Kirschner Wire Fixation with and without Tension Band Wiring for Treatment of Fracture of the Lateral Humeral Condyle in Children

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**Background:** Kirschner wires (K-wires) are commonly used to treat displaced lateral humeral condyle fracture in children. However, K-wire fixation alone is insufficient for early elbow range of motion (ROM) exercises. Fixation combined with tension band wiring (TBW) converts distraction forces into compression forces, which provides more rigid fixation than K-wire fixation alone. Here, we retrospectively evaluated clinical outcomes of patients with displaced lateral humeral condyle fracture treated with TBW or K-wires only.

**Methods:** We identified children with lateral condyle fractures who had undergone surgery during the period from April 2000 through March 2014. Nineteen patients were classified into 2 groups according to treatment: 10 were allocated to the TBW group (TBW and K-wires) and 9 to the K-wires group. The mean interval from injury to surgery was 5.1 days in both groups. Fractures were classified by using the Jacob’s and Milch’s classifications. In addition, we collected and analyzed data on postoperative complications, radiological and clinical evaluations, ROM, and Flynn’s criteria.

**Results:** Mean duration of follow-up was 14.4 months in the TBW group and 5.9 months in the K-wires group. Mean bone union time was 38.6 days and 49.8 days, respectively. Mean duration of cast/splint use was significantly longer for K-wires patients (49.8 days) than for TBW patients (35.8 days). Range of flexion at the final follow-up was significantly lower in the K-wires group.

**Conclusions:** TBW fixation appears to be the optimal treatment for displaced lateral humeral condyle fracture in children, as it facilitates early active range of motion exercises.

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**Key words:** lateral condyle humeral fracture, humerus, comparative study, elbow, children

**Introduction**

Fracture of the lateral humeral condyle is the second most common elbow injury in children. It accounts for 12% of pediatric fractures around the elbow joint and is usually caused by a fall onto an extended arm that generates excessive varus force. Although undisplaced fractures of the lateral humeral condyle are treated nonsurgically, patients with displaced fracture should be treated surgically to prevent complications such as nonunion, malunion, or cubitus varus/valgus deformity. Lateral humeral condyle fractures are intra-articular fractures, and a displacement greater than 2 mm should thus be treated with open reduction and internal fixation (OR/IF). Although several methods for fixation have been described, including fixation using bioabsorbable materials, screws, and Kirschner wires (K-wires) with or without a larger divergence angle, fixation with K-wires is common.

At our center, we previously performed OR/IF with buried K-wires for displaced lateral condyle fracture. However, fixation with K-wires alone was insufficient for early range of motion (ROM) exercises of the elbow joint. Therefore, we have performed OR/IF using tension band wiring (TBW) with K-wires for fixation since 2005. This method converts distraction forces into compression forces, which promotes bone union. Thus, TBW is be-

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believed to provide complete stability to fractures. To date, no study has specifically compared TBW and buried K-wire fixation after open reduction for treatment of lateral condyle fracture. Here, we retrospectively reviewed the records of children treated with TBW or K-wires alone to evaluate clinical outcomes after displaced lateral humeral condyle fracture.

**Materials and Methods**

In this retrospective case series, we analyzed patient records at our center for the period from April 2000 through March 2014. Patient demographic characteristics, medical history, imaging findings, and follow-up data were extracted. This study was conducted in accordance with the ethical guidelines of the 1975 Declaration of Helsinki, after approval from our institutional review board (No. 30-08-988).

**Patients**

Children with lateral condyle fracture of the humerus who had undergone primary surgery were investigated retrospectively. Demographic data, medical history, imaging findings, and follow-up data were extracted from the medical records. Inclusion criteria were age younger than 14 years and presence of lateral humeral condyle fracture treated by OR/IF with TBW or K-wires at our center. Patients with undisplaced fractures, fractures treated with another surgical approach, open fractures, other ipsilateral upper-limb fractures, pathological fractures, or fractures treated later than 14 days after injury were excluded.

The medical records and radiographs of 19 patients were reviewed. Patients were classified into 2 groups according to treatment method: Patients in the TBW group were treated by OR/IF with TBW and K-wires; those in the K-wires group were treated by OR/IF with K-wires only. The characteristics of the patients are shown in Table 1. The TBW group comprised 10 elbows of 10 patients (8 boys, 2 girls), and the K-wires group comprised 9 elbows of 9 patients (6 boys, 3 girls). Mean age at the time of surgery was 6.4 ± 2.8 (range, 3-11) years in the TBW group, and 5.3 ± 2.6 (3-10) years in the K-wires group. The mean interval from injury to surgery was 5.1 ± 3.4 (1-12) days in the TBW group, and 5.1 ± 3.1 (0-10) days in the K-wires group.

