EXERCISE AND QUALITY OF LIFE
Volume 2, No. 2, 2010, 51-62
UDC 616.717-001.5-053.2:615.8

Research article

EFFECTS OF REHABILITATION TREATMENT AND CHARACTERISTICS OF ELBOW CONTRACTURE AFTER SUPRACONDYLAR FRACTURES IN CHILDHOOD

Maja Divjaković and Aleksandra Mikov*
Faculty of Medicine Novi Sad
Institute for Children and Youth Health Care of Vojvodina
Clinic for Children Habilitation and Rehabilitation Novi Sad

Abstract

Supracondylar fractures of humerus are the most frequent arm fractures in childhood. Complications of these fractures most often take the form of elbow contractures. The aim of this paper was to determine effects of rehabilitation treatment and characteristics of elbow contractures. During five-year period (2005-2010), 61 patients with posttraumatic elbow contracture were treated at the Institute for Children and Youth Health Care of Vojvodina. Flynn's three-grade scale was applied to determine the elbow mobility level, prior to treatment and at its end. After the completed physical treatment, there is a highly statistically significant difference in terms of increased flexion and extension of elbow ($p<0.0001$). In 90.16% children, the result was satisfactory upon completed physical treatment. By means of combined application of different forms of physical therapy, treatment results of elbow contractures after supracondylar fractures have significantly improved.

Keywords: rehabilitation, contracture, elbow, supracondylar fracture, children

Introduction

Elbow fractures account for 7-9% of all fractures at childhood age (1), whereas supracondylar fractures of humerus represent the most frequent elbow fractures with frequency of 60-75% (Gajdobranski, Marić, Tatić, Đurić-Nosek i Mikov, 2003; Jandrić, 2007; De Pellegrin, Brivio, Pescatori, & Tessari, 2008; Solazzo, Bertolani, & Traina, 2000; Čekanauskas, Degliute, & Kalesinkas, 2003; De Coulon, Ceroni, De Rosa, Pazos, & Kaelin, 2005; Carmichael, & Joyner, 2006; Foead, Penafort, Saw, & Sengupta, 2004; Patrice Eiff, & Hatch, 2004; Ayadi, Trigui, Tounsi, & Ellouze, 2006). Most of these fractures occur in children up to 10 years of age, most often between 5th and 8th year of age (Gajdobranski et al., 2003; De Pellegrin et al., 2008;

* Corresponding author. Faculty of Medicine Novi Sad, Institute for Children and Youth Health Care of Vojvodina, Clinic for Children Habilitation and Rehabilitation Novi Sad, Hajduk Veljkova 3, 21000 Novi Sad, e-mail: driva@eunet.rs

Solazzo et al., 2000; Arena, Vermiglio, Terranova, Vermiglio, & Arena, 2006). High incidence of these fractures at childhood age is explained by increased laxity of collateral ligament structures at this age, immaturity of the structure of supracondylar region of humerus and specific relation of bone structures in the joint during hyperextension within elbow joint (Gajdobranski et al., 2003). Sex-dependant frequency of supracondylar elbow fractures indicates that these fractures are more frequent in boys than in girls (De Pellegrin et al., 2008; Solazzo et al., 2000; Arena et al., 2006; He, Zhang, & Tan, 2009), whereas in terms of sides, they tend to be more frequent in left elbow due to its defense function during fall (58%), as opposed to the right one (42%) which is more frequently used for catching (He at al., 2009).

Supracondylar fractures of humerus are classified as extensory and flexion types, depending on the mechanism of occurrence.

