Exposed versus Buried Kirschner Wires Used in Displaced Pediatric Fractures of Lateral Condyle of Humerus

Abstract

Background: Comparision of results and complications of exposed versus buried Kirschner wires (K-wires) after open reduction of lateral condyle fractures is scarce and mainly from western population; hence, we envisaged to study the safety and efficacy of exposed and buried K-wires used for fixation of displaced pediatric fracture of the lateral condyle of humerus in Indian setup. **Materials and Methods:** A prospective, nonrandomized, comparative study was conducted in 50 patients with age <12 years, presenting with displaced fracture of lateral condyle of humerus of <2 weeks duration, without associated ipsilateral upper limb injury, who were treated by open reduction and internal fixation with either exposed or buried K-wires (*n* = 25 in each group). At a minimum followup of 3 months, status of fracture reduction, union, evidence of osteomyelitis, carrying angle at the elbow, and elbow range of motion (ROM) were assessed clinicoradiologically. **Results:** Four (16%) patients in exposed group and 1 (4%) in buried group had superficial infection, while 3 (12%) patients in exposed group and 2 (8%) in buried group had deep infection. All the patients with infection responded well to oral antibiotics and regular dressings. Buried group had higher incidence of secondary skin and wire-related complications. **Conclusion:** There was no statistical difference between the two groups but exposed K wires are easy to remove so are preferred over buried K wires.

Keywords: *Children, displaced, K-wires, lateral condyle humerus fracture*
MeSH terms: *Pediatrics, humerus, humeral fractures*

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Introduction

Fractures of the lateral humeral condyle are a common pediatric injury with incidence rate of 10%–20% of all pediatric elbow fractures.[1] Open reduction internal fixation (ORIF) with Kirschner wires (K-wires) is the commonly utilized method of fracture fixation for displaced fractures.[2-11] These K-wires may be either buried beneath the skin or wire ends may be left exposed outside skin.[12-14] Buried K-wires require a second elective operation, while exposed K-wires may be removed in an outpatient setting. This advantage may be offset, however, if there is a higher rate of complications with the exposed wire technique. Risk of infection and adequacy of fixation may also be of concern with the exposed K-wires.[12] Literature specifically comparing the results and complications with exposed versus buried K-wires after open reduction of lateral condyle fractures is scarce and mainly from western population.[12,15,16] Moreover, these studies are retrospective. India is a tropical nation where a lack of general hygiene condition along with economic and climate conditions may lead to high chances of pin tract infection. Simultaneously, another operative procedure under anesthesia (removal of buried K-wires) significantly increases the load over healthcare system in addition to causing parental anxiety. Hence, we envisaged to study the safety and efficacy of exposed and buried K-wires used for fixation of displaced fracture of lateral condyle of humerus in children. The objective of the current study was to compare the superficial and deep infection rate between exposed and buried K-wires treatment options and to compare the two groups for variables such as postoperative fracture reduction, time to fracture union, elbow range of motion (ROM) and carrying angle, postoperative complications (other than infection) such as nonunion, cubitus valgus/varus, and elbow stiffness.

Materials and Methods

The study design was prospective, nonrandomized, comparative study.

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Institutional ethical clearance and informed patient consent were obtained before enrolment of patients for the study. Fifty cases of pediatric lateral condyle fractures of humerus were divided into two groups; Group-1 (exposed K-wires) [Figure 1] and Group-2 (buried K-wires) [Figure 2].

All patients under the age of 12 years presenting with <2 weeks, displaced fracture of lateral condyle humerus (>2 mm), i.e., Jakob Type 2 and 3 without associated ipsilateral upper limb injury were included.[17] The

exclusion criteria were open, undisplaced, and pathological fractures.

