

Original Article



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Dr. Shane Moe



Dr. Hein Latt Win



Dr. Kyaw Kyaw



Dr. Wai Lin Tun



Dr. Ye Htut Aung

Address of Correspondence

Dr. Shane Moe

Consultant Orthopaedic Surgeon, DSOH, Yangon,
Myanmar.

E-mail: drshanemoe@gmail.com

¹Department of Orthopaedics, DSOH, Yangon,
Myanmar.

²Department of Orthopaedics, DSMA, Yangon,
Myanmar.

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Cannulated Screw Versus Kirschner Wire Fixation Following Open Reduction of Lateral Condyle Fracture of Humerus

Shane Moe¹M.D, Ph.D., Hein Latt Win²M.D, Ph.D. FRCS, Kyaw Kyaw¹M.D, Ph.D.,
Wai Lin Tun¹M.D, Ph.D., Ye Htut Aung²M.D

Abstract

Background: Lateral condyle fracture (LCF) of the immature humerus is a transphyseal intra-articular injury. Where there is more than two millimeters of displacement, open reduction and internal fixation (ORIF) with anatomic reduction and secure fixation are essential to avoid complications. The aim of this study is to analyze the outcome of cannulated screw versus two divergent Kirschner wire (K-wire) fixation following open reduction of displaced lateral condyle fracture of humerus.

Methods: A prospective randomized controlled trial was performed including 64 children in 2 treatment groups: Group-A (screw fixation) and Group-B (Kirschner wires). Primary outcome measures were radiological outcome and functional outcome. Secondary outcomes were stability of fixation and post-operative complications.

Results: There was no significant difference in demographic characteristics of the children between two groups. Screw fixation was significantly superior in radiological outcome than K-wires. There was no significant difference in functional outcome or the stability of fixation between the two groups. Surgical site infection and lateral condylar overgrowth were significantly higher in the K-wire fixation group.

Conclusion: Cannulated screw fixation is superior in radiological outcome with fewer complications than K-wire fixation in displaced LCF of humerus in children. But there was no significant difference in functional outcome and stability of fixation.

Keywords: Cannulated screw, Kirschner wire, Lateral condyle fracture of Humerus, Children

Introduction

Fractures of the lateral condyle of the humerus are transphyseal, intraarticular injuries which pose unique treatment challenges [1]. Early recognition, anatomic reduction and secure fixation are essential to avoid nonunion, physeal arrest and deformity. If nonunion becomes established, the outcomes of treatment are less satisfactory.

The treatment goal is to achieve union without residual deformity. In the past, Kirschner wires were widely used. But K-wire fixation is relatively unstable resulting in longer time to union. Complications of K-wire fixation include pin site infection, loss of fixation, implant failure, malunion, nonunion and overgrowth of the lateral condyle. Loss of fixation can subsequently increase the risk of malunion or nonunion [2]. Screw fixation can provide more stable fixation and faster time to union with fewer complications when compared with K-wire fixation [3]. The only drawback of screw fixation is the need for implant removal [4].

The optimal method of fixation for maintaining reduction is still debated [4]. In a systematic review of ten retrospective comparative studies [5], no firm conclusions

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could not be drawn as to whether screw fixation or K-wire fixation was associated with superior functional outcomes. The aim of this study was to analyze the outcome of cannulated screw versus two divergent Kirschner wires in displaced lateral condyle fracture of humerus in children. The hypothesis was that open reduction and internal fixation by using cannulated screw has better radiological and function outcome, better stability and fewer post-operative complications than two divergent Kirschner wires.

Methods

Between January 2021 and June 2022, we conducted a prospective randomized controlled trial, according to the guidelines issued by the Research and Ethical Committee of Defence Services Medical Academy (DSMA), Mingaladon, Myanmar. All children with displaced lateral condyle fractures of the humerus, who were admitted to Defence Services Orthopaedic Hospital (DSOH), Yangon, Myanmar, were divided into two operative groups after randomization; Group A (screw fixation) and Group B (Kirschner wires). Primary outcome measures were radiological outcome (Modified Aggarwal Score) and function outcome (Hardacre Criteria). Secondary outcomes were stability of fixation (by alteration in Baumann's angle and shaft condylar angle) and post-operative complications.

