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Clinical and functional outcomes of pediatric elbow dislocations: Level 1 tertiary trauma center experience

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The study was approved by the Health Science University Istanbul Mehmet Akif Ersoy Chest an Cardiovascular Surgery Training and Research Hospital ethic committee (approval number 2020-084).
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No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Traumatic elbow dislocations have been reported as uncommon in pediatric population. Because of low frequency, there are not many studies on the subject in the literature. The aim of this study was to retrospectively evaluate the radiological and functional results of pediatric patients treated for elbow dislocations in a level-1 tertiary trauma center and to compare the results of simple and fractured dislocations.

Methods: This is a retrospective cohort study of a single center experience diagnosed with pediatric elbow dislocations between 2015 and 2019. The cases were evaluated by dividing them into two groups as simple dislocations and fracture dislocations. Demographic features, injury mechanism, treatment, complications and Mayo elbow performance score (MEPS) were evaluated.

Results: Fifty-seven patients, (46 male/ 11 female), were included in the study, with a mean age of 11.1 (3-15) years. Mean follow up time was 27.2 (12-51) months. While 30 patients had fracture dislocations, 27 patients had simple dislocations. Of 30 patients with fracture dislocations, 19 were operated. Nonunion in the medial epicondyle in five patients, AVN (avascular necrosis) in radial head in two patients, heterotrophic ossification in one triceps, and recurrent dislocation in one patient were detected. According to MEPS, 42 (73%) of 57 patients were excellent, 12 (21%) good, one (2%) moderate, and two (4%) poor. According to MEPS, functional results of simple dislocations were found to be better than those of fracture-dislocations, and this result was statistically significant ($P<0.05$).

Conclusion: Elbow dislocations in children can be treated with good results if they are accurately diagnosed and if concentric stable reduction of the elbow as well as stable osteosynthesis of displaced fractures can be achieved. Simple dislocations are easier to manage and functional results are better, whereas the treatment of fractured dislocations is more complex and complications are more common in follow-up.

Keywords: Pediatric elbow dislocation, Simple dislocation, Fracture dislocation, Complication, MEPS

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Introduction

Traumatic elbow dislocations have been reported as uncommon in skeletally immature patients, with an incidence of 3–6% of all elbow injuries [1, 2]. Pediatric elbow dislocations are usually observed in the second decade when the epiphysis is beginning to close [1, 3].

Elbow dislocations are classified according to displacement of the distal structures, with the most prevalent displacement being posterior or posterolateral. These injuries are often in the form of complex injuries that may be associated with fractures or avulsions, with medial epicondyle avulsions having been reported as the most common concomitant fracture [4]. Coronoid process, radial head, olecranon, trochlea and lateral condyle fractures are observed less frequently [3, 5, 6]. Due to the complex nature of the elbow and to prevent future complications, early diagnosis and effective treatment are required. Therefore, it is extremely important to diagnose and treat pediatric elbow injuries correctly at the time of the initial injury to optimize treatment outcomes. Associated fractures are likely to occur when the physes are still open; when they are closed, collateral ligaments might be ruptured [1]. Pediatric elbow dislocations can be divided into fracture dislocations and simple dislocations without fracture. Although simple dislocation of the elbow in children is usually considered to be a benign injury, which can be treated conservatively with only closed reduction without any sequelae during follow-up, surgical treatment is an option for patients with concomitant fractures. Only a few studies described this injury in children [3-7].

The aim of this study was to retrospectively evaluate the radiological and functional results of pediatric patients treated for elbow dislocations in a level-1 tertiary trauma center.

Materials and methods

The medical records of pediatric patients with elbow trauma who were admitted to the Emergency Department between January 2015 and January 2019 were reviewed. The study inclusion criteria were patient age less than 15 years at the time of dislocation, isolated elbow dislocation or fracture-dislocation, adequate follow-up of at least 12 months and written informed consent provided by the parents for the use of clinical data. Patients with pathological fracture-dislocation, previous surgery of the relevant joint, inappropriate radiological evaluations or missing follow-up data were excluded from the study.

Medical charts were reviewed for the following demographic and presenting variables: trauma mechanism (fall, sports injury, fall from height, or motor vehicle accident) and associated neural and / or vascular injuries. Charts were also examined for length of immobilization (cast) and time from injury to final follow-up visit. Outcomes were assessed with range of motion (ROM) parameters at the final follow-up examination, and the functional outcome was measured using the Mayo Elbow Performance Score (MEPS) [7]. Complications were also recorded (Table 1).