Extensory type of supracondylar fractures of humerus is far more frequent (up to 95%), and it occurs while falling on the palm when the elbow region of the arm is extended, and arm is in abduction (Gajdobranski et al., 2003; Patrice Eiff, & Hatch, 2004; Arena et al., 2006; Gris, Van Nieuwenhove, Gehanne, Quintin, & Burny, 2004). Supracondylar fractures of humerus can be classified according to several different classification systems (Gartland 1959, Holmberg 1945, Von Laer 1997, Wilkins 1996), based on the appearance of radiograms (Platt, 2004). Currently, the most frequently applied one is Gartland's classification which is based primarily on the extent of dislocation. According to this classification, and on the basis of radiograms, supracondylar fractures of humerus are divided in three degrees: I degree without dislocation of fragments, II degree with dislocation of fragments being still in contact (back cortex is intact), and III degree with a complete dislocation of fragments without cortical contact (most frequent type >50%). III degree of supracondylar fractures of humerus occurs when the extended elbow is exposed to rotation. If there are any clinical signs of neurovascular jeopardy, then this fracture is classified as supracondylar fracture of humerus of IV degree (Gajdobranski et al., 2003; Čekanauskas et al., 2003; Patrice Eiff, & Hatch, 2004; Arena et al., 2006; Temple, Bache, & Gibbsons, 2006; Kaiser, Kamphaus, Massalme, & Wessel, 2008).

Flexion type of supracondylar fractures of humerus is considerably less frequent, and it occurs as a consequence of a direct stroke on the back elbow region (Gajdobranski et al., 2003; Arena et al., 2006; Temple et al., 2006; Banović, 1989). These fractures are mostly open due to the effect of direct force on the back lower part of upper arm (Banović, 1989).

In the clinical features, the predominant symptoms are pain and oedema in elbow joint region, haematoma, sensitivity of both condyles and classical S-shaped deformity in elbow region (Gajdobranski et al., 2003; Patrice Eiff, & Hatch, 2004). The relationship between olecranon and epycondyle is not impaired, for which reason these fractures are different from elbow luxation. During clinical examination, it is necessary to pay attention to the condition of soft tissues and a neurocirculatory finding due to a high percentage of associated injuries (Gajdobranski et al., 2003). Oedema and bleeding, if marked, may damage artery blood supply of forearm (Banović, 1989). Pulse a. radialis may be weak or absent, for which reason it should be checked permanently (Patrice Eiff, & Hatch, 2004; Banović, 1989; Griffin, Walsh, Markar, Tang, Boyle, et al., 2008). It is necessary to control motor i.e. sensitive deficit due to the possibility of injury of nerves (n. radialis, n. medianus, n. ulnaris).

Within the supracondylar fractures in children, different complication may occur:

- Deformity
- Vascular injuries (occlusion of brachial artery, compartment syndrome, Volkmann's contracture)
- Neurological injuries (pareses or paralyses of n. medianus, n. radialis, n. ulnaris) (Jandrić, 2007; Patrice Eiff, & Hatch, 2004).

During clinical examination, it is necessary to pay attention to possible interference of neuron-vascular structures, especially with extension fractures in which proximal fragment, when sharp can get in contact by its sharp edge with the brachial artery and n. medianus, n. radialis, and more rarely with n. ulnaris, with an immediate possibility of neuro-vascular complications (Arena et al., 2006). Lesions of nerves are, first of all, contusions, extensions, or compressions, occurring predominantly in n. medianus and n. radialis, including an accompanying reduced function of muscles innervated by them, in addition to reduction of sensibility of the relevant parts (Ayadi et al, 2006). Vascular complication may be manifested for several hours after trauma under the clinical features of "acute ischaemia syndrome", in which ischemic damages are still reversible, however, if the treatment is applied more than 4-6 hours after occurrence of the symptoms, Volkmann's syndrome is inevitable in three-week time, which is surely the most serious complication of supracondylar fractures of elbow (Arena et al., 2006; Griffin et al., 2008). Owing to a correct orthopedic treatment, Volkmannn's contracture occurs only in extreme cases nowadays (Arena et al., 2006). Among late complications, axial deviation of elbow (deformities varus-valgus) is certainly the most significant sequela (Arena et al., 2006).

