Original article
https://doi.org/10.18019/1028-4427-2024-30-1-46-58

Surgical treatment of nonunion of the lateral humeral condyle in children using combined methods of bone grafting and the Ilizarov fixation

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Abstract

Introduction Elbow trauma is common accounting for 40-50 % of all musculoskeletal injuries in children. From them, lateral condyle fractures are the second most common fractures in the pediatric elbow with complications ranging from 3.3 to 54.8 %.

The objective was to determine the effectiveness of nonunion of the lateral humeral condyle (LHC) treated with bone grafts harvested from the patient's fibular shaft and the Ilizarov apparatus.

Material and methods We report surgical treatment of bone defect repaired with bone graft and the Ilizarov apparatus in 57 children with nonunion of the LHC. Maintained articulation between the non-united bone and the radial head, magnitude and direction of displacement, visible resorption of the epimetaphysis, bone deficiency, malaligned upper limb, late ulnar neuritis were the parameters used for outcome assessment. Depending on the type of surgical treatment the patients were divided into 3 groups: Group 1 (n = 13) included patients who underwent open osteosynthesis and bone fixation using 2-3 Kirschner wires; Group 2 (n = 30) consisted of patients who underwent surgery to repair the bone defect between the humerus metaphysis and an non-united fragment of the LHC fixed with wires and immobilized with a cast; Group 3 (n = 12) included patients who were treated with bone graft followed by fixation of the bone and the graft using Ilizarov wires and frame. Two patients underwent supracondylar osteotomy.

Results The outcomes were evaluated based on criteria to include non-union consolidation, joint function, limb alignment and condition of the growth plate. Long-term results were explored in 49 (85.9 %) patients out of 57 over a period of 6 months to 10 years. The results were rates as good in 39 (79.6 %) patients, as fair in 9 (18.36 %) and poor in one (2.04 %) case.

Discussion Various types of operations are reported for non-united fractures and non-unions of the cervical spine to include surgeries from open osteosynthesis to complicated reconstructions.

Conclusion Surgeries aimed at repair of bone defects using fibular autograft facilitated consolidation of non-unions and engraftments.

Keywords: children, humerus fracture, elbow joint, head of the humeral condyle, lateral condyle, non-union, surgical treatment, bone grafting, Ilizarov method

For citation: Urinbaev PU, Davirov ShM, Urinbaev IP. Surgical treatment of nonunion of the lateral humeral condyle in children using combined methods of bone grafting and the Ilizarov fixation. *Genij Ortopedii*. 2024;30(1):46-58. doi: 10.18019/1028-4427-2024-30-1-46-58

INTRODUCTION

Impaired long bone healing of pediatric fracture occurs in 10 %. Unreasonable refusal of surgical treatment can result in complicated and slow fracture healing [1]. Injuries to the elbow joint are common, accounting for 40-50 % of all pediatric musculoskeletal injuries [2, 3]. Despite significant advances in the diagnosis and treatment of elbow injuries in children, poor results account for 16-28 % [4, 5]. Lateral condyle fractures of the elbow are associated with higher rates of complications ranging between 3.3 and 54.8 % [6-9]. Nonunions of the capitellum are observed in 28 % of the fractures [10]. Outcomes of non-united capitellum fractures of the remain disappointing: surgical treatment of non-united fractures of the capitellum [11] can result in poor outcomes ranging between 18 and 26.6 % [12]. Surgical treatment of intra-articular nonunions is challenging [13-18]. With use of many methods, restoration of the lost bone of the lateral condyle, replacement of the bone defect of the central lateral epimetaphysis, being typical for nonunions of the capitellum with valgus alignment of the forearm, are not considered. A bone defect in the central lateral portion of the humeral epiphysis and metaphysis can be seen in patients with long-term nonunions of the capitellum. A surgical procedure offered by the authors included bone grafting of the nonunion and replacement of the bone defect using bone grafts harvested from the fibular shaft of the patients and fixed with the Ilizarov frame [19].

The objective was to determine the effectiveness of nonunion of the lateral humeral condyle (LHC) treated with bone grafts harvested from the patient's fibular shaft and the Ilizarov apparatus.

MATERIAL AND METHODS

Our study includes outcomes of surgical treatment of 57 patients treated with bone grafting using autografts harvested from the fibular shaft and the Ilizarov external fixation. Treatment was performed between 2009 and 2022. Characteristics of the patients at the time of admission are shown in Table 1. Microsoft Excel was used for statistical data processing. The mean value of the parameter and standard deviation were used for descriptive statistics. The differences were considered significant at $p < 0.05$.

Table 1

Characteristics of patients

Description	Number of patients	
	abs.	%
Distribution by gender:		
boys	36	63
girls	21	37
Distribution by age:		
under 5 years	10	18
5-8 years	24	42
8-14 years	16	28
14 years and greater	7	12
Distribution by duration of injury:		
1-6 months	25	44
6 months - 1 year	18	32
1-12 years	14	24

The study received a favourable opinion from the relevant research ethics committee of the Samarkand branch of the Republican Specialized Medical Center for Trauma and Orthopaedics No. 2/12 dated May 17, 2009. The study was performed in accordance with ethical principles for medical research involving human subjects stated in the Declaration of Helsinki developed by the World Medical Association as revised in 2000. Written informed consent was obtained from all patients for publication of the findings without identifying details.