Table 1: Fracture types and complications of the patients

	n	Complications	n
Simple dislocation	27	Valgus deformity	2
		Recurrent dislocation	1
Fracture dislocation			
Medial epicondyle	20	Medial epicondyle nonunion	5
Radius neck	3	Radius head avn	2
Olecranon	2	Heterotropic ossification	1
Medial condyle	1	Varus deformity	2
Lateral condyle	4	Valgus deformity	4
Total	57		17

Treatment protocol

For all dislocations, elbow anteroposterior / lateral radiographs were taken and all reductions were performed under sedation (propofol 1–1.5 mg/kg) in the emergency. Accompanying fractures were treated based on the amount of residual displacement of the fracture. Patients with medial epicondyle fractures with less than 8 mm of displacement after reduction and a negative valgus stress test were treated conservatively, while patients with displacement greater than 8 mm and a positive valgus stress test were treated surgically [8, 9]. Medial and lateral condyle fractures with displacement greater than 2 mm were treated with open reduction and internal fixation (ORIF). Kirschner wires (K-wires) (0.062-inch diameter) were used in all cases. Fracture fixation was performed with two K-wires. In olecranon fractures, patients with more than 2 mm of displacement were operated on using the tension band technique. In patients with radial neck fractures, the surgical procedure was performed as follows: if the reduction was successful after closed reduction, closed pinning was applied; if successful reduction was not achieved (radial neck angle >60°), ORIF was applied. One patient with a radial neck fracture with an angulation of less than 30° was followed up conservatively. Closed reduction and percutaneous pinning with K-wires (K-wire joystick technique) was applied to one patient with an angulation between 30° and 60°, and the open reduction internal fixation (ORIF) with K-wire method was used for two patients with an angulation of more than 60° [10].

Postoperative management

A long-arm splint was initially applied to patients with simple dislocations and fracture-dislocations which were treated conservatively. The splints are removed in two weeks in simple dislocation group and four weeks in the fracture-dislocation group. For operated cases, the K-wires were removed six weeks postoperatively. For olecranon fractures, the K-wires and tension band wires were removed under sedation in six months postoperatively.

Follow-up Assessments

At the final follow-up examinations of the patients, elbow flexion / extension and varus / valgus angle were measured using a goniometer by a physiotherapist who was double blind of the study design. The MEPS form was completed to evaluate elbow function [11]. The MEPS is based on an observer-derived assessment of a variety of clinical criteria (pain, motion, stability and function), which are scored in four subscales separately and then aggregated. The total MEPS score ranges from 5 to 100 points and is considered excellent when the total score is between 90 and 100 points, good between 75 and 89 points, fair between 60 and 74 points and poor below 60 points.

Statistical analysis

Data were analyzed using SPSS for Windows version 23.0 software (SPSS Inc., Chicago, IL, USA). Median with range was used to describe continuous data, whereas absolute count with percentage was used for categorical data. Univariate analysis was performed for demographic and clinical characteristics of patients to predict our two primary outcomes. Student's t-test, the chi-square test and Fisher's exact test were used as appropriate for individual variables. $P<0.05$ was considered statistically significant.

Results

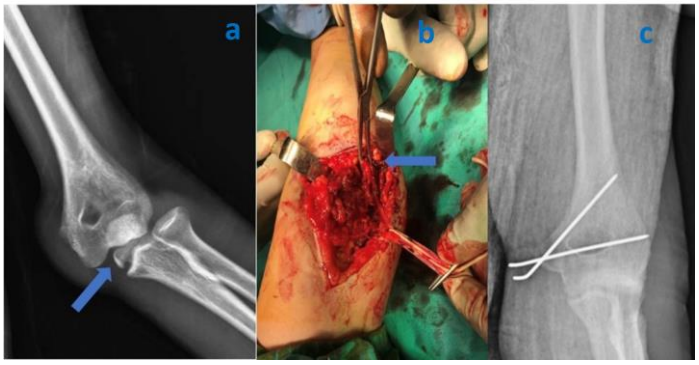
Among 57 patients included in the study, 46 (81%) were male and 11 (19%) were female. The average age was 11.1 (3-15) years, and 42 patients were aged ≥10 years. Dislocation in left and right extremity was seen in 31 (54%) and 26 patients (46%), respectively. The mean follow-up period was 27.2 (12-51) months.

According to the injury mechanism, 46 were because of simple falls. There were four falls from height, four sports injuries and three traffic accidents. All patients in this study had posterior / posterolateral dislocation. As an additional orthopedic injury, distal radius fracture (opposite extremity) was detected in two patients, femur diaphysis fracture in one patient and tibial diaphysis fracture in one patient.