Inclusion criteria were lateral condyle fractures of humerus with more than 2 mm displacement, between 5 to 12 years of age and less than 2 weeks duration since injury. Exclusion criteria were fractures associated with ipsilateral humerus or forearm fractures and children with bicondylar fractures or comminuted fractures of the distal humerus and lateral condyle fractures with a small metaphyseal fragment. The minimum required sample size (62 patients) was calculated by using the two independent means formula [6]. The parent or guardian of children who fulfilled the inclusion criteria were counselled regarding the treatment process. Randomized block design was used for the randomization process.

Fracture displacement was measured from the lateral metaphyseal cortex of the distal part of the humerus to the lateral cortex of the fracture fragment on the anteroposterior and oblique views, and along the posterior cortex on the lateral radiograph. Weiss type 2 and type 3 fractures were selected in this study [7].

Operative Procedure

All children were operated under general anaesthesia and in the supine position with C-arm guidance. The Kocher lateral approach was used for open reduction, taking care to preserve the posterior soft-tissue attachments and vascularity of the displaced fracture fragment. The fracture was reduced gently using a small towel clip. In Group A, a partially threaded

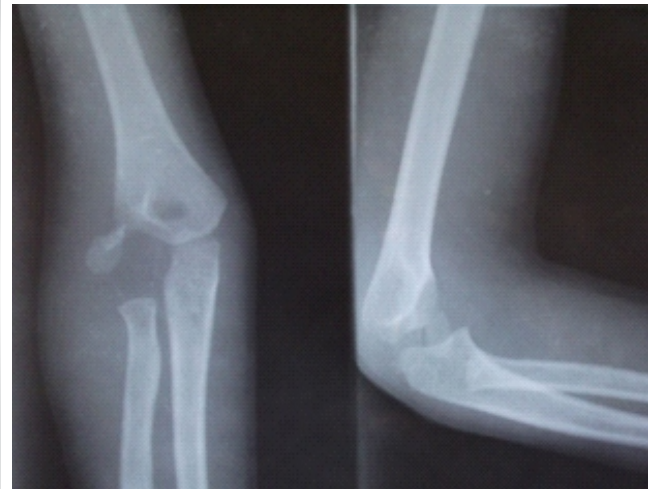


Figure 1: Nine years old boy with Weiss type - 3 fracture

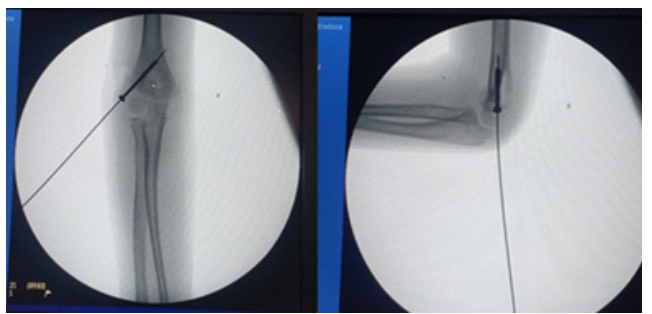


Figure 2: Position of Cannulated Screw under C-arm



Figure 3: Post-operative X ray of the same child

cannulated cancellous screw (4 mm) was used (Fig. 1, 2 & 3). The screw was directed from distal postero-lateral to proximal antero-medial, using the metaphyseal fragment as the entry point for cannulated screw fixation. The screw was placed perpendicular to the fracture line and above the olecranon fossa under image intensification. In Group B, two K-wires (1.5 mm) were used with a divergence of approximately 60 degrees and buried under the skin to avoid pin tract infection (Fig. 4, 5 & 6). Following fixation, the arm was immobilized in a posterior plaster slab with elbow in 90° flexion and forearm in neutral rotation. Check x-ray was taken at 1 week to assess fracture reduction, implant position and stability of fixation. Sutures were removed after 2 weeks. The splint was removed after 4 weeks in both groups. Exercises were started on the 1st post-