Action of different factors related to injuries, diagnostics, and therapeutic interventions on cutaneous structures, soft tissue, and other structures in elbow region may result in occurrence of posttraumatic elbow contractures, as a recognizable sequela in these injuries. Posttraumatic elbow contractures with different degrees of movement reductions in elbow joint, even with functional limit in activities of everyday life, may occur after correctly applied orthopedic treatment of supracondylar fractures in children. Reduced functions in elbow joint may be followed by other neurovascular complications mentioned above (Jandrić, 2007).

The purpose of rehabilitation treatment after supracondylar fractures is to achieve painless and full mobility of the elbow joint, as well as prevention and healing of complications (Arena et al., 2006). Rehabilitation treatment should include active and actively supported exercises for joint mobilization as soon as the condition of certain tissues makes it possible. In order to prevent contractures and reduced mobility of elbow joint, patient's rehabilitation should start as soon as possible, depending on the fracture and stability of soft-tissued structures in these fractures (Tanno, Tanaka, Mukai, Hayashi, & Takenouchi, 2008). Choice and execution of the treatment will depend on the clinical features and radiogram finding of the patient (Arena et al., 2006). While in supracondylar fractures of humerus of I degree, therapeutic procedure is a uniform one (cast immobilization with forearm in pronation, during three weeks, followed by a physical treatment), therapeutic procedures in supracondylar fractures of II degree, especially III degree, are rather different. Supracondylar fractures of humerus of IV degree represent an absolute indication for an urgent surgical treatment (Gajdobranski, 2003). In rehabilitation after supracondylar fractures of humerus, different physical procedures are applied, in order to achieve functional and esthetical restoration after fracture. Medical treatment consists of a combination of active and passive therapeutic programs. Active therapeutic procedures include kinesitherapy, hydro-kinesitherapy and work therapy, whereas the passive ones include electro-therapeutic ones, hot procedures, and cold procedures (Jandrić, 2007).

Method

The sample included 61 patients treated at the Clinic for Children Habilitation and Rehabilitation of the Institute for Children and Youth Health Care of Vojvodina in Novi Sad, during 2005-2009. All patients had posttraumatic contracture of elbow with different degrees of reduced mobility in the joint that occurred after supracondylar fracture of elbow.

Assessment of effects of physical treatment in this research was performed by measuring active range of both elbows (injured and healthy one) in terms of degrees, when the patient was received, during treatment, and upon treatment completion). The degree of elbow mobility at the beginning and at the end of treatment was assessed by Flynn's three-grade scale for each patient (Flynn-1974). Satisfactory results were marked as 3, 2, and 1, whereas the unsatisfactory one was marked as 0. Mark 3 refers to the full range of elbow joint or reduction up to 5^{o}, mark 2 stands for reduced amplitude of elbow movement of 5^{o} to 10^{o}, mark 1 was equivalent to reduced movement amplitude of 10^{o} to 15^{o}. Mark 0 represents a bad therapeutic result with loss of elbow mobility for more than 15^{o}. All patients were included in the proper program of physical therapy, according to the degree of clinical finding. The treatment was initiated after removal of cast immobilisation, mostly within 5 days after removal. This program included kinesitherapeutic procedures as well as other forms of physical therapy (thermo-therapy, work therapy, interference currents, diadynamic currents, electrophoresis with potassium iodide (KJ), laser, massage with green vac apparatus, galvanic current, hydrotherapy, magnet, transcutaneous electric nerve stimulation (TENS). Physical procedures were included depending on clinical finding during treatment. Therapeutic program during treatment was adjusted according to the therapy progress.

Results

Within our sample, 61 children were treated for elbow contracture after supracondylar fracture. The sample included 41 boys (67.21%) and 20 girls (32.79%) (Figure 1). The relation between boys and girls was 2.05:1. Out of 61 children, 29 had left arm fracture (47.54%), whereas 32 had the right arm fracture (52.46%) (Figure 2).

Figure 1. Relations boys-girls.