Twenty-seven patients (47%) had only a simple dislocation without an additional fracture (Figure 1), while other 30 patients had an additional fracture. 19 patients with a concomitant fracture were operated.

Figure 1: Simple posterior elbow dislocation

Figure 2: a. Preoperative X-ray of the incarcerated medial epicondyle. b. Intraoperative view of the incarcerated medial epicondyle after reduction. c. Postoperative X-ray of the incarcerated medial epicondyle.



As an early complication in the follow-up of the fracture-dislocation group, the pulse could not be palpated before reduction in two patients (dislocated medial epicondyle fracture), but circulation was improved after reduction. Three patients (posterolateral dislocation / medial epicondyle fracture) developed ulnar neuropraxia that recovered in 4–6 weeks without sequelae. Early complications were not detected in the simple dislocation group.

In five patients, fibrous nonunion was detected in the medial epicondyle, but there were no functional complaints. Medial epicondyle nonunion was observed in four conservatively followed patients and one patient underwent surgery.

Avascular necrosis developed in the radius head in two patients who underwent open surgery for radial neck fractures. No additional treatment was performed in these two patients, and the pronation loss was measured as 25º (range: 20º–30º). These patients were functionally good, although they were evaluated radiologically as having complications.

Six (four fracture-dislocations and two simple dislocations) patients had valgus deformity in the follow-up examinations. In these patients whose elbows had cubitus valgus deformities compared to the opposite elbow, the mean valgus angle was 7.8° (5°–10°) in the four fracture-dislocation patients and 7.5° (5°–10°) in the two simple dislocation patients

The MEPS score was fair or poor in three patients. The first patient, whose medial condyle fracture was planned to be followed up conservatively, ignored the routine follow-up procedures, and developed varus deformity (17.7º) with nonunion in the last follow-up. In the second patient operated due to dislocation / olecranon fracture, calcification was detected in the triceps muscle and cubitus varus deformity (22º) was identified, but no additional treatment was performed. The third patient, who was in the simple dislocation group, had more than 10 recurrent dislocations, and although surgery was recommended, the patient continued with physical therapy in another hospital.

The functional results of simple dislocations and fracture-dislocations were significantly different ($P<0.05$) (Table 2).

Table 2: Comparison of simple and fracture-dislocation

	Simple Dislocation	Fracture Dislocation	*P*-value
Age (year)	10.8(3.1)	11.3(2.9)	0.555
Follow-up (month)	37.8(8.5)	27.2(10.1)	0.001
Immobilization (week)	2(0)	3.76(0.5)	0.001
MAYO	95.1(10.6)	90(11.8)	0.046
Excellent	22	20	
Good	4	8	
Fair	0	1	
Poor	1	1	
ROM	138.7(2.9)	132.6(13.5)	0.023
Extension Loss	0.5(1.6)	4.6(10.4)	0.04

Discussion

Pediatric elbow dislocations are generally seen in the second decade of life. In a study by Murphy, the average age was reported to be 11 years old [7]. Most pediatric injuries are more common in males [12]. In the present study, the mean age was 11.1 years old, and the proportion of male was significantly higher than female. In the literature, it has been reported that 95% of the dislocations are posterior dislocations, of which 70% are the posterolateral type [5]. In the present study, all patients had posterior dislocations, and 40 (70.2%) were the posterolateral type. These results are consistent with the literature.

Elbow dislocations can be in the form of simple dislocations without a fracture, but they may also be seen with additional fractures. It has been reported that there are concomitant fractures with posterior elbow dislocations in more

than 50% of cases [13]. In the present study, additional fractures were seen in 53% of the patients. In the literature, the most common fracture concomitant with elbow dislocation has been reported to be the medial epicondyle at a rate of 60% [4, 6, 13]. Treatment of medial epicondyle fractures remains a matter of debate. Fracture with displacement <8 mm usually heals conservatively with plaster cast treatment [14]. According to Lieber, even minimally displaced fractures should be treated surgically to ensure the integrity, to prevent the elbow instability and to reduce the occurrence of valgus deformity [4]. In the present study, 20 medial epicondyle fractures were detected. While the partially healed fractures after elbow reduction were treated conservatively, seven patients were treated surgically. The current standard treatment for patients with more than 5 mm of displacement and positive valgus stress test is surgery [15]. In our department, medial epicondyle fractures with a displacement of more than 8 mm and a positive valgus stress test are routinely operated. Therefore, we may have encountered non-union in our four conservatively treated patients.