Based on clinical and radiological findings, patients with nonunion of the capitellum were divided into the following groups:

Group 1 included patients with nonunion with articulation preserved between the nonunion and the radial head, with a slight (up to 3 mm) displacement of the non-united fragment in the lateral direction, without visible resorption of the epimetaphysis;

Group 2 included patients with nonunons with articulation preserved between the nonunion and the radial head, with the nonunion displaced by more than 4-5 mm in several projections: lateral, anterior, posterior, proximal, and visible epimetaphyseal resorption, malaligned limb, with possible late ulnar neuritis;

Group 3 included patients with nonunons with impaired articulation between the nonunion and the radial head, subluxation, dislocation of an nonunited fragment from the joint cavity, impaired axis of the arm, and possible late neuritis of the ulnar nerve.

Physical examination included range of motion (ROM) in the joint, alignment of the upper limb, and innervation of the ulnar nerve.

RESULTS

Joint contracture. Five (8.8 %) patients had a full range of motion and the rest developed contracture with ROM measuring 30° (*n* = 15; 26.3 %), 50° (*n* = 11; 19.3 %), 70 ° (*n* = 12; 21.1 %), 90° (*n* = 5; 8.8 %), 120° (*n* = 9; 15.8 %).

Malaligned forearm bones. Valgus alignment of the forearm bones was observed in 27 (47.3 %) patients: measuring not greater than 10° (*n* = 11; 19.3 %), 15-25° (*n* = 10; 17.5 %) and 30-40° (*n* = 6; 10.5 %) (Fig. 1).

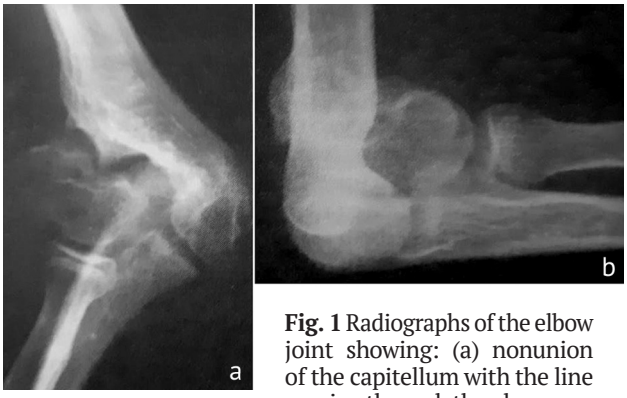

Fig. 1 Radiographs of the elbow joint showing: (a) nonunion of the capitellum with the line passing through the olecranon fossa on the AP view, severe cubitus valgus, osteoporotic bone; (b) anterior displacement of the fragment can be seen on the lateral view with poor proximal alignment

Cubitus valgus result from the bone displaced laterally + proximally, laterally + anteriorly + proximally and epiphyseal and metaphyseal resorption of the shoulder. Severe valgus deformity was seen in patients with unstable nonunions, non-united lateral humeral condyle (LHC) fractures with impaired articulation of the radial head. Varus deformity (*n* = 2) was characteristic of stable nonunions and nonunited fractures with posterior displacement of the LHC (Fig. 2a).

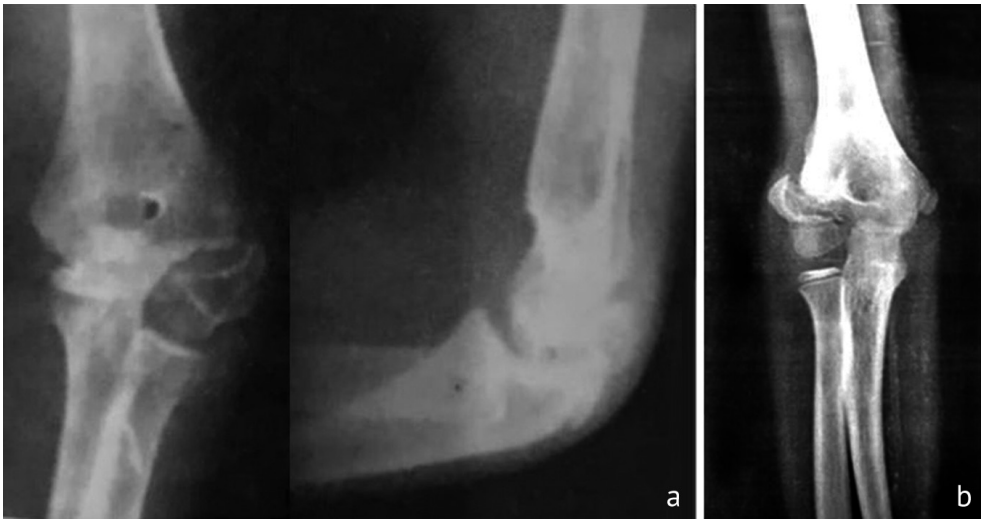

Fig. 2 Radiographs of the upper limb of patients with nonunions of the LHC: (a) without bone defect, osteoporosis of the LHC with cubitus varus; (b) nonunion of the LHC fragment

Late neuritis of the ulnar nerve. There was malalignment between the olecranon process and the medial epicondyle due to valgus alignment of the joint. There was narrowing of the sulcus ulnaris in the condyle, excursion of the nerve during flexion and extension and perineuritis and neuritis due to injury. The external deviation of the forearm bones measured 20-25° in 5 out of 6 patients with impaired ulnar nerve function and 35° in one patient.

