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Original Study Article

Elbow fracture sequelae in children

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ABSTRACT

BACKGROUND: Fractures of elbow joint bones are the most common type of fracture in children. Despite methodological advances in managing these injuries, adverse anatomic and functional outcomes are still common in clinical practice.

AIM: The aim was to evaluate the structure of primary injuries and primary treatment strategies to evaluate the sequelae of elbow bone fractures in children.

MATERIALS AND METHODS: Based on inclusion criteria, a retrospective cohort (n = 115) was formed. Clinical, historical and radiological data were evaluated in patients with sequelae of elbow fracture, admitted for surgical treatment in the clinic of the H. Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery of Russia in 2022–2023. The Shapiro–Wilk test (for less than 50 subjects) or the Kolmogorov–Smirnov test (for more than 50 subjects) were used to test the normality of quantitative parameters. The Pearson's chi-squared test was used to compare percentages in the contingency table analysis.

RESULTS: The mean age of patients in the study population was 11 years (ranging from 4 to 17 years). The duration of injury is 15.6 ± 1.0 months (min = 3; max = 65). Based on the structure of the sequelae, three groups were identified: patients with contracture (42 cases; 36.5%), patients with deformity (31 cases; 27%), and patients with both contracture and deformity (42 cases; 36.5%). Supracondylar fractures of the humerus (40%) and apophyseal fracture of the medial epicondyle (31%) were the most common primary injuries. Primary conservative treatment of the fracture was performed in 82 (71%) patients, primary surgery was performed in 33 (29%) children, and 17 patients were switched from conservative to surgical treatment. A total of 31 (27%) children had repeated procedures.

CONCLUSIONS: Contractures are the most common adverse outcome of elbow fractures in children. Characteristics of conservative treatment and repeated procedures indicate a need for better training of pediatric trauma surgeons. Even today, despite the development of advanced algorithms, the main causes of adverse outcomes are still errors in diagnosis, care strategies, and intervention techniques.

Keywords: fractures; elbow joint; supracondylar fracture; epiphysiolysis; osteosynthesis; contracture; deformation; sequelae of injuries; growth zone; children.

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Оригинальное исследование

Последствия переломов в области локтевого сустава у детей

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АННОТАЦИЯ

Обоснование. Переломы костей, образующих локтевой сустав, встречаются у детей наиболее часто. Несмотря на методологическую разработку оказания специализированной помощи при данных повреждениях, в клинической практике нередко наблюдают негативные анатомо-функциональные исходы.

Цель — анализ последствий переломов костей, образующих локтевой сустав у детей, с оценкой структуры первичных повреждений и первичной тактики лечения.

Материалы и методы. На основе критериев включения сформирована ретроспективная когорта (n = 115). Проанализированы клинические, анамнестические и лучевые данные пациентов с последствиями переломов на уровне локтевого сустава, госпитализированных в клинику ФГБУ «НМИЦ детской травматологии и ортопедии им. Г.И. Турнера» Минздрава России для хирургического лечения в период 2022–2023 гг. Количественные показатели оценивали на соответствие нормальному распределению с помощью критерия Шапиро – Уилка (при числе исследуемых менее 50) или критерия Колмогорова – Смирнова (при числе исследуемых более 50). Процентные доли при анализе многопольных таблиц сопряженности сравнивали с помощью критерия χ^2 Пирсона.

Результаты. Средний возраст пациентов в анализируемой выборке составил 11 лет (от 4 до 17 лет). Давность травмы — 15,6 ± 1 мес. (min = 3; max = 65). В структуре последствий определены три группы: контрактура — 42 случая (36,5 %), деформация — 31 случай (27 %), контрактура и деформация — 42 случая (36,5 %). В структуре первичных травм преобладали чрезмыщелковые переломы плечевой кости (40 %) и апофизеолиз медиального надмыщелка (31 %). Первично получали консервативное лечение по поводу перелома 82 (71 %) пациента, первичное оперативное вмешательство выполнено 33 (29 %) детям; в 17 наблюдениях осуществляли переход от консервативного лечения к хирургическому. Повторные вмешательства проведены 31 (27 %) ребенку.

