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Retrospective Evaluation of The Result of Fixation of Lateral Humeral Condyle Fractures by K-Wires versus Cannulated Screws in Children

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ABSTRACT

Background: fractures of the lateral condyle of the humerus represent the second most common type of fracture of the elbow in children. Although this injury is seen at all ages, it is predominately observed in children aged between 5 and 10 years.

Objective: the purpose of this study is retrospective evaluation of the results of fixation of lateral humeral condyle by K-wires versus cannulated screws in children by assessment of: 1-Time to full union. 2-Range of motion.3-Percentage of complications. 4-According to Hardacre criteria.

Patients and methods: a retrospective study for evaluation of the result of fixation of lateral humeral condyle fractures in children by K-wires vs cannulated screws. Our series was conducted in Al-Azher University Hospitals. 20 patients with humeral condyle fractures were treated by K-wires and cannulated screws.

Results: in group A patients presented by complications as following: extension lag 1 (10%), delayed union (healing at 3–6 months) 1 (10%), revision 1 (loss of reduction at the 3rd day of operation and required revision using pin fixation) (10%), fish tail deformity 0 (0%) and 7 (70%) had no complications. While in group B: extension lag 1 (10%), delayed union 2 (20%), nonunion 1 (10%) (Not healed at greater than 6 months and re-operated using bone graft and pin fixation), revision 0 (0%), fish tail deformity 1 (10%), pin tract infection 1 (10%) and 4 (40%) had no complications.

Conclusion: our study supports that screw fixation may be a viable option, with no nonunions and fewer complications than pin fixation.

Keywords: Fixation of lateral humeral condyle fractures, K-wires, Cannulated screws in children

INTRODUCTION

Fractures of the lateral condyle of the humerus represent the second most common type of fracture of the elbow in children. Although this injury is seen at all ages, it is predominately observed in children aged between 5 and 10 years [(1)]. These injuries are typically the result of an avulsion of a portion of the lateral humeral condyle by pull of the extensor musculature due to a varus force on a supinated forearm (**Milch type II**) or by the direct force of the radial head onto the lateral condyle in the setting of a fall and axial load through an extended elbow (**Milch type I**) [(2)].

Multiple treatment options are available for these fractures, ranging from simple immobilization for nondisplaced or minimally displaced fracture patterns, to operative reduction and fixation with Kirschner wires (K-wires) or screws for displaced fractures. Although some controversy exists with regard to the acceptable amount of displacement, fractures with displacement greater than 2 mm or 3 mm are generally thought to require open reduction and fixation to facilitate union and prevent deformity and articular incongruity. Because of concerns about the possibility of loss of fixation with brief use of K-wires or occurrence of infection with their prolonged use, authors have explored the use of screw fixation for lateral condyle fractures. In theory, screws should be better suited for resisting load in tension, provide more stable fixation, resulting in a higher union rate, with decreased duration of casting (possibly leading to an improved range of motion)[(3)].

AIM OF THE WORK

The purpose of this study is retrospective evaluation of the results of fixation of lateral humeral condyle by K-wires versus cannulated screws in children by assessment of

1- Time to full union.
2- Range of motion.
3- Percentage of complications.
4- According to Hardacre criteria[(4)].

PATIENTS AND METHODS

A. Study design:

A retrospective study for evaluation of the result of fixation of lateral humeral condyle fractures in children by K-wires vs cannulated screws. Our series was conducted in Al-Azher University Hospitals. 20 patients with humeral condyle fractures were treated by K-wires and cannulated screws.

B. Patients selection:

Inclusion criteria

1. Children aged from 2 to 14 years old.
2. Displaced fracture lateral humeral condyle > 2 mm.
3. Closed fracture lateral humeral condyle.
4. Recent fracture lateral humeral condyle.
5. Any joint incongruity.

