Type III Supracondylar Humerus Fractures in Children: Open Reduction and Pinning

Çocuklarda Suprakondiler Humerus Tip III Kırıkları: Açık Redüksiyon ve Pinleme

Supracondylar Humerus Fracture / Suprakondiler Humerus Kırığı

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Özet

Amaç: Humerus suprakondiler kırıkları, çocuk dirsek çevresi kırıklarının en sık görülen tipidir. Açık redüksiyon, deplase olmuş suprakondiler kırıklı hastaların tedavisinde başarılı bir yöntem olarak kullanılmaktadır. Açık redüksiyon yönteminin en önemli avantajı, kırık hattının görülerek tam bir anatomik redüksiyona izin vermesi, iyatrojenik damar ve sinir yaralanma riskinin azlığıdır. Bu çalışmada Gartland ekstansiyon tip III çocuk humerus suprakondiler kırıkların cerrahi tedavisinde uyguladığımız açık redüksiyon ve çapraz pinleme tedavisinin sonuçları değerlendirildi. Gereç ve Yöntem: Gartland tip III ekstansiyon tip humerus suprakondiler kırık gelişen 18 çocuk hasta (5 kız, 13 erkek; ort. yaş 7.3 ± 2.02; dağılım 3-12) çalışmaya alındı. 11 (%61.1) hastanın sağ dirseğinde, 7 (%38.8) hastanın sol dirseğinde kırık mevcuttu. Ortalama ameliyat süresi 53.3 ± 8.5 dakika (dağılım, 45-70). Hastaların ortalama hastanede yatış süresi 1.7 ± 0.75 gün (dağılım, 1-3), ortalama takip süresi 2.2 ± 0.6 yıl (dağılım, 1.5–4) idi. Bulgular: Flynn kriterlerine göre taşıma açısı değişiklikleri altı (%33.3) hastada çok iyi, 12 (%61.7) hastada iyi sonuç alındı. Fonksiyonel değerlendirmede hastaların eklem hareket kaybı değişiklikleri açısından 14 (%77.7) hastada çok iyi, dört hastada (%22.3) hastada ise iyi sonuç elde edildi. Radyolojik değerlendirmede ortalama Baumann açı değişimi 75.6° (dağılım, 70 – 85) idi. Tartışma: Gartland ekstansiyon tip III humerus suprakondiler kırıkların cerrahi tedavisinde açık redüksiyon tekniği ile kırıklarda iyi klinik sonuçlar elde edilebilmektedir. En önemli dezavantajı ise ameliyat sonrası dirsekte oluşan insiziyon skarıdır.

Anahtar Kelimeler

Suprakondiler Humerus Kırıkları; Açık Redüksiyon; Posterior Yaklaşım; Çocuk; Triseps

Abstract

Aim: Supracondylar humerus fractures are the most common type of fractures involving the elbow region in children. Open reduction is a successful method for the management of displaced supracondylar fractures, with the most important advantages being complete anatomical reduction by visualising the fracture line and the lower level of risk for iatrogenic neurovascular injuries. In the present study, we assessed outcomes of open reduction and cross-pinning employed in the surgical management of paediatric Gartland type III supracondylar humerus fractures. Material and Method: The study included 18 children with Gartland extension type III supracondylar humerus fractures (13 boys, 5 girls; mean age: 7.3 ± 2.02 years; range, 3–12). There were fractures in the right elbows of 11 patients (61.1%) and in the left elbows of seven (38.8%). The mean operative time was 53.3 ± 8.5 minutes (range, 45–70). The mean length of hospital stay was 1.7 ± 0.75 days (range, 1–3), while the mean follow-up time was 2.2 ± 0.6 years (range, 1.5–4). Results: According to the Flynn criteria, excellent results were obtained in six patients (33.3%), and good results in 12 (61.7%) regarding changes in the carrying angle of the elbow. Functional assessment results were excellent for 14 patients (77.7%) and good for four (22.3%) regarding their loss of joint movement. Radiographic examinations revealed an average Baumann's angle of 75.6° (range, 70–85). Discussion: Good clinical outcomes can be achieved through the management of Gartland extension type III supracondylar humerus fractures using the open reduction technique. The most important disadvantage, however, is the post-surgical appearance of the elbow incision scar.

Keywords

Supracondylar Humerus Fractures; Open Reduction; Posterior Approach; Child; Triceps

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Introduction

Supracondylar humerus fractures are the second most common fractures after forearm fractures and the most common type of fractures involving the elbow in children [1]. These fractures can cause severe functional and cosmetic problems if left untreated or treated insufficiently [2]. Severe complications include Volkmann's ischemic contracture, neurovascular injuries, cubitus varus/valgus deformity, myositis ossificans and limitations in joint motion [2-5].