Заключение. Среди неблагоприятных исходов переломов на уровне локтевого сустава у детей преобладают контрактуры. Особенности первичной тактики в анализируемой группе в виде консервативного лечения и повторные вмешательства указывают на актуальность совершенствования подготовки специалистов по оказанию травматологической помощи детям. Основные причины негативных исходов на сегодняшний день по-прежнему лежат в ошибках диагностики, тактики оказания помощи и технике выполнения вмешательств, несмотря на разработанные современные алгоритмы.

Ключевые слова: переломы; локтевой сустав; чрезмыщелковый перелом; эпифизеолиз; остеосинтез; контрактура; деформация; последствия травм; зона роста; дети.

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BACKGROUND

The incidence of fractures of the elbow joint bones is approximately 310 cases per 100,000 children younger than 15 years old annually [1]. Most of these fractures are observed in children aged 6–10 years [2], a critical period marked by bone structure development and high growth plate activity. Although the methods and specific features of radiological diagnostics for injuries in the elbow joint region in children are well-documented in the literature [3], osteochondral injuries not visible on radiographs or are underestimated during the initial examination present significant diagnostic challenges. In this trauma category, the frequency of diagnostic and treatment errors exceeds 40% [4, 5]. In contrast, the diagnosis and treatment strategies for more common injuries, such as supracondylar humeral fractures (classified using the Gartland system), are well-covered in the modern literature [6, 7].

An analysis of treatment outcomes in children with elbow joint bone fractures revealed persistent anatomical and functional disorders in 30% of cases. The severity of these structural changes is closely associated with the quality of the provided medical care, where improper treatment strategies serve as a critical contributing factor [8, 9].

These findings underscore the importance of studying the structural characteristics of elbow joint bone injuries and the primary treatment strategies utilized during specialized care for children with anatomical and functional impairments resulting from trauma and acute phase treatment.

This study aimed to analyze the sequelae of elbow joint bone fractures in children, focusing on evaluating the structure of primary injuries and applied primary treatment strategies.

MATERIALS AND METHODS

We analyzed the epidemiological, anamnestic, clinical, and radiological data of patients with post-traumatic deformities and contractures of the elbow joint who were hospitalized for surgical treatment at the H. Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery of the Ministry of Health of Russia in 2022–2023.

Study design: A non-randomized, retrospective, descriptive, and single-center study was conducted.

Primary statistical unit (observation unit): A patient with a post-traumatic contracture and/or deformity of the elbow joint.

Inclusion criteria:

- age: 0–17 years;
- presence of a contracture and/or deformity of the elbow joint resulting from fractures of the elbow joint bones;
- documented provision of medical care for the trauma, including details of prior treatment;
- availability of clinical and radiological examination data;
- hospitalization for surgical treatment of trauma sequelae.

Exclusion criteria:

- no functionally or anatomically significant abnormalities requiring surgical treatment identified during clinical examination;
- lack of archival data to determine the type of initial injury and primary treatment strategy;
- no record of seeking medical assistance after the injury.

We analyzed the anatomical diagnosis, primary treatment strategies, history of repeat interventions, and type of orthopedic sequelae, specifically contracture and/or deformity of the elbow joint.

Statistical analysis was performed using StatTech v. 4.0.6 (StatTech LLC, Russia).

The Shapiro–Wilk test (for sample sizes of <50) or the Kolmogorov–Smirnov test (for sample sizes of >50) were used to test the normality of the quantitative parameters. Percentages in the contingency table analysis were compared using Pearson's chi-square test.

RESULTS

Based on the study design and inclusion criteria, the analyzed group consisted of 115 patients with a mean age of 11.5 ± 0.3 years (min = 4; max = 17) and a mean injury duration of 15.6 ± 1 months (min = 3; max = 65).

The analyzed group included patients from 45 regions of the Russian Federation, with uneven representation across some regions (Fig. 1).

In the structure of orthopedic sequelae, elbow joint contractures were the most prevalent, accounting for 42 cases (36.5%). A combination of contracture and deformation was observed in 42 patients (36.5%), while isolated deformations were less frequent in 31 cases (26.0%).