Fractures were classified according to the method of Jakob et al., with modifications. Type I fracture was defined as a displacement less than 2 mm, type II as a displacement greater than 2 mm, and type III as displacement with rotation of the fragment. Using Jacob’s classification, we identified 9 type II fractures and 1 type III fracture in the TBW group and 5 type II and 4 type III fractures in the K-wires group. Fractures were also classified as type I and type II, in accordance with Milch’s classification of the fracture line on the distal humerus: Type I fracture was present through the capitellar-trochlear groove whereas type II passed through the trochlear groove. Using Milch’s classification, we identified 1 type I and 9 type II fractures in the TBW group and 1 type I and 8 type II fractures in the K-wires group. No preoperative neurological disturbances were observed in either group.

**Surgical Procedures**

Surgery was performed under general anesthesia, and open reduction using a posterolateral approach was performed, with or without a pneumatic tourniquet, with patients in a supine or prone position. Briefly, a lazy S incision (approximately 3-4 cm) was made on the posterolateral side of the distal humerus and extended to the olecranon, while deviating radially. After dissecting through the subcutaneous tissue, the fascial layer on the

| Table 1 Preoperative demographic characteristics of children with displaced lateral humeral condyle fracture |
|--------------------------------------------------|---------------------------------|---------------------------------|---|
| Table 1 Preoperative demographic characteristics of children with displaced lateral humeral condyle fracture |  |  |  |
| Age (years) | 6.4 ± 2.3 | 5.3 ± 2.6 | .39 |
| Male:Female | 8:2 | 6:3 | .44 |
| Left:Right | 6:4 | 6:3 | .57 |
| Interval from injury to surgery (days) | 5.1 ± 3.4 | 5.1 ± 3.1 | .99 |
| Jacob classification (type II:III) | 9:1 | 5:4 | .12 |
| Milch classification (type I:II) | 1:9 | 1:8 | .74 |

TBW: tension band wiring
Data (age and interval from injury to surgery) are presented as mean ± SD.

\*P < 0.05
triceps was separated at its lateral border. The intermuscular plane between the triceps and brachioradialis was then separated to access the distal humerus. Image-intensified radiographic guidance was used in all cases. After open reduction of the displaced fractures, all patients underwent initial fixation with 2 K-wires. In the TBW group, 2 K-wires were inserted with or without a larger divergence angle through the surgical wound and were augmented with TBW by using 0.8-mm suture wires. The K-wires were then bent over the wires and buried beneath the skin (Fig. 1A). In the K-wires group, K-wires were inserted through the surgical wound and bent and buried beneath the skin (Fig. 1B). The surgical technique of open reduction for the fractures did not differ between the 2 groups. Postoperatively, all patients were given an above-elbow, long-arm, fiberglass cast or splint, with the elbow flexed at 90 degrees. All patients were seen at 1 week for radiographic examination and wound inspection. The full cast was changed twice monthly. Active ROM exercises were encouraged after removal of the cast.

**Postoperative Evaluation**

We recorded duration of follow-up, duration of cast or splint use, date of wire removal, and postoperative complications (iatrogenic nerve injury, ratio of nonunion, infection, contracture of the elbow joint, and valgus or varus deformity). Contracture of the elbow joint was defined as loss of extension or flexion of greater than 15 degrees, in accordance with the definition of poor functional outcome in Flynn’s criteria, ie, extension less than −15 degrees or flexion less than 125 degrees. We also evaluated radiographs and clinical outcomes, including ROM and arc of the elbow joint. Postoperative radiographs were used to evaluate humeral deformity and fracture displacement. Radiological evaluations included Baumann’s angle (BA), diaphyseal condyle angle (DCA), and carrying angle (CA). Postoperative loss of fracture reduction was evaluated by BA and DCA angular change (the difference between each angle on radiographs obtained immediately after surgery and at 6-8 weeks postoperatively). The clinical criteria described by Flynn were used to evaluate postoperative cosmetic and functional outcomes at the final follow-up, specifically elbow ROM and CA (Table 2).