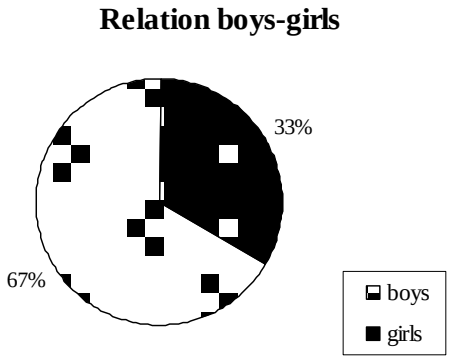


Figure 2. Relations of sides.

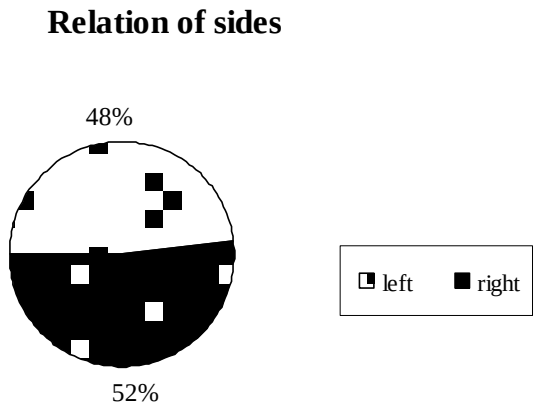


Table 1
Characteristics of the sample

Characteristics		Number
Age	**Average age (years) ± SD**	***7,31±2,91***
Average duration of rehabilitation treatment (days) ±SD		***69,92±48,91***
Average duration of cast immobilisation (days) ± SD		***24,83±7,13***
Average number of days before commencement of physical treatment after removal of cast immobilisation (days)		***4,45±3,52***
Number of children subjected to surgical treatment before commencement of rehabilitation treatment (%)		***68,85%***

Average age of patients was 7.31 ± 2.91 years. Average duration of immobilization was 24.83 ± 7.13 days, whereas duration of rehabilitation treatment was 69.92 ± 48.91 days. Physical treatment was commenced 1-12 days after removal of immobilization, i.e. average number of days before commencement of physical treatment after removal of cast immobilization was 4.45 ± 3.52 days. Before commencement of physical treatment, 42 patients were subjected to surgical procedures (68.85%) (Table 1). All patients were treated by osteosynthesis by Kirschner's needles. During the treatment, Kvengel's apparatus was applied with two patients only.

Results of treatment by physical procedures were classified as satisfactory or unsatisfactory, while elbow mobility was assessed according to Flynn. Within the range of satisfactory results, we differentiated between excellent, good, and favourable results (Table 2).

Table 2

Assessment of elbow joint mobility (Flynn)

Result		***Functional factor (loss of movement in degrees)***	***Degree***
Satisfactory	**Excellent**	0°-5°	**3**
	Good	5°-10°	**2**
	Favourable	10°-15°	**1**
Unsatisfactory	**Bad**	>15°	**0**

Table 3

Assessment of elbow joint mobility (Flynn) at the beginning and end of treatment

MARK	**Commencement of therapy**		**End of therapy**	
	Number of children	**%**	**Number of children**	**%**
3	**0**	**0**	**43***	**70,49**
2	**0**	**0**	**8**	**13,11**
1	**0**	**0**	**4**	**6,56**
0	**61**	**100**	**6**	**9,84**
TOTAL	**61**	**100**	**61**	**100**

Table 3 indicates that all children showed unsatisfactory degree of mobility at the beginning of treatment, i.e. all children were assessed by 0 according to Flynn's classification. From the same table, it can also be seen that the excellent result was recorded with 43 patients (70.49%), good result in 8 (13.11%), and favourable one in 4 patients (6.56%). Unsatisfactory result was observed with 6 patients (9.84%).