Figure 4: Seven year old boy with Weiss type - 2 fracture



Figure 5: Same patient treated with Divergent K-wires



Figure 6: X-ray after K-wire removal

operative day. Anteroposterior, lateral and internal oblique radiographs were performed 4, 8, 12 and 24 weeks after surgery to assess union, radiological outcome and complications. Implants were removed after the fracture had completely united, usually 12 weeks after surgery.

Results

Sixty-four patients met the inclusion criteria and were enrolled in this study. One child in Group A and two children from Group B were lost to follow up due to lockdown from Covid - 19 pandemic. Thus, there were 31 children in Group A and 30 in Group - B who completed the trial.

Outcomes of both treatment groups were analysed at each follow up. Continuous variables were described as means ±

Table 1: Demographic characteristics of the children in each group

Variables	Group A (n = 31)	Group B (n = 30)	p - value
Age (years) (mean ± SD)	7.22 (± 1.83)	7.06 (± 1.63)	0.723
Sex (%)			
Male	23 (74.2%)	21 (70%)	0.715
Female	8 (25.8%)	9 (30%)	
Affected Side (%)			
Right	17 (54.8%)	17 (56.7%)	
Left	14 (45.2%)	13 (43.3%)	0.886
Bilateral	0 (0%)	0 (0%)	
Mechanism of Injury (%)			
Fall on Outstretched Elbow	27 (87.1%)	28 (93.3%)	
Fall from Height	4 (12.9%)	2 (6.7%)	0.671
Weiss Classification (%)			
Type II	14 (45.2%)	12 (40%)	0.684
Type III	17 (54.8%)	18 (60%)	
Duration of Injury (%)			
< 1 Week	28 (90.3%)	26 (86.7%)	0.707
1 – 2 Weeks	3 (9.7%)	4 (13.3%)	

standard deviation (SD). Categorical variables were described as frequency and percentages. Independent Sample t-test (t) was used for continuous variables and Pearson's Chi-Square tests (x²) or Fisher's Exact test for categorical variables. P-value < 0.05 was considered significant.

Demographic characteristics of the children in each group are shown in Table (1). There was no significant difference in age or sex distribution, affected side, mechanism of injury, Weiss classification, and time elapsed since injury between the treatment groups.

Comparison of Radiological Outcome

Radiological outcome was assessed by Modified Aggarwal score [8]. At final follow up (24th week), there were 28 excellent, three good, and no fair or poor result in Group A. There were 21 excellent, nine good, and no fair or poor result in Group B. Children in Group A had superior radiological outcome than Group B at final follow up (p = 0.048).

Comparison of Functional Outcome

Assessment of functional outcome was performed using Hardacre Criteria [9]. There were 28 (90.3%) excellent and three good results in Group A. In Group B, there were 25 (83.3%) excellent and five good results. There was no significant difference (p = 0.423) in functional outcome between the two groups.

Assessment of Stability of Fixation

There was no alteration in Baumann's angle and shaft condylar angle in both study groups at 1, 4 and 8 weeks after surgery.

Comparison of Postoperative Complications within 24 Weeks

Surgical site infection, implant failure, malunion, nonunion

Complication	Group A		Group B		p - value
	No.	%	No.	%	
Surgical Site Infection	0	0	5	16.7	0.024
Implant Failure	0	0	0	0	-
Mal-union	0	0	0	0	-
Non-union	0	0	0	0	-
Lateral Condylar Overgrowth	3	9.68	9	30	0.046

and overgrowth of the lateral condyle were assessed. Infection occurred in Group B and lateral condylar overgrowth was encountered in both treatment groups (Table 2).

