RESEARCH

Retrospective Evaluation of Two Different Percutaneous Pinning Techniques (Medial-Lateral Cross Pin vs Lateral Cross Pin) in Gartland Type 3 Pediatric Supracondylar Humerus Fractures

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Abstract: Supracondylar humerus fractures are the most common elbow injuries in children. Closed reduction percutaneous fixation is the preferred method in the treatment of pediatric supracondylar humeral fractures. The optimal pin configuration is still a matter of debate. As the most commonly used fixation method, medial-lateral cross pinning provides better stability biomechanically but there is an increased risk of ulnar nerve injury. We also used the modified Dorgan method (lateral cross pin) to minimize the risk of ulnar nerve injury and to obtain fixation with similar biomechanical stability. In this study, we compared the results of standard medial-lateral pinning and the modified Dorgan method in the treatment of Gartland type 3 supracondylar fractures. We retrospectively analyzed 54 patients (32 males, 22 females) with pediatric supracondylar humerus fractures who were treated at the Ankara City Hospital Orthopedics and Traumatology Clinic between 2019 and 2021 years. In clinical and functional evaluation, we evaluated joint range of motion, carrying angle, complications, Baumann angle and Flynn criteria. The mean age of the patients was 6.3 years. The most common injuries were falling while playing (64.81%), then fall from a bicycle (16.66%), traffic accidents (12.96%) and fall from a height (5.55%). The mean follow-up was 30.68 weeks (24-48 weeks). There was no ulnar or radial nerve injury or major reduction loss in any postoperative patient. Superficial pin tract infection was seen in only two cases, which resolved with simple medical interventions. According to Flynn functional criteria, the result for group 1 was excellent in 80.0% and good in 20.0% and the result for group 2 was excellent in 83.33% and good in 16.67%. There was no significant difference between the groups in terms of clinical and functional outcomes, neurovascular injury, union time. It is well known that poor sleep quality is related with depression and anxiety.

INTRODUCTION

Supracondylar humerus fractures are the most common elbow injuries in children, accounting for about 60% of all elbow injuries in the first decade of life [1]. These injuries are divided into flexion and extension types. In general, the extension type are more common. According to the Gartland classification, extension type fractures are divided into three. Non-displaced fractures, displaced fractures with intact posterior cortex and completely displaced fractures without cortical contact[2]**.** It can be associated with complications such as supracondylar humerus fractures, compartment syndrome, neurovascular injuries, iatrogenic neurovascular injury, malunion and elbow stiffness[3,4]. Cubitus varus due to loss of reduction is the most common deformity and its incidence ranges from 5% to 21% [5-6]. The incidence of iatrogenic ulnar nerve injuries after percutaneous fixation with medial and lateral entry pinning is approximately 15% according to Chai [7].

Closed Reduction percutaneous fixation is the preferred method for the treatment of pediatric displaced supracondylar humerus fractures. The optimal pin configuration that provides stable fixation and minimizes the risk of neurovascular injury is still controversial. Different pinning methods have been defined. Many authors such as Flynn and Swenson, report that he used two cross pins placed medially and laterally [5,8]. They claim that this technique has the advantage of providing better biomechanical stability. However, there is a possibility of injury to the ulnar nerve in 2-8% of cases during insertion of the pin into the medial. Arino et al. recommend sending two pins laterally to avoid ulnar nerve injury [6]. Although it is safer, the reliability of fixation provided biomechanically compared to the cross pinning method of lateral pinning is controversial. For this reason, a new method was described by Dr John Dorgan, orthopedic surgeon at Alder Hey Children's Hospital in Liverpool, with a different perspective on a lateral pinning. With this method, the pins are placed laterally, but unlike the classical lateral pinning, the second pin is sent from the lateral superior to the medial inferior. Thus,

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by lateral cross-pinning, the risk of ulnar nerve injury is eliminated and a more stable fixation is provided biomechanically [9].

For this reason, we aimed to equate the results of standard percutaneous medial-lateral pinning with the three-pin lateral cross pinning method in the treatment of Gartland type 3 supracondylar fractures, which we applied in our clinic.

MATERIALS and METHODS

Design

The study was conducted in accordance with the principles of the Helsinki Declaration. After obtaining the approval of the Ankara City Hospital Ethics Committee (approval: E1-21-1907). We retrospectively analyzed patients with pediatric supracondylar humerus fractures treated at the Ankara City Hospital Orthopedics and Traumatology Clinic between 2019 and 2021 years. As inclusion criteria; Patients who underwent closed reduction percutaneous fixation technique due to Gartland type 3 supracondylar fracture were identified. Patients under 3 years of age, over 12 years of age, those with open fractures, those with neurovascular damage, those requiring open reduction were not included in the study. Fifty-four patients who met the criteria were included in the study. Thirty patients with standard medial-lateral cross pinning were determined as Group 1, and 24 patients with lateral cross pinning were determined as Group 2.

