

Epidemiologic features and management of elbow dislocation with associated fracture in pediatric population

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Abstract

This study was conducted to explore epidemiologic features of traumatic elbow dislocation with associated fractures in pediatric population following appropriate treatment options.

Incidence of elbow dislocation with associated fractures was analyzed in 67 children using elbow radiographs. Treatment for the displaced elbow joint was performed by closed reduction and proper immobilization. Surgical intervention was applied to restore the correct alignment of the fracture. Mayo Elbow Performance Score (MEPS) was used to measure elbow joint function.

Incidence of pure dislocation was observed in 7 of 67 children (10.45%). Elbow dislocation was typically accompanied by a single or multiple fractures in 39 (58.21%) and 21 (31.34%) of 67 children, respectively. In contrast, lateral humeral condyle fracture and medial humeral epicondyle fracture accounted for 35.90% and 30.77% of pediatric elbow fractures. All children with elbow fracture-dislocations received surgical intervention by open reduction and internal fixation. During follow-up, 56% to 92% of children displayed significant recovery of elbow function with improving MEPS after the displaced elbow and fractured fragments were reduced and held in place for weeks. There were statistical differences in MEPS between the types of fractures ($P < .05$ or $P < .01$).

Incidence of isolated elbow dislocation without fracture is low; rather, it is frequently associated with fractures. Early surgical intervention achieves stable fixation and bony union with utility in improving elbow function in the pediatric population.

Abbreviations: MEPS = Mayo Elbow Performance Score, SPSS = Statistical Package for the Social Science.

Keywords: children, elbow dislocation, epidemiological analysis and MEPS, fracture

1. Introduction

Traumatic elbow dislocation with associated fractures in pediatric population represents approximately 10% to 12% of all pediatric fractures.^[1,2] Though fracture of any extremity is rarely life-threatening, the unique anatomy and the intimate location of neurovascular structures in elbow often result in a spectrum of injuries with associated complications.^[3,4]

Treatment of elbow injuries remains challenging in part because accurate definitions of the patterns of injury, the specific roles of the component structures contributing to stability of the

elbow, and a rational approach to treatment have not been fully determined. Unlike fractures of the clavicle or proximal humerus, pediatric elbow fractures are more likely to require precise, often surgical reduction since elbow fractures heal fairly quickly in children and it is harder to achieve good long-term results if the fracture fails to unite in proper position.^[5,6] Therefore, it is extremely important that pediatric elbow injuries should be diagnosed and treated correctly at the time of the initial injury to optimize treatment outcomes.

The purpose of this study was to explore epidemiologic features of elbow dislocation with associated fractures in the pediatric age group. Our data indicate that incidence of simple elbow dislocation in children is rather low and most dislocations are typically associated with fractures in the study cohort. Early surgical intervention benefits to achieve the good results of the elbow function.

2. Patients and methods

2.1. Pediatric population and inclusion criteria

Between January 2005 and December 2015, 67 children from 5 to 14 years old (mean age 9.5 years) were managed with either closed or open reduction of acute traumatic dislocation of the elbow joint according to the presence of bone fracture. The study group included 10 females and 57 males at the time of the evaluation. The left elbow was involved in 30 cases and the right in 37. This study was approved by the Ethical Committee of Beijing Jishuitan Hospital in January of 2017 (Approval number, JLK201701-08). The parents of all children signed written informed consent forms for this study.

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XML collected data and prepared the manuscript. GSY analyzed data and prepared the paper. ML interpreted patient data. YG revised the manuscript. All authors read and approved the final manuscript.

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Major inclusion criteria were as follows: all children having restricted and painful elbow range of motion; age <14 years; no systemic diseases associated with elbow injuries; no history of operations involving the elbow and juvenile idiopathic arthritis; all children available for evaluation of elbow function with a mean duration of 5-year follow-up after surgical treatment; and parents of the children signed written informed consent forms for collection of clinical data.

