

Medial mini-open versus percutaneous pin fixation for type III supracondylar fractures in children

Ersin Erçin, M.D.,¹ Mustafa Gökhan Bilgili, M.D.,¹ Emre Baca, M.D.,¹ Serdar Hakan Başaran, M.D.,² Alkan Bayrak, M.D.,¹ Cemal Kural, M.D.,¹ Mustafa Cevdet Avkan, M.D.¹

¹Department of Orthopaedics and Traumatology, Bakırköy Dr. Sadi Konuk Training and Research Hospital, İstanbul-Turkey

²Department of Orthopaedics and Traumatology, Karabük University Faculty of Medicine, Zonguldak-Turkey

ABSTRACT

BACKGROUND: The present objective was to compare medial mini-open and percutaneous treatment of pediatric supracondylar fractures according to fluoroscopy time, duration of surgery, and iatrogenic ulnar nerve injury.

METHODS: A total of 104 Gartland type III supracondylar humerus fractures were prospectively evaluated between 2011 and 2013. Patients were divided into 2 groups according to type of fixation. In Group A (41 patients), medial pin was inserted with mini-open incision with 2 lateral pins inserted percutaneously. In Group B (63 patients), all pins were inserted percutaneously. Mean follow-up time was 14.1 ± 1.2 months in Group A, and 14.6 ± 2.1 months in Group B. All patients were postoperatively evaluated for nerve injury with both motor and sensory function assessment. Length of surgery, total fluoroscopy time, fluoroscopy time for medial pin insertion, Baumann's angle, humeral capitellum angle, final carrying angle, and range of motion were recorded.

RESULTS: Sensorial evaluation showed that Group A had 3 poor, and 1 fair results, and Group B had 2 poor, and 1 fair results. No statistically significant differences were observed, including no differences in either surgery or total fluoroscopy times between groups. However, fluoroscopy time during medial pin placement was significantly lower in the mini-open group.

CONCLUSION: In conclusion, similar results of both techniques were observed, and both carry risk of iatrogenic ulnar nerve injury. Medial pin placement is easier and less demanding when used with mini-open technique.

Keywords: Fracture; humerus; pediatric; supracondylar fracture; ulnar nerve.

INTRODUCTION

Supracondylar humerus fractures are those most likely to require surgery in children.^[1,2] Closed reduction and percutaneous pin fixation are the current treatment modalities. The primary disadvantages of the percutaneous technique are ulnar nerve injury and prolonged use of fluoroscopy.^[3] In the literature, incidence of ulnar nerve palsy ranges from 0–14.3% after closed pinning.^[4–8] Due to this risk, some authors advocate only lateral pin placement, while others advo-

cate medial mini-open technique.^[9,10] However, whether mini-open approach is necessary to avoid iatrogenic ulnar nerve injury has yet to be clarified.

Fluoroscopy usage is essential for closed reduction and percutaneous K-wire fixation of supracondylar fractures, yet few studies have addressed radiation exposure in displaced supracondylar humeral fractures. In a recent study, authors concluded that surgeons were exposed to direct radiation beam a median of 13% of surgery duration.^[11] The present objective was to compare medial mini-open and percutaneous treatments of pediatric supracondylar fractures by fluoroscopy time, surgery duration, and occurrence of iatrogenic ulnar nerve injury.

MATERIALS AND METHODS

A total of 132 Gartland type III supracondylar humerus fractures were treated with closed reduction and crossed K-wire fixation between 2011 and 2013. Informed consent was obtained from patients and from the ethics committee.

Inclusion criteria were patients with Gartland type III frac-

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Address for correspondence: Ersin Erçin, M.D.

Bakırköy Dr. Sadi Konuk Eğitim ve Araştırma Hastanesi,

Ortopedi ve Travmatoloji Kliniği, İstanbul, Turkey

Tel: +90 212 - 414 23 32 E-mail: ersine@hotmail.com

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tures who had 2 lateral and 1 medial pins placed during surgery. Patients with preoperative neurovascular injuries, open fractures, previous ipsilateral elbow fractures, or flexion fractures were excluded. Specifically, 3 patients with flexion fractures, 3 with open fractures, 4 with preoperative nerve paralysis (2 median, 1 ulnar, 1 radial nerve), 1 who had undergone previous surgery for olecranon fracture, 2 who did not attend final examination, and 15 patients who had undergone only 1 lateral and medial pin fixation were excluded from the study.

A total of 104 patients were included. Patients were divided into 2 groups according to type of fixation: medial mini-open (Group A) and percutaneous (Group B). Four attending physicians treated the patients, while residents under the supervision of an attending physician performed some surgical procedures. Children were randomized based on which orthopedic surgeon was on trauma call: 2 surgeons (M.G.B., E.E.) used medial mini-open technique (on patients in Group A), while the others (E.B., S.H.B.) used percutaneous technique, (on patients in Group B). The same pin configuration—lateral divergent 2 pins and 1 crossed medial pin—was used. All patients underwent surgery under general anesthesia with closed reduction by fluoroscopic control in supine position.