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Exclusion criteria

1. Children aged below 2 and above 14 years old.
2. Non displaced fracture or minimally displaced fracture lateral humeral condyle < 2 mm
3. Open fracture lateral humeral condyle.
4. Neglected fracture lateral humeral condyle.
5. Other distal humerus fracture other than fracture lateral humeral condyle (supracondylar fracture humerus).

Sample size: The study contained 20 patients who met the inclusion criteria. All patients were followed retrospectively for minimum of 6 months

Preoperative management protocol

- **On admission:**
  1. Careful history taking and clinical examination done for all patients.
  2. Radiological assessment.
  3. Laboratory testing
- **Preoperative preparation:**
  1. Above elbow slab with good padding to all the bony prominences.
  2. Proper analgesia with caution to hepatic and renal patients
  3. Proper control of blood sugar in diabetic patients
  4. Cardiac consultation for risky patients and to assess their fitness to surgery.
  5. Control of any other comorbidities.
  6. Anesthesia consultation.
- **Informed consent:**

An approval of the study was obtained from Al-Azhar University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation.

- **Operative procedures**
  - ***Anesthesia:***

All patients were received general anesthesia.

Prophylactic intravenous antibiotic (3rd generation cephalosporin) was given to all patients before surgery.

  - ***Positioning and preparation:***

The patient was positioned supine on the operating table, with the fractured elbow on a short radiolucent arm board and a pneumatic tourniquet applied.

  - ***Operative technique:***

❖ **Open reduction internal fixation by K-wires**

❖ **Technique**

The elbow was exposed through a 5- to 6-cm lateral approach, placing two-thirds of the incision above the joint and one-third distal. The interval between the brachioradialis and the triceps was opened.

The dissection was carried down to the lateral humeral condyle. The joint's anterior surfaces were exposed by separating the fibers of the common extensor muscle mass.

Soft-tissue detachment was limited to only that necessary to expose the fragment, the fracture, and the joint; the posterior soft tissues were left intact. With widely displaced fractures, these soft tissues often were already stripped and we could follow the fracture hematoma directly into the joint. Care was taken to prevent injury to the distal humeral articular surface, which often is rotated into the wound. Retracting the antecubital structures exposed the anterior joint surface. A small metacarpal retractor was passed across the joint to the opposite side, taking care to protect the ulnar nerve medially.

The trochlea and fracture site were inspected. The displacement and the size of the fragment were always greater than is apparent on the radiographs because much of the fragment was cartilaginous (Figures 1-4).

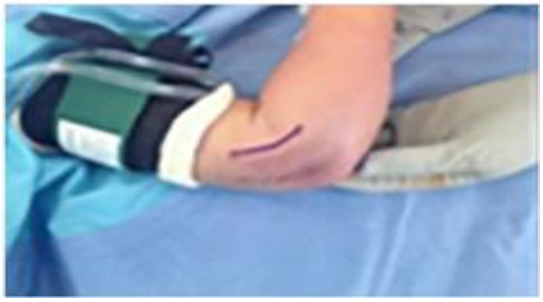

Figure (1):

Figure (1):

Figure (3):

Figure (4): Exploration of fracture site.

The fragment was usually rotated as well as displaced. The joint was irrigated to remove blood clots and debris, the articular surface and the metaphyseal fragment were reduced accurately, and the reduction was confirmed by observing the articular surface, particularly at the trochlea. The position was held with a small tenaculum, bone holder, towel clip, or percutaneous pins as "joysticks". Two smooth K-wires were inserted in a parallel or slightly divergent configuration, across the physis, and into the humeral metaphysis, penetrating the medial cortex of the humerus (Figure 5).

Figure (5): Closure of skin in layers, note the wires protruding through the skin.