Supracondylar humerus fractures are classified into two groups based on the direction of the displacement: flexion and extension [2]. Extension fractures are more common than flexion fractures, and were classified into three subgroups by Gartland [6]: type I, with no displacement; type II, with moderate displacement and intact posterior cortex and type III, with complete displacement.

The primary goal of the surgical treatment of supracondylar humerus fractures is to achieve complete recovery of the motion of the elbow joint and normal cosmetic appearance [2, 3, 7, 8]. Open reduction is one type of surgical treatment that has been used successfully in the management of displaced supracondylar humerus fractures [9]. The most important advantages of this method include complete anatomical reduction by visualising the fracture line and lower risk for iatrogenic vascular and neurological injuries [2, 8, 9].

In the present study, we assessed the outcomes of open reduction and cross-pinning employed in the surgical management of paediatric Gartland extension type III supracondylar humerus fractures.

Material and Method

The study included 18 children (5 girls, 13 boys; mean age, 7.3 ± 2.02 years; range, 3–12) with Gartland extension type III supracondylar humerus fractures who underwent open reduction and fixation by Kirschner (K)-wires between 2011 and 2014 (Table 1). Exclusion criteria were as follows: age >16 years, Gartland type I-II fractures, open fractures, metabolic bone disease and ipsilateral upper extremity fracture. There were fractures in the right elbows of 11 patients (61.1%) and in the left elbows of seven patients (38.8%). All fracture operations were performed on the same day. The study was conducted in accordance with the Declaration of Helsinki.

Table 1. Demographic characteristics of patients.

Patients, n	18
Years of age, mean ± SD (range)	7.3 ± 2.02 (3–12)
Gender, n (%)	
Female	5 (27.7%)
Male	13 (72.3%)
Years of follow-up, mean ± SD (range)	2.2 ± 0.6 (1.5–4)
Fracture location, n (%)	
Right elbow	11 (61.1%)
Left elbow	7 (38.8%)

SD, standard deviation.

Surgical Technique

At the elbow region, a skin excision was made beginning from 5 cm proximal and extending to 1–2 cm distal to the olecranon via a posterior approach. The distal humerus was exposed through the medial and lateral aspects of the triceps muscle, preserving the ulnar nerve and not detaching the triceps from its insertion in the olecranon. After reduction of the fracture, fixation was achieved under fluoroscopy by a cross-pin configuration of 2–3 K-wires (1.5 mm in thickness; Figure 1). K-wires were bent over

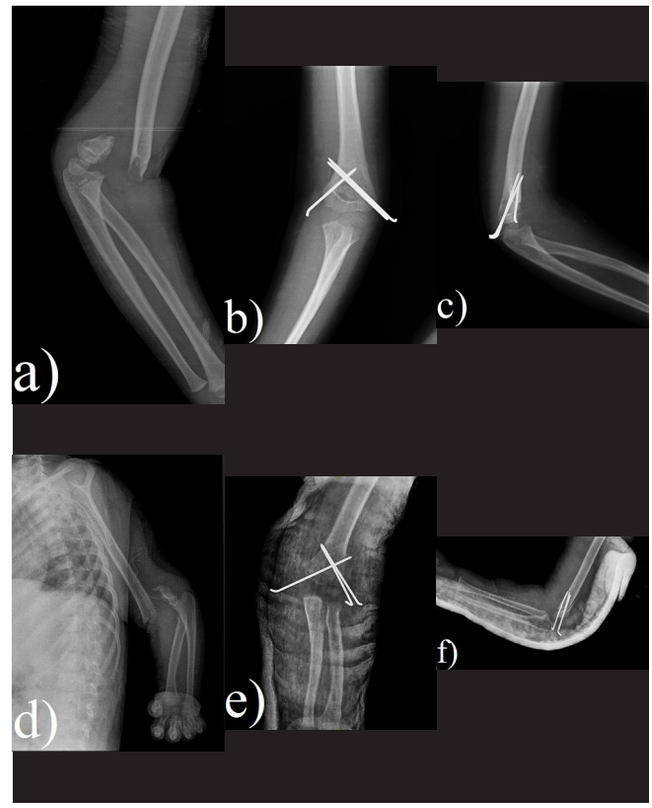


Figure 1. Pre- and post-operative radiographic images of patients with Gartland extension type III supracondylar humerus fractures. (a, b, c, d, e, f)

the skin and the wound was closed. After surgery, a long arm cast was applied to maintain a neutral position of the forearm and elbow joint. Weekly wound care was performed, and skin sutures were removed on post-surgical day 10. The K-wires and long arm cast were removed without anaesthesia at an outpatient clinic 3–4 weeks after surgery based on patient age and radiological findings. Active exercises were prescribed in order to improve the range of motion of the elbow.