In Group A (41 patients), 1 pin was inserted percutaneously from the lateral aspect of the elbow across the lateral cortex to the medial cortex, with the elbow in hyperflexion, before a small medial incision of 1–1.5 cm was made over the medial

epicondyle. Superficial dissection was performed to ensure that the pin had been placed in the medial epicondyle and that the ulnar nerve was not anteriorly subluxated over the medial epicondyle. The medial pin was then placed in extended arm position, starting from the medial epicondyle to the lateral cortex. Then, another lateral pin was inserted percutaneously across the lateral cortex to the medial cortex. In Group B (63 patients), all pins were inserted percutaneously from the lateral side with the same order.

During surgery, total fluoroscopy time and fluoroscopy time for medial pin insertion were measured. After fixation of the fracture, pins bended outside the skin, and posterior long-arm splints were applied in the neutral position. Pins were removed after 3–4 weeks. All patients were clinically and radiologically evaluated at 1 week, 4 weeks, 3 months, and 6 months. Evaluation consisted of assessment of the carrying angle, measurement of range of motion of the elbow, and neurologic examination. All patients were evaluated for nerve injury with both motor and sensory function assessments. Sensory assessments were made by Semmes-Weinstein monofilament test and static 2-point discrimination test. Monofilament 2.83 was considered normal, and in static 2-point discrimination, <6 mm was considered normal, 6–10 mm was considered fair, and 10–15 mm was considered poor.^[12]

In radiographic evaluation, anteroposterior and lateral radiography of the elbow was assessed by 2 researchers (E.E. and

Table 1. Patients data

	Medial mini-open incision	All percutaneous group	p
No. of patients	41	63	
Age (year)	6.2±2.65	6.67±3.11	0.425
Sex		0.946	
Male	25	38	
Female	16	25	
Side			0.082
Right	14	12	
Left	27	51	
Mono Filament			0.593
Normal	37	60	
Fair	1	1	
Poor	3	2	
Time from trauma to surgery (hour)	17.15±6.67	15.1±6.77	0.132
Fluoroscopy time for medial pin (second)	8.85±3.07	10.52±3.39	0.012
Fluoroscopy time for lateral pin (second)	32.76±6.07	30.94±6.85	0.01
Total fluoroscopy time (second)	41.61±9.25	41.46±10.03	0.939
Anesthesia time (minutes)	47.71±14.44	53.56±21.83	0.134
Hospitalization time (day)	2.2±1.12	1.98±1.29	0.393
Pin removal time (day)	30.8±5.93	30.33±5.74	0.687

M.G.B.). Baumann angle was measured on the anteroposterior radiograph of the elbow at 3-month follow-up. Humero-capitellar angle was measured at the lateral elbow radiograph. Single-measure intraclass correlation coefficient was used for continuous variables, while Cohen kappa coefficient was used for categorical variables. Good interobserver agreement (0.6–0.8) was found for all continuous variables, and almost perfect agreement (>0.8) was found for all categorical variables. Carrying angle was measured by full-circle goniometer and compared with the contralateral arm.

NCSS statistics software (2007; NCSS, LLC., Kaysville, Utah, USA) was used for statistical analysis. Statistical comparisons among groups were made with the Mann-Whitney U-test, Pearson's chi-squared test, and independent samples t-test. A *p* value <0.05 was accepted as significant.

RESULTS

Demographic characteristics and surgical properties are shown in Table 1. No significant differences were found ($p>0.05$) between groups regarding Baumann angle, humero-capitellar angle, carrying angle, elbow extension, or elbow flexion. Patients were compared according to hospitalization time, pin removal, C-arm time for medial pin placement, total fluoroscopy time, and anesthesia time. Hospitalization time, pin removal time, total fluoroscopy time, and anesthesia time showed no significant difference. However, fluoroscopy time for medial pin placement was significantly shorter in Group A ($p=0.012$), while lateral pin placement time was significantly shorter in Group B ($p=0.01$) (Table 1).

All patients had normal motor function at postoperative first-week control. According to monofilament test, all patients had normal, 2.83 results. However, on static 2-point discrimination test, Group A included 3 poor, and 1 fair results, while Group B included 2 poor, and 1 fair results (<6 mm was considered normal, 6–10 mm was considered fair, 10–15 mm was considered poor). No significant difference was found, regarding these results. ($p=0.593$). All patients had complete return of nerve function and full movement of the elbow at 6-month follow-up. No alteration was made to treatment of patients with poor or fair results; no reduction loss was observed during follow-up. All incisions in the mini-open group healed without complication.

