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ARTICLE

Outcome of Lateral Pining in Management of Pediatrics Supracondylar Fractures in Sudanese Patients

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Abstract

Background: Supracondylar humerus fractures are one of the commonest injuries in pediatric, resulting mostly from fall on outstretched hand. It is associated with potentially serious injuries. Most of Gartland type II and all type III injuries require closed reduction, pinning and long arm cast for three weeks. There is an ongoing debate on the optimal pinning configuration.

Objectives: the main objectives of the study are to determine the radiological outcome, functional outcome and the complications associated with lateral pinning of supracondylar humerus fractures in paediatrics.

Materials and methodology: the study included 31paediatric patients with supracondylar humerus fracture. All of them underwent closed reduction percutaneous pinning with two lateral k wires. Surgeries took place in deferent centres in Khartoum state. Data sheet was used to collect data which included humerocapitellar line, Baumann angle, Flynn criteria for function and post operative complications.

Results: the radiological outcome was good. Humerocapitellar alignment was normal in (87%) and lost in (13%). Baumann angle was normal in(81%) and abnormal in (19%). The functional outcome was excellent in (87%) and good in (13%) for both elbow range of motion and carrying angle. (3%) developed minor infection. None of the patients have experienced neurovascular injury or malunion.

Conclusion: the lateral pinning emerged to be a good option for paediatric supracondylar humerus fracture providing sufficient stability and low risk of iatrogenic neurovascular injuries and malunion.

Keywords: supracondylar humerus fracture, closed reduction percutaneous pinning, Gartland classification, humerocapitellar line, Baumann angle and Flynn criteria.

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1 | BACKGROUND

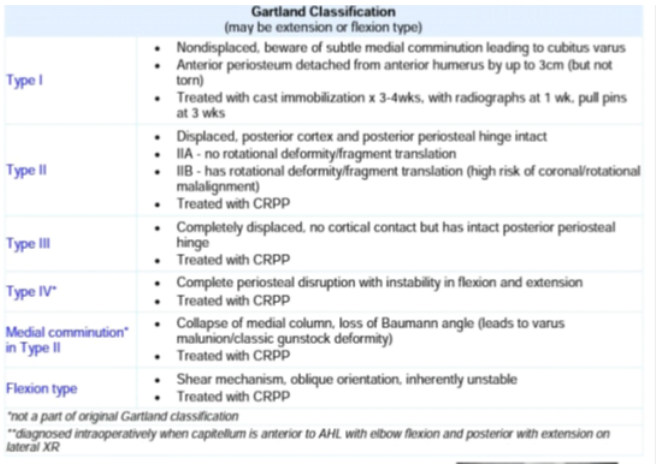
Supracondylar humeral fractures are the commonest childhood elbow fractures (70%), the peak age of incidence is between 3-10 years. They occur more frequently in boys than girls(1). The importance of these injuries comes from the disastrous associations such as anterior Interosseos nerve injury, radial nerve injury, ulnar nerve injury (which is mainly associated with flexion type injuries or iatrogenic). Notably, nerve injuries are usually neuropraxia and undergo spontaneous resolution. Vascular injuries and compartment syndrome are also recognized complications. Malunion was also documented as a complication(2).

The elbow is a hinge joint, which is composed of three articulations: Ulno-humeral joint, Radio-Capitellar joint and the proximal Radio-Ulnar joint. One should be familiar with the six ossification centers, their age of appearance and fusion should be put in mind.

1. Capitellum appears in 1 year and fuses in 12 years
2. Radial head appears in 4 years and fuses in 15 years
3. Medial epicondyle appears in 6 years and fuses in 17 years
4. Troclea appears in 8 years and fuses in 12 years
5. Olecranon appears in 10 years and fuses in 15 years
6. Lateral epicondyle appears in 12 years and fuses in 12 years

All authors in the literature have agreed upon the importance of effective treatment of supracondylar fractures. That is because of the morbidity it carries and the complications and disability that my follow maltreatment.(6)

For type I fractures, there is no debate on the role of conservative treatment by means of cast immobilization for 3-4 weeks(7). On the other hand, most of type II and all type III fractures mandate operative



Gartland Classification
(may be extension or flexion type)

Type I	• Nondisplaced, beware of subtle medial comminution leading to cubitus varus • Anterior periosteum detached from anterior humerus by up to 3cm (but not torn) • Treated with cast immobilization x 3-4wks, with radiographs at 1 wk, pull pins at 3 wks
Type II	• Displaced, posterior cortex and posterior periosteal hinge intact • IIA - no rotational deformity/fragment translation • IIB - has rotational deformity/fragment translation (high risk of coronal/rotational malalignment) • Treated with CRPP
Type III	• Completely displaced, no cortical contact but has intact posterior periosteal hinge • Treated with CRPP
Type IV*	• Complete periosteal disruption with instability in flexion and extension • Treated with CRPP
Medial comminution* in Type II	• Collapse of medial column, loss of Baumann angle (leads to varus malunion/classic gunstock deformity) • Treated with CRPP
Flexion type	• Shear mechanism, oblique orientation, inherently unstable • Treated with CRPP

*not a part of original Gartland classification
**diagnosed intraoperatively when capitellum is anterior to AHL with elbow flexion and posterior with extension on lateral XR

FIGURE 1:

FIGURE 2: Garland *classification of supracondylar fracture*

FIGURE 3: *radio logical signs of supracondylar fracture*

k wires fixation after either closed or open reduction(7)(8)(9).

