Analiza statystyczna wartości kąta ramienno-przedramiennego po złamaniu nadkłykciowym u dzieci

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Statistical analysis angle values brachiocephalic-foream after epicondyle of the humerus fracture in children

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Streszczenie
Wyniki. W grupie badanej odchylenie kąta ramienno-przedramiennego w kończynie po złamaniu wykazywało 72,3% pacjentów. Zniekształcenie szpotawe wystąpiło u 13,9%. Kąt ramienno-przedramienny o wartości 180º (*cubitus rectus*) wystąpił u 17,8.%. Zmniejszenie kąta ramienno-przedramiennego mieszczące się w zakresie koślawości (odchylenie szpotawe) stanowiło 17,8%. Zwiększenie koślawości stawu łokciowego wystąpiło w 22,8% przypadków.
Materiał i metody. Do badania włączono 282 pacjentów ze złamaniem nadkłykciowym przemieszczonym kości ramiennej. Podczas badania ogólna liczba dzieci hospitalizowanych z powodu urazu stawu łokciowego wynosiła 488.
Cel. Celem pracy było określenie najczęściej występujących odchyleń od stanu prawidłowego po przebytym złamaniu, a także czynników mających wpływ na odległe następstwa złamania nadkłykciowego kości ramiennej.
Wprowadzenie. Złamania nadkłykciowe kości ramiennej należą do typowych urazów wieku dziecięcego. Złożona budowa anatomiczna i biomechanika stawu łokciowego powodują, że zagadnienie leczenia i oceny wyników złamań nadkłykciowych nadal jest przedmiotem badań naukowych. W piśmiennictwie wiele prac poświęcono patomechanizmowi, rodzajom leczenia, zapobieganiu powikłań.

Wnioski. Złamania nadkłykciowe kości ramiennej stanowią 57,9% wszystkich urazów stawu łokciowego u dzieci. Odchylenie kąta ramienno-przedramiennego wystąpiło w 72,3% przypadków. Najwięcej, bo 22,3% zaobserwowano deformacji koślawych. Szpotawość łokcia wystąpiła u 13,9% dzieci. Niski odsetek obserwowanych deformacji szpotawych był wynikiem przyjętej metody pomiaru. Przy rejestrowaniu każdego odchylenia odsetek obserwowanych przypadków szpotawości stawu łokciowego wzrasta do 49,5%.

Słowa kluczowe. Złamania nadkłykciowe, dzieci, ocena.

Summary

Introduction. The brachial epithelial fractures of the humerus are typical childhood traumas. Complex anatomy and biomechanics of the elbow cause that the treatment and evaluation of the results of the epidural fractures is still being investigated. In the literature many works have been devoted to pathomechanism, types of treatment, prevention of complications.

Objective. The aim was to determine the most frequently occurring deviations from the normal state after a fracture and factors affecting the distal consequences of fracture of the superficial humeral humerus.

Material and methods. 282 patients with transverse epicardial displacement of the humerus were included. During the study the total number of children hospitalized due to the injury of the elbow was 488.

Results. 73.3% of patients had a deviation of the shoulder and forearm angle after fracture. Valvular deformity was reported in 13.9%. 180º (cubitus rectus) arm-and-mouth angle occurred in 17.8%. The reduction of angina in the range of valvular heart disease occurred in 17.8%. Increased elbow flexion occurred in 22.8% of cases.

Conclusions. The brachial epithelial fractures of the humerus account for 57.9% of all injuries to the elbow joint in children. The deviation of the brachial-forearm angle occurred in 72.3% of cases. Most of them, because 22.3% of the lumbar deformities were observed. The elbow varus occurred in 13.9% of children. The low rate of observed deformation was the result of the accepted measurement method. At the recording of each deviation, the percentage of observed cases of elbow joint increased to 49.5%.

Keywords. Epicondylic fractures, children, evaluation

Introduction

Epicondyle of the humerus fractures belong to the most typical injuries observed in tender age, however, they still arouse numerous diagnostic, therapeutic as well as prognosticative controversies. A complicated structure and the biomechanics of a cubital joint make the question of the treatment and the assessment of the effects of the epicondyle of the humerus fractures still remain the subject of many scientific studies. Numerous works that can be found in professional literature mainly focus on a pathomechanism, types of treatment and preventing any, likely to appear, complications [1,2,3,4,5,6]. Somewhat fewer works deal with the assessment of further possible consequences of this type of injury [7,8,9,10,11,12].

Because conglutination of the epicondyle of the humerus fractures is a long-lasting process (it is additionally affected by the bones growth process), the final results must be perceived from a broader perspective.

Due to a specific anatomic structure and the physiology of conglutination, the injuries differ in their character, process and possible complications.

The period of the most dynamic growth of the skeletal system ends at the age of about 6-9, however it continues until the complete development of the growth cartilage that takes place at the age of about 16-18. The growth itself is possible due to the presence of the growth cartilage that enables bones to get longer. The growth cartilages are located in the end part of bones between their epiphysis and metaphysis. In comparison to adults, the periosteum in children is thick and also a bit looser in the area where growth cartilage is located. The cortical layer is thinner at the epiphysis and thicker at the distal end of a bone, and tendon ligaments as well as joint capsules are very strong. All this causes that the injuries of long bones observed in juveniles, most frequently appear in the area of a bone epiphysis and metaphysis and the fracture very often happens to go across the growth cartilage. There is also a possibility of breaking the growth cartilage without breaking the bone itself, which means, that in this case exfoliation of the epiphysis or the damage of the growth cartilage between epiphysis and metaphysis can be observed. To describe this kind of injuries, the Salter- Harris classification, which takes into consideration the way the fracture crosses the growth cartilage and the adjacent bone, is applied [13].