Pin site infection occurred in 2 (4.9%) patients in Group A, and 3 (4.8%) patients in Group B. Oral antibiotics were used in all cases. No significant difference in occurrence of infection was observed between groups ($p>0.05$). No deep infection or osteomyelitis occurred.

DISCUSSION

Surgical treatment of displaced supracondylar humeral fractures consists of open or closed reduction with K-wire

fixation. Closed reduction and percutaneous fixation with crossed K-wires shows successful results. However, debate persists regarding optimal pin fixation technique. Biomechanical studies suggest that medial and lateral crossed K-wire fixation is the most stable.^[13,14] Some authors assert the importance of an additional medial K-wire to prevent reduction loss.^[15,16]

Incidence of iatrogenic nerve injury of 14.3% was recently reported in surgically treated cases of supracondylar humerus fracture. In the same study, the ulnar nerve was reported as that most commonly injured (82.1%), followed by the radial (7.7%) and median (5.1%) nerves.^[5] In a randomized prospective study, the ulnar nerve was injured in 3 of 557 (0.53%) cases with laterally introduced pins. Medially introduced pins resulted in ulnar nerve injury in 49 of 808 (6%) cases. The same authors found a 21% rate of reduction loss in cases of laterally placed pins. Medial and lateral pin placement had a significantly lower reduction loss rate of 4%.^[10]

In spite of biomechanical advantages to medial and lateral crossed wire fixation, ulnar nerve injury is a potential complication of medial pin placement. In order to reduce the risk of ulnar nerve palsy, several precautions are suggested, including making a small incision over the medial epicondyle for direct visualization.^[17] However, it is not clear whether a mini-incision technique can prevent iatrogenic ulnar nerve injury. Although visualizing the ulnar nerve via a small incision prior to pin placement is theoretically less risky, ulnar nerve lesions are usually caused by the prevention of normal anterior translation to the ulnar nerve, rather than penetrations of the nerve.^[18] In 2 studies in which lateral-pin and crossed-pin medial mini-open techniques were compared, no iatrogenic ulnar nerve injury was reported in either group. Both techniques were determined to be effective for treatment of supracondylar humerus fractures.^[10,19]

In a meta-analysis of randomized controlled trials, crossed-pinning fixation was determined to carry greater risk of iatrogenic ulnar nerve injury than lateral pinning, and the latter technique was recommended.^[20] In a single retrospective cohort study that included 65 patients (29 Gartland type III and 36 Gartland type II fractures), authors reported 1 iatrogenic ulnar nerve injury and recommended crossed-pin fixation with mini-open technique as a safe and reliable method.^[4] The present is the first study to compare medial mini-open crossed-pinning and percutaneous crossed-pinning techniques. No significant difference in incidence of ulnar nerve injury was found between the techniques ($p=0.593$).

Initial neurovascular examination is vital in determining whether injury is the result of fracture displacement or surgical complication. The importance of preoperative neurologic examination was emphasized in a recent study, as was the potential for preoperative neurologic deficit to be missed in initial management.^[21]

Ulnar nerve injury results in numbness of the little finger and the ulnar half of the ring finger. Sensory disturbance can be evaluated with threshold tests (such as the monofilament test). Alterations in sensory conduction are more sensitive indicators of nerve injury and found to correlate more directly with physical examination findings.^[22] In the present patients, monofilament test was conducted at 1 postoperative week. Group A had 3 poor and 1 fair results, while Group B had 2 poor and 1 fair results. No significant difference was observed. No patient had neurologic deficit in hand movement on physical examination. All sensory deficits were resolved at 6-month follow-up.

While fluoroscopy usage is essential, radiation exposure is a risk.^[23,24] Few reports have addressed fluoroscopy time of supracondylar humeral fracture surgery. In a study comparing open reduction and internal fixation with closed reduction and internal fixation in Gartland type III supracondylar fractures, surgery and fluoroscopy times were significantly longer in the closed reduction and fixation group.^[3] In another study of supracondylar humerus fractures, fluoroscopy time increased when closed reduction was intraoperatively switched to open reduction. The authors suggested that radiation exposure time be a factor when selecting surgical approach in prolonged closed reduction surgeries.^[25] The present surgery and fluoroscopy times were consistent with others reported.^[3,25] In theory, open incision should have additional risk of morbidity, though there is no evidence that medial incision in mini-open technique causes additional healing problems. This may be due to the small incision size and minimal dissection required. No differences in healing were presently observed between the groups.

No significant difference in surgery or fluoroscopy times were observed between groups. However, fluoroscopy usage during medial pinning was significantly lower in the mini-open group. This may be due to clearer identification of medial epicondyle and easier pin placement, without ulnar nerve concern.