Radiological examination. Anteroposterior and lateral views of the elbow joint were practical for evaluation of a fracture pattern (epiphysiolysis, osteoepiphysiolysis), location of the start of the fracture line (often in the trochlea), direction of the fracture in relation to the long axis of the shoulder (< 45°, > 45°), bone displacement (lateral + proximal, lateral + anterior + proximal),

amount of displacement (< 2 mm, > 2 mm), presence of a gap-diastasis, rotation, rotation of the fragment, preserved articulation with the radial head, protrusion of the fragment (subluxation, dislocation), bone resorption, bone deficiency of the epiphysis, metaphysis, bone defect of the nonunion, engraftment, fusion of the nonunion, restoration of the anatomical structure and the condition of the growth zone and the articular ends of the elbow joint.

Nonunion of the condylar head can develop because of different reasons. In our series, 13 (23 %) patients had nonunited fractures, and 44 (77 %) had pseudarthrosis. Among 44 patients with pseudarthrosis, 9 (20.5 %) had lateral displacement with bone rotation, subluxation, dislocation of the fragment, lacking contact of the fracture surfaces and impaired articulation of the lateral head. The resulting regenerate on the fracture plane cannot provide consolidation due to the rotation of the planes in different directions. One patient had successful reduction during the previous stage of treatment with secondary displacement, 3 patients had poor reduction, 5 patients were treated with plaster immobilization for 2-3 weeks.

Among 35 patients, 6 (17 %) had a fracture of the epiphysiolysis pattern, the rest had an epimetaphyllary fracture: the fracture line originated in the trochlear groove, crossed the growth zone, passed along the metaphysis and ended above the epicondyle. The fracture surface consisted of heterogeneous cartilage and bone tissue. For this group of patients, the bone displacement of fragments could be termed as lateral + proximal by 4-5 mm with resultant gap-diastasis of 2-3-4 mm or greater seen between the fragments. At the previous stage, 6 patients underwent closed reduction, which was successful in two cases, but with repeated secondary displacement in a plaster cast; 4 had failures and the rest were treated with a plaster cast. A few years later, nonunions that developed after ununited fractures with slight displacement with preserved articulation with the radial head were associated with delayed development of the central trochlea and the lateral condyle, resorption, epiphyseal and metaphyseal defects (Fig. 8), disappearing olecranon fossa, the forearm bones being displaced laterally at an angle of 20-40°. Post-traumatic late neuritis of the ulnar nerve could occur due to overstretching and pressing against the medial epicondyle with resultant secondary contracture of the joint. Some patients showed radiological signs of osteoporosis (Fig. 1, 3).

Fig. 3 Radiographs of the elbow joint showing nonunion of the capitellum (left). Dimensions of the defect formed after realignment could be visualized in the figure on the right

For such a pathology, surgical treatment should be aimed at stimulating reparation, filling the bone defect, achieving fusion of the nonunion, realigning the axis of the arm, creating anatomical conditions for restoring joint function and eliminating signs of late post-traumatic neuritis.

A method of surgical treatment of pseudoarthrosis of the lateral humeral condyle has been proposed with use of two diaphyseal bone grafts taken from the patient's fibular shaft, between metaphysis and the fragment replacing the bone defect formed at the site of the false joint. This technology

helps stimulate the repair of an osteoporotic bone, fusion of the nonunion, restoration of the impaired olecranon fossa, elimination of valgus alignment of the arm, avoiding supracondylar osteotomy and creating anatomical conditions for the elbow function.

The grafts were taken subperiosteally. The grafts length equated the size of the diastasis between the metaphysis and the nonunited fragment, measured intraoperatively to eliminate cubitus valgus. Grafts of 0.5-0.7 cm, about 1 cm, about 1.5-2 cm were normally used. The inside graft placed in the diastasis was shorter than the outside graft. One graft was used first in isolated cases to be followed by the use of two grafts (Fig. 4).

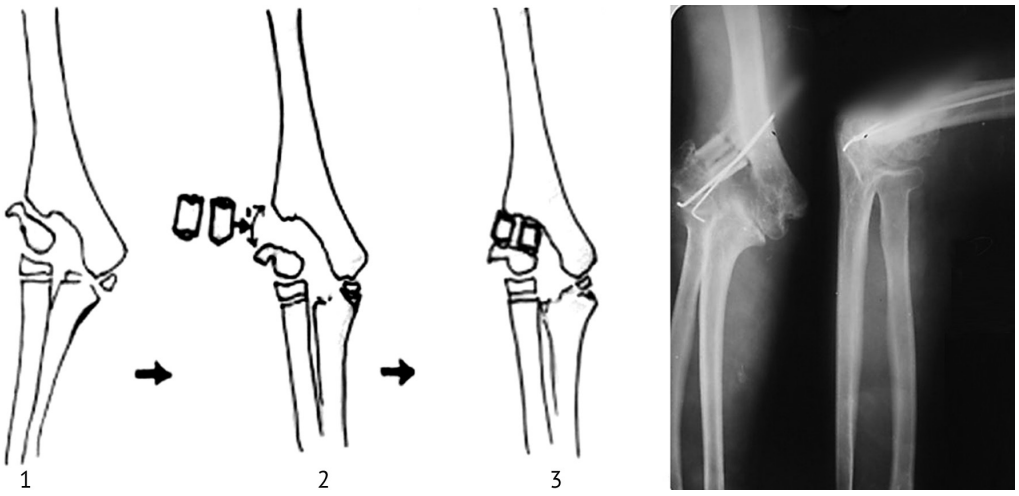

Fig. 4 Diagram of the operation and radiographs of the patient's elbow joint after bone grafting (clinical observation of the authors)