Fractures and exfoliations of the distal end of the humeral bone were classified as: epicondyle fractures, lateral epicondyle fractures, medial condyle fractures, medial epicondyle fractures and type T intercondylar fractures. Due to the fact that the fracture can go across the growth cartilage causing its permanent damage and lead to the condition where its part will grow slower than the circumjacent tissues. Therefore, possible complications that might occur after this type of injury concern the limb growth disorder resulting in the departure from its right axis (the brachiocephalic-forearm angle disorder). Similarly to the cases of other types of fractures, it is possible to observe a delayed process of conglutination or even its total lack, accompanied by the process of forming a pseudarthrosis. In case of the damage of the arteries supplying epiphysis and metaphysis with blood, the occurrence of ischaemic necrosis of the broken condyles can be expected. The group of complications that are likely to appear immediately after this type of injury happens, include blood circulation disorder in the whole limb. The damage appearing adjacent to a median, cubital and radial nerve may result in a neurological disorder of the injured limb. Displacement and mal union of bone fragments, with time, lead to a joint's flexibility degeneration. This degeneration may also be the effect of a contracture of soft tissues located in a cubital joint, caused among others, by too long fixation time of an injured limb. The occurrence of various complications may also be affected by the presence of infection [14].

Treatment of a fracture of a distal end of a humeral bone depends on a type and an extent of bone fragments dislocation. In case of fractures showing no signs of displacement, the only applied treatment, is fixation by means of a plaster cast. If bone fragments inside the joint happen to be displaced, replacing the fragments in their anatomical position is absolutely necessary in order to reconstruct the joint. It may be done either manually or by means of a traction, as far as possible, without surgical opening of the joint, however under constant

radiological control. If it is required, the replaced bone fragments are fixed by means of Kirschner pins. In case an external replacement is impossible (difficult technical conditions, unstable bone fragments, specific types of fractures, e.g. a fracture of a lateral condyle of a humeral bone or type T and Y fractures), an internal replacement is applied accompanied by surgical opening of a joint capsule, and bone fragments are fixed by means of Kirschner pins. In case of recurring dislocation of bone fragments or delayed union fracture, surgical replacement is applied and the fragments are replaced by means of screws. Surgical treatment with the use of special techniques is also applied in case of complications, such as formation of a pseudarthrosis [14]**.**

As it has already been mentioned, one of the most serious complications that are likely to appear after epicondyle of the humerus fractures, is a valgus or varus deformity of a cubital joint [7, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 10, 12].

A right brachiocephalic-forearm angle is said to have the values between 5º and 15º of valgus [27, 28, 29, 30, 31].

Due to the fact that the axis of a cubital joint (while being bent and unbent) constitutes a secant line of the brachiocephalic-forearm angle, the axes of both, an arm and a forearm are parallel and overlap each other when the cubital joint is completely bent. [27, 28, 29, 31]. Any dysfunction of the brachiocephalic-forearm angle results in the disturbance of the above mentioned ratios, which means that an arm and a forearm position against each other at a slight angle [27, 29, 31]. As far as it has been found in professional literature so far, the only relationship that can be undoubtedly proved, is the one between epicondyle of the humerus fracture and a cubital joint deformity, varus or valgus [7, 15, 16, 17, 18, 19, 21, 22, 24, 10, 32]. However, the pathomechanism of the brachiocephalic-forearm angle change still arouses a number of controversies.

The most frequently observed deformity after epicondyle of the humerus fracture is a formation of a varus cubital joint - lat. *cubitus varus* [15, 33, 16, 17, 19, 21,22, 32].

Photo 1 .A patient E.H.(hist.No.483/95) aged 16. Varus deformity (30º) after epicondyle of the right humerus fracture.

The opinion that can be sometimes found in literature, is that any decrease observed in the brachiocephalic-forearm angle value, gives the basis to talk about a varus cubital joint [28, 33, 16, 19, 22, 23].

Another varus deformity that is relatively often observed, is the one in which the brachiocephalic-forearm angle value increases. However, the reason causing the above described deformities still remains a disputable issue [18, 23, 24, 10].

Some authors believe that the initial injury destroys the growth cartilage of the epiphysis of a distal end of the humerus [34, 35, 36, 18, 37, 38, 3, 39, 10, 11].

Others think that this kind of deformity is the effect of insufficient replacement, in particular, allowing internal rotation and displacement of a paracentral distal bone fragment [40, 41, 16, 42, 17, 19, 21, 24]. However, the opinion of the latter can be relatively easily disproved, since the above described deformity of the brachiocephalic-forearm angle happens to occur also in case of fractures lacking any displacement [35, 36, 37, 43, 10].

Aim

All possible deviations from standard values after epicondyle of the humerus fractures may be caused by various factors. A complicated anatomical structure of a humerus and an injury happening at the age when child bones are in the period of a very fast growth, make these factors impossible to be clearly determined.

The subject matter of this study was to determine the deviations from standard that are most likely to be observed after this type of fractures, as well as the factors strongly affecting the further consequences of epicondyle of the humerus fractures. In order to make the assessment of the methods of treatment applied to heal kind of fractures relatively objective, the injured cubital joints were examined a long time after the injury, when the process of treatment had already been completed.

During the study, the analysis of the age structure of the examined group of patients and its influence on the observed departures from the limb axis together with further problems with flexing the joint, was made. The patients' sex and the side on which the injury took place, were determined. Another important aim of the study was to determine the type of the injury leading to epicondyle of the humerus fracture in children, as well as to find mutual relationship between the type of the injury and the further possible consequences of the fracture.