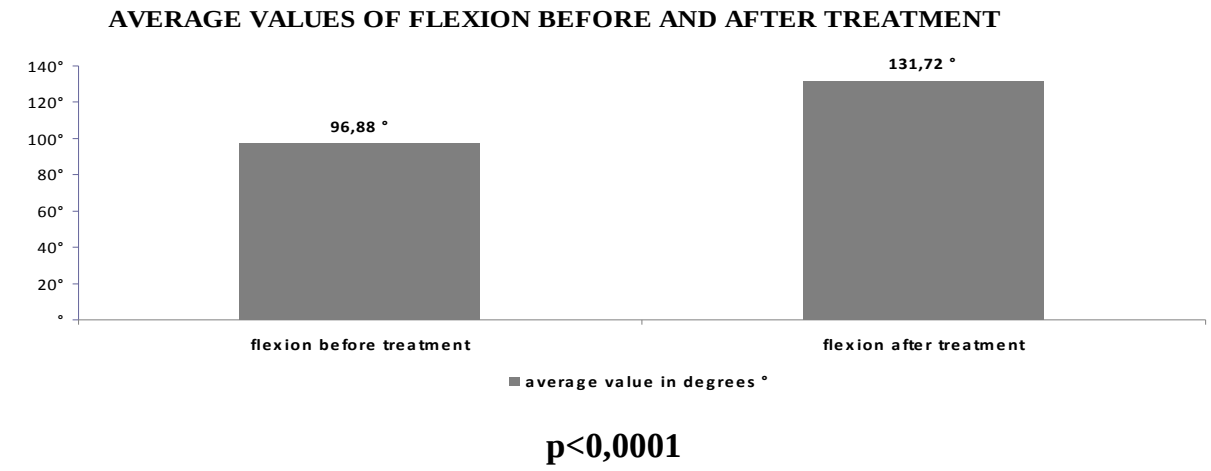
Table 4

Frequence of lesions of nerves and assessment of elbow mobility at the beginning end of treatment

Injury affected nerve	Number of patients	Assessment of elbow mobility at the beginning of e-treatment (Flynn)				Assessment of elbow mobility at the end of e-treatment (Flynn)			
		3	2	1	0	3	2	1	0
n. ulnaris	7	-	-	-	7	5	2	-	-
n. medianus	1	-	-	-	1	1	-	-	-
n. ulnaris + n.radialis	1	-	-	-	1	1	-	-	-
n. medianus + n.radialis	1	-	-	-	1	1	-	-	-
n.ulnaris+n.medianus+n.radialis	1	-	-	-	1	1	-	-	-

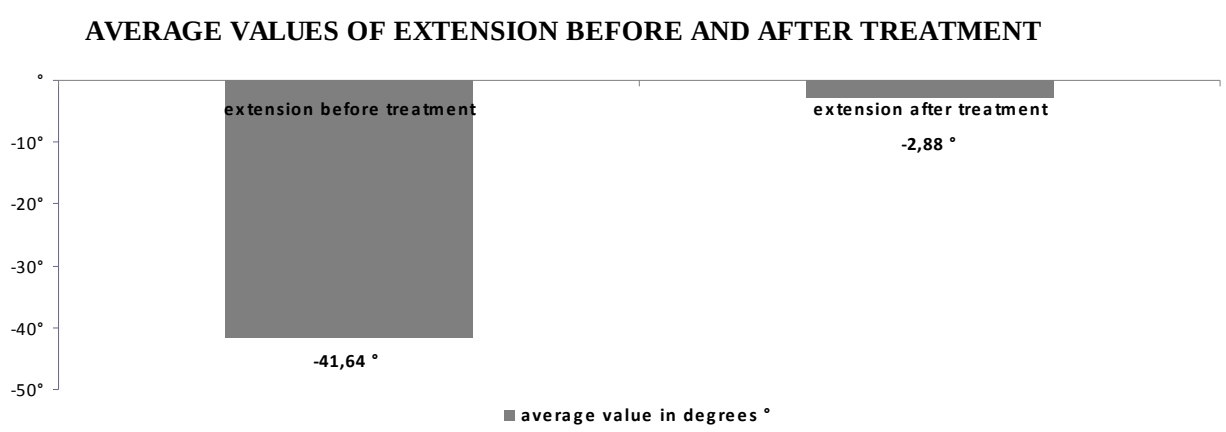
Transitory neurological injuries were recorded with 11 patients. 7 patients had lesion of n. ulnaris, 1 patient had lesion of n. medianus, 1 patient had lesion of n. ulnaris and n. radialis, 1 patient had lesion of n. medianus and n. radialis, and 1 patient had lesion of three nerves (u. ulnaris, n. medianus, and n. radialis). All patients showed satisfactory results at the end of treatment, out of which 9 patients got mark 3, and 2 patients got mark 2 (Table 4).