The vast majority of surgeons believe that k wires alone are the gold standard of treatment for those kinds of fractures, while some minority consider the use of laterally applied external fixation in conjunction with one or two lateral pins(6). They suggest that the external fixation provides good splinting that would save the patients from the cast immobilization and its complications. This camp clams that good functional results are guaranteed through this technique. The technique –according to the fore mentioned study- carries no extra risk for ulnar nerve injury.

Despite the above mentioned agreement on k wires fixation for displaced supracondylar fractures, there has been an ongoing debate regarding the orientation of the k wires.

For many authors, the crossed (medial and lateral) pins are superior to lateral entry point k wires in terms of stability -specially against rotational and varus applied forces(10)(11).

In contrast the lateral entry k wires (parallel or divergent) showed comparable stability to cross pinning and even more stability in fractures with coronal lateral obliquity, sagital oblique fractures, low and high transverse fractures with better results for divergent pattern. Excellent outcome was obtained in 96%

-even with less experienced hands- while poor outcome was obtained in 4% which was linked to cosmoses(12).

In fractures with medial comminution a combination of lateral pinning and one medial pin was found to be superior above all other configurations(11). As a result the camp that support the lateral k wires has developed many techniques to improve the quality of reduction as well as the ability to maintain reduction. They advice firstly the surgeon must engage the medial and lateral columns in the proximal fragment(3,13). Secondly the k wires have to be as far as possible from each others in the fracture site(3,13), thirdly, the surgeon must grasp sufficient bone in both fragments(3,13), and lastly the surgeon must always have a low threshold for a third pin, especially in fractures associated with medial comminution(3,13).

The medially applied k wire was found to be harmful to the soft tissues, specially linked to iatrogenic ulnar nerve injury which was found to show spontaneous resolution(14)(15)(9). In a study by Skaggs, David L and others (which was published in journal of bone and joints), one patient showed persistent motor and sensory deficit after two years (16). Ulnar nerve injury was found in 15% of patients when applied in hyper flexion and in 4% when applied in extension(16).

A systematic review of crossed versus two lateral pinning technique done by Brauer, Carmen Alisa and others (which was published and the journal of paediatric orthopaedics) showed that the probability of ulnar nerve injury is five times higher with crossed pins. When all iatrogenic nerve injuries were included, they were found to be 1,84 times higher with cross k wires(17).

In a Meta analysis done by Jia-Guo Zhao and others (which was published by the association of bone and joint surgeons2013), there was no deference in radiological, functional outcome or complication rate between lateral and cross k wires with higher rate of iatrogenic ulnar nerve injury in the later(9).

Shannon, FintanJ and others conducted a study (which was published in the journal of paediatrics orthopaedics), they suggest two crossing k wires from a lateral approach. One of them retrograde and the other antigrade just touching the medial condylar cortex(18). By this means a combination of the concept of crossing "stability" and ulnar nerve protection is achieved with 90% excellent and good results according to Flynn criteria.

Supplementary information The online version of this article (10.15520/arjmcs.v7i07.352) contains supplementary material, which is available to authorized users.

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	Loss of elbow flexion/ extension	Loss of forearm supination/ pronation	Loss of wrist flexion/ extension	Change in carrying angle
Excellent	0 to 5	0 to 15	0 to 15	0 to 5
Good	6 to 10	16 to 30	16 to 30	6 to 10
Fair	11 to 15	31 to 45	31 to 45	11 to 15
Poor	>15	>45	>45	>15

FIGURE 4:

2 | FLYNN CRITERIA

Objectives

To assess the outcome of lateral entry k wires in treatment of supracondylar fractures

Specifically

1. To identity the radiological outcome of lateral pinning in forms of humerocapitellar line and Baumann angle.
2. To determine the functional outcome according to Flynn criteria.
3. To assess the complication rate associated with lateral pinning.

Methodology

Descriptive prospective hospital based study in Khartoum north teaching hospital. The study will be conducted throughout a period of one year include all pediatric patients with supraconsular fracture treated with C.R.P.P using two lateral pins.

2.5 Inclusion criteria:

- Pediatric patients ”open physics” treated by C.R.P.P using two lateral parallel k wires.
- Patients with pure supracondylar fracture.
- Both genders

2.6 Exclusion criteria:

- Patients with open fractures.
- Patients treated by Open reduction.
- Patients with epsilateral fracture
- Patients with preexisting nerve injury.

All patients underwent closed reduction and percutaneous pinning following standard surgical techniques. We chose to use lateral entry K wires with deferent configurations (parallel, divergent and convergent). We apply long arm posterior slap for all patients which was removed with the pins after an average of three weeks. After six weeks all patients were reviewed for radiological signs (humerocapitellar line and Baumann’s angle), functional outcome according to modified Flynn criteria and complications.

FIGURE 5: *Sample of lateral k wires fixation*

3 | RESULTS

There were 31 patients with supracondylar humerus fracture, who were treated with closed reduction and two lateral pinning. Surgeries took place in deferent centers.

Regarding age, 16 patients “52%” were (7-10yrs), 13 patients “42%” were (4-6yrs) and two patients “6%” were (1-3yrs) as shown in (figure3). Regarding gender, 27 patients “87%” were males while 4 patients “13%” were females as demonstrated in (figure4). Regarding hand dominance 25 patients “81%” were right handed while 6 patients “9%” were left handed (figure5).