It was also essential to find out the incidence of the occurrence of a permanent defect of cubital joints and compare the findings with those obtained after examining the healthy joints. The analysis also concerned the incidence of the occurrence of various undesired consequences caused by epicondyle of the humerus fractures, especially the limb axis deviation, i.e. brachiocephalic-forearm angle disorder (*cubitus varus, cubitus valgus*)

Material and methods

282 patients, suffering from the displaced epicondyle of the humerus fractures, hospitalised in the Pediatric Surgery Ward of T. Marciniak hospital in Wrocław in the years 1990-95, constituted the material for the analysis in this study. That time, the total number of children hospitalised because of the injury of a cubital joint equaled 488. 57.9% of the cases

were the ones of epicondyle of the humerus fractures. 282 of those patients were diagnosed with the fractures showing bone displacement, i.e. according to a three-stage classification of fractures, these were the cases of the second or third stage.

- 4 cases of the compound fractures (1.4%)
- 7 cases of flexion fractures (2.5%)

The group of hospitalised children consisted of 83 girls, (29.1%) and 199 boys (70.9%). 101 of the recorded fractures were these of the right upper extremity (35.8%), the remaining cases, i.e. 181 fractures were the ones of the left upper extremity (64.2%).

The whole group of the injured children that was analysed in the study, was divided into three categories, depending on their age:

- Children between 1 and 5 years of age – 81 patients (28.7%)
- Children between 6 and 10 years of age – 144 patients (51.1%)
- Children over 10 years of age – 57 patients (20.2%)

The average age of the children treated because of a displaced epicondyle of the humerus fracture, turned out to be 7.7 years (standard deviation – 3.3 years)

In most cases, the mechanism causing the fracture was based on an ordinary one level fall, actually observed in 52.3% of children.

Next distinguished group of injuries were the ones caused by two level falls (e.g. falls from the height) all resulting in epicondyle of the humerus fractures - 34.5%.

Road traffic accidents were the causes of epicondyle of the humerus fractures in case of 12.5%.

Other causes leading to epicondyle of the humerus fractures were found in only 2 cases (0.7%).

Various methods of treating epicondyle of the humerus fractures were used. In cases of 231 children (81.9%) conservative treatment was applied, which means that the injuries were treated by means of replacement and plaster cast fixation. Treatment with the use of traction was applied in 19 cases of epicondyle of the humerus fractures (6.7%). 14 cases (5.0%) were treated by means of replacement and internal fixation with the use of either pins or screws. Surgical treatment was applied in all cases of compound fractures accompanied by the damage of nerves and blood vessels. The total number of fractures treated surgically amounted to 18 (6.4%).

While analysing the methods of treatment, the time of bone fragments immobilisation in case of epicondyle of the humerus fractures together with the period of using a traction, were also taken into consideration. On average, the child treated by means of a particular method, had to wear a plaster cast for 24.7 days. The longest time of immobilisation amounted to 49 days, whereas the shortest to 7 days (standard deviation – 6.2 days).

The time of treatment with the use of a traction was also analysed. It turned out that, on average, the traction was used for 13.8 days (standard deviation – 3.8 days). The longest observed period was 22 days and the shortest 6 days.

The value of the brachiocephalic-forearm angle, at its complete extension, was measured by means of a protractor during the orthopedic examination. The right value of the

brachiocephalic-forearm angle was defined as 15º of valgus. The deviation of the humerus from 180º towards the central line of the body was labelled as varus.

The analysis of the group of patients who underwent control examination

The control examination comprised 101 patients. The examination was conducted between November 1999 and July 2001, i.e. between 4 and 11.5 years after the injury had taken place. The examined patients were between 8 and 23 years old.

The age of these patients at the moment they got injured looked as follows:
- between 1 and 5 years of age – 25 children (24.8%)
- between 6 and 10 years of age – 56 children (55.4%)
- over 10 years of age – 20 children (19.8%)

Epicondyle of the humerus fracture was diagnosed in case of 29 girls (28.7% of all patients), whereas the majority of children with the above mentioned injury, were boys – 72 cases (71.3%).

Epicondyle of the left humerus fractures were found in case of 65 children (64.4%), and only 36 cases (35.6%) showed epicondyle of the right humerus fractures.
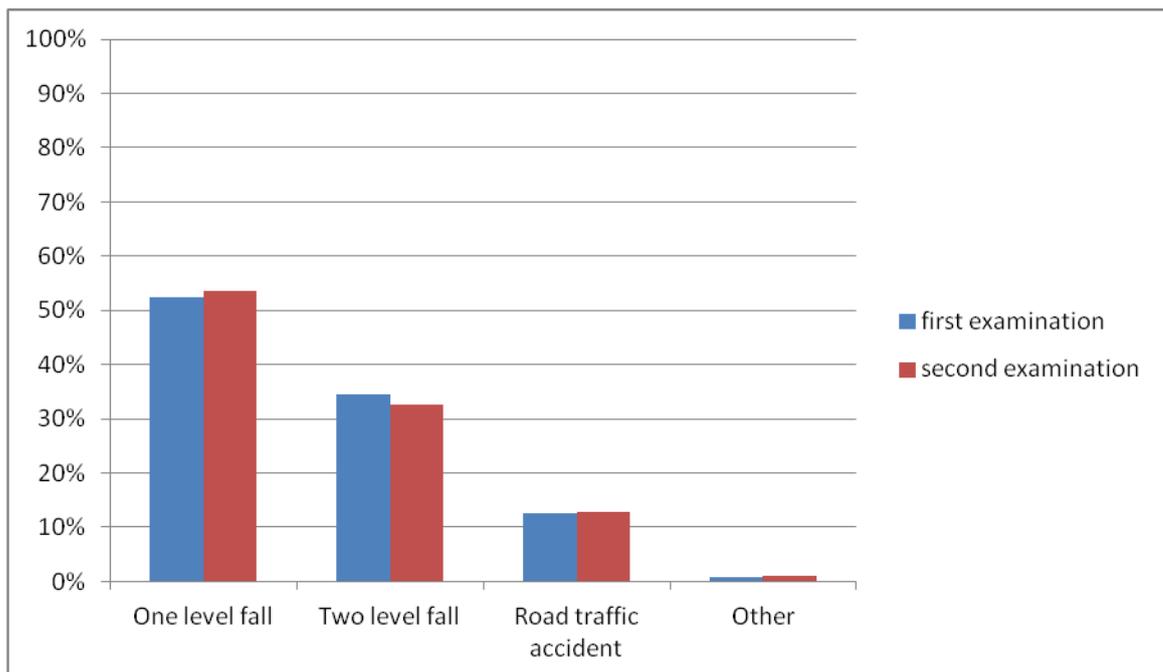