Figure 3. Average values of flexion before and after treatment.



p<0,0001

Figure 4. Average values of extension before and after treatment.



p<0,0001

There is a highly statistically significant difference in terms of increased elbow flexion and extension after completed physical treatment ($p<0.0001$). Average flexion value at the beginning of the treatment amounted to 96.88 degrees (96.88 ± 14.12), and after the treatment it reached 131.72 (131.72 ± 8.89) (Figure 3). The average value of extension before the treatment was -41.64 degrees (-41.64 ± 17.39), while after the treatment it was -2.88 degrees (-2.88 ± 6.47) (Figure 4).

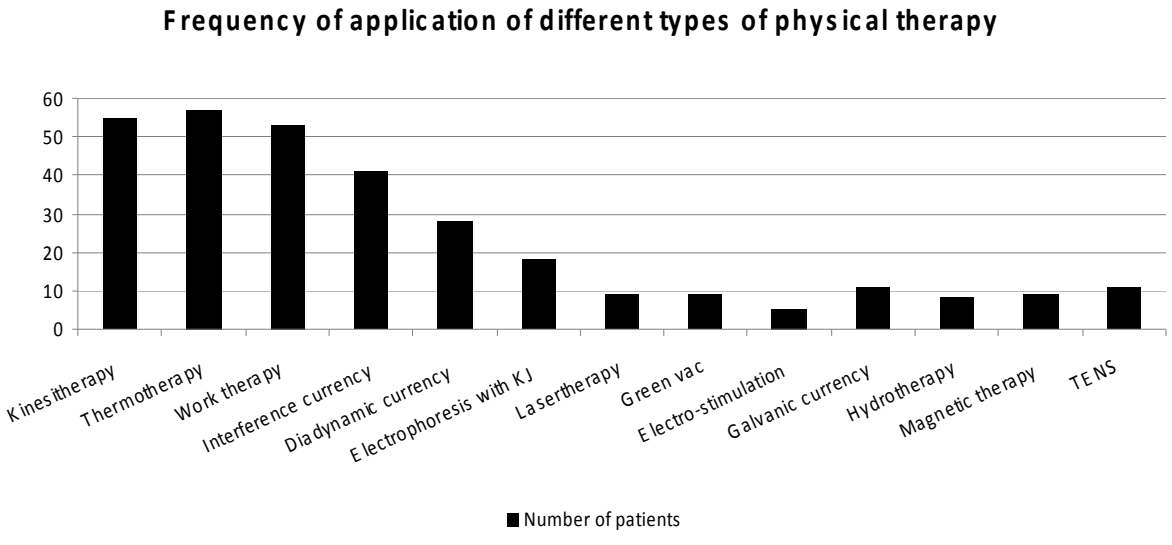
During physical treatment, different therapy types were used. Thermotherapy and kinsitherapy were applied in the highest number of patients. Sequence of applied therapies as per their frequency is the following: work therapy, therapy with interference currency, therapy with diadynamic currency, electrophoresis with KJ, therapy with galvanic currency, TENS, laserotherapy, green vac, magnetic therapy, hydrotherapy, and electrostimulation (Table 5, Figure 5).