Plain radiographs anteroposterior and lateral view of the injured elbow were taken. Jakob Type 2 and 3 were planned for ORIF with smooth K-wires using lateral approach to the distal humerus.[18] The K-wires were buried or left exposed as per preoperative categorization. Standard antibiotic protocol of preoperative intravenous injection of 3rd-generation cephalosporin and aminoglycoside was given

Figure 1: Exposed group. (a) Preoperative radiographs anteroposterior and lateral views showing Jakob Type 3 lateral condylar humerus fracture (b) Followup radiographs anteroposterior and lateral views at 3 months showing lateral condylar overgrowth (c) Followup at 1 year anteroposterior and lateral view showing reduction in lateral condylar overgrowth (d) Clinical photograph showing extension and flexion (e) Inflammation on 7th postoperative day

Figure 2: Buried group (a) Preoperative radiographs anteroposterior and lateral views showing Jakob Type 2 lateral condyle fracture (b) Radiographs anteroposterior and lateral views at 3 months followup showing union (c) Radiographs anteroposterior and lateral views at 1 year followup showing union (d) Suture line infection with pus at 7th postoperative day (e) Clinical photograph at 1 year followup showing flexion (f) Clinical photograph showing tenting of skin over K-wire at 6 week followup

30 min before surgical incision, followed by 48 h of same intravenous antibiotic therapy.

Postoperative above elbow Plaster of Paris slab immobilization was given in all cases and was continued for 8 weeks. X-ray was done on the postoperative day-1 to assess the fracture reduction, wire placement, and configuration. Fracture reduction was assessed by using Baumann's angle[19] and anterior humeral line[20] (AHL). The patients were discharged on 3rd postoperative day. Subsequently the patients were followed on 7th day, 14th day, 6 weeks, and 3 months or later. At 7th day followup, patients were reviewed for wound inspection. Suture removal and repeat wound inspection were done at 2 weeks. At 6 weeks followup, slab radiograph was done to assess fracture reduction, union, and/or radiological signs of osteomyelitis, if any. Superficial infection was managed by short course of oral antibiotics. Deep infection was managed by antibiotics along with wound lavage or surgical debridement along with wire removal if necessary. In Group-1, wires were removed at 6 weeks or earlier if necessitated by presence of nonresponding infection. In Group-2, wires were removed electively after radiographic union unless deemed necessary in lieu of any postoperative skin/wound complications such as skin abrasion, tenting of skin over K-wires or exposure of K-wires, or infection. At 3 months followup, the following parameters were assessed clinicoradiologically; status of fracture reduction, status of union, any evidence of osteomyelitis, carrying angle at the elbow, and elbow ROM.

Statistical analysis

Statistical analysis was performed with SPSS 20.0 for Windows (SPSS Inc., Chicago, IL, USA). Categorical data were compared with Chi-square test and Fisher's exact test as applicable. Continuous data were compared with the Mann–Whitney test for nonparametric data and the unpaired *t*-test for parametric data. Intergroup and intragroup comparisons of Baumann's angle were done by repeated measure ANOVA (*F*-test). Statistical significance was defined as $P < 0.05$.

Results

The characteristics of both the groups are shown in Table 1. The age of patients ranged between 1.5 and 11 years with a mean age of 5.90 ± 2.43 years. Extremity was right in 9 (18%) cases and left in 41 (82%) cases ($n = 50$). The comparison of two groups is depicted in Table 2.

Patients were operated at mean duration of 4.64 ± 3.01 days in Group-1 and 4.36 ± 3.30 days in Group-2 ($P = 0.755$; nonsignificant). In both the groups, the wires configuration and fractures reduction observed are given in Table 3. In Group-1, 4 (16%) cases had superficial (presence of signs of inflammation along the incision or the pin site, serous discharge, or hypergranulation tissue at the pin site in the absence of any of the criteria defined for deep infection) while 3 (12%) cases had deep infection (presence of

Table 1: Comparison of injury characteristics in both the groups (*n*=25)