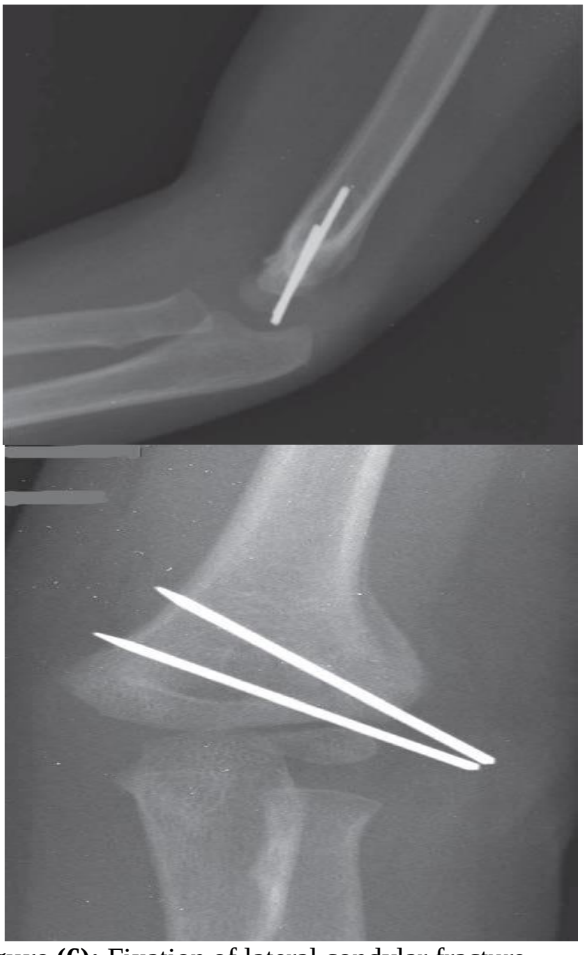

Figure (6): Fixation of lateral condylar fracture.

Internal fixation by screws technique:

Screw placement was through the nonarticular portion of the lateral condyle and through the metaphyseal fragment, with an attempt to gain purchase in the dense bone just lateral to the olecranon/coronoid fossae, or to achieve bicortical screw fixation. Cannulated 4.0 or 4.5 mm screws were used in all cases.

- **Postoperative follow up:**

The arm was placed in a posterior splint or a bivalve long arm cast with the elbow flexed 90 degrees. After the operation was finished, all the patients were transferred to the ward and the following protocol was done:

The cast was worn for 4 to 6 weeks after surgery until the fracture was healed. The pins could be removed at 4 to 6 weeks if union was progressing. Gentle active motion of the elbow was usually resumed and then continued until full range of motion returned. The screws were removed at 8 to 10 weeks if union was progressing and the slab was worn for 3 weeks and then removed to allow active motion of the elbow until full range of motion returned. Intravenous broad-spectrum antibiotic was given for all patients for 5 days and oral antibiotics were continued.

All patients were followed in the outpatient clinic as follows:

- ***After 3 days*** postoperative: To asses, postoperative x-ray to ensure reduction and positioning of either pins or screw.
- ***After two weeks*** postoperative: for wound condition and removal of stitches in case of screw fixation.
- ***After 6 – 8 weeks***: for removal of K-wires if the fracture is united.
- ***After 8- 10 weeks*** for arranging for screw removal in operating theater if the fracture is united.
- ***After 3 months*** to assess the complication of nonunion, malunion, range of motion of elbow joint.
- ***After 6 months***: to assess range of motion in comparison to the healthy side.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean±standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. The P-value <0.05 was considered significant.

RESULTS

Age and sex of patients (Tables 1 and 2).

Table (1): Comparison between two groups according to age (years).

Age (years)	Screw (group A) (n=10)	Pins (group B) (n=10)	P-value
Range	2-14	2-14	>0.05
Mean±SD	7.64±2.28	7.18±1.83	

Table (2): Comparison between two groups according to gender.