Figure 1. Mechanism causing injury and leading to epicondyle of the humerus fracture

In the group of children who took part in the control examination, the following methods of treatment were applied:
- replacement and plaster cast fixation - 81.2%.
- a traction followed by a plaster cast - 5%.
- internal immobilisation of bone fragments - 5.9%.
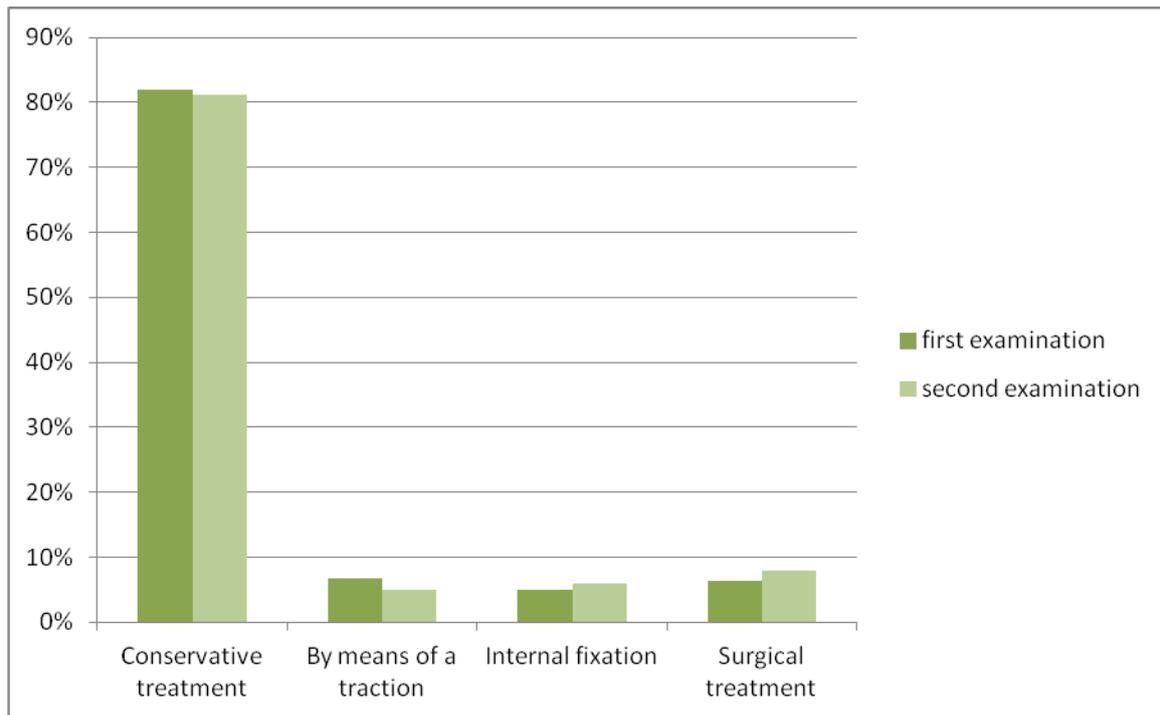- surgical treatment - 7.9%.

*Figure 2. Methods of epicondyle of the humerus fractures treatment*

9 children in this group (8.9%) were found to suffer from some complications, such as a nerve damage. In 4 cases (3.9%), the complications regarded a radial nerve, in 3 cases (2.9%) a median nerve and in 2 cases (1.9%) a cubital nerve.

Vascular complications were discovered only in one case regarding the damage of a humeral artery. This appeared to be 1% of all the patients who took part in the control examination.

Comparing the results obtained in both groups, it must be admitted that the number of patients who took part in the control examination, constitutes the representative group of all the cases of epicondyle of the humerus fractures treated in the Pediatric Surgery Ward in the years 1990-1995.