Characteristics	Group 1 (%)	Group 2 (%)
Mean age±SD (years)	7.08±2.100	4.72±2.189
Sex		
Male	22 (88)	15 (60)
Female	3 (12)	10 (40)
Limb involved		
Right	5 (20)	4 (16)
Left	20 (80)	21 (84)
Mechanism of injury		
Fall on ground while playing	11 (44)	13 (52)
Fall from wall	6 (24)	4 (16)
Fall on stairs	4 (16)	6 (24)
Fall from bicycle	4 (16)	2 (8)
Jakob type		
Type 2	8 (32)	16 (64)
Type 3	17 (68)	9 (36)
Milch type		
Type 1	7 (28)	10 (40)
Type 2	18 (72)	15 (60)

SD=Standard deviation

Table 2: Comparison of Group 1 and 2 outcome in lateral condyle fractures

Characteristics	Group 1 (%)	Group 2 (%)	*P*
Injury to surgery duration (days)	4.64±3.01	4.36±3.30	0.755
Infection	7 (28)	3 (12)	0.157
Anterior humeral line intersected through middle third of capitellum	21 (84)	15 (60)	0.059
Baumann's angle at 3rd month (°)	82.24±9.53	82.80±7.87	0.804
Elbow arc of motion (°)	132.96±10.90	130.84±9.59	0.469
Elbow flexion (°)	134.76±3.90	134.04±5.37	0.590
Extensor lag elbow (°)	2.44±7.99	3.20±8.083	0.761
Lateral condylar overgrowth	11 (44)	12 (48)	0.777
Carrying angle (°)	6.48±6.43	3.72±5.48	0.215

constitutional signs of fever, pus discharge from wound or pin site, concomitant septic arthritis of elbow with or without radiological signs of osteomyelitis, such as periosteal reaction and sclerosis of the fracture fragment). In Group-2, 1 (4%) case had superficial while 2 (8%) cases had deep infection ($P = 0.157$; nonsignificant). Early removal of K-wires (i.e., before 6 weeks) was not done in any of the cases in either of the groups. In Group-1, K-wires were removed at 6 weeks of followup in all cases. In Group-2, 4 (16%) patients had skin abrasion and 3 (12%) patients had secondary exposure of K-wires. Nine (36%) patients developed late tenting of skin over K-wires, which necessitated removal of K-wires between 6 and 8 weeks.

In Group-1, radiological union was seen at 6 weeks of followup, except two patients with Jakob Type 3 fracture,

Table 3: Wire placement, number of wires used and fracture reduction in both the groups (*n*=25)

Variables	Group 1 (%)	Group 2 (%)
Wire placement		
Parallel	4 (16)	11 (44)
Divergent	14 (56)	14 (56)
Criss-cross	7 (28)	0
Number of wires		
2	16 (64)	24 (96)
3	9 (36)	1 (4)
Fracture reduction		
Anatomical	23 (92)	23 (92)
Nonanatomical	2 (8)	2 (8)

in which it was seen at 8 weeks. Mean union time in Group-1 was 6.16 ± 0.554 weeks while in Group-2 was 6 ± 0.000 weeks.

Anterior humeral line and Baumann's angle

At final followup, AHL intersected through middle third of the capitellum in 21 (84%) cases in Group-1 and 15 (60%) cases in Group-2 (*P* = 0.059; nonsignificant).

In Group-1, mean of Baumann's angle at 6th week was 83.16 ± 10.42 and at 3rd month was 82.24 ± 9.53, while in Group-2, mean was 82.40 ± 7.02 and 82.80 ± 7.87, respectively. There was no statistically significant difference in Baumann's angle at 6th week and 3rd month within the groups (*P* = 0.721) and between the groups (*P* = 0.804). Hence, acceptable fracture reduction was achieved and maintained satisfactorily in both the groups.

Carrying angle and deformity

Mean carrying angle was 6.48° ± 6.43° in Group-1 and 3.72° ± 5.48° in Group-2 with no statistically significant difference (*P* = 0.215). All carrying angles were measured clinically with the goniometer with the forearm supinated and elbow in maximum extension.