2.2. Imaging of elbow dislocation and fracture

Small elbow fractures associated with dislocations can be missed on radiographs so the images must be carefully reviewed. The diagnosis of any associated fracture fragments is important in deciding the appropriate management of the injury. In this study, the minimal radiographic series included anteroposterior and lateral images, while an oblique radial head-capitellum view can help detect subtle fractures by removing osseous overlap of the radial head and coronoid. Anteroposterior and lateral radiographs of an elbow joint were routinely taken since supracondylar, lateral condylar, and medial epicondylar fractures are most common in pediatric elbow trauma.^[7] Optimal elbow radiographic technique required the children to tolerate full extension of the traumatized elbow for the frontal projection and 90° of flexion for the lateral and oblique views. Splints and other materials included on the radiograph may also adversely affect the image quality. On plain radiographs, the oblique view provided visualization of the radial head and coronoid process, and the anteroposterior view may demonstrate an avulsion fracture of the lateral or medial condyle. These images also provided views for observing the positions of the screw or pin to secure internal fixation of fracture. Additionally, neurovascular status required to be determined in pediatric elbow trauma because the brachial artery and ulnar and median nerves may be entrapped.

2.3. Treatment approach of elbow dislocation and fracture

Typically simple elbow dislocations without fractures healed after closed reduction following by about 2 weeks of immobilization in a splint according to the severity of ligament injuries. Briefly, a child was given an anesthetic medication to reduce or stop the pain sensation of the dislocated elbow joint. The doctor manipulated the elbow back in place by pulling down on the child's wrist and levering his/her elbow back into place. After that, x-rays were done to make sure the child's elbow stayed in place and then the elbow joint was appropriately immobilized in a splint that may keep the elbow bent usually for about 2 weeks.

For children with fracture dislocation, surgical intervention was executed by open reduction and internal fixation with a screw and pins. Intraoperative fluoroscopy was used. Elbow stability was tested by varus and valgus stress under fluoroscopy. A cast was then applied over the screw and pins and remained in place for about 4 weeks of immobilization after a test for elbow stability was satisfactory. Fracture healing was observed on elbow radiographs about 3 months after surgery.

Symptoms of median nerve compression were treated by surgical decompression. Briefly, anesthesia was slowly infiltrated from the medial elbow crease and obliquely 4cm distally and centrally to cover the course of the lacertus fibrosus. A 3-cm vertical incision was placed in the flexion crease of the cubital fossa. Careful dissection was made subcutaneously to the pronator teres fascia, taking great care to identify and protect

branches of the medial antebrachial cutaneous nerve after any hematoma was removed from the fracture site. The pronator teres fascia was incised and followed laterally, allowing exposure of the lacertus fibrosus, which was subsequently divided. By retracting the pronator teres muscle medially, the median nerve was readily exposed. The tissues around the elbow including lacertus fibrosus, 2 heads of pronator teres, and the fibrous arch of the flexor digitorum superficialis were divided, which decreased pressure on the nerve.

2.4. Evaluation of Mayo Elbow Performance Score

The Mayo Elbow Performance Score (MEPS) is an instrument used to test the limitations to use the elbow during the activities of daily living caused by the pathology.^[8] MEPS were assessed after an average follow-up interval of 5.3 years (1.2–10.1 years) at the time of surgery. Elbow-scoring systems are based on the observer-derived assessment of a variety of clinical criteria (pain, motion, stability, and function), which are scored into 4 subscales separately and then aggregated. The aggregate score then is assigned a categorical ranking that ranges from excellent to poor.^[9] In this study of 67 children with traumatic dislocation of elbow, MEPS is rated on a 100 point-scale according to the limitations to use the injured elbow.

2.5. Statistical analyses

Values on MEPS were expressed as a percentage for population proportion in the investigated cohort. Statistical analysis was performed using Statistical Package for the Social Science (SPSS, version 13.0). The chi-square test (χ^2) was conducted to analyze and compare the significance of MEPS between the 2 groups. A *P* value of <.05 was considered significant.

