Long-term comparative study of internal fixation with Kirschner wires or cannulated screws for displaced medial epicondyle fractures of the humerus in children: A 10-year follow-up of 42 cases

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ABSTRACT

BACKGROUND: The rationale behind the decision-making on which type of fixation to use in displaced medial epicondyle fractures is not well elucidated. This study aims to compare the long-term clinical and radiographic outcomes of internal fixation with either Kirschner wires (K-wires) or cannulated screws in children with displaced medial epicondyle fractures.

METHODS: In this study, 42 consecutive children who underwent surgical treatment for medial epicondyle fractures displaced more than 5 mm were categorized into two groups as follows: group A, 22 children undergoing fixation with K-wires and group B, 20 children undergoing fixation with a screw. The mean age was nine (median, 10.5; range, 6–14) years in group A and 15 (16, 10–17) in group B. The overall follow-up was 10 (median, 10; range, 5–15) years. To assess patients' clinical outcomes, the Mayo Elbow Performance Scores (MEPS) were used in addition to the elbow range of motion (ROM) at the last follow-up. During the radiographic assessment, possible deformities secondary to the epicondyle fracture were examined on final follow-up radiographs.

RESULTS: The main MEPS were 95 (median, 95; range, 85–100) and 93 (94, 85–100) in groups A and B, respectively (p=0.18). In ROM, no significant differences were observed (p=0.43). In the radiographic assessment, one patient from each group developed a fibrous union, and one from each group had hypoplasia. There was no significant relationship between the deformity and fixation type (p=0.34, \( \chi^2 \) test).

CONCLUSION: Two smooth K-wires for younger children and screw fixation for children near skeletal maturity may provide favorable clinical and radiological outcomes at long-term follow-up, with low morbidity and radiographic deformity.

Keywords: Fracture fixation; Kirschner wire fixation; medial epicondyle humerus fracture; pediatric elbow fracture; screw fixation.

INTRODUCTION

Although medial epicondyle fractures of the humerus constitute approximately 12% of all pediatric elbow fractures, the literature is controversial regarding the management of these pediatric fractures.\(^1\) The disagreement lies particularly in identifying the suitable treatment method for children with considerable displacement (>5 mm). Traditional knowledge suggests that displaced medial epicondyle fractures can be nonoperatively treated with satisfactory outcomes despite a high rate of pseudarthrosis.\(^2,3\) However, in recent years, there is an emerging consensus that such patients may benefit more from open reduction and internal fixation.\(^1,4\)

The most commonly used methods for the fixation of displaced fractures include Kirschner wires (K-wires) in younger...
patients with open physis and screws with or without a washer in children near skeletal maturity. However, as per our literature review, the rationale behind the decision-making on which type of fixation to use in such fractures has not been well elucidated in the literature.

To contribute to the relevant literature, in this study, we aim to investigate the rationale behind the decision on the type of fixation in such fractures, by comparing the long-term clinical and radiographic outcomes of surgical treatment using either K-wires or cannulated screws in children with displaced medial epicondyle fractures.

MATERIALS AND METHODS

After obtaining approval from the institutional review board, 51 consecutive patients who underwent open reduction and internal fixation for the treatment of displaced fracture of the medial humeral epicondyle from 2003 to 2013 were retrospectively reviewed in this study. Based on the eligibility criteria (Table 1), nine children were excluded from this study; the remaining 42 (31 male and 11 female) patients were included and invited for a final follow-up examination. Parents were informed that medical records will be used for scientific purposes only, and written informed consent was obtained at the final visit.

Patients were categorized into two groups based on the fixation method as follows: group A and group B. Internal fixation was performed with 2 K-wires in group A and a screw in group B. Group A comprised 22 children (16 male and six female), and group B comprised 20 children (15 male and 5 female; Fig. 1). During the initial operation, the mean age of the children was nine (median, 10.5; range, 6–14) in group A and 15 (16, 10–17) years in group B. The mean follow-up was 10 (median, 11; range, 6–15) in group A and 10 (9.5, 5–15) years in group B. Children in either group were comparable concerning demographic data (p>0.05 for gender, side, number of participants, and duration of follow-up; Table 2).