In regards to side of trauma, 20 patients “65%” had right elbow injury while 11 patients “35%” had left elbow injury (figure6). In regard of mode of trauma, 30 patients “97%” fell on out starched hand, while only one patient had direct trauma as illustrated in (figure7).According to Gartland system, 26 patients “84%” were Gartland type III while 5 patients “16%” were Gartland type II (figure8).

Regarding surgical timing, 14 patients “45%” were operated (7-10days) after trauma, 11 patients “36%” were operated (4-6days) after trauma and 6 patients “19%” were operated (1-3days) after trauma as shown in (figure9). Operative time was less than half an hour in 19 cases “61%” and more than half an hour in 12 cases “39%” as shown in (figure14). The operator was an orthopaedic resident in 24 cases “77%”, a specialist in 5 cases “16%” and a consultant in 2 cases “6,5%” (figure15)

Surgical timing had no impact on the outcome as illustrated in (figures10-13). Moreover, experience of the operator had no impact on the outcome as illustrated in (figures16-19).

After six weeks, radiological examination illustrated that humerocapitellar line was normal in 27 patients “87%” and abnormal in 4 patients “13%” as illustrated in (figure20). The Baumann angle was normal in 25patients “81%” and abnormal in 6 patients “19%” as demonstrated in (figure21).

After six weeks, function was assessed according to Flynn criteria. All the patients had excellent outcome regarding wrist movement and forearm rotation. Regarding elbow range of motion, 27 patients “87%” had excellent outcome and 4 patients “13%” had good outcome as shown in (figure22). In regard to carrying angle, 27 patients “87%” had excellent outcome and 4 patients “13%” had good outcome (figure23).

None of the patients developed neurovascular complications or loss of reduction. One patient “5%” developed pin tract infection as illustrated in (figure24).

Healing Baumann angle was significantly affected by intra operative Baumann angle with a P-value of (,oo3) as demonstrated in (tables 1,2). Healing humerocapitellar line affects both elbow range of motion and carrying angle with a significant P-value of less than (,o5) as shown in (tables 3-6). Healing Baumann angle significantly affects both elbow range of motion and carrying angle with P-values of (,003) and less than (,05) respectively) as illustrated in (tables 7-10).

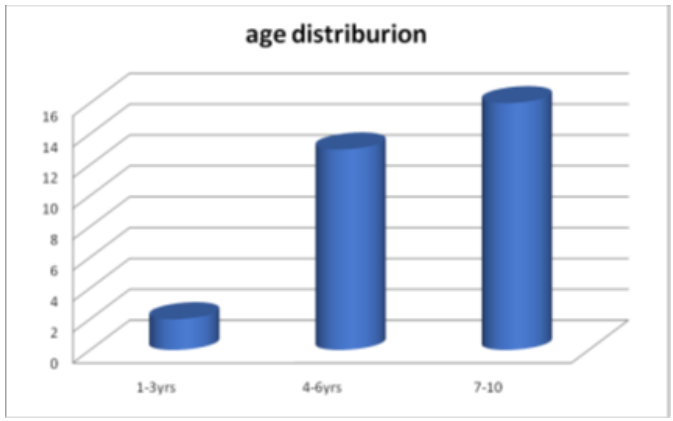

FIGURE 6: *Demonstrates age distribution of patients with supracondyler fracture*

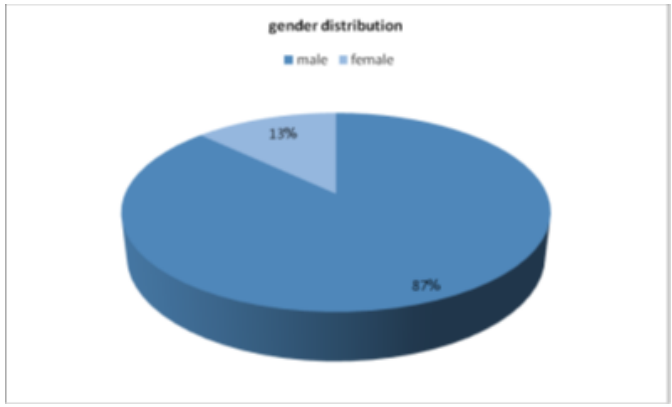

FIGURE 7: *Demonstrates gender distribution of patients with supracondylar fracture*

Table 1: Demonstrates the relation between intra-operative Baumann’s angle and Baumann’s angle six weeks post-operative.

HEALING.BA	IMMEDIATE.BA		Total
	Normal	Abnormal	
Normal	25	0	25
Abnormal	4	2	6
Total	29	2	31

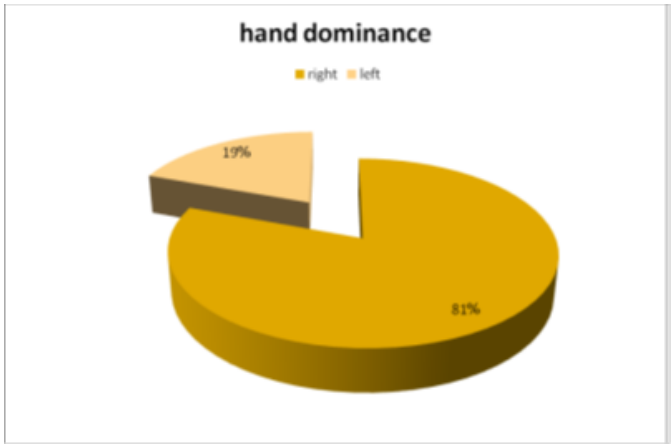

FIGURE 8: Illustrates *the hand dominance ofpatients with supracondylar fracture*