Results

In the examined group of patients, the deviation of the brachiocephalic-forearm angle of the injured humerus was observed in 73 children (72.3%). A varus deformity was found in case of 14 patients (13.9%) and the brachiocephalic-forearm angle of the value of 180º (*cubitus rectus*) in case of 18 (17.8.%). The decrease in the brachiocephalic-forearm angle value, but within the range of valgus, was observed in case of 18 children, which is 17.8% of all cases. The increase of a cubital joint valgus was found in 23 cases (22.8%).
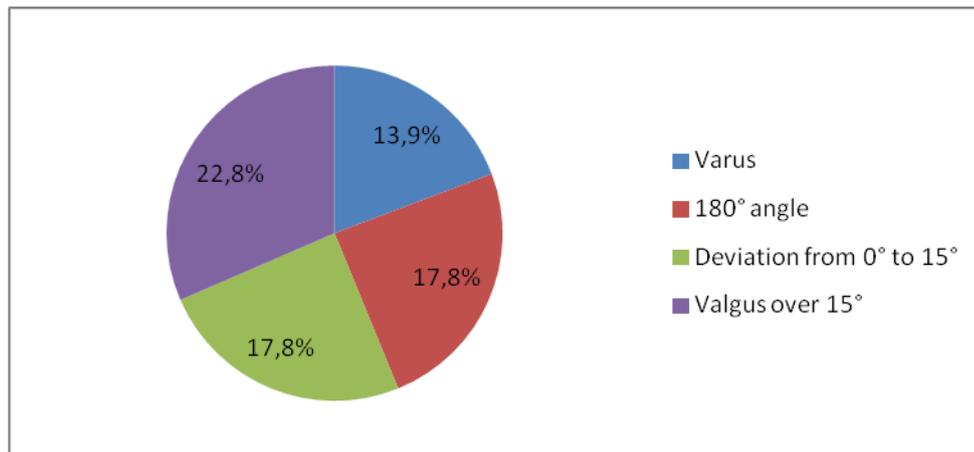
Figure 3. Number of patients showing different values of the brachiocephalic-forearm angle in comparison to the control group

Depending on the child's age at the time of injury, the brachiocephalic-forearm angle acted as follows:

Deformity	Patients' age
	Average [years]
Right angle	7.9
Varus	7.2
180° angle	8.1
Deviation from 0° to 15°	8.2
Valgus	8.0

Table 1. The change observed in the brachiocephalic-forearm angle value in relation to the patient's age at the time of injury

The age of children from the earlier created groups was compared, but no statistically significant differences were found (p>0,05).

Depending on the type of injury, the change of the brachiocephalic-forearm angle value acted as follows - only one level falls, two level falls and road traffic accidents were analysed.

The relationship between age of children and gender was also compared. Both variables are of a qualitative nature, so the chi-square test was used. The analyzes assume a significance level of 0.05. This means that the statistical significance of the test at the level less than 0,05 allows the null hypothesis to be rejected (thus allowing for the existence of a dependency between the variables).

The following test result was obtained:

Age	Gender	
	Female	Male
1 to 5	22,0%	31,2%
5 to 10	54,9%	49,7%
Over 10	23,2%	19,1%

Table 2. The relationship between age and sex of patients.

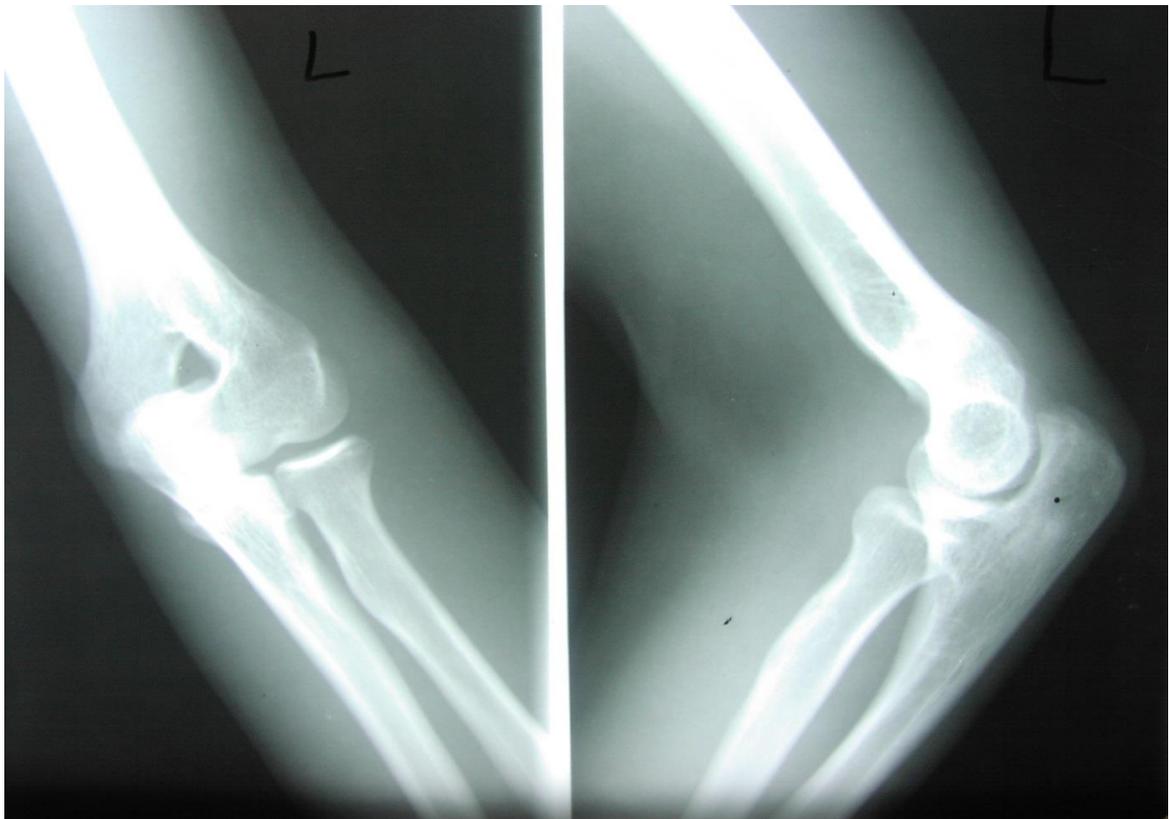No correlation exists between variables. The result is p> 0.05. The same variable in the control group was as follows:

Photo 2. Patient J.J.(hist. No 101/92) age 18. The value of the brachiocephalic-forearm angle 180° after epicondyle of the humerus fracture

	One level fall	Two level fall	Road traffic accident
Angle without deviation	14	8	6
Varus	8	7	2
Angle 180°	8	8	1
Angle between 0° and 15°	11	4	2
Valgus	12	8	2

Table 3. The change of the brachiocephalic-forearm angle value depending on the cause of injury

The type of injury observed in the above mentioned groups was compared, but no statistically significant differences were found (p>0,05).