At the final follow-up, anteroposterior and lateral elbow radiographs were obtained. Cosmetic and functional results were evaluated based on radiographs using the Flynn criteria (Table 2) [10], and the Baumann's angle was measured in all patients (Figure 2). The neurovascular status was recorded pre- and post-operatively.

Table 2. Flynn criteria for grading supracondylar humerus fractures [10].

	Cosmetic factor: carrying angle loss (°)	Functional factor: motion loss (°)
Excellent	0–5	0–5
Good	6–10	6–10
Fair	11–15	11–15
Poor	>15	>15

Results

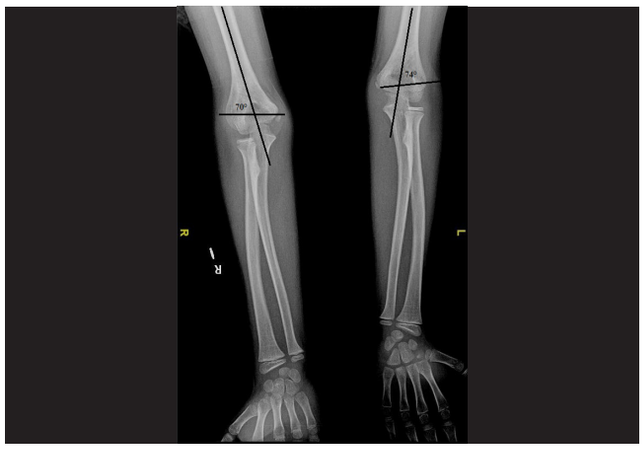


Figure 2. The change in the Baumann's angle two years after surgery in a patient with a Gartland type III supracondylar fracture of the right humerus.

The mean operation time was 53.3 ± 8.5 minutes (range, 45–70), and the mean hospitalisation time was 1.7 ± 0.75 (range, 1–3) days. The mean follow-up time was 2.2 ± 0.6 years (range, 1.5–4). In the three patients who had anterior interosseous nerve lesions before surgery, lesions completely recovered within 3–4 months after surgery; the nerve injuries were considered as neuropraxia. No wound site infections or superficial pin-tract infections developed in any patient.

According to the Flynn criteria, excellent results were obtained in six patients (33.3%), and good results in 12 (61.7%) regarding changes in the carrying angle of the elbow (Figure 3). In the functional assessment, excellent results were obtained for 14 patients (77.7%) and good results for four (22.3%) regarding their loss of joint movements (Figure 4). The radiographic examination revealed an average Baumann's angle of 75.6° (range, 70–85).



Figure 3. The change in the carrying angle of the elbow four years after surgery in a patient with a supracondylar fracture of the left humerus(a). Incision scar at the elbow(b).

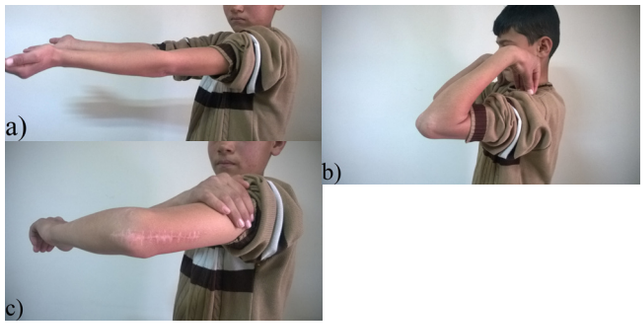


Figure 4. Pictures of a patient three years after surgery; a) Elbow extension. b) Elbow flexion. c) Incision scar.

None of the patients complained of elbow pain or developed neurological deficits, myositis ossificans or cubitus varus. The most common complaint involved the appearance of the post-surgical incision scar (Figure 5).



Figure 5. Incision scar formation two years after open surgery.

Discussion

For supracondylar humerus fractures, the primary goal is to achieve anatomical position and support it by fixation while providing maximum stability and minimum morbidity [2, 8, 11]. The treatment guidelines for type I and II fractures have been well established, and many methods have been recommended for the treatment of type III fractures [8, 12]. Type III fractures may be associated with neurovascular injuries, and treatment may be complicated by malunion, elbow stiffness, iatrogenic neurovascular injury and compartment syndrome [12]. Surgical treatment of type III fractures is complicated and entails technically difficult orthopaedic procedures.