3. Results

3.1. Epidemiologic analysis of elbow dislocation in children (n=67)

Incidence for each type of single fracture was calculated as a percentage of the investigated cohort, respectively. The results are shown in Figure 1. The data indicated that incidence of pure elbow dislocation was observed in 7 of 67 children (10.45%) (Fig. 1A and Table 1). Elbow dislocation was associated with a single fracture in 39 of 67 children (58.21%) and multiple fractures in 21 of 67 cases (31.34%), respectively. The distribution of single fractures is shown in Figure 1B and Table 2. Over 70% of the single fracture occurred in the lower part of the humerus in the children with elbow dislocation.

3.2. Identification and management of lateral humeral condyle fractures

Radiographic examination of elbow dislocation was routinely executed and the results are shown in Figure 2. The images displayed lateral dislocation of the right elbow and displacement of a lateral humeral condyle due to an avulsion fracture (Fig. 2A). Anatomic reduction and K-wire stabilization was executed. To avoid the posterior vascular pedicle to the fracture fragment, the anterolateral approach was selected. Double pin fixation was performed for healing (Fig. 2B). A cast was then applied over the pins, and the cast and pins remained in place for about 4 weeks. Treatment with these techniques resulted in return of elbow

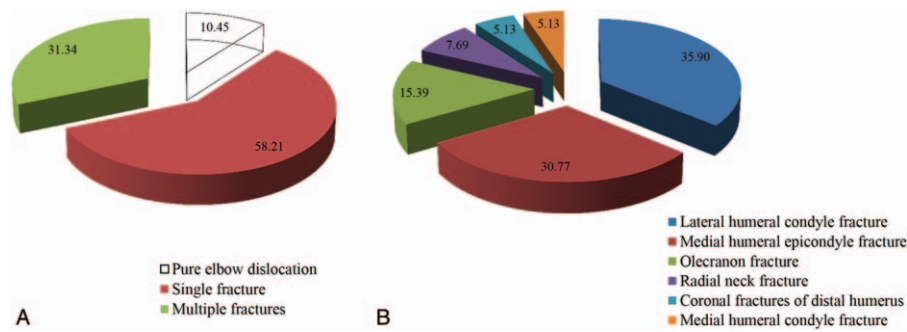


Figure 1. Epidemiologic analysis of bone fractures associated with elbow dislocation. Demographic data of children (n=67) with elbow fracture dislocation: Population proportion for elbow injuries was examined in the study cohort (A). Incidence for each type of single fracture (B) was expressed with a percentage of population proportion in the investigated cohorts, respectively.

function and near normal range of motion after the cast was removed and the pins were removed after consolidation of the fracture was visible on x-ray images.

3.3. Identification and management of medial humeral epicondyle fracture

The images display posterior and lateral dislocation of the right elbow with a small avulsion fracture of medial humeral epicondyle (Fig. 3A). The avulsed epicondylar fragment was entrapped in the elbow joint (Fig. 3B). Screw fixation was performed (Fig. 3C). A satisfactory result was achieved with recovery of elbow function.

3.4. Medial humeral condyle fracture with compression of median nerve and olecranon fracture

The results regarding the fracture and compression of median nerve are shown in Figure 4. The images displayed posterior dislocation of the right elbow with medial humeral condyle avulsion fracture (Fig. 4A). Compression of median nerve in the injured elbow was diagnosed due to lack of movement and sensation in the median nerve distribution. Surgical decompression of the nerve was immediately executed to release the compression by the fracture end (Fig. 4B). Surgical treatment included exploration of median nerve in the proximal forearm, an incision (2–3cm) of the antecubital fossa in a vertical fashion across the joint, and the release of the nerve. Fixation of the medial epicondyle fragment was performed with double pins (Fig. 4C).