In Group-1, 3 (12%) patients developed a cubitus varus deformity of <13° and 4 (16%) patients developed cubitus valgus deformity of >14°, while in Group-2, 7 (28%) patients developed a cubitus varus deformity of <8°. None of the patients required revision corrective surgery other than for removal of buried K-wire.

Elbow range of motion

At the final followup, the mean arc of elbow motion of 132.96° ± 10.90° in Group-1 and 130.84° ± 9.59° in Group-2 (*P* = 0.469; nonsignificant). Flexion of elbow was more than 125° in all the patients of both the groups with a mean of flexion 134.76° ± 3.90° in Group-1 and 134.04° ± 5.37° in Group-2 (*P* = 0.590; nonsignificant). Mean extension lag of elbow was 2.44° ± 7.99° in Group-1 and 3.20° ± 8.083° in Group-2 (*P* = 0.761; nonsignificant).

Lateral condylar overgrowth

Radiological lateral condylar overgrowth of humerus occurred in 11 (44%) patients in Group-1 and 12 (48%) patients in Group-2 (*P* = 0.777; nonsignificant). There was no pain or interference with daily activities, and no surgical intervention was required.

Discussion

There is a paucity of literature comparing outcome in exposed versus buried K-wires fixation in lateral condyle fractures, and there is no study from the Indian subcontinent.

In our study, overall, there were 37 (74%) males and 13 (26%) females in the age group of 1.5–11 years. The age distribution showed a predilection of injury in the age group 5–10 years in males and <5 years in female. The mechanism of injury reflected preponderance toward fall on ground while playing in both the groups. Left nondominant elbow showed a predilection of injury in both the groups (80% in Group-1 and 84% in Group-2). Milch Type 2 was the most common fracture pattern in both the groups (72% in Group-1 and 60% in Group-2).

In our study, higher rate of superficial (16%; *n* = 25) and deep infection (12%; *n* = 25) in Group-1, while lower rate of superficial (4%; *n* = 25) and deep infections (8%; *n* = 25) in Group-2 was seen within 3 weeks of operative intervention. This higher rate of superficial and deep infection (although not statistically significant) in exposed group was similar to study by Launay *et al.*[12] However, Ormsby *et al.*[16] and Chan and Siow[15] noted lower infection rates in exposed cohort [Table 4]. The reason for this is unclear but may reflect differences in threshold for diagnosing infection, surgical technique, and perioperative antibiotic protocols.

We preferred to make separate stab over skin for insertion of K-wire rather than to pierce the skin directly by K-wire in Group-1 which may cause thermal skin necrosis around the wire leading to infection.[15] In Group-1, both infections were pin site, except in one case where superficial infection of surgical wound occurred. The only two patients who underwent K-wire insertion through surgical incision had infection; however, we are unable to draw any conclusion with respect to this observation. However, since K-wires inserted through the surgical incision are in direct continuity with the fracture site, a pin site infection can track to fracture. Hence such wire placement should be avoided.

In Group-2 at 6 weeks followup, tenting of skin over K-wire occurred in nine cases, skin abrasion in four cases, and secondary exposure of K-wire in three cases. We believe that it occurred due to soft tissue swelling which occurred immediately after injury and subsided a few days later resulting in secondary tenting of skin over K-wire

Table 4: Comparison of infection rate in different published study with current study in both the groups

Study	Study type	Infection rate in exposed group		Infection rate in buried group	
		Superficial, *n* (%)	Deep, *n* (%)	Superficial, *n* (%)	Deep, *n* (%)
Launay *et al*.[12] (*n*=57)	Retrospective	8 (25)	1 (3.1)	2 (8)	0
		32	32	25	25
Chan and Siow[15] (*n*=75)	Retrospective	1 (3)	0	0	0
		33	33	42	42
Ormsby *et al*.[16] (*n*=124)	Retrospective	7 (10.94)	1 (1.56)	8 (13.33)	1 (1.67)
		64	64	60	60
Our study (*n*=50)	Prospective	4 (16)	3 (12)	1 (4)	2 (8)
		25	25	25	25