Depending on the treatment applied, the change of the brachiocephalic-forearm angle value looked as follows:

Deformity	Conservative treatment	Treatment by means of a traction	Internal fixation	Surgical treatment
Angle without deviation	22	3	1	2
Varus	10	3	0	1
Angle 180°	12	4	0	2
Angle between 0° and 15°	10	4	3	1
Valgus	16	3	2	2

Table 4. The change of the brachiocephalic-forearm angle value depending on the treatment applied

An analysis was also made to verify the relationship between the type of fall and the injured limb. Both variables are of a qualitative nature, so the chi-square test was used. This test is used to analyze relationships between qualitative variables. The analyzes assume a significance level of 0.05. This means that the statistical significance of the test at the level less than 0,05 allows the null hypothesis to be rejected (thus allowing for the existence of a dependency between the variables).

The following test result was obtained:

			Kind of fall		
			One level fall	**Two level fall**	**Road traffic accident**
Uper extrenity	**Right**	**N**	37	47	16
		%	25,2%	48,5%	45,7%
	left	**N**	110	50	19
		%	74,8%	51,5%	54,3%
Overall		**N**	147	97	35
		%	100,0%	100,0%	100,0%

Table 5. The relationship between the type of fall and the injured limb.

There is a relationship between variables. The result is p <0.05. This means that the assumed hypothesis can be accepted because it has been confirmed in the studies conducted.

The same variables in the control group were as follows:

			Kind of fall		
			One level fall	Two level fall	Road traffic accident
Uper extrenity	Right	N	8	5	2
		%	14,8%	15,2%	15,4%
	Left	N	46	28	11
		%	85,2%	84,8%	84,6%
Overall		N	54	33	13
		%	100,0%	100,0%	100,0%

Table 6. The relationship between the type of fall and the injured limb.

No correlation exists between variables. The result is p> 0.05. This means that the assumed hypothesis should be rejected because it was not confirmed in the studies conducted.

The methods of treatment applied in the above mentioned groups were compared, but no statistically significant differences were found (p>0,05).

Having examined all symmetrical extremities, valgus was observed in case of 89 patients, which is 88.1% of all cases, *cubitus rectus* in 11, which is 10.9%, and varus in 1 case, which is only 1%. The average value of the brachiocephalic-forearm angle amounted to 8.5º, for girls, on average this value reached 11.4º, and for boys – 7.2º.

Photo 3. Patient J.T.(hist. No 183/92) age 11. Valgus of a cubital joint 6 weeks after epicondyle of the humerus fracture.

Conclusions

1. Epicondyle of the humerus fractures appear to constitute 57.9% of all injuries of a cubital joint observed in children. Boys happen to suffer from this type of injury more often – 70.9% of all cases, and the fracture usually concerns a left upper extremity – 64.2%. The average age of the injured children is 7.7 years, and the most frequently observed cause of epicondyle of the humerus fracture is one level fall – 52.2%.

2. The deviation of the brachiocephalic-forearm angle was found in 72.3% of cases. The most frequently observed deformities were the ones showing the features of valgus – 22.3% of all cases. A varus cubital joint was observed in 13.9% of the patients. Low rate of the observed varus deformities was the result of the measuring method applied in the study. In case, each deviation from the right angle is registered, the rate of the observed cases of a varus cubital joint increases to 49.5%.

Discussion

According to the data collected from various sources, the frequency of epicondyle of the humerus fractures occurrence in relationship to the occurrence of other types of a cubital joint injuries, oscillates between 50 and 65%. Similar values concerning epicondyle of the humerus fractures in children appear in the materials collected by the authors of this study themselves [9, 18, 31, 39, 110, 114, 119].

In this study, the distinction between sexes seems to be very similar to the one presented in the works of Cheng and associates as well as Weinberg and associates, where the percentage of the injuries observed in case of boys oscillates between 65 - 70%, and in case of girls it appears to be on the level between 30 and 35%. [18, 114] Some authors relate this characteristic distinction between sexes to the higher level of boys' mobility at the age when most epicondyle of the humerus fractures happen [18, 31, 39].

The patients' age range, presented in the analysed material, complies with the one described by other authors in their works. The average age of the examined children, which turned out to be 7.7 years, reflects the age reported in national and foreign literature [18, 31, 114]. According to Nacht and associates, the main reason why epicondyle of the humerus fractures happen most frequently in children at the age of 7-8, is remodelling of cartilaginous epiphysis of a distal humeral bone, which partly loses its cartilage flexibility and, at the same time, the bone is not strong enough yet [81]. According to Fansworth, the main reason why epicondyle of the humerus fractures happen most frequently in children at the mentioned above age, is „exceeding the critical fracture angle" of the metaphysis due to a hyperextension of the extremity receiving the high force impact of the fall [31]. The same argument is used by Weinberg and associates to explain why a one level fall is most frequently considered to create the broadest group of injuries that lead to epicondyle of the humerus fractures [114].

The mechanisms causing epicondyle of the humerus fractures, presented by the authors of this study on the basis of the material they collected, are in compliance with mechanisms found in the works of other authors [18, 31, 39, 110, 114]. As it was mentioned earlier in the text, the main cause of such injuries is a one level fall (on a straight upper extremity). Other types of injuries are observed less frequently [18, 31, 39, 110, 114].