Surgical Technique

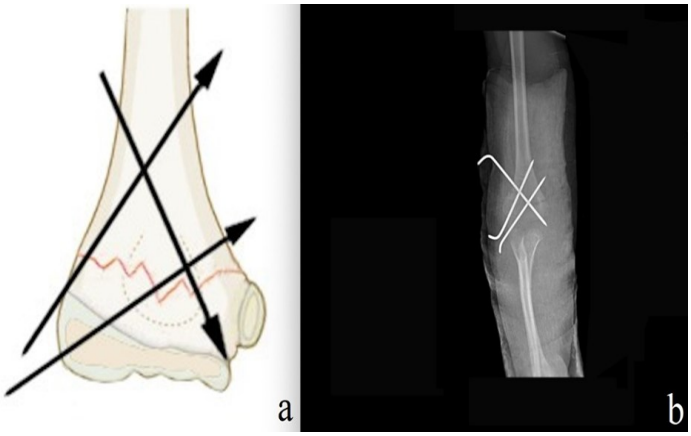
All patients received general anesthesia. The operations were performed by a single orthopedic surgeon. A single dose of parenteral cefazolin prophylaxis was given to all patients 30-60 minutes before the operation. 1.5-2.2 mm diameter K-wires were used in the procedures.

Traction was applied with the forearm in supination. Fracture displacement was corrected in the coronal plane by applying medial-lateral force to the fracture while maintaining traction. The posterior displacement of the fracture was then corrected by hyperflexing the elbow and applying a posterior force while bringing the forearm to pronation. Reduction was confirmed by a sterile draped C-arm. After the closed reduction maneuver, two K-wires were placed over the lateral epicondyle in Group 1 patients, holding the opposite cortex. Then, the elbow was flexed to 90°. The ulnar nerve was rounded back with the opposite thumb. A K-wire was placed over the medial epicondyle to hold the opposite cortex **(**Figure 1).

Figure 1: Postoperative x-ray image of the patient with medial-lateral cross pinning.

In Group 2 patients, two K-wires were placed over the lateral epicondyle in the same way, holding the opposite cortex. The third wire was sent through the lateral cortex in the proximal part of the fracture line towards the medial condyle (Figure 2). The adequacy of reduction and fixation was checked with the C-arm. Pins are bent to prevent migration. The pins were cut from the outside of the skin to prevent reoperation. Postoperatively, a long arm cast was applied with the elbow in 90° flexion.

Figure 2: Schematic image of the lateral cross pinning technique (a), postoperative x-ray image (b)



Postoperative Evaluation

The patients were evaluated according to the postoperative 1st, 3rd, 6th week, 3rd and 6th month control data. The plaster was removed in the 3rd week and range of motion (ROM) exercises were started. Antero-posterior and lateral radiographs were taken in all controls visits. After the radiographs showed signs of union in the fourth or sixth week, the pins were removed without anesthesia. Patients were evaluated with neurovascular status, infection, passive joint movements and carrying angle measurements. Flynn criteria and Baumann angle were used in clinical evaluation. Classified as excellent, good, moderate and poor according to two Flynn criteria defined by loss of motion in degrees and loss of carrying angle in degrees [5]. Elbow carrying angle was measured with the patient standing, arms at the sides and palms facing forward. The angle between a line drawn from the coracoid process of the scapula to the midpoint of the elbow and a second line drawn from the midpoint of the wrist to the midpoint of the elbow was determined as the carrying angle. The angle was measured with a goniometer and compared to the opposite extremity .

RESULTS

Demographic data of the patients, type of fracture, length of hospital stay, average delay from injury to surgery, follow-up time are given in Table 1. The most common injuries were falling while playing (64.8 %), then fall from a bicycle (16.6 %), traffic accidents (12.9 %) and fall from a height (5.5 %). None of the patients had neurovascular deficits at the time of admission. Pin tract infection developed in two cases (two case in group 1) as a postoperative complication. But all the infections were superficial and healed. There was no ulnar or radial nerve deficit or major reduction loss in any postoperative patient. The mean radiological and clinical union times were 5.1 weeks. The mean time to union was 5.06 weeks in group 1 and 5.19 weeks in group 2. There was no significant difference in terms of radiological and clinical union times ($P > 0.05$). There was also no significant difference regarding the change in Baumann angle, total elbow motion, carrying angle ($P > 0.05$). The functional and cosmetic results of the patients according to the Flynn criteria are given in Table 2.