Table 5

List of applied physical methods in treatment of contractures after supracondylar elbow fracture

Type of therapy	**Applied**		**Number of days** (for those where it was applied)	
	Num-ber	**%**	Average number of days	Standard deviation
Kinesitherapy	**55**	**90,16**	**42,25**	**42,25±38,56**
Thermotherapy	**57**	**93,44**	**20,12**	**20,12±11,86**
Work therapy	**53**	**86,88**	**18,28**	**18,28±9,73**
Interference currency	**41**	**67,21**	**10,78**	**10,78±4,59**
Diadynamic currency	**28**	**45,9**	**11,0**	**11,0±5,66**
Electrophoresis with KJ	**18**	**29,51**	**11,0**	**11,0±4,46**
Lasertherapy	**9**	**14,75**	**10,11**	**10,11±1,62**
Green vac	**9**	**14,75**	**12,22**	**12,22±3,19**
Electro-stimulation	**5**	**8,2**	**30,4**	**30,4±19,7**
Galvanic currency	**11**	**18,03**	**22,45**	**22,45±15,0**
Hydrotherapy	**8**	**13,11**	**10,62**	**10,62±4,95**
Magnetic therapy	**9**	**14,75**	**13,0**	**13,0±6,4**
TENS	**11**	**18,03**	**5,64**	**5,64±3,17**

Figure 5. Frequency of application of different types of physical therapy.



Discussion

Children age of our sample, including 61 patients with elbow contractures after supracondylar fracture, ranged between 2-14 years, amounting to average 7 years of age. This finding was in accordance with literature sources, where average age for this type of elbow fracture ranges between 6 and 8 years (Gajdobranski et al., 2003; Jandrić, 2007; Čekanauskas et al., 2003; He et al., 2009; Gris et al., 2004; Bombaci, Gereli, Kucukyazici, & Gorgec, 2000; Karapinar, Ozturk, Altay, & Kose, 2005; Sibinski, Sharma, & Bennet, 2006; Gadgil, Hayhurst, Maffulli, & Dwyer, 2005; Keppler, Salem, Schwarting, & Kinzl, 2005). In our sample, over two thirds of patients were boys, which is also in accordance with literature sources (1, 2, 5, 6, 11, 13, 20, 21, 22, 23, 24). Most children got injured due to fall during play. Such increased frequency of injuries in boys is explained by different types of games practiced by boys and girls.

Average length of rehabilitation treatment in our sample was about 70 days, whereas average duration of cast immobilization was 25 days. Period of rehabilitation treatment in our sample is somewhat longer than that found in literature sources, which was averagely 5 to 8 weeks (Jandrić, 2007; Arena et al., 2006). This can be explained by the fact that all patients in our sample had marked elbow contractures at the beginning of the treatment (according to Flynn, all of them were within unsatisfactory range), for which reason a longer rehabilitation treatment was necessary for the best possible functional recovery. Duration of cast immobilization complies with the accessible literature sources, with an average of 3 weeks (Gajdobranski, 2003; Čekanauskas, 2003; Keppler et al., 2005).

Surgical treatment of supracondylar fractures in our sample was applied in about 69% of patients. All patients were treated by the method of orthopedic reposition and percutaneous fixation of fragments, using two Kirschner's needles controlled by radiogram. In the accessible literature sources, this method is referred to as the most frequently applied one, owing to its simple application procedure and minimum invasiveness, as well as excellent results in treatment of these kinds of fractures (Gajdobranski et al., 2003; Čekanauskas et al., 2003; Arena et al., 2006; Gris et al., 2004; Karapinar et al., 2005). According to analyses of He, Zhang and Tan (2009), surgical method of placing two parallel wires proved the most efficient one since 93.18% patients treated by this method achieved positive results at the end of the treatment. In groups treated by other methods, effects were considerably lower (He et al., 2009). Some authors believe that the method of placing two parallel needles laterally only is the best method due to reduced possibility of iatrogenous nerve injury of ulnar nerve (Bombaci et al., 2005; Slongo, Schmid, Wilkins, & Joeris, 2008).