The opinions concerning the occurrence of epicondyle of the humerus fractures of either left or right extremity found in international literature are consistent [18, 31, 114]. In majority of reports, fractures of a left humeral bone take the dominant position. According to Fansworth the reason for this is that the majority of human beings are right-handed, thus the muscles of the left upper extremity are weaker and do not support the cubital joint well enough, in case of the fall [31]. According to Cheng, the factor responsible for statistically higher number of epicondyle of the left humerus fractures, is a „protective instinct" presented by right-handed people while incidentally falling [18].

As it was mentioned above, various methods of treatment of broken extremities can be applied. Some authors definitely prefer a method of conservative treatment [4, 16, 17, 53, 68, 77, 86, 102, 113, 116]. According to literature, in this group, the way of replacement, immobilisation and its duration, all comply with the method of treatment the particular author uses. On average, according to literature, immobilisation time lasts about 21 days [4, 16, 17, 53, 69, 114]. According to Lala and associates, the broken extremity remained in plaster cast for 6 weeks. However, the material presented by the authors included 2 cases of ectostosis, which was not recorded in the examined material [41, 61].

According to literature, the method of treatment with the use of an overhead traction is recommended by numerous authors [19, 24, 33, 45, 88]. According to Palmer and associates, this method is very likely to lift internal rotation in the frontal plate of the distal bone fragment, thus reduce the incidence of the brachiocephalic-forearm angle disorder [88]. The

duration of treatment with the use of this method was very similar in majority of authors and, on average, amounted to 13.8 days [19, 24, 45,88].

Internal fixation, just like other methods mentioned above, was used according to the reports of other authors [29, 30, 35, 63, 65, 66, 81, 92, 117, 123]. In this kind of treatment, the method described by Fowles and Kassab in 1974, was used [30]. This method is to eliminate the possibility of secondary displacement of bone fragments, which is often found to be the reason why the conservative treatment method fails [29, 66, 81, 117, 121]. Many authors recommend to leave surgical treatment to cases of complicated fractures accompanied by nerves and blood vessels damage and compound fractures [4, 29, 33, 45, 53, 121]. The opponents of this method claim that a surgery may result in the decrease in the mobility range of the treated limb [3, 90, 99].

The consequence of epicondyle of the humerus fracture that is considered most serious, is the deviation of the brachiocephalic-forearm angle from the natural one [9, 21, 25, 28, 32, 47, 51, 54, 62, 74, 87, 103, 122]. Most frequently, the value of this angle shows the features of a slight valgus therefore, according to, e.g., Ippolito and associates, in a healthy extremity it amounts to 12.6°, on average, and the range of the measurement goes between 5° and 20° [47]. In Aebi's opinion, the valgus of a cubital joint in men lies in the values between 0° and 14°, on average 6.5°, and in women between 4° and 20°, on average 14° [1]. L. Smith says: in boys the value is between 0° and 11°, on average 5.4° and in girls, between 1° and 12°, on average 14° [104]. In the group of the measurements of the healthy extremity presented in this study, 88.1% of cubital joints on the healthy side showed valgus deviation, in 11% of cases, the brachiocephalic-forearm angle value accounted to 0°, and in one case a varus cubital joint was observed. The problem of measuring the brachiocephalic-forearm angle is raised by quite a number of authors [1, 8, 14, 25, 40, 100]. Methodology that seems to be best described in literature, is the methodology based on roentgenograms with anteroposterior projection. In some studies, the brachiocephalic-forearm angle value is expressed in the way described by Beals [8, 25], some other authors prefer the method elaborated by Harbauer [6, 40, 16, 87], and the remaining ones do not mention any method of measuring this angle at all [9, 21, 28, 32, 47, 51, 74]. Unfortunately, radiological measurements are connected with a relatively big number of mistakes and inconveniences, such as, e.g. the necessity of using a big format X-ray plate and the great possibility of obtaining inaccurate assessment of this angle, especially when problems with appropriate extension of the joint appear. According to Dowd and associates, the measurement done by means of a goniometer differs from the radiological measurement by less than 5° [25]. Taking into consideration the fact that excessive X-raying of either healthy (control group) or post fracture joints may be harmful, it seems that the advantages of measuring the brachiocephalic-forearm angle value by means of an orthopedic goniometer predominate its disadvantages [25, 81, 93, 116].

According to various studies, a varus cubital joint is the most frequently observed deformity after epicondyle of the humerus fractures [9, 21, 25, 28, 32, 47, 51, 54, 62, 74, 87, 103, 122]. The incidence of the occurrence of this kind of deformity ranges between 30% according to Beals and 57% according to Sandegaard [8, 99]. Such a big difference observed in the obtained results is caused by numerous factors: a method of treatment, a child's age and the fact of leaving displaced bone fragments not reduced. Unfortunately, no clear-cut definition of a varus cubital joint can be found in literature. Some authors believe that each