Depending on the surgical treatment used, our patients were grouped as follows (Table 2):

Group 1 included patients who underwent open osteosynthesis and bone fixation using 2-3 Kirschner wires (n = 13);

Group 2 included patients who had a bone defect repaired between the humeral metaphysis and a nonunited fragment of the LHC using wires and external immobilization with a plaster cast (n = 30);

Group 3 included patients who were treated with fixation of bone fragments and grafts using wires and Ilizarov frame after bone grafting (n = 12). The Ilizarov external fixation was used at the second stage after bone grafting in cases of the graft – metaphysis fusion with no fusion of the graft and the capitellum (n = 6).

Table 2

Distribution of patients by type of surgical intervention

Types of surgical interventions used for patients with non-united fractures and nonunions of LHC	Number of patients	
	abs.	%
Open metal osteosynthesis, fixation with wires	13	22.81
Bone grafting, fixation with wires	30	52.63
Bone grafting, fixation with wires and the Ilizarov frame	12	21.05
Supracondylar osteotomy	2	3.51
Total	57	100

Supracondylar osteotomy was performed for two patients.

Clinical instance of nonunion of the capitellum with a history of 9 years (Fig. 5).

We report a clinical example showing fusion of the medial graft and nonunited lateral graft over a period of 3 months of immobilization with a plaster cast that fused after application of the Ilizarov apparatus. Patient K.N., born in 2005, her clinical appearance and radiographs dated 2018.12.10 and 2019.01.29 (Fig. 6).

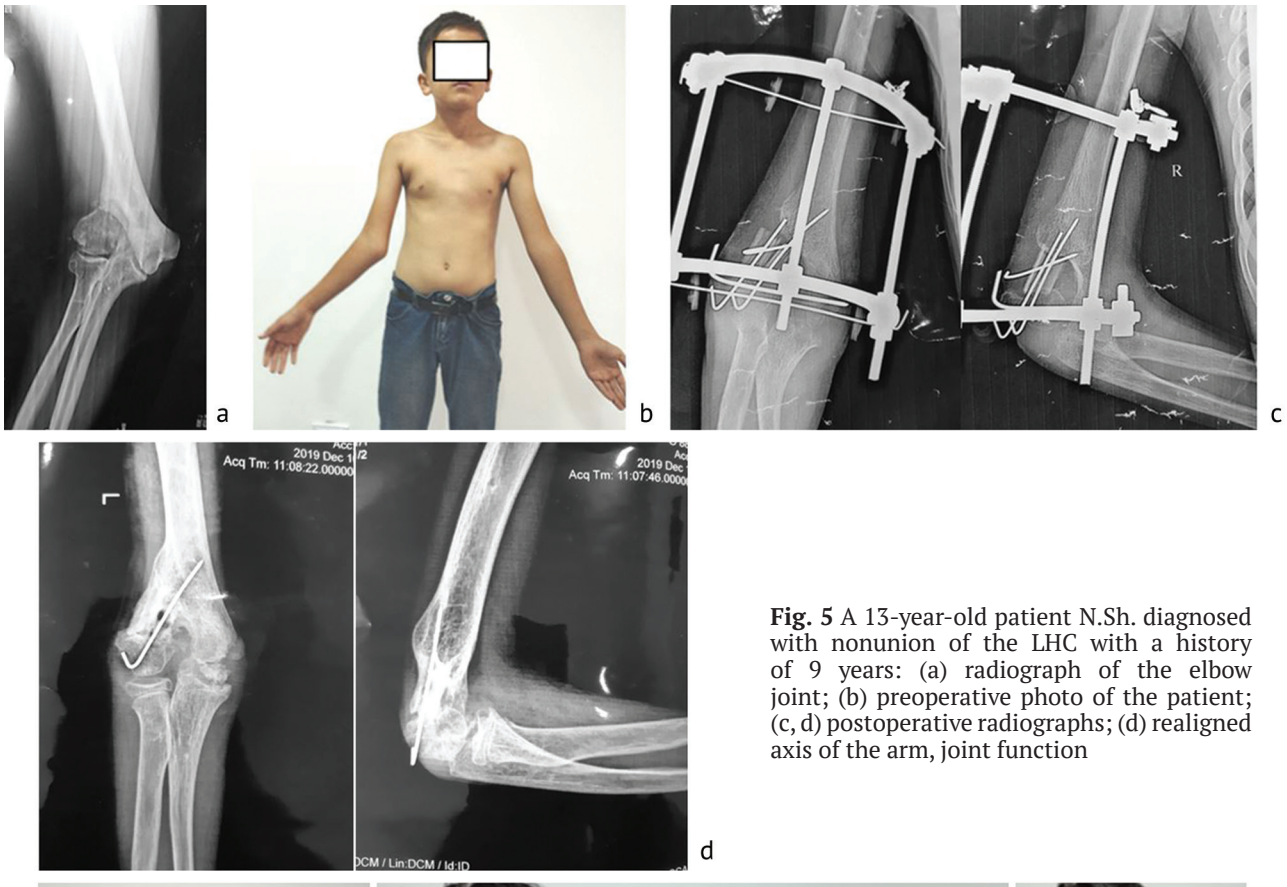

Fig. 5 A 13-year-old patient N.Sh. diagnosed with nonunion of the LHC with a history of 9 years: (a) radiograph of the elbow joint; (b) preoperative photo of the patient; (c, d) postoperative radiographs; (d) realigned axis of the arm, joint function