Based on the documentation, the structure of the anatomical diagnoses primarily reflected supracondylar fractures and apophyseal fractures of the medial humeral epicondyle (Table 1).

Eighty-one patients (70%) were primarily treated with conservative treatment, involving immobilization followed by rehabilitation therapy (e.g., therapeutic exercises) without reduction or skeletal traction, which was the predominant approach to post-injury management. An active treatment approach, consisting of various manipulations and surgical interventions, was used in 34 cases (30%). Additionally, a shift from conservative treatment to surgical intervention was noted in 14 patients (17.2%). Overall, 31 patients (27%) underwent repeated manipulations or interventions, including closed and open reductions and osteosynthesis.

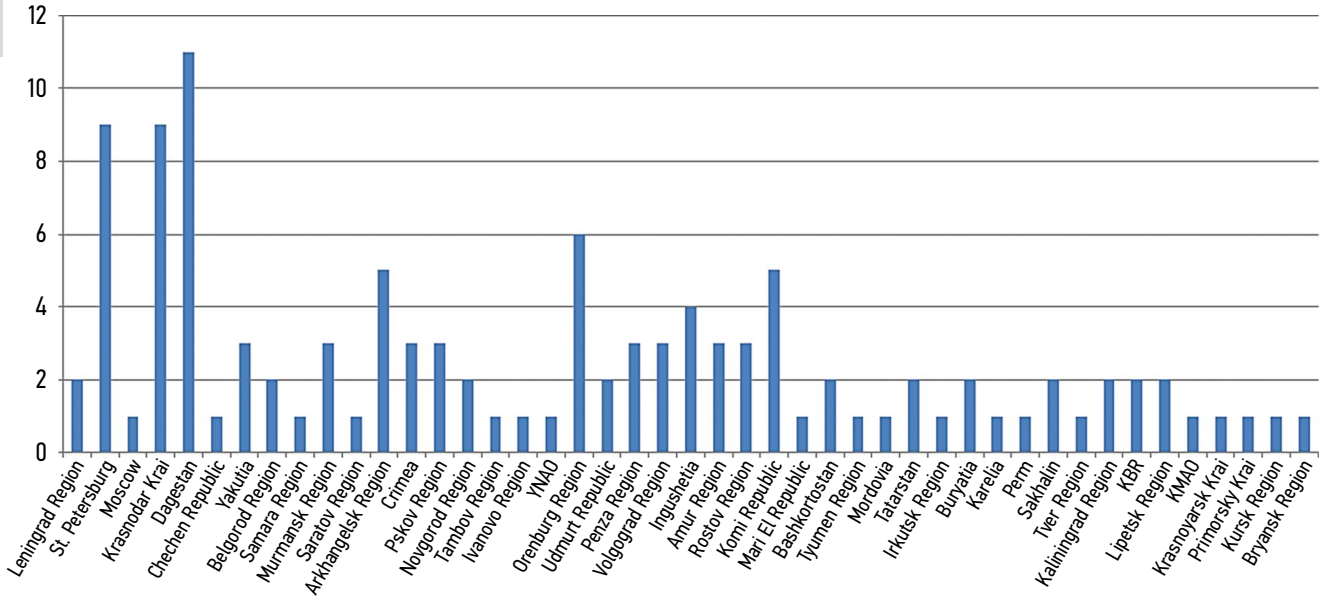

Fig. 1. Distribution of patients by regions of the Russian Federation. YNAO, Yamalo-Nenets Autonomous Okrug; KBR, Kabardino-Balkarian Republic; KMAO, Khanty-Mansi Autonomous Okrug (Yugra)

Table 2 shows the statistical analysis of the incidence of orthopedic sequelae based on the anatomical location of the injury. The structure of the injuries varied significantly among patients with different orthopedic sequelae (χ^2 test, Pearson $p = 0.002$). Supracondylar humeral fractures and apophyseal fractures of the medial humeral epicondyle were the predominant injury types across all three patient groups with sequelae.

The analysis of the primary treatment strategy based on the fracture localization in the elbow joint region showed distinct trends. In the group of patients primarily treated conservatively, supracondylar humeral and apophyseal fractures of the medial humeral epicondyle were the most commonly observed injuries. In contrast, patients who underwent closed reduction had a relatively higher number of apophyseal fractures of the medial epicondyle (Table 3).