Sex	Screw (group A) (n=10)	Pins (group B) (n=10)	P-value
Male	7 (70%)	6 (60%)	>0.05
Female	3 (30%)	4 (40%)	

Time to full union: (in weeks) (Table 3, 4)

We noted that in group A time to full union was minimum 6 weeks, maximum 12 weeks with a mean time was 8.49±1.79 weeks, while in group B time to full union was minimum 6 weeks, maximum was 14 weeks with a mean time was 9.69±2.21 weeks which is not significant statistically.

Table (3): Comparison between two groups according to time needed to full union.

Time needed to full union	Screw (group A) (n=10)	Pins (group B) (n=10)	P-value
6 weeks	2 (20.0%)	1 (10.0%)	>0.05
7 weeks	3 (30.0%)	3 (30.0%)	
8 weeks	2 (20.0%)	3 (30.0%)	
9 weeks	1 (10.0%)	1 (10.0%)	
10 weeks	1 (10.0%)	1 (10.0%)	
12 weeks	1 (10.0%)	0 (0.0%)	
14 weeks	0 (0.0%)	1 (10.0%)	

Table (4): Comparison between two groups according to time needed to full union.

Time needed to full union (wks)	Screw (group A) (n=10)	Pins (group B) (n=10)	P-value
Range	6-12	6-14	>0.05
Mean±SD	8.49±1.79	9.69±2.21	

Total arc of motion: (Table 5)

Table (5): Comparison between two groups according to total arc of motion.

Total ARC of motion	Screw (group A) (n=10)	Pins (group B) (n=10)	P-value
Range	103-155	82-154.50	0.007*
Mean±SD	42.3±11.45	31.5±16.43	
Median	146.8	133.9	
Mode	149.4	133.9	

Table (6): Summary of range of motion.

	Screw (N=20)	Pins (N=20)	P-Value
Extension [mean±SD]	-1.94±5.50	5.08±6.85	>0.05
Min/max	-5_15	-5_20	
Median	0.0	5.0	
Extension >15(%)	1 (10)	2 (20)	
Flexion *[mean±SD]*	142.8±8.2	134.5±11.5	0.039*
Min/max	115-155	105-150	
Median	143.3	137.7	
Flexion<120 (%)	1 (10)	2 (20)	
Total arc *[mean±SD]*	142.3±11.45	131.5±16.43	0.007*
Min/max	103-155	82-154.50	
Median	146.8	133.9	

The median values for range of motion were increased in the screw fixation group, but the rate of clinically significant loss of range of motion was not different between the two groups.

N.B: this table shows that there is a significant statistical difference between total arc of motion and flexion range according to type of fixation but there is no statistically significant difference in extension range.

Complications: (Table 7)

Table (7): Frequencies statistics according to complications in each group.

	Type	Frequency	Percent
Screw group A)	Extension lag < 15°	1	10%
	Delayed union (healing at 3-6 months)	1	10%
	Revision (loss of reduction 3rd day post-operative, revision using pins)	1	10%
	Fish tail deformity	0	0%
	None	7	70%
	Total	10	100%
Pins group B)	Extension lag	1	10%
	Delayed union	2	20%
	Nonunion	1	10%
	Revision	0	0%
	Fish tail deformity	1	10%
	Pin tract infection	1	10%
	None	4	40%
	Total	10	100%

Hardacre criteria: (Table 8)

Evaluation of treatment outcomes in humeral lateral condyle injuries were followed according to (**Hardacre criteria**) [105]:

Table (8): Comparison between two groups according to Hardacre criteria.

Hardacre criteria	Screw group A) (n=10)	Pins group B) (n=10)	P-value
Excellent	7 (70%)	5 (50%)	>0.05
Good	2 (20%)	4 (40%)	
Poor	1 (10%)	1 (10%)	

All cases were followed according to Mayo elbow score (Table 9)

Table (9): Comparison between two groups according to Mayo elbow score.