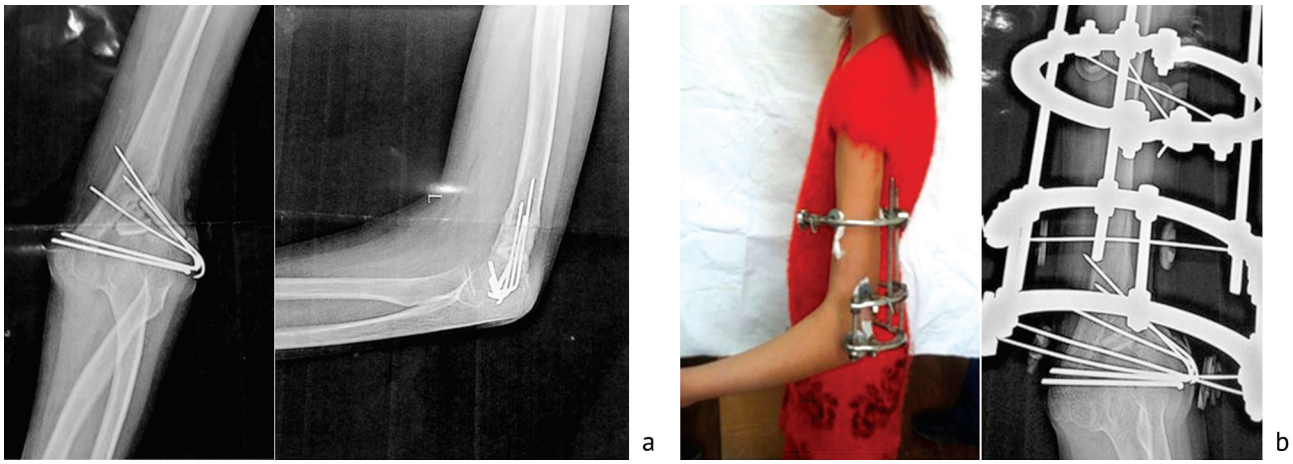

Fig. 6 Patient K.N.: (a) radiographs of the elbow joint dated October 12, 2018; (b) clinical appearance and a radiograph dated January29б 2019 during treatment with the Ilizarov apparatus

A supracondylar osteotomy was performed for two patients of group 3 with nonunions of the LHC developed after a fracture and dislocation of a fragment from the joint cavity, with impaired articulation with the radial head. The end of the central fragment shaped as a tent was deepened, the surface of the distal fragment adapted, the bone reduced and fixed with Ilizarov wires and the frame (Fig. 7).

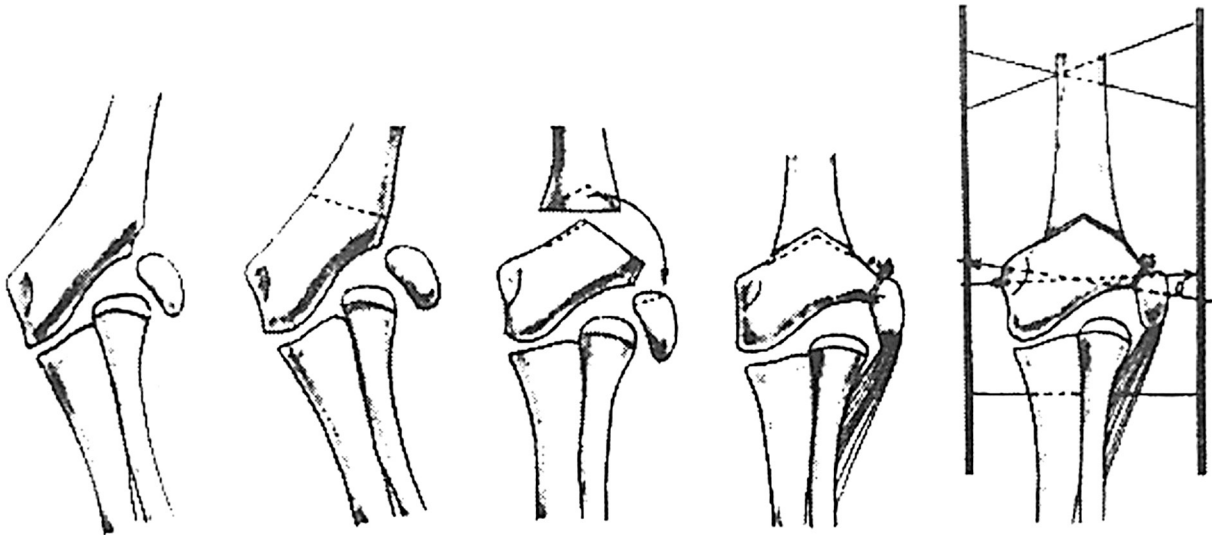

Fig. 7 Diagram of the operation performed for the patients of the third group with nonunions of the LHC and impaired articulation of nonunited fragment, the radial head and cubitus valgus

Results of bone grafting performed for nonunions of the capitellum

Long-term results must be evaluated in a differential manner, taking into account the severity of the fracture (nonunion, pseudarthrosis) based on objective criteria for assessing long-term outcomes. The fusion of pseudarthrosis, joint function, the arm axis, and the growth zone were assessed (Table 3).