Discussion

Radiological Outcome

In this study, Modified Aggarwal score was used to assess the radiological outcome including the quality of reduction, evidence of avascular necrosis, growth plate status, joint congruity, grade of union and deformity (mainly lateral prominence). Group-A children had superior radiological outcome than Group-B at final follow up according to Modified Aggarwal score ($p = 0.048$). This difference was mainly due to increase number of lateral condylar overgrowth in Group-B children. On the other hand, there were no differences in other parameters like union, status of growth plate, avascular necrosis, congruity of articular surface and deformity.

This study is consistent with the finding of Baharuddin and Sharaf [10]. The authors reported 95% excellent results (19 out of 20 children) with screw fixation in displaced LCF. Saraf and Khare [11] found 80% excellent and 20% good results according to Modified Aggarwal Score following K-wire fixation. After studying 12 children with displaced LCF of humerus within four weeks duration, Sial et al [12] found excellent results in 91.67% and good results in 8.33% with K-wire fixation. The author concluded that ORIF with K-wire is an effective treatment method in all displaced LCF if treated early. In one comparative study, Singh et al [13] compared K-wire and cannulated screw fixation for displaced LCF of paediatric humerus and found significant differences ($p = 0.013$) between the two groups. Outcomes were excellent in 25 children (69.45%), good in 3 (8.33%) and fair in 8 (22.22%) in screw fixation group compared to K-wire with 12 excellent (37.5%), 5 good (15.62%), and 15 fair (46.88%) results. The paper concluded that screw fixation had better outcome due rigid anatomical fixation as well as early mobilization and restoration of elbow function. The authors recommend that whenever metaphyseal fragment is large enough, screw fixation should be used.

Functional Outcome

According to Hardacre Criteria, there were 90.3% excellent results in Group- A and 83.3% excellent results in Group-B at

final follow up. Good result was 9.7% and 16.7% in Group- A and Group- B, respectively. There were no poor results in either group. All children in this study united well within 24 weeks and regained full function of the elbow. There was no significant difference ($p = 0.423$) in functional outcome between the two groups.

In the comparative study, Li and Xu [14] found that clinical outcomes were excellent in 65.62% of screw fixation and 73.33% of K-wire fixation, according to Hardacre criteria. Gilbert et al [3] concluded that there was no significant difference in functional outcomes according to Hardacre criteria. The authors highlighted that screw fixation needed fewer days in a splint resulting in superior range of motion at final follow up. Screw fixation was also associated with less nonunion and quicker time to union. There were three nonunions attributable to improper K-wire configuration. 60° divergence between the K-wires is recommended to achieve a more stable construct [15]. In a comparative study, Stein et al. [4] achieved 100% union in both groups. However, the authors found that K-wires had less capacity to compress and retain the fragments in place. In a systematic review, Birkett et al [5] found that the highest rates of excellent functional outcome were seen with lag screw fixation (95%) compared to K-wire fixation (83.3%), but the results were comparable between two groups.

Stability of Fixation

In this study, stability was assessed by measuring alteration in Baumann's angle and Shaft Condylar Angle at 1, 4 and 8 weeks after operation. There was no alteration in Baumann's angle and Shaft Condylar Angle in both study groups at each follow up. Biomechanical studies [16, 17] show superior stability with screw fixation. Li and Xu [14] reported that the K-wires migrated in 13% of cases due to not engaging the far cortex, but all fractures united within 12 weeks without loss of reduction. There was no screw loosening nor instability of reduction in screw fixation group.

Stein et al [4] found that the mean postoperative Baumann angle was 77.6° ($\pm 4.1^\circ$) initially and 74.2° ($\pm 5.8^\circ$) at final follow up in screw group. The mean postoperative Baumann angle was 75.4° ($\pm 2.6^\circ$) initially and 75.9° ($\pm 2.1^\circ$) at final follow up in the K-wire group. There was no significant difference between the two groups.