Mayo elbow score	Screw (group A) (n=10)	Pins (group B) (n=10)	P-value
Excellent	7 (70%)	6 (60%)	>0.05
Good	2 (20%)	3 (30%)	
Poor	1 (10%)	1 (10%)	

CASE PRESENTATIONS

Case No. (1)

History:

8 year-old male, student, who fell from height, and was not diabetic. He had a lateral condyle humeral fracture of the left humerus (Milch II). He was admitted to Al-Hussein hospital on the same day of trauma

On admission clinical examination and plain x-rays were done. The patient was given proper analgesia, put in above elbow slab and admitted to department where he was prepared to surgery which was done later on the same day of trauma.

Anesthesia: General.

Operation:

- Approach: direct lateral approach.
- Reduction: open without complication.
- Method of fixation: screw fixation.
- Operative time: about 45 min. No blood loss observed. No drain.
- Postoperative: No blood loss observed.
- Postoperative stay: one day.

Follow up:

- 3 Days postoperative: routine x-ray to ensure reduction and fixation.
- 2 weeks postoperative: check wound status and stitches removal.
- 3 weeks postoperative: removal of slab and patient started motion at elbow joint.
- 3 weeks postoperative: removal of slab and patient started motion at elbow joint.
- 6 weeks postoperative: clean wound, follow up x-ray showed union of the fracture.
- 8 weeks postoperative: arrange for reoperation for screw removal.

  Secondary procedure was at the 9th week.
- 4 months postoperative: no complication detected and the motion at elbow joint returned to normal in comparison to the healthy side and Hardacre criteria were excellent.
- 6 months postoperative: assess of range of motion in according to the healthy side.

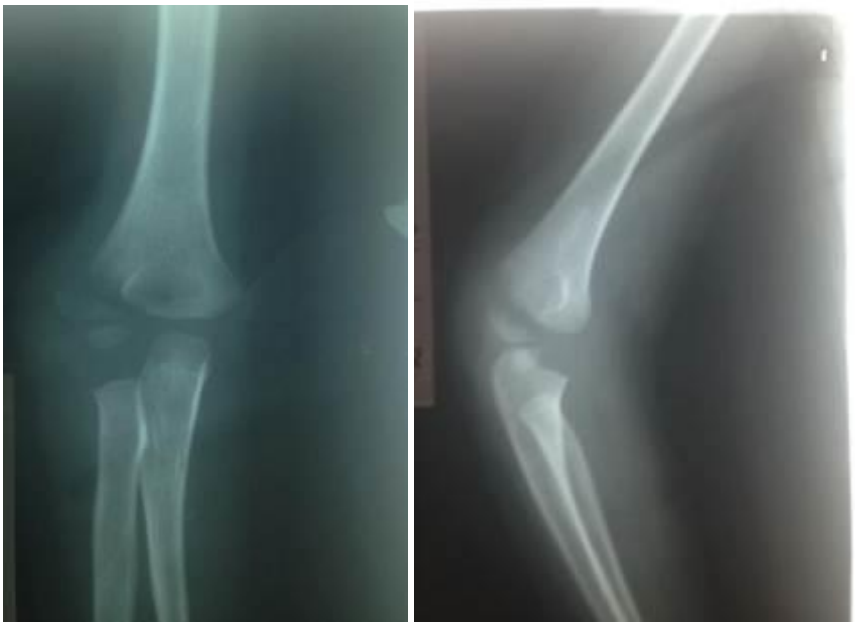

Figure (7): Preoperative x-rays of case no.1

Figure (8): Follow up x-ray of case no.1 after 8 weeks

Figure (9): Postoperative x-rays of case no.1 after removal of screw

Figure (10): Postoperative picture of patient. Case No. 1.

Case No. 2

Female patient 2.5 years old fell on outstretched hand, she had a lateral condyle humeral fracture of the left humerus Milch type (2), she was admitted at Sayed Galal Hospital at the same day

On admission clinical examination and x- rays were done. She was given proper analgesic and put in above elbow slab and admitted to the Department where she was prepared to surgery, which was done later on the same day of admission

Anesthesia: General.