Table 3

Criteria for assessing long-term results of non-union fractures, pseudarthrosis of the head of the humeral condyle in children

Criteria	Score
According to the bone fusion or non-union:	
1. The fusion is well aligned, but there is a uniform thickening of the condyle with olecranon fossa partially filled with bone tissue	4
2. Fusion is malaligned, the bone being rotated in the sagittal plane at least 20-25 degrees, laterally displaced, proximally at least 5 mm	3
3. Nonunion (resorption) of a fragment of the head of the condyle	2
Joint function (range of motion (ROM):	
1. ROM from 110 to 130° (N – 140-145°)	4
2. ROM from 80 to 110°	3
3. ROM up to 80°	2
Alignment of the upper limb:	
1. Straight elbow, valgus alignment of the forearm bones of at least 5° from physiological valgus	4
2. Valgus alignment 6-15° from physiological valgus	3
3. Valgus alignment of 20° or greater from physiological valgus	2
Impaired growth of the condyle and other components of the elbow joint:	
1. Premature closure of the growth plate in children older than 14 years	4
2. Premature closure of the growth plate in children aged 8-13 years; deformation of the epiphysis capitulum humeri, relative enlargement of the radial head and the coronoid process	3
3. Premature physeal closure in children aged 5-8 years, significant enlargement of the radial head, coronoid process, filling of anatomical fossae with bone tissue, narrowing of the joint space	2

The resulting sum of scores was divided by the number of characteristics and an average score was measured to rate the result as good, fair or poor. The outcome was evaluated as good with 15-16 scores in 4 criteria. For example: 15:4 = 3.75 (4 + 4 + 4 + 3). The outcome was evaluated as fair with a score of 11-14. For example: 12:4 = 3.0 (3 + 3 + 3 + 3). Poor result scored less than 10. For example: 10:4 = 2.5 (3 + 3 + 2 + 2).

The 12 patients who underwent bone grafting and Ilizarov external developed bone union. Out of 30 operations of bone grafting, fixation with 3-4 wires and external immobilization with a plaster cast, union was achieved in 24 (80 %) patients. The fusion period was 2-3 months, was obtained on the side of the Metaphyseal union was achieved in 6 (20 %) patients with weak consolidation noted on the side of the LHC and radiological nonunion. Pseudarthrosis consolidated in the patients with closed application of the Ilizarov apparatus at the second stage.

Resorption of bone grafts on the side of the LHC was observed in two patients who underwent reoperation. Bone grafting using the Ilizarov apparatus was performed in one patient who developed fusion of pseudarthrosis. Another patient had a recurrent nonunion. Long-term treatment results were examined in 49 (85.9 %) out of 57 patients over a period of 6 months to 10 years. Good results were obtained in 39 (79.6 %) patients, 9 (18.36 %) had fair outcomes and one result (2.04 %) was rated as poor. An operation to transpose the ulnar nerve, anterior to the medial epicondyle was performed for 7 patients with very long follow-up periods of 10 to 17 years, with late post-traumatic neuritis of the ulnar nerve and good elbow function, satisfactory alignment of the nonunited fragment and a small cubitus valgus.

DISCUSSION

Nonunion of the elbow fractures can be caused by localization (intra-articular injury), osteochondral involvement, instability, conservative treatment of displaced injury (lateral + proximal), with diastasis between the fragments and lack of external immobilization for an appropriate period. The period of external immobilization required for the healing of an acute fracture can range from 4 weeks according to G.M. Ter-Egiazarov et al. [20] to 4-6 weeks as reported by KS Song [21]; JM Weiss [22]; S Yuxi [23]; to 8-12 weeks according to JC Flyn [24].

Specific localization of the fracture, the fracture line, a small (up to 3-5 mm) lateral bone displacement without rotation prove diastasis along the fracture. This leads to a polycyclic course of the reparative regeneration process and requires longer immobilization. An outward + proximal displacement can be observed with peculiar direction of the fracture line with the fragment sliding laterally and rising upwards along the fracture plane. It can be suggested that the cartilaginous surface of the fracture at the epiphysis partially outstands the osseous portion of the fracture at the metaphysis (Fig. 8).