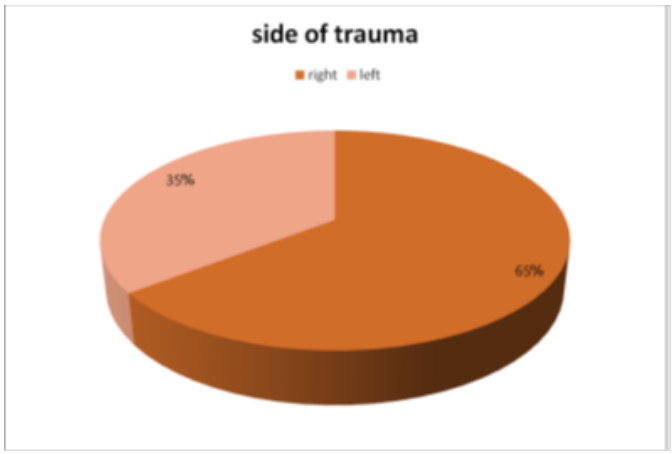

FIGURE 9: Shows *side of trauma of the affected patients.*

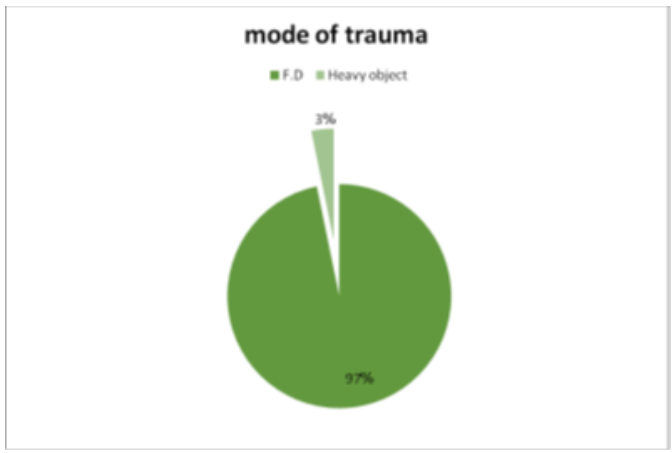

FIGURE 10: *shows the mode of trauma*

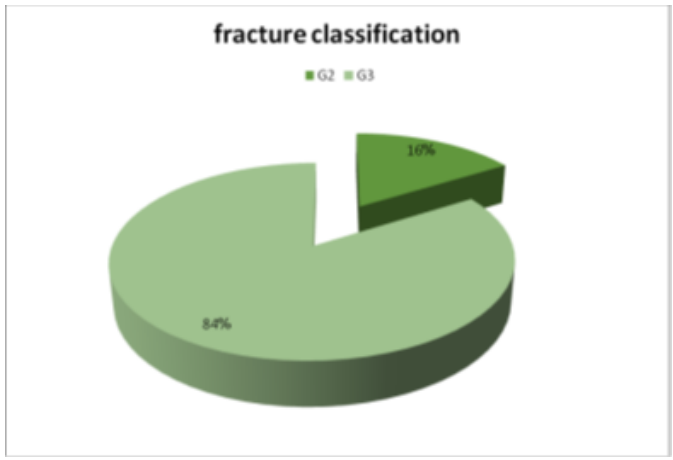

FIGURE 11: *Illustrates fracture classification.*

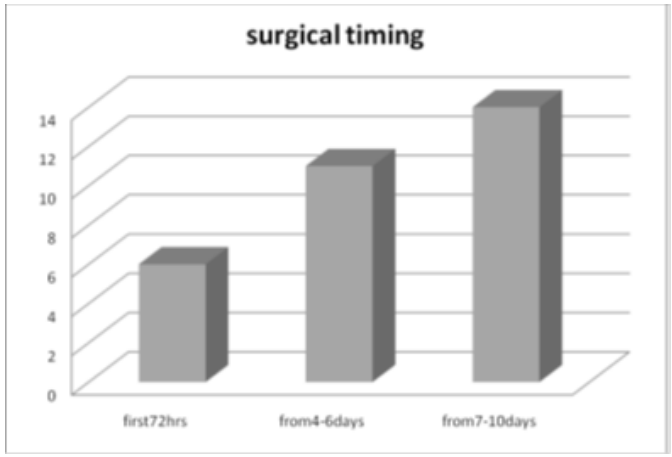

FIGURE 12: Demonstrates *surgical timing*

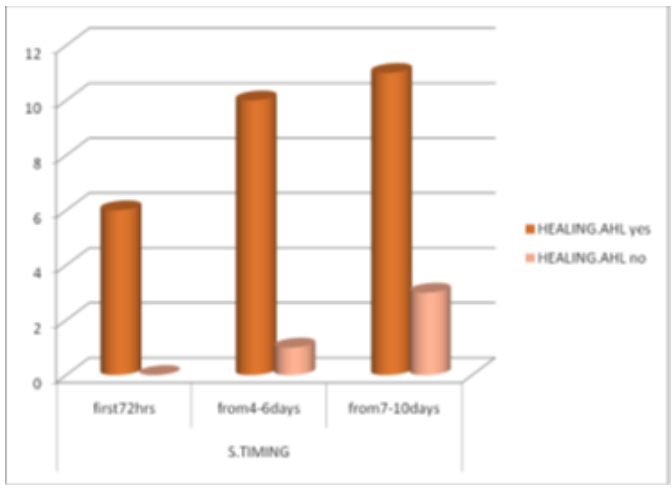

FIGURE 13: Illustrates *the correlation between the surgical timing and the humerocapitellar line six weeks post-operative.*