Incarceration of the intra-articular medial epicondyle is seen in 5–18% of medial epicondyle fractures and may cause irreducible dislocations [16]. In the present study, five of the 20 medial epicondyle fractures were of the incarcerated medial epicondyle type. Patrick stated that the ulnar nerve could be damaged with repetitive manipulations, and therefore fragments could not be removed by manipulation, so surgical removal was recommended [17]. In the present study, reduction was achieved after manipulation in one of the five incarcerated cases, while the other four patients were treated surgically and fixed without attempting a second reduction (Figure 2).

Fractures of the lateral condyle are the second most commonly associated injury following posterolateral elbow dislocation according to Lieber's series [4] and others [13], but some authors describe this injury as very rare [18, 19]. All displaced intra-articular fractures, such as fractures of the lateral condyle, with a gap of more than 2 mm of the articular surface require accurate reconstruction to prevent lack of extension as well as growth disturbances [6, 20]. Similarly, screw fixation allows early mobilization and also yields high fragment compression compared with K-wire fixation. In our department, these operations are performed with K-wires. Screws are not preferred because a second operation would be required to remove the screw.

Radial head and neck fractures may be seen with elbow dislocations. Although closed reduction and pinning are recommended in pediatric radius neck fractures, open reduction and pinning can be performed in cases that cannot be reduced as closed. Concomitant radius neck fractures cause proximal radioulnar synostosis or radial neck pseudoarthrosis, both of which severely limit elbow movements [1, 21]. Major risk factors are open reduction maneuver, severe trauma, subtotal periosteal disruption and complete dislocation of the radius head [22]. In the study by Lieber [4], three of the four cases were fixed using closed reduction with a K-wire, and one patient was operated on with open reduction. Pseudoarthrosis developed in one patient during follow-up, which was attributed to total dislocation, open surgery, inadequate reduction and early removal of the implant. In the present study, four radius neck fractures accompanied the dislocation. One of the patients was treated with closed reduction and K-wires, fixation was obtained with ORIF + K-wires in two patients, and one patient was followed up conservatively. Despite the union in the two patients who underwent open surgery, they developed avascular necrosis in the radius head. Although these two patients had pronation loss, they did not describe any problems in daily life.

Olecranon fractures usually occur in anterior dislocations in the form of avulsions. In a study by Rasool [5], five olecranon fractures were reported. In the current study, two patients had olecranon fractures, and surgical treatment was performed with the tension band method. In one patient in the current study who was operated on for an olecranon fracture, cubitus varus deformity developed with calcification in the triceps.

Medial condyle fractures occur as a result of high-energy trauma and therefore can be observed with other injuries around the elbow, especially elbow dislocation and radial head dislocation [2, 3]. Nonunions, particularly when left untreated, have been reported by different authors in 7.4–33.3% of patients [4, 5, 12]. The medial condyle fracture in the present study was followed conservatively due to the displacement being <2 mm, but nonunion and cubitus varus deformity developed due to the fact that the patient did not come to the outpatient clinic regularly and the plaster treatment was terminated by his family.

In a study by Sofu et al. [23] in which 12 patients with simple elbow dislocations were evaluated, ROM was 119.5 ± 17.8, and the mean MEPS value was 91.6. In the present study, patients with simple dislocation had higher ROM (138.7 ± 2.9) and MEPS values (95.1 ± 10).

Recurrent dislocation is rare in children and is caused by the capsule and ligament structures not healing sufficiently after traumatic dislocation [24, 25]. Only two recurrent dislocations have been reported as case reports [26, 27]. In recurrent dislocations in adults, hinged fixators are applied after soft tissue relaxation, but the results are unknown [28]. In one patient in the present study with no additional fracture, reduction was performed due to recurrent dislocation. This recurrent dislocation was thought to be due to ligamentous instability, and although surgical treatment was recommended, it was refused, and the patient continued treatment with physical therapy at another centre.

Early complications in dislocations are neural and vascular problems [5]. Vascular injuries are rare [29]. Vascular injuries can be intimal damage, thrombosis or direct injuries [24]. Rasool et al. reported that one brachial artery injury occurred, and vascular repair was performed [5]. In the present study, in two patients in the fracture-dislocation group, the pulse could not be palpated before reduction, but circulation returned to normal after reduction. Nerve injury is rare after elbow dislocations, although ulnar nerve injury is often seen in medial epicondyle fractures with dislocations [30]. There were three cases of ulnar nerve paraesthesia in the present study in the fracture-dislocation group, all of which fully recovered within four to six weeks.

Loss of elbow range of motion is the most commonly reported complication in elbow dislocations. Extension defects in particular are the most prominent sequelae of elbow dislocations.