The primary indication for surgical treatment was fractured with a displacement of more than 5 mm (Fig. 2). The choice of fixation type, i.e., K-wires or a screw, was determined based on the age and skeletal maturity of the patients. K-wires were used in younger children with years of growth remaining, whereas a screw was used in children near skeletal maturity.

Relevant dislocations of the elbow (n=2 and 3 in groups A and B, respectively) were reduced at the time of admission. Concomitant fragment entrapment in the elbow joint (n=3 and 4; Fig. 3), ulnar nerve palsy (n=1 and 2), and severe valgus instability on fluoroscopy under general anesthesia during the operation (n=6 and 5 in groups A and B, respectively) were recorded.

Outcome Measures

During the clinical assessment, the elbow range of motion (ROM) and valgus angle of the elbow were measured using a universal standard goniometer by the senior resident at the final follow-up. In addition, the Mayo Elbow Performance Scores (MEPS) were performed for functional assessment of the following four items: pain (max 45 points, from no pain to severe pain), stability (max 10 points, from stable to grossly unstable), ROM (max 20 points, from >100° to <50°), and daily activities (max 25 points).

| Table 1. Eligibility criteria for inclusion and exclusion of the study participants |
|---------------------------------|---------------------------------|
| **Inclusion criteria** | **Exclusion criteria** |
| A diagnosis of displaced fractures of the medial humeral epicondyle | <2 years of follow-up |
| Age <18 years at the time of surgery | Lost to follow-up |
| Cases which underwent open reduction and internal fixation with either Kirschner wires or a screw with or without a washer | Open fractures |
| Being willing to participate in this study | Concomitant ipsilateral upper extremity fractures |
| Being unwilling to participate in this study | |
During the radiographic assessment, according to the deformity classification of Skak et al.,[6] possible deformities secondary to the epicondyle fracture were examined on the final follow-up anteroposterior elbow radiographs by the senior orthopedic surgeon. Furthermore, postoperative complications were documented from medical records. Skak et al. described the five types of postoperative radiographic deformities for the medial epicondyle fractures by comparing both the elbows on equivalent AP elbow radiographs: fibrous union or pseudarthrosis, a double-contoured epicondyle, an ulnar sulcus, and hypoplasia or hyperplasia of the epicondyle.

**Surgical Technique**

All operations were performed under general anesthesia within four days after the injury by two senior orthopedic surgeons. Children were positioned in the supine position with the injured elbow on an arm board. prophylactic antibiotics were administered as a single dose 30 min before skin incision and continued up to 48 hours after the operation at 6-hour intervals. After a pneumatic tourniquet was applied, the fracture site was exposed via a posteromedial incision over the medial epicondyle in all children. The ulnar nerve was routinely identified and protected but not transposed. The ulnar nerve was anteriorly transposed in only three children with ulnar nerve symptoms (n=1 and 2 in groups A and B, respectively).

In group A, the fracture was fixed with two non-threaded smooth K-wires in a parallel configuration. In group B, the fragment was fixed with a 4.5-mm cannulated screw in large children and a 3.5-mm cannulated screw in smaller elbows. In three children with a fragmented epicondyle, a washer

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**Table 2.** Demographic characteristics of the study participants

<table>
<thead>
<tr>
<th></th>
<th>Group A (22 children, 22 elbows)</th>
<th>Group B (20 children, 20 elbows)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at surgery, year</td>
<td>Min-Max (Median) 6–14 (10.5)</td>
<td>10–17 (16)</td>
<td>&lt;0.01ª</td>
</tr>
<tr>
<td>Gender</td>
<td>Female 6</td>
<td>5</td>
<td>1.00ª</td>
</tr>
<tr>
<td></td>
<td>Male 16</td>
<td>15</td>
<td>0.49ª</td>
</tr>
<tr>
<td>Side</td>
<td>Dominant 5</td>
<td>7</td>
<td>0.18ª</td>
</tr>
<tr>
<td></td>
<td>Nondominant 17</td>
<td>13</td>
<td>0.21ª</td>
</tr>
<tr>
<td>Follow-up duration, year</td>
<td>Min-Max (Median) 6–15 (11)</td>
<td>5–15 (9.5)</td>
<td>0.18ª</td>
</tr>
<tr>
<td></td>
<td>Mean 10</td>
<td>10</td>
<td>0.21ª</td>
</tr>
</tbody>
</table>

ªStudent's T-test; ªFisher's exact test; *p<0.05. Min: Minimum; Max: Maximum.