increasing the risk of skin abrasion and secondary exposure of K-wire in Group-2. However, Thomas *et al*.[21] reported one serious infection in one of the seven children treated with buried K-wires. In this child, the wires eroded through the skin. Delayed diagnosis of the infection resulted in septic arthritis, osteomyelitis, and avascular necrosis. None of our patients developed osteomyelitis, septic arthritis, or avascular necrosis of capitellum or trochlea in any group. In other study by McGonagle *et al*.,[22] skin abrasion was most common complication and occurred in 13 out of 55 cases. One of these patients had a wound infection requiring treatment with intravenous and oral antibiotics before wire removal. Thomas *et al*.[21] advocated 3 weeks of K-wire stabilization and began elbow mobilization after the elapse of this period. They reported one case of delayed union in a patient whose K-wires were removed at 19 days. So in our study, early removal of K-wires before 6 weeks was not done in any patient; however, after 6 weeks in buried group, 36% cases needed K-wire removal because of K-wire-related complications. Radiological union at 6 weeks was seen in both the groups, except in two patients of Jakob Type 3 fracture in Group-1 which required 8 weeks for fracture union. None of our cases underwent delayed union; hence, wires can be safely removed at 6 weeks without fear of loss of reduction or delayed union or malunion.

Radiologically, lateral condyle overgrowth was seen in 11 cases in Group-1 and 12 cases in Group-2 with no statistically significant difference. It did not produce any substantial functional problems with elbow motion. This complication was reported by Launay *et al*.[12] and Chan and Siow,[15] and they showed high rate of lateral condyle overgrowth in exposed as compared to buried. Launay *et al*.[12] believed that prolonged postoperative immobilization seems to contribute to the formation of lateral condyle overgrowth and occurred significantly with postoperative immobilization for 6 weeks compared immobilization for <6 weeks (78.0% vs. 42.9%, respectively). The reason for lateral condyle overgrowth is due to the formation of bone beneath an osteoperiosteal flap.[21] However, in our study, lateral condyle overgrowth does not appear to be due these factors as postoperative immobilization of elbow was same in both

the groups. However post operative overgrowth could be attributed to elevation of periosteal flap intra operatively or increased blood supply on lateral side post operatively.

Jakob *et al*.[17] reported 19.2% cubitus valgus deformity while 8.3% cubitus valgus and 36% of cubitus varus deformity was reported in the study by So *et al*.[23] At final followup in our study, there was no significant difference ($P = 0.215$) in carrying angle in both the groups. However, the followup in our study was relatively short.

AHL passed through middle third of the capitellum in 84% cases in Group-1 and 60% cases in Group-2. However, there was no statistically significant difference ($P = 0.059$). Chan and Siow[15] observed similar results in 72 cases.

Elbow ROM was fairly preserved post surgery in both groups., Launay *et al*.[12] reported loss of flexion range from 0° to 25°, loss of extension range from 0° to 30°, and loss of motion of flexion extension arc range from 0° to 50° in their study.

The current study had following limitations; small sample size, short followup period, and it being a nonrandomized comparative study, as compared to Randomized controlled study and subsequent parental choice also had an impact on the study However, it was a prospective study.

Our study shows that with respect to the incidence of superficial and deep infections, there is no significant difference in the use of exposed versus buried wires. On the contrary, buried wires may have a higher incidence of secondary skin related complications such as skin abrasion, tenting of skin over K-wires, and secondary exposure of K-wires through the skin which may occur as a consequence of wire back out or subsidence of the soft tissue swelling around the elbow postoperatively. On the other hand, exposed K-wires can be easily removed as an outpatient procedure avoiding a second anesthesia and operative procedure for K-wire removal in case of buried wires. Both the groups did not show any significant difference with respect to fracture reduction, union rates, postoperative deformity, or functional ROM.

To conclude exposed K wires are easy to remove and there being no statistical difference between both groups in any parameter. We recommend keeping the K wires exposed.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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