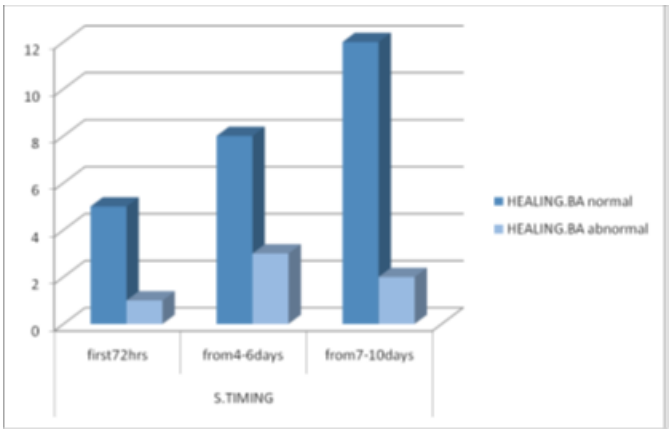

FIGURE 14: Demonstrates *the correlation between surgical timing and Baumann's angle six weeks postoperative.*

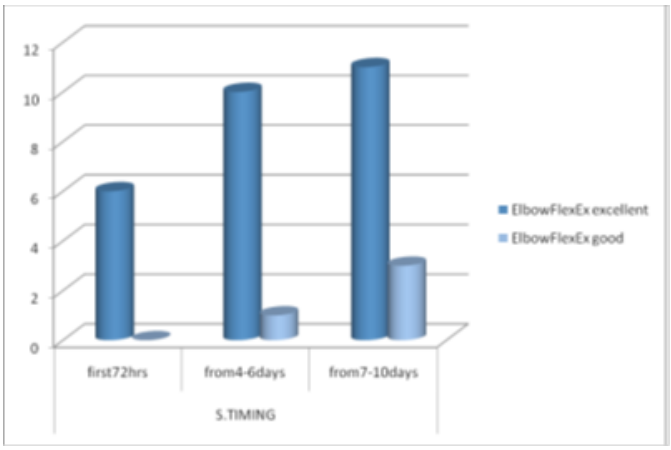

FIGURE 15: Shows *the relation between surgical timing and elbow flexion/extension six weeks post-operatively.*

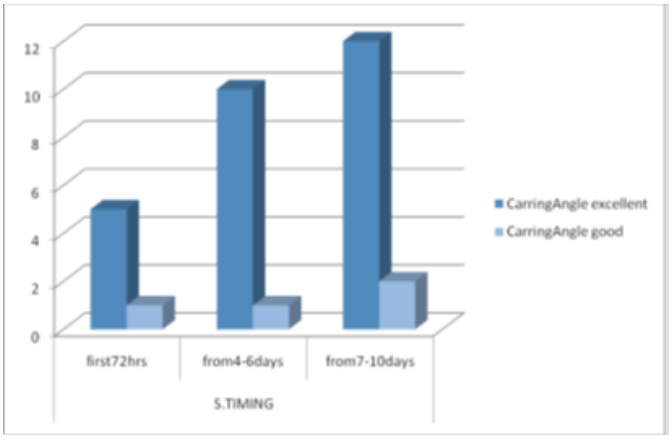

FIGURE 16: Shows *the relation between surgical timing and the carrying angle six weeks post-operatively.*

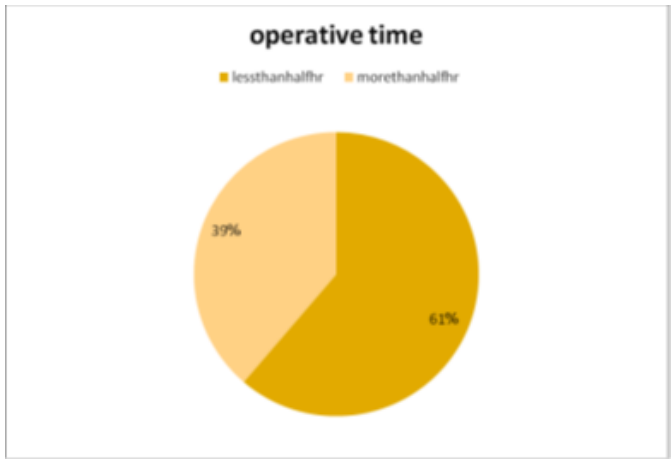

FIGURE 17: *Illustrates the operative time.*

FIGURE 18: *Demonstrates the deferent levels of the operator.*

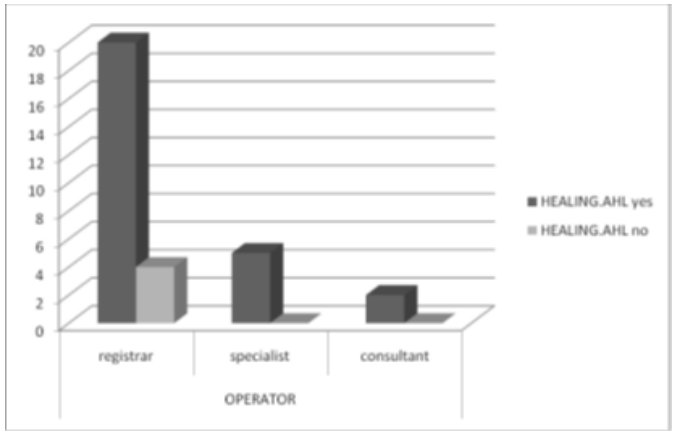

FIGURE 19: Illustrates *the relation between the seniority of the operator and the humerocapitellar line six weeks postoperative.*