In terms of olecranon fracture, pediatric elbow dislocation with associated olecranon fractures required surgical intervention and internal fixation with removable pins. The displaced fracture was reduced through a standard open approach and 2 percutaneously placed pins were applied to stabilize displaced transverse and oblique olecranon fractures. The elbows were immobilized in a plaster cast at 90° postoperatively for about 4 weeks. Successful

fracture healing was observed by regular trabecula crossing the fracture site and absence of sclerotic borders on the standard radiographs.

3.5. Assessment of Mayo Elbow Performance Score

MEPS for fracture-induced elbow dysfunction were evaluated with a follow-up interval of 5 years and the results are shown in Figure 5 and Table 3. The data regarding major events of the elbow fractures were expressed with a percentage of the fractured children (Fig. 5A), multiple fractures (Fig. 5B), humeral lateral condyle fracture (Fig. 5C) and medial epicondyle fracture (Fig. 5D), respectively. MEPS from fair to excellent calculation were shown in 90.48% to 93.9% of children with the elbow injuries, whereas the score was poor only in 6.0% to 9.5% of the children after surgical treatment in this pediatric cohort. However, population proportion of excellent MEPS was lower than the proportions of either good or fair MEPS in multiple elbow fractures. There were statistical differences in distributions for children with dislocated fractures between the fair to excellent scores and the poor score ($P < .05$ or $P < .01$).

4. Discussion

In epidemiological analysis of 67 children with traumatic elbow dislocation, population proportion for pure elbow dislocation occurred in 7 of 67 children (10.45%), indicating that incidence of simple dislocation was low in this retrospective study. The low incidence of simple dislocation was probably related to the initial on-site management of elbow dislocation since some of the elbow injuries happened in sporting events.^[10,11] Conversely, an associated fracture was typically encountered with a high incidence rate (single fracture [58.21%]; multiple fractures [31.24%]) in the pediatric age group. In terms of treatment,

Table 1
Overview of pediatric elbow trauma.

Type of injury	Number (%)
Elbow dislocation	7 (10.4)
Single fracture	39 (58.2)
Multiple fractures	21 (31.3)

Table 2
Population proportion of children with single fracture.

Fracture location	Number (%)
Lateral humeral condyle fracture	14 (35.9)
Medial humeral epicondyle fracture	12 (30.8)
Olecranon fracture	6 (15.4)
Radial neck fracture	3 (7.7)
Coronal fractures of distal humerus	2 (5.1)
Medial humeral condyle fracture	2 (5.1)

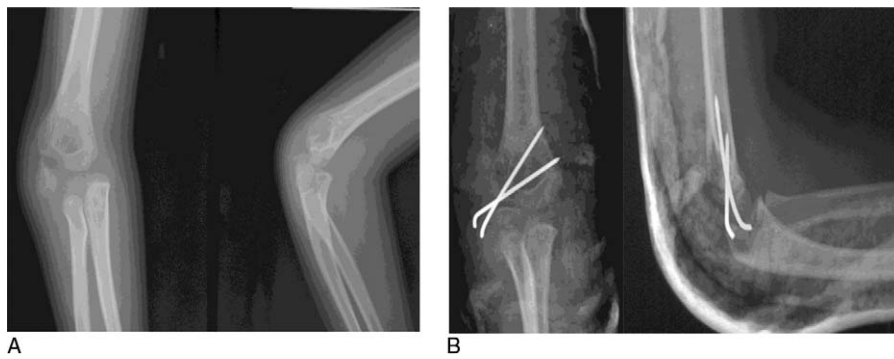


Figure 2. Images and treatment of humeral lateral condyle fracture. The images displayed lateral dislocation of the right elbow. A lateral humeral epicondyle avulsion fracture is visible (A). Double pin fixation was used to stabilize the fracture (B).