In a series of pediatric elbow dislocations, Di Gennaro reported that 37% of the study group had extension loss [31]. In the follow-up of patients with pediatric elbow dislocations, Murphy found the mean flexion to be 126° ± 14°, and the average terminal extension loss was 5° ± 7°. No significant correlation was determined between age, gender, mechanism of injury, presence of a related fracture, type of fracture, need for open reduction and measurement of flexion or extension [7]. In the present study, there was no loss of extension in the simple dislocation patients, but there was 4.5° ± 12° loss of extension in the fracture-dislocation patients. There was a significant difference according to ROM between simple dislocations and fracture-dislocations, which is consistent with the findings in the literature.

For patients who developed valgus deformity of the elbow, like all other patients, the mechanism of trauma was falling on an open hand and valgus strain. Elbow valgus deformity was determined in an average of one year of follow-up. Cubitus valgus is the most frequently observed complication after elbow dislocation. It is more often seen in dislocations associated with other injuries and leads to growth disturbance around the elbow [32]. Since there is a natural valgus angle present in the elbow, cubitus valgus deformity can be cosmetically tolerated. Most cubitus valgus deformities are not clinically problematic. However, the increase in elbow carrying angle seems to be an independent factor of ulnar neuropathy that develops in the absence of trauma [33]. Our patients who developed valgus deformity had no complaints other than cosmetic appearance.

Different rates of functional results after elbow dislocations have been published. Murphy et al. [7] reported outcomes according to the MEPS as 72% excellent, 18% good, 9% moderate and only one patient with poor results. Lieber et al. [4] reported 100% excellent / good results in simple dislocations and 96% excellent / good results in fracture-dislocations. Rasool et al. [5] found 67% excellent / good and 30% moderate / poor results. In the present study, when the patients were evaluated radiologically, the complication rates seemed to be high, but since these complications did not cause functional limitations, the MEPS values were found to be high. The comparison of the current study with similar studies in the literature is given in table 3.

The limitations of the present study are its retrospective design, follow-up of some of the patients was less than two years, and there was incomplete evaluation of chondral and ligamentous injuries or coronoid avulsions since magnetic resonance imaging was not performed. The strength of the study is having more patients compared to similar studies. In addition, prospective studies to be performed on more patients are needed to reach more definite conclusions.

Table 3: Elbow fracture dislocations in children, literature review

	n	Associated fractures	n	Complications	n	Results% (excellent and good)
Murphy[7]	145	Medial epicondyle	80	A symptomatic heterotopic ossification	2	
		Lateral condyle	17	Ulnar neuritis	2	
		Olecranon	3	Subjective instability	1	90%
		Radial head/neck	12	Fracture nonunion fixation	3	
		Other upper extremity fracture	16	Instability reconstruction	4	
				Neural decompression	2	
				Infection	2	
				Compartment syndrome	1	
				Contracture release	3	
				Osteochondritis dissecans lesion	1	
Lieber [4]	56	Medial epicondyle	10	Ulnar nerve	3	48%
		Lateral condyle	5	Median nerve	1	
		Lateral epicondyle	1	Brachial artery injury	1	
		Radial neck	4	Cubitus recurvatum	2	
		Transcondylar fracture	1			
		Processus coronoideus	2			
		Collateral ligament (isolated)	3			
		Collateral ligament (and fracture)	7			
Carlioz [13]	58	Medial epicondyle	24	Pulse deficit	4	90%
		Olecranon	1	Ulnar nerve	2	
		Lateral flakes of bone	5	Osteochondral flap (ulna)	2	
		Coronoid	2	Radioulnar synostosis	2	
		Combined	2			
Present study	57	Medial epicondyle	20	Pulse deficit	2	94%
		Radius neck	3	Ulnar nerve	3	
		Olecranon	2	Medial epicondyle nonunion	5	
		Medial condyle	1	Heterotrophic ossification	1	
		Lateral condyle	4	Recurrent dislocation	1	
				Radius head avn	2	
				Medial condyle malunion	1	

Conclusion

Elbow dislocations are rare injuries. A dislocation of the elbow in a child may be associated with an unrecognized additional fracture. There should be a high index of suspicion, with good clinical examination and meticulous assessment of the radiographs and systematic examination of the medial (medial epicondyle, olecranon, coronoid, medial condyle) and lateral compartments (radial head, lateral condyle) for associated fractures or avulsions. Simple dislocations are easier to manage and functional results are better, whereas treatment is more complicated and complications may develop in patients with concomitant fractures. Elbow dislocations in children can be treated with good results if they are accurately diagnosed and when concentric stable reduction of the elbow as well as stable osteosynthesis of displaced fractures can be achieved. In addition, families should be informed about possible complications, and it should not be forgotten that patients may require effective physical therapy during follow-up.

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