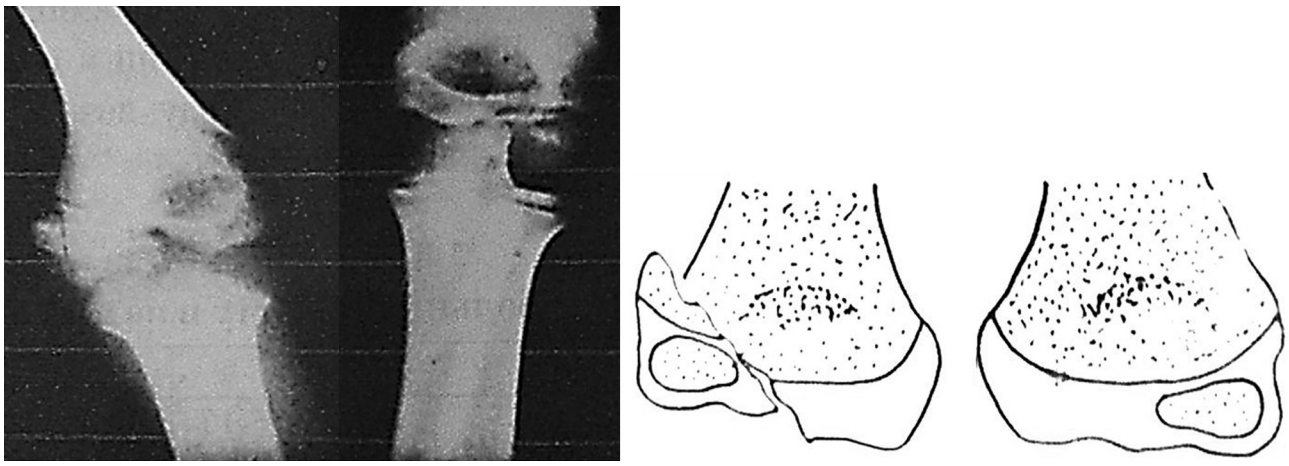

Fig. 8 Photo of radiographs and a diagram of a LHC fracture with lateral + proximal displacement, contact of heterogeneous tissues: the cartilaginous surface of the epiphysis is located opposite the osseous wound of the metaphysis

There is a contact of dissimilar tissues, which apparently slows down the formation of the regenerate that fails to be solid over the usual period of immobilization. Nonunion may occur in the cases with early exercising of the joint. The lateral condylus fragment and the fracture surface consist mainly of cartilaginous tissue. (Fig. 9).

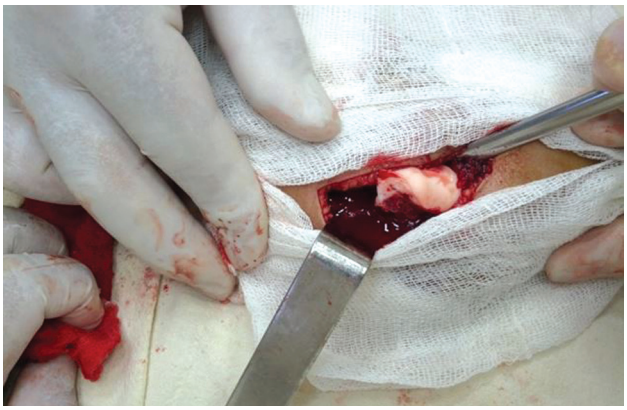

Fig. 9 Intraoperative photograph of a fragment of the lateral condyle of the humerus in a four-year-old child. The fragment consists of cartilage tissue

The fracture surface consists of bone tissue in the metaphyseal part and of the cartilage tissue in the epiphyseal portion. Regeneration processes occur with different intensity in the tissues. This was confirmed by the experiments reported by G.I. Lavrishcheva [25]. Despite the fact that most favorable conditions were created for osteochondral healing, "uneven" healing of wounds was noted in several experiments. There was no cartilaginous fusion in 25 % of the rabbits after 14-16 days and in 33 % after 19-21 days and in 50 % after 30 days with healing seen in the bone wound.

Fractures of the lateral epimetaphysis of the distal articular end of the humerus are often referred to as "fractures of the head of the humeral condyle" (LHC) (capitulum humeri).

The term fracture of the lateral condyle of the humerus describes more accurately the fracture pattern based on clinical and radiological findings of pseudarthrosis of capitellum. Various surgeries used to treat nonunited fractures and pseudarthrosis of the LHC include modalities from open osteosynthesis to complex reconstructive operations. The surgical strategy would be dependent on the position of the fragment: with the fragment being well aligned, the arm axis mainly maintained, joint contracture not seen, the surgery are not indicated due to a possible deterioration in the range of motion in the joint. Open reduction and bone fixation is indicated for pseudarthrosis of the LHC without pronounced valgus alignment of the forearm bones. Wires, a cortical bone graft in the form of a screw, screws are used to fix the bone fragment. Cubitus valgus can be corrected with supracondylar osteotomy. Plaster cast, skeletal traction, Ilizarov apparatus are used for external fixation. Transposition of the ulnar nerve anterior to the joint can be employed when needed.

Delayed consolidation at various stages of long bone repair and bone regeneration is termed differently: slowly healing fractures, non-uniting and non-united fractures, post-traumatic pseudarthrosis and long bone defects of. Each of the above terms can be a portion of a phase complicated by failed fracture consolidation and pathological process of reparative bone regeneration. The timing for transition from one stage of nonunion to another is different and depends on several factors including localization of injury; child's age; the extent of impaired regeneration processes; microcirculatory disorders; the presence or absence of osteoporosis and the treatment strategy. The results of treatment of non-united capitellum fractures remain disappointing. The rate of poor outcomes ranges from 18 to 26.6 % after surgical treatment of non-united LHC fractures. Insufficient knowledge of the causes of failed consolidation and the lack of comprehensive examination is one of the significant problems in the diagnosis and treatment of LHC fractures with a complicated course [26]. Imaging is the main diagnostic method of pediatric fractures and their consequences; computed tomography, thermography, laser Doppler flowmetry, and ultrasonography are also practical.