In a retrospective cohort analysis, Ganeshalingam et al [18] found that there was no difference in Baumann's angle or carrying angle between the two study groups. Although Baumann's angle was slightly increased in the K-wire fixation compared with the screw group, there was no correlation that the likelihoods of regaining a contralateral Baumann's angle was varied by type of fixations [16].

In the retrospective comparative study of Luo et al [19], mean

Baumann angle was $15^{\circ} (\pm 4^{\circ})$ with screw fixation and $16^{\circ} (\pm 3^{\circ})$ in the K-wire group. The authors concluded that there was no significant difference between two groups ($p = > 0.05$). The K-wire group had advantages over cannulated screw in terms of fracture union and ease of implant removal.

Postoperative Complications

The main complications of lateral condylar fracture of humerus (surgical site infection, implant failure, malunion, non-union and overgrowth of the lateral condyle) were assessed in this study. Lateral condylar overgrowth was the most frequently encountered complication in our study (9.68% in Group A and 30% in Group B).

Surgical site infection occurred in 17% of cases in the K-wire fixation group. No other complications like implant failure, mal-union and non-union were seen in this study.

Sharma et al [20] reviewed the results of two types of fixations (screw versus K-wire) and found that there was 9.09% superficial infection with K-wire fixation which were controlled by antibiotic therapy alone.

Li and Xu [14] reported superficial infection in 16.7% of cases in the K-wire fixation group only. Lateral prominence occurred more frequently in children treated by K-wires (36.7%) compared to screw fixation (12.5%).

Pribaz et al [21] found that 92% of children treated with K-wire developed lateral condylar overgrowth. The study pointed out that the advance of an overgrowth was associated with the extent of initial fracture displacement and due to improper configuration or insecure fixation.

Gilbert et al [3] found that the incidence of local infection was 2.4% following screw fixation and 4.7% with K-wire fixation. There was no significant difference in infection rate in that study. 9.68% of lateral condylar overgrowths were observed in K-wire group and none in screw fixation. In the K-wire fixation group, the nonunion rate at 6 months follow-up was 10% and treated with bone grafting. Only one delayed union in the screw group was found which was healed well at 12 weeks. The overall complication rate was 31% with K-wire and 7.5% in the screw group.

In the level III retrospective study of Stein et al [4], the infection rate was significantly increased with K-wire fixation (22.7% infection rate) than screw (no infection). The author concluded that screw fixation achieved excellent reduction without infection, deformity or premature physal arrest.

In a retrospective cohort study of Ganeshalingam et al [18], surgical site infection (SSI) occurred in 2.9% of screw fixation and 4.2% of K-wire. Implant failure was found in 1.9% of screw group and 0.9% of K-wire. Malunion was observed as 1.9% in screw group and 1.3% in K-wire, but there was no significant difference between two groups. Nonunion occurred in 5.1% of K-wire fixation but none in screw group. Nonunion rate was

5.1% in the K-wire group, resulting significant difference ($p = 0.02$) between two groups. There was overgrowth of the lateral condyle in 9.9% of screw group and 2.1% of K-wire. Lateral condylar overgrowth was more common with screw fixation which was not consistent with the present study. This may be due to difference in configuration of screw fixation. The rates of complications in the present study are comparable with previous literature.

Strengths of this study include prospective analysis with proper randomization between two groups, usage of ideal configuration of either screw or K-wire fixation and planned postoperative protocol. Limitations of this study include: (1) some of the patients could only be contacted over the phone or by video conferencing due to the Covid-19 pandemic; (2) measurement inaccuracies in Baumann angle and shaft condylar angle cannot be ruled out due to the presence of a plaster cast in early follow up; (3) describing lateral condylar overgrowth is a vague term with the possibility of inter-observer variations; (4) short follow up period of six months.

Conclusion

Cannulated screw fixation provided superior radiological outcomes and fewer complications than Kirschner wires fixation in the treatment of displaced lateral condyle fracture of humerus in children. There was no significant difference in functional outcome and stability of fixation between two fixation methods.

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

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