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**Figure 2.** The radiograph demonstrates a medial epicondyle fracture, with a considerable displacement (>5 mm).

**Figure 3.** (a, b) Radiographs show an incarcerated medial epicondyle in the elbow joint (blue arrows), with valgus instability.
was added to enhance the fixation surface area and minimize the risk of more fragmentation of the epicondyle with compression. Directions of the K-wires or screws were controlled using fluoroscopy, and no olecranon fossa penetration was detected. The construct and stability were evaluated with direct observation and fluoroscopic imaging intraoperatively.

**Postoperative Rehabilitation Protocol**

Postoperatively, the elbow was immobilized at 90° flexion and neutral rotation with an above-elbow splint (well-padded dorsally) for three weeks. During this period, wrist and hand exercises were permitted if the pain was tolerable. From three to six weeks following the operation, all children were encouraged free elbow mobilization, using a hinge brace to preserve the elbow from valgus and varus forces. At six weeks, the brace was removed, and the children were encouraged to attend noncontact activities. At 12 weeks, returning to previous activities was permitted. The K-wires were removed under general anesthesia between the 4th and 8th weeks postoperatively.

**RESULTS**

The clinical outcomes of patients are shown in Table 3. At the final follow-up, with favorable elbow function, all children returned to their daily life with no limitations. Regarding the MEPS, both groups exhibited similar results ($p=0.18$). Moreover, all children exhibited a satisfactory elbow ROM, and no significant differences were observed between the two groups ($p=0.43$). Six and eight children in groups A and B had an extension loss with a mean degree of seven (median, 5; range, 5–10) and six (5, 5–10), respectively. Furthermore, eight and seven children in groups A and B developed supination loss with a mean degree of five (median, 5; range, 3–10) and six (5, 5–10), respectively. Additionally, physical examination revealed no cases of valgus instability.

The radiographic results are presented in Table 3. Based on the method of Skak et al., one patient from each group developed a fibrous union, and one patient from each group had hypoplasia. Furthermore, one patient in group A developed epicondylar hyperplasia, and one patient in group B had nonsymptomatic ulnar sulcus deformity. No significant relationship was observed between the deformity and fixation type ($p=0.34$, $\chi^2$ test). In both groups of children, the radiographic solid union was obtained at an average of six (range, 4–10) and seven (range, 5–10) weeks in groups A and B, respectively ($p=0.65$) (Figs. 4 and 5).

Concerning postoperative complications (Table 3), two patients in group A suffered from pin track infections that resolved with regular pin track dressing and antibiotics. One patient in group B developed a superficial wound infection that resolved with local wound care and oral antibiotics. No late neurological or other complications were observed at the final follow-up. No significant difference was observed in complications between groups A and B ($p=0.33$).

### Table 3. Clinical and radiographic outcomes of the children in both groups

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion Range of motion degree (°), Min-Max (Median), Mean</td>
<td>110–140 (127.5)</td>
<td>115–140 (127.5)</td>
<td>0.43a</td>
</tr>
<tr>
<td>Extension loss*</td>
<td>5 –10 (5)</td>
<td>5 –10 (5)</td>
<td>0.95b</td>
</tr>
<tr>
<td>Supination loss*</td>
<td>3 –10 (5)</td>
<td>5 –10 (5)</td>
<td>0.53b</td>
</tr>
<tr>
<td>Mayo Elbow Performance Score, Min-Max (Median), Mean</td>
<td>85–100 (95)</td>
<td>85–100 (94)</td>
<td>0.18a</td>
</tr>
<tr>
<td>Fibrous union</td>
<td>1</td>
<td>1</td>
<td>0.34c</td>
</tr>
<tr>
<td>Hypoplasia</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hyperplasia</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ulnar sulcus deformity</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pin-track infection</td>
<td>2</td>
<td>0</td>
<td>0.33c</td>
</tr>
<tr>
<td>Superficial wound infection</td>
<td>0</td>
<td>1</td>
<td></td>
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</tbody>
</table>