Surgical treatment of intra-articular pseudarthrosis is a difficult procedure. A variety of surgical treatments including osteosynthesis, supracondylar osteotomy, transposition of the ulnar nerve were

offered for treatment of capitellum based on the anatomical and functional changes of the elbow joint [3, 6, 18, 27-30]. Wires, screws [31-35] in combination with a bone graft, screws [36-38], and compression osteosynthesis [39, 40] were used to fix the bone. Autospongy bone tissue [41], homoplasty of the articular end [42] and joint replacement were treatment options [43]. Removal of the fragment [44] was not supported.

It has been suggested that nonunited fractures with good fracture position do not require surgical treatment but should be delayed until adulthood or until the when the deformity requires surgical correction [45, 46]. Other authors believe that surgical treatment can result in fusion with the risk of greater limitation in joint function, and extra-articular surgery can be offered using supracondylar osteotomy for valgus alignment of the forearm bones [7, 47, 48]. Early surgical treatment can be considered for nonunion with minor displacement and no noticeable limitation of elbow function. In case of significantly displaced bone fragment, the role of surgical treatment is questionable, because of a risk of early epiphyseal closure [49].

SI Stamatin et al. reported a case of homoplasty of the distal humerus in a 9-year-old child for valgus deformity associated with a defect in the articular end due to a fracture of the lateral condyle of the humerus [42]. At a long term, the forearm bones are set in a position of lateral deviation at an angle of 20-40°, patients can develop secondary contracture and late post-traumatic ulnar nerve neuritis.

GM Ter-Egiazarovs reported surgical intervention for the deformity using nonunited fragment to be placed in the bed and fixed with bone grafts; supracondylar osteotomy to be followed by skeletal traction [50]. The procedure could be added by bone fixation using Ilizarov wires and the frame [28, 29].

NA Ovsyankina et al. reported fixation of the fragment of the condylar head to the anatomical bed using a metal screw with the false joint to be covered with a bone autograft harvested from the distal humerus, with the brachioradialis muscle with vessels and nerves [51]. Patients with nonunited fractures and pseudarthrosis can be successfully treated with open osteosynthesis, conventional debridement of the false joint, bone reduction and fixation to the metaphysis with 3 or 4 wires. Bone replacement is indicated for patients with pseudarthrosis and a significant epimetaphyseal defect. It is common knowledge that replacement of diaphyseal bone defect was historically produced with the bone grafting developed by Lexer, described by VD Chaklin [11] regarding pseudarthrosis, a diaphyseal defect, tumor removal of processes using match stick grafts [6]; regarding bone defects after open injuries [12]. According to the researchers, an 11 cm long free autograft taken from the patient's fibula and transplanted onto a bone defect in the ulna showed good survival rate. This is consistent with the opinion of GI Lavrishcheva that the process of reconstruction or assimilation of the graft occurs most quickly with the transplantation of fresh autoplastic bone, and somewhat slower with homoplastic bone [25].

We filled the diastasis with bone grafts taken from the patient's fibula to achieve fusion by replacing the bone defect. Grafts with a length of 0.5-0.7 cm, about 1 cm, 1.5-2 cm were required. The internal graft placed in the diastasis was shorter than the external graft. Fixation was produced with 4-5 wires. External immobilization with a plaster cast facilitated fusion of the pseudarthrosis in 80 % of patients. Fusion was achieved from the metaphysis and grafts in 20 % of patients. The Ilizarov apparatus was practical for providing healing of the fragment and the grafts at the second stage of the procedure. The bone fusion occurred within 2-3 months of the Ilizarov application. All the grafts survived with the exception of 2 patients who could achieve fusion with repeated bone grafting. These clinical observations serve to understand the feasibility of bone grafting for nonunion of the capitellum/LHC. The procedure has greater indications for patients with severe osteoporosis of the nonunited fragment.

CONCLUSION

An intra-articular injury, a risk of impaired blood supply, bone instability (tendency to displacement), the cartilaginous surface of the epiphyseal part, a contact with the metaphyseal bone wound, and the polycyclic course of regeneration with failed callosity expected to develop within an appropriate timing are important factors affecting non-union of LHC fractures.

Patients with pseudarthrosis of the LHC, a bone defect at the pseudarthrosis can benefit from a surgery aimed to replace the bone defect with bone grafts taken from the fibula. The transplants have shown good survival rates, with the exception of a few cases. The valgus alignment of the forearm bones can be addressed with the anatomical prerequisites created for restoring ROM in the joint, eliminating osteoporosis of the LHC fragment. The use of the Ilizarov apparatus facilitates fusion of the pseudarthrosis in all cases. Postoperative immobilization with a plaster cast ensures fusion of the pseudarthrosis in 80 % of patients.

Conflict of interest *Not declared.*
Funding *Not declared.*

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The article was submitted 12.04.2023; approved after reviewing 07.08.2023; accepted for publication 01.12.2023.

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