**Statistical Analysis**

All statistical analyses were done with SPSS 18 (SPSS Inc, Chicago, IL, USA). Quantitative variables are expressed as means ± SD or medians with ranges, and qualitative variables as percentages. Group comparisons for categorical data were made with the Pearson chi-square or Fisher exact tests, depending on the theoretical sample size, and continuous data were assessed with the Welch t-test or Mann-Whitney U-test. P values less than .05 were considered statistically significant.

**Results**

**Overview**

There was no significant difference between groups in the preoperative demographic variables age, sex, affected side, interval from injury to surgery, follow-up, or frac-

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**Table 2** Flynn’s criteria (cosmetic and functional factors)

| Results     | Rating   | Cosmetic factor, CA loss (degrees) | Functional factor, ROM loss (degrees) |
|-------------|----------|-----------------------------------|---------------------------------------|
| Satisfactory| Excellent| 0 to 5                             | 0 to 5                                 |
|             | Good     | 5 to 10                            | 5 to 10                                |
|             | Fair     | 10 to 15                           | 10 to 15                               |
| Unsatisfactory| Poor    | >15                                 | >15                                    |

CA: carrying angle. ROM: range of motion

The presence of any cubitus varus deformity is defined as Poor.
The outcomes for the groups are shown in Table 3-6. All patients required a second surgery to remove the wires. The follow-up time differed by 8.5 months; however, this difference was not significant \( (P = .07) \) (Table 3). Duration of cast/splint use was longer for patients in the K-wires group than for those in the TBW group, and the difference was significant \( (P < .05) \). Patients in the K-wires group used an upper-arm cast or splint for an average of 7 weeks after surgery. These patients were encouraged to perform active ROM exercises before bone union was achieved, but many complained of elbow pain and were unable to perform active ROM exercise for several weeks after removal of the cast or splint. Moreover, many patients required immediate removal of the K-wires after radiological confirmation of callus formation.
Fixation of Lateral Condyle Fracture

Table 6  Cosmetic and functional outcomes, according to Flynn’s criteria

|                          | TBW (n = 10) | K-wires (n = 9) | P value |
|--------------------------|--------------|-----------------|---------|
| Cosmetic factor          |              |                 |         |
| CA of injured elbow      | 8.2 ± 6.8    | 8.3 ± 5.9       | .99     |
| CA of contralateral elbow| 13.8 ± 6.3   | 11.6 ± 4.1      | .37     |
| Loss of CA               | 5.2 ± 5.1    | 4.0 ± 6.0       | .65     |
| Cosmetic factor; rating of Excellent and Good (%) | 80 (8/10) | 77.8 (7/9) | .67     |
| Functional factor        |              |                 |         |
| ROM (Arc) of injured elbow | 138.2 ± 9.6 | 124.4 ± 17.6    | .06     |
| ROM (Arc) of contralateral elbow | 149.7 ± 7.9 | 146.7 ± 9.7     | .47     |
| Loss of ROM (Arc)        | 11.5 ± 10.6  | 15.0 ± 17.9     | .62     |
| Functional factor; rating of Excellent and Good (%) | 70 (7/10) | 55.6 (5/9) | .43     |
| General evaluation       |              |                 |         |
| Rating of Excellent and Good (%) | 50 (5/10) | 33.3 (3/9) | .40     |

CA: carrying angle, ROM: range of motion
Data are mean ± SD

because irritation from the K-wires caused elbow pain.

Time to radiographic union was slightly longer in the K-wires group, but the difference was not significant.

Bone union was achieved faster in the TBW group than in the K-wires group, but the difference was not significant (P = .05). The wires were left in situ for approximately the same duration in both groups.

Complications

No patient showed evidence of nonunion, fracture displacement, deep infection, neurovascular complications, or cubitus varus or valgus. Superficial wound infections were treated effectively with oral antibiotics (n=1 in each group). Contracture of the elbow joint was observed in 1 patient in the TBW group and in 4 patients in the K-wires group, but the difference was not significant. One patient in the K-wires group had severely restricted flexion and required joint capsular release, which was performed at the time of K-wire removal.

Radiographic Evaluation

The radiographic results are summarized in Table 4. BA and DCA were measured immediately postoperatively and at 6-8 weeks after surgery. We found no significant differences between the 2 groups. DCA measured immediately postoperatively was higher in the TBW group than in the K-wires group, but the difference was not significant. There was no significant loss of reduction in BA or DCA, as compared with the contralateral side, in either group.