simple dislocation was just treated by closed reduction. Duration of immobilization may approximately reach 2 weeks based on the consideration that immobilization of the affected elbow for longer than 3 weeks in patients following an elbow dislocation has been associated with loss of range of motion.^[12] All children with fractures underwent surgical procedures by open reduction and internal fixation to reduce the displaced fragment and stabilize the fracture with a screw or pins, followed by cast immobilization for about 4 weeks since pediatric elbow fractures typically required a longer period of time to immobilize the elbow.^[13,14] Based on the results of epidemiological analysis and management of the fractured elbows, it is reasonable to emphasize the complexity of pediatric elbow injuries and the necessity of surgical intervention at the initial evaluation of the

dislocated elbow since incorrect diagnosis and delayed treatment would lead to instability or poor functional outcomes.^[3,15,16]

Our data showed that about one-third of children presented lateral condylar elbow fractures in the dislocated elbows and radiographic findings manifested the presence of a posteriorly displaced fragment in the elbows, indicating a high incidence rate of the fracture in the pediatric age group. Dislocated elbow joint was managed by open reduction and 2 pins were placed to keep the fractured fragment in place after the broken bone was aligned properly under direct visualization. A cast was applied over the pins, and the cast and pins remained in place for 4 weeks. A good outcome was achieved with return of elbow function. Though the treatment options depend on the extent of primary displacement and stability of the fracture,^[17] it was worth to mention that early



Figure 3. Images and treatment of medial humeral epicondyle fracture. The images displayed posterior and lateral dislocation of the right elbow. A medial epicondyle avulsion fracture is visible (A). The epicondylar fragment is entrapped in the elbow joint after manual reduction (B). Screw fixation was performed (C).

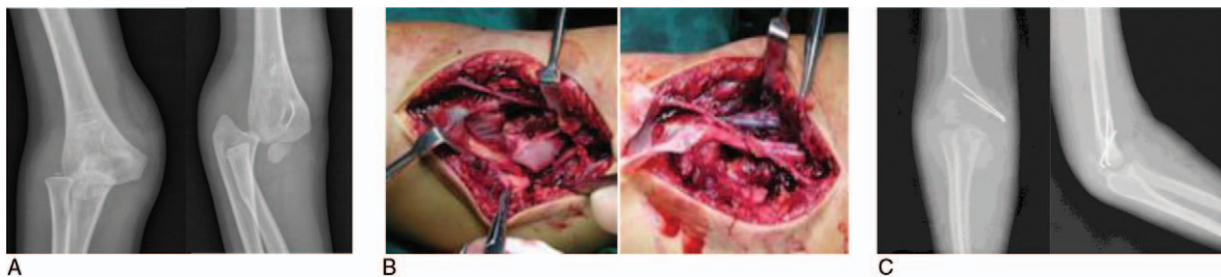


Figure 4. Images and treatment of medial humeral condyle fracture with compression of median nerve. Medial humeral condyle fracture occurred in the right elbow (A). Compression of median nerve in the elbow was caused due to the fractured fragment and surgical decompression of the nerve was executed (B). Rigid internal fixation was performed with double pins (C).