Operation:

- Approach: direct lateral approach.
- Reduction: open without complication.
- Method of fixation: K-wires fixation.
- Operative time: about 45 min. No blood loss observed. No drain.
- Postoperative: No blood loss observed.
- Postoperative stay: one day.

Follow up:

- 3 Days postoperative: routine x-ray to ensure reduction and fixation.
- 2 weeks postoperative: check wound status and stitches removal.
- 3 weeks postoperative: removal of slab and patient started motion at elbow joint.
- 3 weeks postoperative: removal of slab and patient started motion at elbow joint.
- 6 weeks postoperative: clean wound, follow up x-ray showed union of the fracture.
- 8 weeks postoperative: arrange for reoperation for K-removal.
- 4 months postoperative: no complication detected and the motion at elbow joint returned to normal in comparison to the healthy side and Hardacre criteria were excellent.
- 6 months postoperative: assess of range of motion in according to the healthy side.

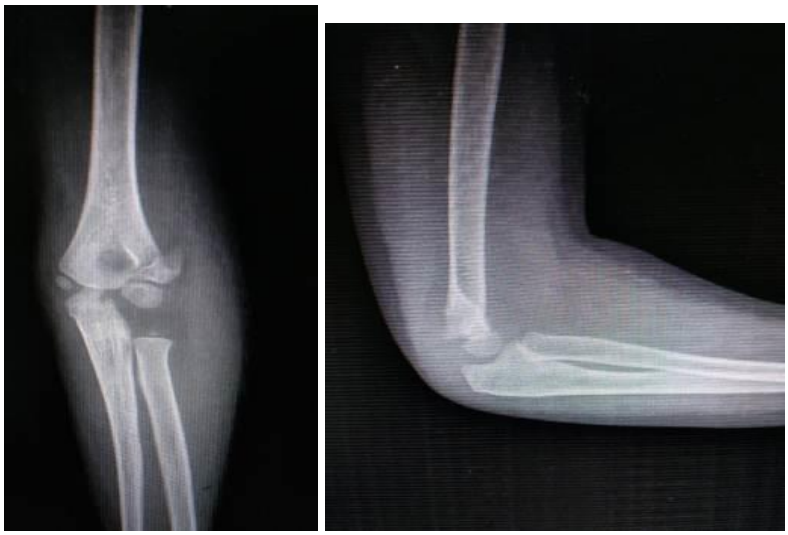

Figure (11): Preoperative x-rays of case no.2

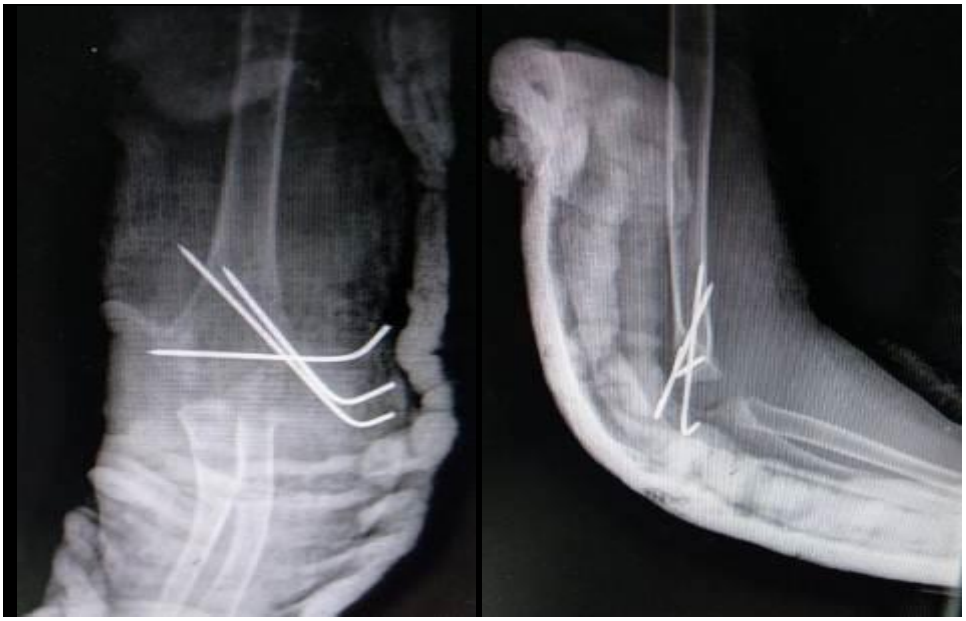

Figure (12): Postoperative x-rays of case no. 2

Figure (13): Postoperative x-rays of case no.2 after 3 week

Figure (14): Postoperative x-rays of case no. 2 after removal of K-wires

DISCUSSION

We compared our results with the results of the studies in literature, which compared the two techniques in management of pediatric lateral condyle fracture.

We found a study; **Gilberta *et al.*** [5], which compared the 2 techniques in management of pediatric lateral condyle fractures:

Table (10a): Comparison between our study and **Gilberta *et al.*** [5]**.**

Characteristics	Our study			Gilberta *et al.* [5]		
	Screw (N=10)	**Pins (N=10)**	**p-Value**	**Screw (N=41)**	**Pins (N=43)**	**p-Value**