Thirty-one patients required repeated closed or open reductions. In two cases, open procedures were performed for fragment correction and re-osteosynthesis after unsuccessful attempts at closed reduction (performed twice in one case and thrice in another). Repeat interventions were primarily performed in children with supracondylar fractures, medial epicondyle apophyseolysis, and Monteggia injuries (Table 4).

The structure of injuries requiring repeat surgical interventions at local healthcare facilities showed significant variation compared with those who did not undergo surgery (χ^2 test, Pearson $p = 0.018$). Compared with other injury types, supracondylar humeral fractures and medial epicondyle apophyseolysis were the most common among patients requiring repeat operations.

DISCUSSION

Our study data emphasized the importance of addressing suboptimal outcomes in treating children with elbow joint bone fractures. Even within this monocenter analysis, the number of patients requiring surgical correction for complications was several dozen. A search in global scientific databases, such as PubMed for “Consequences of fractures in the elbow joint in children” yielded 51 results without time restrictions, compared with 2100 results for “Fractures in the elbow joint in children” (search date: September 5, 2024). These results show a significant interest of the professional community in primary care approaches to elbow joint injuries in children, whereas the long-term outcomes appear to be relatively underexplored.

Modern literature provides detailed tactical approaches to managing elbow joint bone fractures, guided by widely used classifications and the degree of fragment displacement [10]. For instance, supracondylar humeral fractures are typically managed using the Gartland classification, which defines indications for conservative treatment, closed reduction, and open reduction [11, 12]. Recent studies published over the past 3–5 years have largely focused on optional surgical techniques and osteosynthesis methods for supracondylar fractures, opportunities, and efficacy of early rehabilitation programs [13–18]. However, attention to the indications determining the initial treatment strategy is limited, which likely reflects the clarity of this issue among specialists. In the analyzed cohort, patients with supracondylar humeral fractures were the most frequently represented group. Notably, most of these patients initially received

Table 1. Distribution of patients by anatomical types of injuries

Primary diagnosis	*n*
Supracondylar humeral fracture	46 (40%)
Apophyseal fracture of the medial humeral epicondyle	36 (31%)
Radial head fracture	10 (9%)
Combination of forearm dislocation and apophyseal fracture of the medial humeral epicondyle	9 (8%)
Humeral condylar head fracture	8 (7%)
Monteggia fracture	6 (5%)
Total	115 (100%)

Table 2. Statistical analysis of the incidence of orthopedic sequelae depending on the anatomical site of injury

Injury type	Sequelae group			*p*
	Contracture (*n*, %)	Deformation (*n*, %)	Combination (*n*, %)	
SCHF	12 (28.6%)	16 (51.6%)	18 (42.9%)	0.002: Comparison between SCHF and AMN with other types of injuries
FHCH	4 (9.5%)	0 (0.0%)	4 (9.5%)	
FD and AFMEH	2 (4.8%)	0 (0.0%)	7 (16.7%)	
AFMEH	13 (31.0%)	13 (41.9%)	10 (23.8%)	
MF	2 (4.8%)	1 (3.2%)	3 (7.1%)	
FRH	9 (21.4%)	1 (3.2%)	0 (0.0%)	

Note: SCHF, supracondylar humeral fracture; FHCH, fracture of the humeral condylar head; FD and AFMEH, forearm dislocation and apophyseal fracture of the medial epicondyle of the humerus; AFMEH, apophyseal fracture of the medial epicondyle of the humerus; FRH, fracture of the radial head; MF, Monteggia fracture.