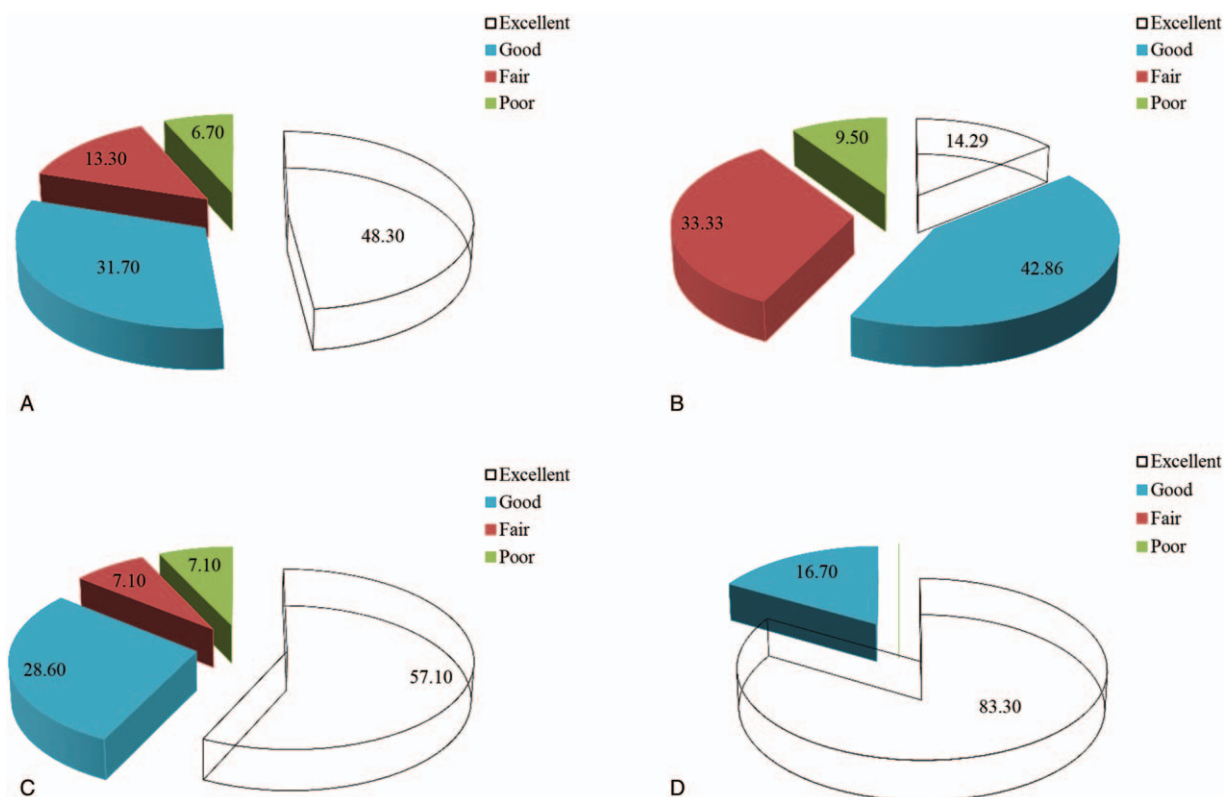


Figure 5. Evaluation of Mayo Elbow Performance Score (MEPS). MEPS was observed after an average time of 5-y follow up. The demographic data are expressed with a percentage of children with bone fracture (A), bone fracture at 2 or more regions (B), lateral humeral condyle fracture (C), and medial humeral epicondyle fracture (D), respectively. We noted significant statistical differences between the group of children with fair to excellent MEPS scores and the group with poor MEPS score.

and proper surgical treatment would benefit to avoid elbow deformity and functional impairment since the fracture was unstable and tended to become displaced due to pull of forearm extensors even when immobilized.^[18] Restricted range of motion is common after open reduction and fixation in children with elbow fractures.^[19] It has been reported that an initial rapid recovery in elbow motion can be expected after a lateral humeral condylar fracture in a child, with progressive improvements for up to 1 year after the injury. This recovery is slower if the patient is older, has a longer healing time, and has a more severe injury.^[20]

Medial epicondyle fractures accounted for 30.77% of elbow fractures. These injuries frequently occurred due to a fall on the outstretched hand and a valgus force combined with contraction of the forearm flexors.^[21,22] Since the fracture may be displaced significantly with the fragment trapped in the elbow joint,^[23,24] open reduction and screw fixation were required followed by a cast for about 4 weeks. Open reduction of elbow dislocation and

internal fixation of the fracture resulted in improved elbow function. Medial epicondyle avulsion fractures are common in older children, typically arising from sport incidents.^[25] Though the medial epicondyle fracture is extra-articular and contributes little to the longitudinal growth of the humerus, incarceration of the medial epicondyle fragment following pediatric elbow dislocation leads to the risk of growth disturbance, articular incongruence, and disability.^[26,27] In addition, the ulnar nerve enters the forearm as it passes behind the medial condyle. Fractures in this region place the ulnar nerve at considerable risk for injury.^[28] To establish the correct diagnosis of this fracture in young children can be challenging to identify on elbow radiographs since it occurs through a cartilage plane between the developing ossification center in the epicondyle and the main part of the humerus.^[29]

In the cohort of children who sustained fractures, there were only 2 children (5.13%) diagnosed with medial humeral condyle fracture, indicating that the fracture was much less common than

Table 3
Evaluation of Mayo Elbow Performance Score.