Small population size and short follow-up period were the present limitations, in addition to the method of randomization used. Although a randomized clinical trial would be ideal, an extremely large study group would be needed to assess iatrogenic ulnar nerve injury. It was concluded in a systematic review that a minimum of 1000 patients would be needed to determine difference in complication rates ($\alpha=0.05$, $\beta=0.8$, difference to detect=0.035).^[16] It was concluded in another review that a sample size of 2000 patients would be needed according to 1.6% difference ($\alpha=0.05$, $\beta=0.20$, power=80%) in cases of iatrogenic ulnar nerve injury, and the difficulties inherent in conducting such an investigation were emphasized.^[26]

Given the near impossibility of conducting such large prospective randomized studies, surgeon-randomized trials retain their value in the comparison of surgical treatment

methods of supracondylar humerus fractures.^[27–29] In surgeon randomization, there is the risk that the surgeon may choose the mini-open technique if unable to palpate the ulnar nerve due to swelling. Rates of iatrogenic ulnar nerve injury would have been higher if the percutaneous technique had also been used in this group of patients.

The present study was the first to evaluate neurologic deficiency with monofilament test after surgical treatment of supracondylar humerus fractures. Similar surgery times show that the mini-open technique does not increase surgery time. All fractures united without radiological or clinical complications after 6 postoperative months. Ulnar nerve injury occurred in 7.3% of Group A patients, and in 3.2% of those in Group B. That this difference was not statistically significant may be due to palpation of the ulnar nerve during protection attempts.

In conclusion, medial mini-open technique had similar results to percutaneous technique; both carry the risk of iatrogenic ulnar nerve injury. Medial pin placement without injury is still a challenge in pediatric supracondylar humerus fracture surgery. Aside from the additional morbidity risk of mini-open incision, medial pin placement is easier and less demanding in mini-open technique.

Compliance With Ethical Requirements

The authors declare that they have no conflict of interest. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. Local institutional review board approval was also obtained.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - ÖZET

Çocuk tip III suprakondiler humerus kırıklarında medial mini açık teknikle perkütan tekniğin karşılaştırılması

Dr. Ersin Erçin,¹ Dr. Mustafa Gökhan Bilgili,¹ Dr. Emre Baca,¹ Dr. Serdar Hakan Başaran,²
Dr. Alkan Bayrak,¹ Dr. Cemal Kural,¹ Dr. Mustafa Cevdet Avkan¹

¹Bakırköy Dr. Sadi Konuk Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, İstanbul

²Karabük Üniversitesi Tıp Fakültesi, Ortopedi ve Travmatoloji Kliniği, Zonguldak

AMAÇ: Bu çalışmada, çocukluk çağında görülen suprakondiler humerus kırıklarında medial mini açık teknikle perkütan tekniği karşılaştırıldı, floroskopi zamanı, cerrahi süre ve iyatrojenik ulnar sinir hasarı araştırıldı.

GEREÇ VE YÖNTEM: 2011 ve 2013 yılları arasında ameliyat edilen 104 adet Gartland tip III suprakondiler humerus kırığı ileriye yönelik olarak incelendi. Birinci gruptaki (Grup A) 41 hastaya medial mini açık insizyonla medialden bir ve lateralden iki adet pin ile fiksasyonu yapıldı. İkinci gruptaki (Grup B) 63 hastaya tüm pinler perkütan yerleştirildi. Ortalama takip süresi Grup A'da 14.1±1.2 ay ve Grup B'de 14.6±2.1 aydır. Cerrahi sonrası hastalar sinir yaranlanması açısından motor ve duyu muayeneleri yapıldı. Cerrahinin süresi, toplam floroskopi süresi, medial pin için floroskopi süresi, Baumann açısı, humerokapitalar açısı ve eklem hareket açıklığı değerlendirildi.

BULGULAR: Duyu incelemesinde Grup A'da üç kötü ve bir orta sonuç, Grup B'de iki kötü ve bir orta sonuç elde edildi. İstatistiksel olarak fark saptanmadı. Gruplar arasında cerrahi süre ve toplam floroskopi süresi açısından fark saptanmadı. Medial mini açık yapılan grupta medial pin fiksasyonu sırasında floroskopi süresi daha kısa saptandı.

TARTIŞMA: Medial mini açık teknik ve perkütan tekniğin her ikisinin de iyatrojenik ulnar sinir yaranama riski mevcuttur. Medial mini açık teknikte medial pin yerleştirme işlemi daha kısa süre floroskopi kullanımı açısından avantajlıdır.

Anahtar sözcükler: Humerus; kırık; pediatrik; suprakondiler kırık; ulnar sinir.

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