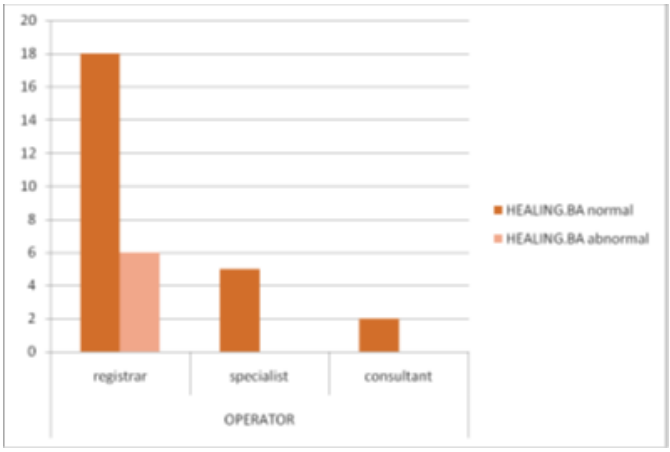

FIGURE 20: Illustrates *the relation between the seniority of the operator and Baumann's angle six weeks postoperative.*

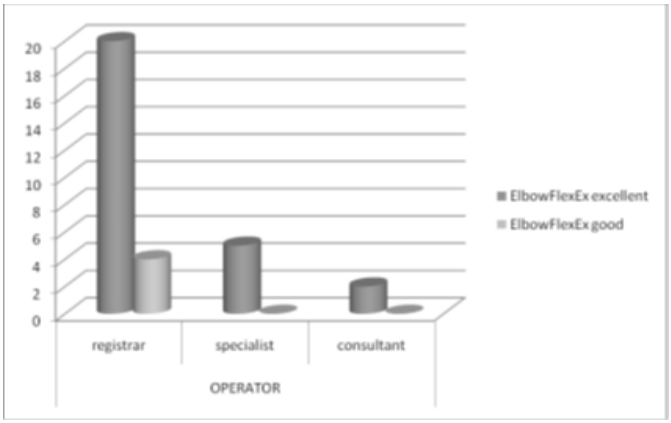

FIGURE 21: *Shows the relation between operator's seniority and the elbow flexion/extension six weeks postoperative.*

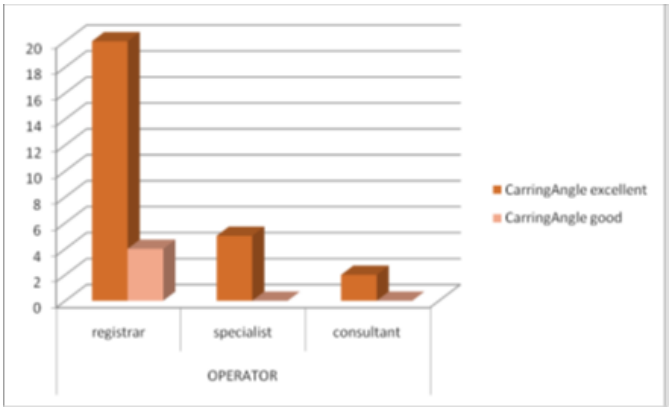

FIGURE 22: Shows *the relation between operator's seniority and the carrying angle six weeks post-operatively.*