*Descriptive and comparative statistics were performed for only children with extension and supination loss. Radiographic deformities were evaluated based on the classification of Skak et al. Student’s T-test; Mann-Whitney U test; Chi-square test $p<0.05$. Min: Minimum; Max: Maximum.
Operative treatment with open reduction and internal fixation has a crucial role in avoiding the painful nonunion and minimizing the risk of symptomatic valgus instability.\[5\] The present study provides additional evidence that fixation with either K-wires or screws could confer proper fracture reduction and maintain stabilization for fracture healing with similar clinical and radiographic outcomes at long-term follow-up. Besides, several authors prefer K-wires in younger patients with open physeal fractures, whereas screws are mostly used for children near skeletal maturity.\[1,7–9\] However, to our knowledge, the rationale behind this preference has not been investigated well. We, therefore, clarified this rationale by directly comparing the clinical and radiographic outcomes of both fixation types in children with displaced medial epicondyle fractures.

Ip and Tsang\[9\] reviewed 24 consecutive children with the medial humeral epicondylar fracture displaced greater than 5 mm who underwent operative treatment by one of the three methods, including two parallel K-wires, two parallel K-wires plus a tension band, and a screw plus an anti-rotation K-wire. The author suggested that two parallel K-wires plus tension band should be performed for younger children who still have growth potential because this approach minimizes the risk of developing cubitus varus deformity due to a screw across the growing epiphysis. Consistently with Ip and Tsang's approach, we mostly preferred a screw with or without a washer for children near skeletal maturity and K-wires for younger children with years of growth remaining. We observed no cubitus varus or valgus deformity with satisfactory ROM and MEPS.

Skak et al.\[6\] classified the radiological deformities following displaced medial epicondyle fractures treated conservatively or surgically using K-wires, sutures, or palmar nails as follows: pseudarthrosis or a fibrous union, a double-contoured epicondyle, an ulnar sulcus, and simple hyperplasia or hypoplasia of the epicondyle. Two of these deformities were associated with the fixation type used in their study. Pseudarthrosis was noted after treatment with plaster or suturing, and hypoplasia was observed after pin fixation. Accordingly, the authors suggested that nailing causes extra damage to a likely injured growth plate, whereas inserting K-wires by drilling may cause less damage. However, they did not specify which fixation type they applied for which age group. At our institution, the choice of fixation type for displaced medial epicondyle fractures was determined based on the age and skeletal maturity of the patient. We observed four types of deformities, including a fibrous union, hypoplasia, hyperplasia, and ulnar sulcus deformity; there was no significant relationship between the deformity and fixation type. Therefore, we considered that the choice of fixation type according to skeletal maturity was likely to reduce the risk of development of such deformities.

Approximately 50% of such fractures may be accompanied by elbow dislocation, and the fragment may be incarcerated within the joint with an incidence of at least 15%\[7,10\] in some children, the concomitant dislocation of the elbow may spontaneously reduce and accordingly be unrecognized.\[11\] Compared with the literature, the present study revealed a similar rate of fragment entrapment (group A, 3/20; group B, 4/22) and a low rate of concomitant elbow dislocation (group A, n=2/20; group B, n=3/22). This low rate may be attributable to the spontaneous reduction of the elbow dislocation after the trauma.

The management of coexisting ulnar nerve palsy is equivocal.\[4\] Most authors\[12–14\] suggest that routine exploration or transposition of the ulnar nerve is not essential because the nerve may be more sensitive to partial devascularization following transposition in current trauma versus that in an

**DISCUSSION**

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We transposed the ulnar nerve in three children with ulnar nerve symptoms (group A, n=1; group B, n=2) and obtained complete neurological recovery. Therefore, we support the notion that anterior transposition should be only performed for children with nerve compression signs.\[^{[14]}\]

Concerning postoperative complications, three modern series reports of pediatric medial epicondyle fractures\[^{[7,9,15]}\] were operatively treated using either K-wires or screws reported a postoperative infection rate of less than 1% (1/188, superficial wound infection). However, in contrast with these studies, we recorded two-pin track infections following K-wire fixation and one superficial wound infection following screw fixation. Other complications have not been reported in these surgical series.\[^{[7,9,15]}\] The operative treatment of such fractures raises a concern regarding iatrogenic nerve injury. Lately, Marcus et al.\[^{[16]}\] reported two cases of severe iatrogenic radial nerve injuries secondary to the guidewire of the cannulated fixation systems. In our case series, we did not experience such a complication.