Table 3. Statistical analysis of the primary treatment strategies depending on the fracture localization in the elbow joint region

Fracture localization	Primary strategy			
	Immobilization only	CR	CRMOS	OROS
SCHF	31 (67.4%)	1 (2.6%)	10 (21.5%)	4 (8.5%)
FHCH	4 (50%)	0 (0.0%)	0 (0.0%)	4 (50%)
FD and AFMEH	7 (77.8%)	1 (11.1%)	1 (11.1%)	0 (0.0%)
AFMEH	29 (80.5%)	2 (5.5%)	1 (2.8%)	4 (11.2%)
MF	2 (33.3%)	1 (16.7%)	0 (0.0%)	3 (50%)
FRH	8 (72.7%)	0 (0.0%)	0 (0.0%)	2 (27.3%)

Note: SCHF, supracondylar humeral fracture; FHCH, fracture of the humeral condylar head; FD and AFMEH, forearm dislocation and apophyseal fracture of the medial epicondyle of the humerus; AFMEH, apophyseal fracture of the medial epicondyle of the humerus; FRH, fracture of the radial head; MF, Monteggia fracture; CR, closed reduction; CRMOS, closed reduction and metal osteosynthesis; OROS, open reduction and osteosynthesis.

Table 4. Analysis of repeat intervention rates in supracondylar humeral fractures compared with other injury types

Fracture localization	Repeat Interventions		*p*
	Not performed	Performed	
SCHF	31 (36.9%)	15 (48.4%)	0.018: Comparison between SCHF and AFMN with other injury types
FHCH	7 (8.3%)	1 (3.2%)	
FD and AFMEH	8 (9.5%)	1 (3.2%)	
AFMEH	29 (34.5%)	7 (22.6%)	
MF	1 (1.2%)	5 (16.1%)	
FRH	8 (9.5%)	2 (6.5%)	

Note: SCHF, supracondylar humeral fracture; FHCH, fracture of the humeral condylar head; FD and AFMEH, forearm dislocation and apophyseal fracture of the medial epicondyle of the humerus; AFMEH, apophyseal fracture of the medial epicondyle of the humerus; FRH, fracture of the radial head.

conservative treatment (immobilization without reduction). Despite this, 14/81 patients in the conservative treatment group eventually required a shift to an active treatment strategy. Nevertheless, this did not prevent the development of long-term sequelae. The widespread use of conservative treatment at the initial stage likely reflects diagnostic or tactical errors during the initial medical visit.

The analysis of interventions and manipulations, including the anatomical localization of injuries, raises concerns about the effectiveness of closed reduction in cases of apophyseal fractures of the medial epicondyle, as maintaining the apophysis in a reduced position is challenging [19]. Non-operative treatment is generally indicated for fractures with minimal displacement (up to 2 mm). However, surgical treatment is recommended for athletes to prevent valgus instability and facilitate a quicker return to sports activities [20–23].

The high frequency of repeat interventions in approximately one-third of patients is particularly alarming. These data highlight the potential for an increased risk of orthopedic complications in patients undergoing repeat procedures and technical deficiencies in the original interventions [24]. These deficiencies may be due to operator-dependent factors or insufficient material and technical resources, such as the absence of C-arms or powered surgical equipment. Considering the wide geographic distribution of patients in the analyzed cohort, the issues of diagnosing and treating elbow joint fractures in children during the acute phase are significant at the local level and across the Russian Federation in general.

CONCLUSION

Although elbow joint injuries in the pediatric population have long been a subject of clinical interest, they remain a relevant topic in modern scientific and specialized literature, with well-established diagnostic and treatment algorithms. However, our retrospective analysis of elbow joint injury outcomes underscores the need for enhanced attention to the issue. Addressing the identified gaps requires focused educational efforts and the implementation of organizational and methodological improvements to optimize care delivery for pediatric patients.

ADDITIONAL INFORMATION

Funding source. The study had no external funding.

Competing interests. The authors declare that they have no competing interests.

Ethics approval. The local ethics committee of the H. Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery, Ministry of Health of Russia, approved this study (Protocol No. 24-6, dated September 20, 2024).

Consent for publication. Consent was obtained from all patients or their legally acceptable representatives for participation and publication of information.

Author contribution. All authors made a significant contribution to the study and preparation of the article, and each read and approved the final version before it was published.

Major contributions were distributed as follows: *V.I. Zorin* developed the study design, analyzed data, and wrote the manuscript; *S.A. Lukyanov* collected and analyzed data, wrote the manuscript; *D.Yu. Grybok* collected and analyzed the data.

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