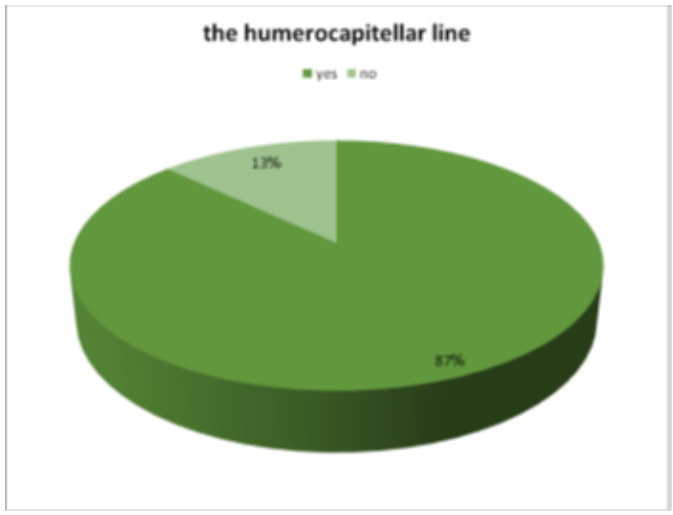

FIGURE 23: Illustrate *the humerocapitellar line sign after six weeks.*

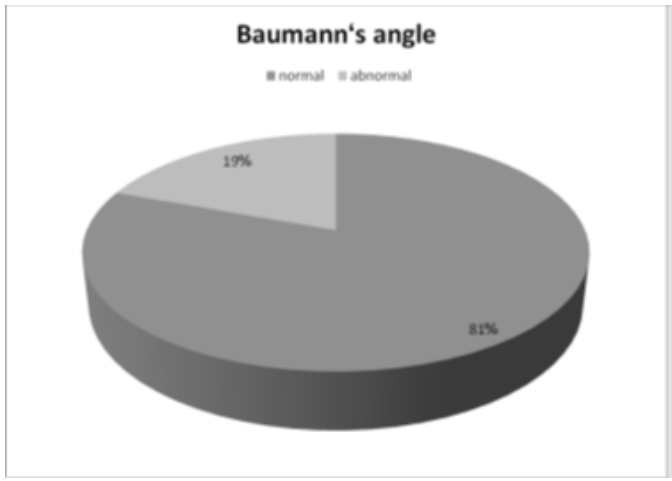

FIGURE 24: *showing the Baumann's angle after six weeks.*

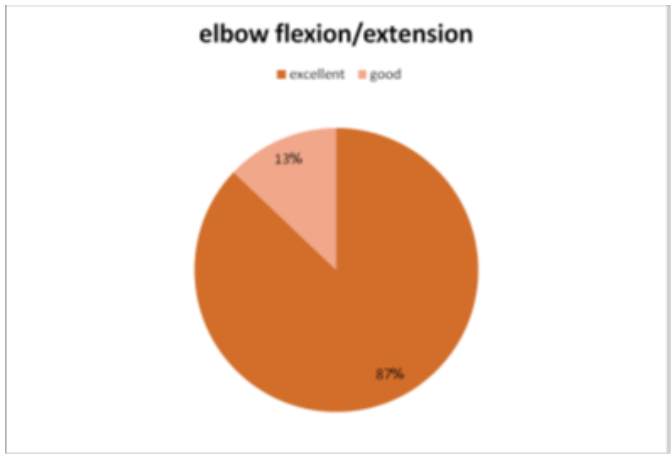

FIGURE 25: Demonstrates *the elbow flexion/extension after six weeks.*

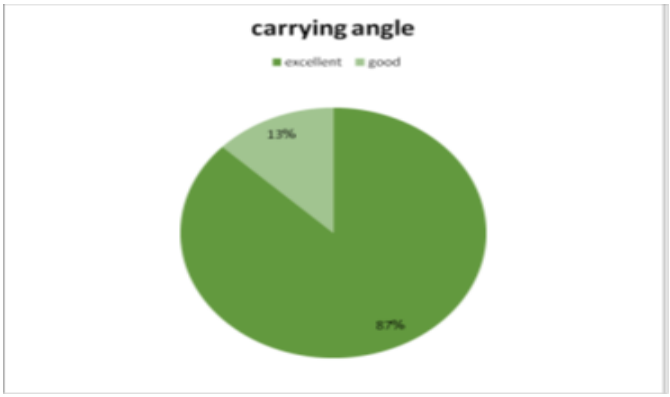

FIGURE 26: *Illustrates the carrying angle after six weeks.*

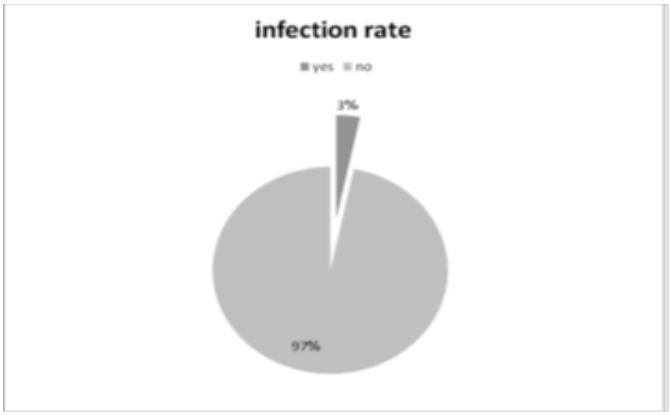

FIGURE 27: *illustrating the infectionrate after surgery.*

Table 2: demonstrates the relation between intra-operative Baumann's angle and Baumann's angle six weeks post-operative

Chi-Square Tests

Pearson Chi-Square	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Continuity Correctionb	8.908a	1	.003		
Likelihood Ratio	4.241	1	.039		
Fisher's Exact Test	7.193	1	.007		
N of Valid Cases	31			.032	.032

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .39.

b. Computed only for a 2x2 table

Table 3: shows the relation between six weeks humerocapitellarand the elbow flexion/extension six weeks post operatively.

Elbow FlexEx	HEALING.AHL		Total
	Yes	no	
excellent	27	0	27
good	0	4	4
Total	27	4	31

Table 4: illustrates the relation between six weeks humerocapitellar line and the elbow flexion/extension six weeks post-operatively.

Chi-Square Tests

Pearson Chi-Square	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Continuity Correctionb	31.000a	1	.000		
Likelihood Ratio	22.740	1	.000		
Fisher's Exact Test	23.842	1	.000		
N of Valid Cases	31			.000	.000

a. 3 cells (75.0%) have expected count less than 5. The minimum expected count is .52.

b. Computed only for a 2x2 table

Table 5: shows the relation between six weeks humerocapitellar line and carrying angle six weeks post operatively

Carring Angle	HEALING.AHL		Total
	Yes	no	
excellent	26	1	27
good	1	3	4
Total	27	4	31

Table 6: shows the relation between six weeks humerocapitellar line and carrying angle six weeks post-operatively.

Chi-Square Tests

Pearson Chi-Square	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Continuity Correctionb	15.758a	1	.000		
Likelihood Ratio	10.052	1	.002		
Fisher's Exact Test	10.789	1	.001		
N.of Valid Cases	31			.003	.003

a. 3 cells (75.0%) have expected count less than 5. The minimum expected count is .52.

b. Computed only for a 2x2 table

Table 7: illustrates the relation between six weeks Baumann's angle and elbow flexion/extension six weeks post-operatively.

