% of their elbow extension strength is maintained when compared to a contralateral, normal elbow. Because there is a lower chance of ulnar nerve damage with lateral pinning as opposed to cross pinning, Woratanarat P et al. (2019) recommended it for the treatment of juvenile supracondylar humerus fractures.²⁸

CONCLUSIONS

Achieving an anatomic reduction is the major objective of therapy for displaced pediatric supracondylar humerus fractures. A fixation with less morbidity and better stability should bolster this decrease. Taking all of these into account, we think that closed reduction combined with percutaneous lateral pinning is a safe, effective, and dependable procedure.

Conflict of Interest: None

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REFERENCES

- Ilyas AM, Jupiter JB. Treatment of distal humerus fractures. *Acta Chir Orthop Traumatol Cech.* 2008 Feb. 75 (1):6-15. [Medline].
- Pollock JW, Faber KJ, Athwal GS. Distal humerus fractures. *Orthop Clin North Am.* 2008 Apr. 39 (2):187-200, vi. [Medline].
- Wong AS, Baratz ME. Elbow fractures: distal humerus. *J Hand Surg Am.* 2009 Jan. 34 (1):176-90. [Medline].
- Ihsanullah, Inam M, Khalid, Shabir M, Ali MA. Outcome of Supracondylar Fractures of Humerus in children treated with Dorgan's Surgical Technique. *J Pak Orthop Assoc.* 2020;31(4):153-156.
- Riseborough EJ, Radin EL. Intercondylar T fractures of the humerus in the adult. A comparison of operative and non-operative treatment in twenty-nine cases. *J Bone Joint Surg Am.* 1969 Jan. 51 (1):130-41. [Medline].
- Milch H. Fractures and fracture-dislocation of the humeral condyles. *J Trauma.* 1964. 4:592-607.
- Farley FA, Patel P, Craig CL, Blakemore LC, Hensinger RN, Zhang L, et al. Paediatric supracondylar humerus fractures: treatment by type of orthopaedic surgeon. *J Child Orthop.* 2008 Mar. 2 (2):91-5. [Medline]. [Full Text].
- Pescatori E, Memeo A, Brivio A, Trapletti A, Camurri S, Pedretti L, et al. Supracondylar humerus fractures in children: a comparison of experiences. *J Pediatr Orthop B.* 2012 Nov. 21 (6):505-13. [Medline].
- Michelson GM, Novi M, Leigh M, Giorgini A, Porcellini G, Tarallo L. Supracondylar fractures in children: management and treatment. *Acta Biomed.* 2021 Jul 26;92(S3):e2021015. doi: 10.23750/abm.v92iS3.11725. PMID: 34313666; PMCID: PMC8420822.
- Silva M, Pandarinath R, Farng E, Park S, Caneda C, Fong YJ, et al. Inter- and intra-observer reliability of the Baumann angle of the humerus in children with supracondylar humeral fractures. *Int Orthop.* 2010 Apr. 34 (4):553-7. [Medline].
- Lee SS, Mahar AT, Miesen D, Newton PO. Displaced paediatric supracondylar humerus fractures: biomechanical analysis of percutaneous pinning techniques. *J Pediatr Orthop.* 2002 Jul-Aug. 22 (4):440-3. [Medline].
- Zionts LE, McKellop HA, Hathaway R. Torsional strength of pin configurations used to fix supracondylar fractures of the humerus in children. *J Bone Joint Surg Am.* 1994;76:253-6. [PubMed] [Google Scholar]
- Skaggs DL, Hale JM, Bassett J, Kaminsky C, Kay RM, Tolo VT. Operative treatment of supracondylar fractures of the humerus in children. The consequences of pin placement. *J Bone Joint Surg Am.* 2001 May. 83-A (5):735-40. [Medline].
- Skaggs DL, Cluck MW, Mostofi A, Flynn JM, Kay RM. Lateral-entry pin fixation in the management of supracondylar fractures in children. *J Bone Joint Surg Am.* 2004 Apr. 86-A (4):702-7. [Medline].
- Athwal GS, Goetz TJ, Pollock JW, Faber KJ. Prosthetic replacement for distal humerus fractures. *Orthop Clin North Am.* 2008 Apr. 39 (2):201-12, vi. [Medline].
- Hill CE, Cooke S. Common Paediatric Elbow Injuries. *Closed Orthop J.* 2017. 11:1380-1393. [Medline].
- Iyer RS, Thapa MM, Khanna PC, Chew FS. Paediatric bone imaging: imaging elbow trauma in children--a review of acute and chronic injuries. *AJR Am J Roentgenol.* 2012 May. 198 (5):1053-68. [Medline].
- Lyons J, Ashley E, Hoffer MM. Ulnar nerve palsies after percutaneous cross-pinning of supracondylar fractures in children's elbows. *J Pediatr Orthop.* 1998;18:43-45. [PubMed] [Google Scholar]
- Rasool MN. Ulnar nerve injury after K-wire fixation of supracondylar humerus fractures in children. *J Pediatr Orthop.* 1998;18(5):686-690..
- Omid R, Choi PD, Skaggs DL. Supracondylar humeral fractures in children. *J Bone Joint Surg Am.* 2008 May. 90 (5):1121-32. [Medline].
- Leitch KK, Kay RM, Femino JD, Tolo VT, Storer SK, Skaggs DL. Treatment of multidirectional unstable supracondylar humeral fractures in children. A modified Gartland type-IV fracture. *J Bone Joint Surg Am.* 2006 May. 88 (5):980-5. [Medline].
- Shaath K. Lateral condyle fracture - paediatric. *Orthobullets.* Available at <http://www.orthobullets.com/pediatrics/4009/lateral-condyle-fracture--pediatric>. Accessed: July 18, 2018.
- Lampignano J, Kendrick LE. *Bontrager's Textbook of Radiographic Positioning and Related Anatomy.* 9th ed. St Louis: Elsevier; 2018.
- Pirone AM, Graham HK, Krajchich JI. Management of displaced extension-type supracondylar fractures of the humerus in children. *J Bone Joint Surg Am.* 1988;70:641-50. [PubMed] [Google Scholar]
- Lee KM, Chung CY, Gwon DK, Sung KH, Kim TW, Choi IH, et al. Medial and lateral crossed pinning versus lateral pinning for supracondylar fractures of the humerus in children: Decision analysis. *J Pediatr Orthop.* 2012;32:131-8. [PubMed] [Google Scholar]
- Dua A, Eachempati K, Malhotra R, Sharma L, Gidaganti M. Closed reduction and percutaneous pinning of displaced supracondylar fractures of humerus in children with delayed

- presentation. Chin J Traumatol. 2011;14:14–9. [PubMed] [Google Scholar]
27. Erpelding JM, Mailander A, High R, Mormino MA, Fehringer EV. Outcome following distal humeral fracture fixation with an extensor mechanism-on approach. *J Bone Joint Surg Am.* 2012;94:548–53. [PubMed] [Google Scholar]
28. Woratanarat P, Angsanuntsukh C, Rattanasiri S, Attia J, Woratanarat T, Thakkinstian A. Meta-analysis of pinning in supracondylar fracture of the humerus in children. *J Orthop Trauma.* 2012;26:48–53. [PubMed] [Google Scholar]