deviation of the brachiocephalic-forearm angle value towards varus deformity should be included into the group defined as *cubitus varus* [14, 25]. Others think that the deformity can be classified as a varus cubital joint if the brachiocephalic-forearm angle value exceeds 0º [99, 116, 122]. The reasons leading to this kind of deformity still arouse numerous controversies among different authors [6, 9, 11, 47, 116]. Historically, it was Siris, who as the first, in 1939, claimed that the main reason causing a varus deformity of a cubital joint was a not reduced paracentral displacement of a distal bone fragments [101]. In 1940, Brewster and Karp showed the difference between the results in the length of a humeral bone, depending on the fact whether it was measured on its medial or lateral side [11]. According to these authors, this observation was to prove a growth stimulation of a lateral condyle of a humeral bone, i.e. osteogenesis of a capitulum and a lateral epicondyle of the humerus, which led to a varus deformity of a cubital joint. A similar opinion concerning growth mechanisms was expressed in 1953 by Attenborough who claimed in his work that the factor responsible for a varus cubital joint is the damage of a growth cartilage in the metaphysis of the humerus [5]. In 1978, Palmer and associates described the formation of a varus deformity of a cubital joint as the effect of a growth disturbance after epicondyle of the humerus fracture [88]. Another group of authors denies the participation of the growth factor as the reason causing a varus deformity of a cubital joint [32, 69, 101, 104, 116]. This group of opinions, similarly to what Siris says, is dominated by the claim that the main reason leading to a varus cubital joint is the wrong, non-anatomic reduction of bone fragments that happen to appear in epicondyle of the humerus fractures. In 1955, Madsen and in 1959, French, published their findings concerning the role of displacements of a distal bone fragments in internal rotation observed in epicondyle of the humerus fractures [32, 69]. In 1943 , Aitken, then in 1951 King and Secor, in 1960, L. Smith, in 1972 D'Ambrosia and in 1976, Lund-Kristensen and Vibild, all, in their publications, presented the view that the reason causing a varus deformity of a cubital joint is a medial angular displacement in a frontal plane of a distal bone fragment [2, 21, 54, 68, 104]. In this group of opinions (most commonly found in literature) there is also the view presented by L. Smith, who, in his study, described a precise pathomechanism responsible for the occurrence of a varus deformity of a cubital joint after epicondyle of the humerus fracture [104].

According to literature, a valgus deformity of a cubital joint is much less likely to occur [6, 62, 71, 99, 116]. The reasons leading to this type of deformity are quite similar to those causing a varus deformity of a cubital joint - cubitus varus [5, 11, 32, 69, 86, 101]. The difficulty of comparing the obtained results, basically lies in the lack of a precise definition of a valgus deformity of a cubital joint in the available literature [6, 14, 25, 62, 121]. A relatively high ratio of valgus deformities of a cubital joint found in the study, may be the effect of the applied research method, where each, even the slightest difference between the brachiocephalic-forearm angle value of the injured extremity and the healthy one, was registered.

In the authors' opinion, a varus cubital joint seems to be only an „aesthetic defect", which hardly ever or never disturbs the right functioning of an extremity [14, 51, 116]. Any surgical treatment of this type of a defect is recommended to be put off, due to recurring of the deformity in the course of the child's growth process [32, 47, 51, 54, 68, 74, 87, 104, 122].

An interesting observation was made by Ippolito, who after operating on patients with a varus cubital joint, in some cases discovered the loss of a corrected angle of the axis of the extremity he operated on, after its growth process ended [47].

The issue that attracts attention in the results obtained in the course of the study, is a relatively high ratio of the brachiocephalic-forearm angle disturbances observed in relation to a „healthy" side – 72.3%.

The ratio of varus deformities (13.9%) presented in the study, turns out to be lower than the one described in literature. It is probably the effect of the applied measuring method, which classified as varus deformities only these cases that exceeded the value of 0°. However, when the values of ratios representing varus deformities and "varus deviations" were added, the final result reached the level of 31.7%. Thus, it can be said that this result fully corresponds with the results found in the works of numerous authors [6, 9, 25, 42, 79, 87, 104].

In their publications, various authors describe the relationship between children's age, methods of treatment and the incidence of the occurrence of the brachiocephalic-forearm angle disturbances after epicondyle of the humerus fracture [6, 75, 88, 102, 106, 115]. According to the supporters of the opinion that the deformity of the brachiocephalic-forearm angle is affected by the child's growth process, the younger the child, the deeper the deformity [5, 11, 88]. On the other hand, the supporters of the view that the quality of bone fragments replacement affects the brachiocephalic-forearm angle deviations, claim that some methods of treatment (a traction, internal fixation, surgery) are very likely to decrease the incidence of the occurrence of the brachiocephalic-forearm angle deviations [14, 22, 24, 29, 30, 35, 45, 53, 61, 66, 81, 88, 103, 112].

In the conducted comparative analysis of the brachiocephalic-forearm angle values, the correlation between the injured child's age, the method of treatment and the type of injury causing epicondyle of the humerus fracture, was not found.

In the examined group of children, the influence of physiotherapeutic treatment on the brachiocephalic-forearm angle values and a range of motion in a cubital joint, was not observed. Only in case of children over 10, who underwent physiotherapy, statistically significant increase in the value of an arm circumference was observed.

Many classifications were introduced in order to assess the effects of epicondyle of the humerus fractures [6, 19, 24, 29, 45, 78, 121]. All these classifications assess the values in the objective, measurable way, i.e. most frequently they focus on the brachiocephalic-forearm angle values and the range of motion in a cubital joint (bending – unbending). According to these classifications, the group including undesired effects comprises the patients who show the symptoms related to functioning of a peripheral nervous system, i.e. pains, paresis or disturbances of sensation. Classifications created by such authors as: Mitchel and Adams, Flynn, Dodge and Hoyer belong to the group of the most well-known ones [24, 29, 45, 78].

Comparison of the subjective assessment of the patients with the objective assessment of the brachiocephalic-forearm angle values, the range of motion in a cubital joint and the presence of neurological symptoms, proved that children with neurological problems were found in all the response groups and the range of the brachiocephalic-forearm angle values together with the range of motion in a cubital joint, oscillate between right values and these showing a huge deficit of mobility. Physical activity of children observed in all groups is also comparable.

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