Elbow FlexEx	HEALING.BA		Total
	Normal	Abnormal	
Excellent	24	3	27
Good	1	3	4
Total	25	6	31

Table 8: illustrates the relation between six weeks Baumann's angle and elbow flexion/extension six weeks post-operatively.

Chi-Square Tests

Pearson Chi-Square	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Continuity Correctionb	9.111a	1	.003		
Likelihood Ratio	5.477	1	.019		
Fisher's Exact Test	7.127	1	.008		
N.of Valid Cases	31			.016	.016

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .77.

b. Computed only for a 2x2 table

Table 9: illustrates the relation between six weeks Baumann's angle and carrying angle six weeks post-operatively.

Carring Angle	HEALING.BA		Total
	Normal	Abnormal	
Excellent	25	2	27
Good	0	4	4
Total	25	6	31

Table 10: illustrates the relation between six weeks Baumann's angle and carrying angle six weeks post operatively.

Chi-Square Tests

Pearson Chi-Square	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Continuity Correctionb	19.136a	1	.000		
Likelihood Ratio	13.663	1	.000		
Fisher's Exact Test	16.203	1	.000		
N of Valid Cases	31			.000	.000

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .77.

b. Computed only for a 2x2 table

4 | DISCUSSION

Supracondylar humerus fractures are one of the commonest childhood injuries that require full attention. It is the commonest injury around pediatric elbows. They are associated with potential neurovascular injuries and malunion with poor cosmetic outcome. Thus, they require prompt assessment and management. Surgical treatment has been described for unstable injuries. K wire fixation is the standard of care for such injuries. Two major configurations have been described, crossed or lateral K pinning. This study was conducted to assess the outcome of the lateral pinning configuration.

The demographics of the study population were comparable to those of the literature. The majority were male children in the age group (7-10 years). Comparable demographics were found by Kou RY et al with male predominance and average age of (5-12years)(6). Most of the patients were right handed and most of them were injured in their right elbow, however, no significant correlation was found between side of trauma and hand dominance. The majority "84%" of the patients were classified as Gartland type III, a figure that is comparable to Mazda et al study which showed that "74%" of surgical candidates to be type III(12) .

Assessment of the radio logical outcome revealed good results in most of the patients. Specifically, humerocapitellar alignment and Baumann angle which were found to be normal in over (80%) of the patients. These results were matching with a study (published by Eberhardt O et al in Jchild ortho) which showed (87%) excellent radiological outcome(8). In addition, Mazda K et al found a change in humerocapitellar alignment in 22% and in Baumann angle in 19%.(12)

A publication of the association of bone and joint surgeons conducted by Jia-Guo Zhao et al. on May 2013 revealed no deference in radio logical outcome between crossed or lateral pinning(9). In our study, healing Baumann angle was found to be significantly affected by intra operative Baumann angle, a result which is comparable to that found in the J child ortho (published by Eberhardt O et al) which stated that resulting radiological malalignment was due to bad initial reduction.(8)

Assessment of the functional outcome illustrated excellent outcome of wrist movement and forearm rotation in all patients. On the other hand, Regarding elbow range of motion and carrying angle, patients showed excellent out come in (87%) and good outcome in (13%). These results were found to be matching with those of Eberhardt O et al which revealed excellent outcome in (90%)(8), and Mazda K et al (12) which showed excellent results in (91%). Moreover, Jia- Guo Zhao et al results showed no deference between crossed and lateral wiring by means of stability.(9)

In contrast Larson, loren et al concluded that crossed pinning is more stable than lateral in medial comminution.(11).in addition, a model based biomechanical study by Chao Feng et al found crossed pinning to be superior during valgus loading and lateral pinning to be superior during rotational stresses.(19). Zenios et al found out that out of 21 patients, 6 patients were stable with two lateral pins, 10 patients needed addition of a third lateral pin and five cases required addition of one medial pin.(20). Amre Hamdi et al demonstrated that divergent lateral pins are more stable than parallel pins.(21) Apart from one case report of pin tract infection, there were no reported complications, neurovascular injury or malunion. This results reinforce Jia-Guo Zhao et al study (comparing crossed and lateral pinning) could not identify significant deference between the two methods in terms of pin tract infection, reoperation or compartment syndrome. Furthermore, they reported (4,5%) risk of ulnar nerve injury with a medial pin.(9).

While assessing correlations, the surgical timing was not found to have a significant impact on the radiological or functional outcome. Additionally the seniority of the operator did not affect the radiological or functional outcome. This matches with the results of Mazda K et al which demonstrated (96%) excellent outcome even with less experienced hands.(12). In contrary, elbow range of motion and carrying angle was affected significantly by the two the radiological factors (humerocapitellae alignment and Baumann angle). This is contrasting the results of Mazda K et al which did not found a correlation between radiological signs and functional outcome.(12).

5 | CONCLUSION

The two lateral K wires configuration is a valid option for treatment of pediatric supracondylar humerus fracture. It provides an excellent radio logical outcome in over (80%), an excellent functional outcome in (87%) and a good safety profile against iatrogenic neurovascular injuries and malunion.

Recommendations:

Careful assessment of pediatric patients with supracondylar humerus fracture and appropriate choice of treatment should be done. Lateral pinning needs to be considered as a good and safe operative option. Therefore, junior staff should be trained regarding the principles of the technique.

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