Table 1: Demographic data of the patients, type of fracture, length of hospital stay, average delay from injury to surgery, follow-up time

Variables	Group 1 (n=30)	Group 2 (n=24)	P value
Sex distribution[a]			
Male	18	14	p=0,414
Female	12	10	p=0,324
Mean age of the patient (years)	6.13± 2.06	6.55±2.17	p = 0.175
Side affected[a]			
Right	11 (36.6 %)	9 (37.5 %)	p= 0,057
Left	19 (63.3 %)	15 (62.5 %)	p=0,356
Fracture type[a]			
Posteromedial	22 (73.3 %)	19 (79.1 %)	p= 0,327
Posterolateral	8 (26.6 %)	5 (20.8 %)	p=0,401
Hospital stay (days)[b]	2.16±0.45	2.37±0.54	p= 0.669
Average delay from injury to surgery (days)[b]	0.75±0.54	0.85±0.58	p= 0.281
Average follow-up (weeks)[b]	30.16±9.36	30.89±11.13	p= 0.586

[a]Values are given as the number of patients
[b]Values are given as the mean and SD

Table 2: The functional and cosmetic results of the patients according to the Flynn criteria

	FLYNN Functional			FLYNN Cosmetic		
	Group 1	**Group 2**	**p value**	**Group 1**	**Group 2**	**p value**
Excellent	24 (80 %)	20 (83.3 %)	p= 0.34	22 (73.3 %)	18 (75 %)	p = 0.39
Good	6 (20 %)	4 (16.6 %)	p = 0.41	8 (26.6 %)	6 (25 %)	p = 0.44
Moderate	0	0		0	0	
Poor	0	0		0	0	

DISCUSSION

Gartland Type 3 supracondylar humeral fractures are fractures that require urgent surgical treatment because they are unstable and complications are serious. It is aimed to heal without loss of elbow movements, to have a cosmetically normal appearance and to recover without deformity during remodeling, and therefore full anatomical reduction and stable fixation are aimed [11,12]. Many different treatment methods are applied depending on the vessel and nerve injury, displacement, and soft tissue edema. Since different approaches and results have been reported such as the number of pins to be used (2 or 3), medial-lateral cross pinning, only lateral pinning and lateral cross pinning, there is no consensus on treatment. This brings a lot of controversy. Medial pin placement, in particular, carries a risk of iatrogenic ulnar nerve injury. Although techniques such as elbow extension or medial mini-incision are recommended to protect the ulnar nerve, the rate of ulnar nerve injury during medial pinning varies between 1.4% to15.6% in the literatüre [13,14,15]. However, these methods also have disadvantages such as loss of reduction, additional surgical incision and prolongation of the operation time.

Techniques in which pins were inserted laterally were used to avoid ulnar nerve injury. However, stability in these techniques has also been a matter of debate and different results have been reported. Bloom et. al. reported that there was no difference between lateral pinning and lateral-medial pinning in their biomechanical study. They even found that there was more stiffness in the lateral pinning duringextension [16].

Chen et. al. similarly stated that there was no biomechanical difference in lateral-medial and only lateral pinning, but stated that the fracture shape, pin thicknesses used and the way the pins were placed laterally (divergent, parallel) affected these results [17]. On the contrary, there are many publications reporting that the desired biomechanical stability cannot be achieved in lateral divergent or parallel pinning methods, especially when compared to torsional forces, it is more unstable and reduction losses are higher than in patients who are applied medial cross pins [18,19,20]. It has also been particularly emphasized in the literature that crossing [21,22] pins contributes to stability. Apart from the pin configuration, the number of pins also has an effect on stability. Although 2 pins are usually placed, reduction is also made with more than 2 pins in comminuted and more complex fractures. Claireaux et al has been shown that fracture reduction is maintained better with three wires in crossed configuration (two lateral and one medial wire) and had a smaller change in Baumann angle compared to those fractures treated with other pin configurations [23]. In similar biomechanical studies, mechanical stability was found to be much higher in cases with 2 and 3 pins in the same and different configurations, in those with 3 pins [16,24,25,26]. In our study, in order to avoid ulnar nerve damage, the pins were placed crosswise from the lateral and the same results were obtained in cases with medial-lateral cross pinning. In addition, the risk of ulnar nerve injury was eliminated by placing the pins laterally, and the stability recommended in the literature was provided by using 3 pins and placing them diagonally.

In supracondylar humerus fractures, since the ends of the pins are

left outside the skin, the probability of pin site infection also increases, and it is found to be 2.4% (1 to 21%) on average [18]. It adversely affects the postoperative functional results and can cause serious ROM loss. It is known that the placement of pins is effective in relation to the causes of infection. Parikh et. al. investigated the relationship between pin location and infection and found that intracapsular pins increased the infection rate. In addition, in the same study, they found higher rates in parallel placed pins and stated that parallel placed pins passed through the joint capsule more. On the contrary, they found that there was a significantly lower rate of infection in cross and divergent pinning. They stated that lateral pinning would be a better option because it reduces the risk of neurological injury and has less infection rates [27]. In our study, fewer infections were observed in our patients with lateral cross pinning, but there were no neurological complications in either group.

Our most important limitation is the retrospective design of our study and the small number of cases. In addition, our other limitations are that it is not compared with cases placed in other configurations and that our follow-up period is insufficient for future deformities. We believe that prospective clinical studies and biomechanical studies using many different configurations and numbers of pins are necessary.

Conclusion

Our method is a reliable method like other methods. There was no significant difference between the groups in terms of clinical and functional outcomes, neurovascular injury, union time.

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