Mean age (SD)	6.45 (2.21)	6 (1.77)	>0.05	6.2 (3.03)	5.2 (2.33)	0.0909
Min/max	3-9	3-9		2–14	2–12	
Male (%)	7 (70)	6 (60)	>0.05	29 (70.7)	30 (69.8)	0.9230
Union *Yes* *No* *Delayed*	 9 (90) 0 1 (10)	 8 (80) 1 (10) 1 (10)		 39(97.5) 0 1 (2.5)	 31 (81.6) 3 (7.9) 4 (10.5)	
Complications [n (%)]	3 (30)	6 (60)	0.013	3 (7.5)	13 (31.0)	0.0074
Infection [n (%)]	0 (0)	2 (20)		1 (2.4)	2 (4.7)	
Mean time to union (SD) (weeks)	7.45 (1.572)	8.50 (2.090)	>0.05	7.8 (2.92)	9.6 (4.37)	0.0462
Mean follow-up (SD) (months)	6.8 (0.83351)	6.6 (0.68056)	>0.05	6.4 (5.09)	7.2 (11.3)	0.6804

Table (10b): Comparison between our study and **Gilberta *et al.* [5].**

Characteristics	Our study			Gilberta *et al.* [5]		
	Screw (N=10)	**Pins (N=10)**	**p-Value**	**Screw (N=35)**	**Pins (N=32)**	**p-Value**
Extension [mean (SD)] *Min/max* *Median* *Extension>15(%)*	-1.94±5.50 -5-15 0.0 1 (10)	5.08±6.85 -5-20 5.0 2 (20)	0.104	3.1(5.04) −5.0-15.0 0.0 3 (8.6)	7.9 (16.62) −10.0- 70.0 5.0 3 (9.4)	0.2057
Flexion[mean(SD)] Min/max *Median* Flexion<120 (%)	142.8±8.2 115-155 143.3 1 (10)	134.5±11.5 105-150 137.7 2 (20)	0.039*	141.2(11.87) 110.0–155.0 145.0 3 (8.6)	132.1(14.28) 100.0–150.0 140.0 3 (9.4)	0.0142
Total arc [mean (SD)] Min/max *Median*	142.3±11.45 103-155 146.8	131.5±16.43 82-154.50 133.9	0.007*	137.1(15.72) 100.0–155.0 145.0	129.1(20.91) 60.0–150.03 136.0	0.1158
Hardacre criteria Excellent Good Poor	 7 (70 %) 2(20%) 1(10%)	 5(50%) 4(40%) 1(10%)		 30(94%) 2 (6%) 0	 25(86%) 1 (1%) 3 (10%)	

Our results were similar to **Gilberta *et al.* [5]** showing statistically difference regarding complication rate and flexion range but no statistically difference regarding time to union. Additionally our study also showed statistically difference regarding total arc of motion.