According to many authors, the ideal treatment for type III supracondylar humerus fractures is closed reduction and percutaneous pinning [11, 13, 14]. However, the results from several studies using open reduction and pinning suggested that it is at least comparable to, or even favourable to, closed reduction and pinning [11, 13, 15]. Traditionally, open reduction had been reserved for cases in which closed reduction failed, displacement recurred or vascular complications occurred during the closed attempt [5, 16]. Additionally, certain portions of the displaced fractures cannot be reduced using the closed method. Brachialis muscle entrapment at the fracture site, for example, is the most common cause of blocked reduction, as the distal spike of the proximal fragment is driven through the substance of the muscle [17, 18]. Furthermore, open surgery preferred after one or two attempts at closed reduction may produce adverse effects on the epiphysis and also lead to myositis ossificans [12]. Considering these factors, we achieved osteosynthesis by open surgical intervention in Gartland type III fractures without attempting closed reduction. The rationale for this approach was that it afforded the opportunity to avoid complications related to manoeuvres, the possibility of achieving reduction more readily and the potential for reductions in radiation exposure doses during surgery.

Kazımoğlu et al. [12] reported that outcomes of closed reductions demonstrated no superiority over open reductions in their study, which compared closed surgery and open reduction via

the lateral approach in Gartland extension type III supracondylar fractures.

In supracondylar humerus fractures, open surgical intervention can be achieved via anterior, posterior, medial, lateral or postero-medial approaches [2, 8, 11-13, 19-21], each of which has associated advantages and disadvantages. The posterior approach can allow for effective surgical access by exposing both cortexes directly, although it is thought that the posterior approach can cause loss of joint movement abilities [13, 19, 20]. In a long-term study, Gürkan et al. suggested that the posterior approach with a V transection of the triceps muscle was a reliable surgical approach which was not associated with morbidity [20]. The results of a study conducted by Özkoç et al., in which a postero-medial incision was used for the open reduction of supracondylar humerus fractures, suggested that the postero-medial incision was an easy, safe and cosmetic incision for open reduction of supracondylar humerus fractures [8]. Proponents of the anterior approach posited that it provided for excellent exposure of the fracture site and had the advantage of not adding surgical injury to the unharmed posterior structure [17, 19]. In our study, we completed the surgical intervention with medial and lateral distinct incisions, which allowed for the exposure and reduction of fractures without detaching the triceps from its insertion in the olecranon after the posterior long incision of the skin. In this way, surgical intervention was achieved without harming the triceps muscle while exposing both columns of distal ends of humerus.

Open reduction has been associated with disadvantages including loss of motion, myositis ossificans, increased risk for infection, prolonged hospital stay and formation of marked scar tissue at the incision line [2, 5, 11, 13, 14]. However, we observed no adverse event other than incision scars in our patients. The mean length of hospital stay was 1.7 ± 0.75 days (range, 1–3) in our study. It should be noted that a study by Sibly et al. [14] found no correlation between stiffness and surgical approach.

The results of a few studies have suggested that closed reduction with two lateral pins was an effective method associated with avoidance of iatrogenic ulnar nerve injuries [22, 23]. However, biomechanical studies have definitively demonstrated that the cross-pin configuration is more stable than the two lateral pin configuration [23, 24]. The results of a study by Zionts et al. [24] indicated that the most stable K-wire composition was a cross-pin configuration with two K-wires used at medial and lateral locations. According to Sankar et al. [25], the loss of fixation is more likely to occur when Gartland type III fractures are treated with the two lateral pin fixation operation. Because we were of the opinion that more stable fixation was needed in Gartland type III fractures, the cross-pin configuration was used in our study.

Nerve injuries associated with displaced supracondylar humeral fractures may be attributable to the injury itself or to iatrogenic injury during treatment [3, 13]. The ulnar nerve is most commonly injured after percutaneous crossed K-wires treatment, with an incidence of 2–6% [3, 7, 8, 11, 13, 23]. No neurological problems occurred in our study, as we preserved the ulnar nerve during open surgery. The pin tract infection rate has been reported as 2–7% [11, 13, 20, 26]; however, no infections developed in our study.

Traditionally, acute treatment of displaced supracondylar fractures has been recommend [8, 20]. The reasons behind the recommendation were to decrease the risk of peri-operative complications, such as compartment syndrome, infection and nerve injuries, as well as reduce the probability of conversion to an open reduction [2, 5, 11, 13]. However, the results of several studies have found no significant differences between early and delayed treatment of supracondylar humeral fractures in children with regard to perioperative complications and the need for open reduction [26-28]. All patients in our study underwent surgery within one day after anaesthesia preparation, and no adverse events were observed due to early surgical intervention.

Our study has also some limitations. There is not any control group such as results of closed reduction or opened reduction with triceps muscle dissection that we could compare with our opened reduction surgical technique.

In conclusion, good reductions were obtained using the open reduction technique via a posterior approach without transection of the triceps muscle. Additionally, good clinical outcomes were also achieved in the management of Gartland extension type III supracondylar humerus fractures. However, the incision scar formation after open surgery remains problematic from a cosmetic perspective.

Competing interests

The authors declare that they have no competing interests.

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