Flexion, Extension, and ROM

Mean values for flexion, extension, and ROM are shown in Table 5. Patients in the K-wires groups had a significant loss of flexion, as compared with patients in the TBW group. No other significant difference was observed. According to Flynn’s criteria, half the patients in the TBW group were classified as excellent or good, whereas, most were fair or poor in the K-wires group. There was no significant difference between groups when patients were classified with Flynn’s criteria (Table 6).

Discussion

No study has specifically compared TBW and buried K-wire fixation after OR/IF for lateral condyle fracture. The present study compared clinical outcomes of these 2 procedures. One patient in each group developed a superficial wound infection; however, both were effectively treated with a short course of oral antibiotics. The rate of infection related to K-wire fixation with subcutaneous wires was 11% (1/9 cases), which was close to previously reported rates (3% to 8%)19,20. We observed contracture of the elbow joint in 1 patient in the TBW group and in 4 patients in the K-wire group, but there was no significant difference between groups. However, there was a significant difference in duration of external fixation and loss of flexion between groups. This disparity is attributable to the difference in the adequacy of internal fixation.

Although buried wires were bent close to the bone, to prevent fracture displacement, the fracture fragment was not sufficiently stable to allow patients to engage in early active ROM exercise. Numerous studies have reported that extended use of a plaster splint or cast was required after internal fixation with K-wires19. Foster et al.13 reported that 6-8 weeks of elbow joint immobilization was
required after open reduction with K-wire fixation. Lauer et al.\(^2\) reported that patients required a long-arm cast or splint for 4-10 weeks after internal fixation with K-wires. In our study, patients in the K-wires group used an upper-arm cast or splint for an average of 7 weeks after surgery. Although patients were encouraged to perform active ROM exercises before bone union, many reported elbow pain that prevented such exercises. Indeed, many patients in the K-wires group were unable to perform active ROM exercises for several weeks after cast/splint removal. Moreover, many patients required immediate removal of the K-wires after radiological confirmation of callus formation, because irritation caused by the K-wires resulted in elbow pain. In contrast, almost all patients in the TBW group were able to undergo active ROM exercise, without irritation attributable to fixation, at about 5 weeks postoperatively, which suggests that TBW provided greater stability than did K-wire fixation alone.

Time to radiographic union was slightly longer in the K-wires group, but the difference was not statistically significant. Although early active ROM exercises are essential to prevent restricted ROM, radiographic union was not evident at 4 weeks after OR/IF. Because lateral condyle humeral fracture is an intra-articular fracture, delayed radiographic union is a concern. Thus, if fixation is not reliable for early active ROM exercises, surgeons may choose to leave the fixation with a cast or splint. Although we noted no loss of reduction or malunion in patients in the K-wires group, many patients in that group were unable to perform early active ROM exercises, because of irritation caused by K-wires. We believe that TBW helps provide stable fixation, thereby encouraging early active ROM exercises.

**Limitations**

This study has some limitations. The most important limitation of this retrospective study is that the duration of follow-up might have been too short to identify a significant loss of flexion in the K-wires group. Although average follow-up was 10 months, the minimum follow-up period was only 3 months. This shorter follow-up was particularly evident in the K-wires group. In addition, the number of patients in both groups was small. Larger sample sizes would increase statistical power and provide a clearer understanding of the benefit of TBW in this surgical procedure.

Overgrowth of the lateral condyle has been noted in previous studies\(^6\). In this series, no patient showed radiographically or clinically apparent lateral overgrowth. While the short follow-up limits the ability to detect long-term problems (eg, growth arrest, fish-tail deformity, cubitus valgus or varus)\(^8\),\(^9\), the absence of lateral overgrowth suggests good outcomes and a low incidence of clinically significant problems. Nevertheless, a longer follow-up is required in order to exclude any late deformities of the injured elbow.

**Conclusions**

This study evaluated the safety and effectiveness of fixation with TBW and buried K-wires after OR/IF for lateral condyle fracture. Fixation with only 2 K-wires may be inadequate for patients requiring early active ROM exercises, which help prevent elbow joint contracture. TBW with K-wires thus appears to be the optimal method for fixation of lateral humeral condyle fracture.

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