	Number (%)				N
	Excellent	Good	Fair	Poor	
Elbow fractures	29 (48.3)	19 (31.7)	8 (13.3)	4 (6.7)	60
Multiple fractures	3 (14.3)	9 (42.9)	7 (33.3)	2 (9.5)	21
Lateral humeral condyle fracture	8(57.1)	4 (28.6)	1 (7.1)	1 (7.1)	14
Medial humeral epicondyle fracture	10 (83.3)	2 (16.7)	—	—	12

medial epicondyle fractures. Nevertheless, one child presented with signs of median nerve compression. Surgical intervention for decompression of the nerve was executed with anatomic reduction of the dislocated elbow and internal fixation using double pins. The child achieved satisfactory results of the range of elbow motion after adequate immobilization of the fracture. Median nerve compression following a pediatric elbow injury is rare and misdiagnosis can result in permanent disability.^[30] A clinical diagnosis is based on weakness, pain over point of compression, and positive scratch collapse test.^[31] Despite the unique nature of the patient's symptoms, some patients have an excellent prognosis with conservative management.^[30] It has been reported that the nerve injury found exclusively in the skeletally immature, especially in elbow fracture dislocation, should be an indication for surgical exploration and release of the entrapped nerve.^[32] Although it was difficult to draw a conclusion from 1 case only, we believed that a correct diagnosis and early surgical intervention of elbow trauma were important to obtain a good result in treating the complication. Surgical treatment of median nerve compression has traditionally been associated with a large S-shaped incision to release all potential sites of compression. Our technique allows the opportunity to treat the child with a relatively minor surgical procedure.

Our data also showed that incidence of olecranon fractures accompanying elbow dislocations is low. Appropriate treatment of fractures depends mainly on the anatomic site of the fracture, fracture displacement, and fracture stability.^[33] Though open reduction and internal fixation led to satisfactory results in children with displaced olecranon fractures, it is necessary to point out that the ulnar nerve is closely related to the medial aspect of the olecranon, and therefore, prone to injury.^[34]

MEPS of pediatric elbow injuries were evaluated with an average follow-up of 5 years based on the fact that MEPS is an effective instrument to test the range of motion of the elbow.^[35,36] Clinical outcomes from fair to excellent scores were observed in 90.48% to 93.9% of children with fractures, whereas the score was poor only in 6.0% to 9.5% of the children after surgical treatment. However, we want to highlight the fact that we undertook a retrospective survey and a control group managed by nonoperative treatment is missing. The majority of children with fracture dislocation achieved satisfactory outcomes at the time of follow-up. In further analysis, population proportion with excellent MEPS was lower in the multiple fracture group when compared to other groups with either excellent or good MEPS, not only suggesting the severity of the injuries but also indicating the importance of early recognition of the fractures with timely and correct treatment in preventing delayed and incomplete recovery of elbow function. Elbow fracture dislocations are often accompanied by injury to shoulder or wrist joints.^[37]

Limitations of our study were as follows. First, this is a retrospective study with selective hospital cases, so a selection bias is probably influencing our results. Second, though orthopedic pins can be used for fixing many different fracture patterns, they are inadequate in terms of being non-rigid, pin loosening, pin tract infections, tendon impalement, and possible neurovascular injury. Despite these limitations, the study has significance concerning treatment options for pediatric elbow injuries.

In conclusion, incidence of elbow dislocation without fracture is low in children who sustained an elbow dislocation. According to a good outcome of MEPS, early surgical intervention in

unstable elbow fracture dislocations resulted in bony union and good elbow function in the majority of children treated.

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