Stiffness represents the most frequent complication following elbow injuries when treated by splint immobilization. Therefore, early active elbow motion is a vital part of the postoperative rehabilitation protocol following the operative treatment.\[^{[17]}\] Louahem et al.\[^{[15]}\] stated that six of 139 children (4%) developed extension deficits of <20°. Similar to our postoperative rehabilitation protocol, the authors immobilized the elbow at 90° flexion and neutral rotation for a mean of four weeks and then allowed elbow mobilization. In our study, three children after K-wires fixation and two after screw fixation suffered from extension loss of <10°. Accordingly, it seems that both fixation methods can provide satisfactory elbow ROM despite a 3–4-week postoperative immobilization period to secure fixation.

This study has several important limitations. The first limitation is the retrospective nature of data collection, which may raise the concern of recall bias. Another potential limitation was its relatively small sample size, including 42 fractures although our cohort size was large compared with most of the studies that we have cited. This may limit the power of the results, and therefore further studies with larger samples may identify significant differences in all the variables analyzed in the present study. Last, surgeries were performed by three different surgeons, which may have provided biased results due to the surgeon’s experience. Additionally, results in selection bias may cause differences in complication rates between the two techniques. However, as previously mentioned, the choice of fixation type was mostly determined based on skeletal maturity. Despite these limitations, this is a preliminary study to directly compare the long-term clinical and radiographic outcomes of internal fixation with either Kirschner wires or cannulated screws in children with displaced medial epicondyle fractures.

Conclusion

We recommend operative treatment for children with medial epicondylar fractures displaced more than 5 mm. The early use of two smooth K-wires for younger children and delayed use of screw fixation for children near skeletal maturity might provide favorable clinical and radiological outcomes during long-term follow-up, with low morbidity and radiographic deformity.

**Informed Consent:** Written informed consent was obtained from the patients for the publication of the case report and the accompanying images.

**Peer-review:** Internally peer-reviewed.


**Conflict of Interest:** None declared.

**Financial Disclosure:** The authors declared that this study has received no financial support.

**REFERENCES**

14. Anakwe RE, Watts AC, McEachan JE. Delayed ulnar nerve palsy after...
Ergin et al. Long-term results of surgical treatment for pediatric displaced medial epicondyle fractures

OLGU SERİSİ - ÖZET

Pediatrik deplase mediyal epikondil kırıklarının cerrahi tedavisinde Kirschner teli veya kanüllü vida ile internal tespit uzun dönem sonuçlarının karşılaştırılmalı çalışması: 42 olgunun 10 yıllık takip sonuçları

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İstanbul Üniversitesi Istanbul Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, İstanbul

AMAC: Literatürde, deplase mediyal epikondil kırıklarının cerrahi tedavisinde hangi tespit materyalinin kullanılacağını karar vermenin aranacağı yetersiz arastırmaları bulunmaktadır. Çalışmamızda, deplase mediyal epikondil kırığı olan çocukların Kirschner teli (K-teli) ve kanüllü vida ile internal tespit uzun dönem klinik ve radyografik sonuçlarını karşılaştırılmıştır.


BULGULAR: Ortalama MEPS, A ve B gruplarında sırasıyla 95 (ortanca, 95; aralık, 85–100) ve 93 (94, 85–100) olarak tespit edildi (p=0.18). ROM'da anlamlı bir fark gözlemedi (p=0.43). Radyografik incelemelerde her gruptan birer hasta fibroz kaynama saptanırken, her gruptan birer hasta hipoplasili mevcuttu. Deformite ve tespit tipi arasında anlamlı bir ilişki saptanmadı (p=0.34, χ² testi).

TARTIŞMA: Deplase mediyal epikondil kırıklarının cerrahi tedavisinde, iskelet olgunluğuna yakın çocuklar için vida ile tespit, daha küçük çocukların için ise K-teli ile internal tespit düşük morbidite ve radyografik deformite oranları ile uzun süreli takiplerde olumlu klinik ve radyolojik sonuçlar sağlayabilir.

Anahtar sözcükler: Humerus mediyal epikondil kırığı; Kirschner teli ile tespit; pediatrik dirsek kırığı; vida ile tespit.