Li and Xu [6] in their study reported the results of screw fixation (32 patients) compared with K-wire fixation (30 patients). They observed no significant difference in clinical outcome and no nonunion. They reported more frequent limitation of motion and a higher rate of infection in the K-wire group. They observed clinically apparent lateral overgrowth in 37% of patients treated with K-wires and 12% of those treated with screws. They also observed differences in the carrying angle in 23% of patients treated with K-wires (six of seven of these appearing to have cubitus varus), whereas 19% of screw fixation patients had apparent cubitus valgus.

Results of K-wire fixation were reported by **Boz *et al.* [7]**, who observed excellent functional results at an average follow-up of 39 months in 71.3% of 69 patients. Of the patients, 47% were observed to have lateral condylar overgrowth. Nonunion, however, was not observed in any patient.

In a study by **Thomas *et al.* [8]**, 104 patients underwent a 3-week period of K-wire fixation, with one instance of nonunion, two cases of infection, and a 44% incidence of abnormal elbow shape on late review (which included lateral condylar overgrowth and excessive bone formation over the outer surface of the condyle).

In a study by **Skak *et al.* [9], they** described the use of K-wire and Palmer nail fixation in 21 patients, reporting that all but one case was radiographically healed at a later review. It was documented that, in all of these patients, the distal humerus was wider in comparison with the unaffected side following healing. Two of these patients subsequently developed avascular necrosis of the trochlea.

Of 16 fractures treated with K-wire fixation by **Jenyo and Mirdad [10],** malunion was observed in one case, resulting from loosening of a K-wire, and nonunion was observed in one case, requiring subsequent bone grafting and screw fixation.

In a study by **Weiss *et al.* [11]; they** observed no nonunion and a 3.8% infection rate in the entire group of patients treated with K-wire fixation and 4 weeks of cast fixation. Among the 73 patients who had displacement requiring open reduction, nine had malunion, loss of reduction, or nonunion.

In another large series of 105 patients with K-wire fixation following open reduction for displaced fractures, **Leonidou *et al.* [12]** reported 96% excellent results with no nonunions, no loss of motion and four patients with cubitus varus.

With regard to screw fixation, **Loke *et al.* [13]** examined 34 patients with an average follow-up of 24.5 months and found the average time to radiographic union to be 6.9 weeks. Excellent functional results were observed in 82%. Lateral overgrowth was observed in two patients, lateral condylar avascular necrosis resulting in a valgus

deformity in two patients, and a fishtail deformity in three patients.

In one study **Sharma *et al.* [14]** followed up 37 children in whom 4.0 mm cancellous lag screws were placed, with a mean follow-up of 4.8 years. Painless, full range of motion was observed in 36 of the 37 patients. The one outlying patient was observed to have a delayed union with loss of 10° of elbow motion in comparison with the contralateral side. Mild fishtail deformity was also observed in three of the cases, but this was not observed to be functionally relevant. There was no instance of nonunion, avascular necrosis, or premature epiphyseal fusion.

In a study by **Hasler *et al.* [15]** they studied 66 fractures, of which 27 were treated with metaphyseal lag screw placement. At a mean follow-up of 10 years, all 27 of the operative cases demonstrated anatomic union, symmetric carrying angles with the unaffected side, and full range of motion.

CONCLUSION

Surgeons currently treat lateral condyle fractures with K-wires or screws, but only smaller prior study compared the two approaches. Our study supports that screw fixation may be a viable option, with no nonunions and fewer complications than pin fixation. These potential advantages have to be weighed against the need for subsequent screw removal. Longer follow-up will be required to assess effects on growth.

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