In 18% of our sample, i.e. in 11 patients, lesion was observed in peripheral nerves, most frequent of which was n. ulnaris. According to the research of Ayadi et al. (2006), injury of n. radialis was the most frequent one, whereas the injury of n. ulnaris was the most rarely diagnosed nerve injury. However, according to our research the latter was the most common nerve injury (Ayadi et al., 2006). In our sample one of the patients had lesion of all three nerves, 7 patients had lesion of n. ulnaris, 1 had n. medianus lesion, whereas isolated lesions of n. radialis were not observed, but they occurred in combination with lesion of n. ulnaris i.e. n. mediannus in both combinations in 1 patient. All 10 patients with lesion of nerves at the end of the treatment showed satisfactory recovery results in terms of range of movements and paresis of nerves. Frequency of neurological complications after supracondylar fracture of elbow is slightly higher in our sample than the finding of a group of authors, according to which it ranged between 9 and 11% (Čekanauskas et al., 2003; Karapinar et al., 2005; Tiwari, Kanojia, & Kapoor, 2007). This frequency difference in terms of neurological complications can be explained by different characteristics of the sample in terms of severity and extent of the

fracture. The fact that our sample showed full recovery of paresis of affected nerves, after the applied physical treatment, suggests the lightest form of injury of the nerve neurapraxia. According to the findings of Ayadi et al. (2006), lesions of nerves observed immediately after fracture mostly heal spontaneously during treatment of the fracture itself, which is in contrast to those observed after the completed treatment when the treatment of an injury itself is longer-lasting, and requires grafting in certain cases (Ayadi et al., 2006).

Prior to commencement of rehabilitation treatment in our sample, all patients had elbow contracture which was over 15 degrees. Average flexion in the elbow was about 97 degrees, while full extension tell short for about 42 degrees on an average, before the treatment. After completed treatment, there was a statistically highly significant increase of flexion and extension of elbow, which contributed to reduction of the existing contractures. 90% of examined patients achieved satisfactory result at the end of rehabilitation treatment. 10% patients maintained over 15 degrees contractures, so that flexion at the end of rehabilitation treatment was about 119 degrees on an average, with 12 degrees missing for full extension. According to the obtained results, we can conclude that these values did not significantly affect functional ability of patients in terms of mobility of the elbow and limitations of everyday life activities, even though, according to the applied Flynn's classification, they belong to a group with bad treatment results.

According to Keppler et al. (2005), children with elbow contractures after supracondylar fracture treated by physical therapy commenced a couple of days after removal of cast immobilization showed faster recovery than the children who were not treated by physical therapy (Keppler et al., 2005). According to Čolović et al. (2008), early rehabilitation of children after supracondylar elbow fracture results in significantly better elbow functioning, with treatment supposed to begin within 15 days after removal of cast immobilization (Divjaković, Mikov, & Gajdobranski, 2010), which is in compliance with our treatment since it began 1-12 days after removal of immobilization.

With patients from our sample who showed unsatisfactory results, there was statistically significant difference in movement range (flexion and extension in elbow) before and after the treatment, but other parameters (duration of treatment, applied surgical procedure, and physical therapy procedures) did not show any significant difference. The fact that all accessible physical procedures were applied and that there was no difference between groups with satisfactory and unsatisfactory results in terms of applied procedures, we can draw a conclusion that unsatisfactory treatment results may also be a consequence of a more complicated fractures which caused major damages in elbow region with a consequence of incomplete recovery in terms of achieving full range of movements.

During physical treatment of patients with elbow contractures, after supracondylar fractures, the following therapies were most frequently applied: thermotherapy, kinesitherapy, work therapy, and electric therapy. Kinesitherapy was applied in almost all patients, with an average duration of 6 weeks. Our results, as well as results of other authors (Jandrić, 2007; Arena et al., 2006; Divjaković et al., 2010) indicate that movement as a therapeutic instrument, applied through a complex of exercises within active treatment methods (kinesitherapy, and work therapy), including applied effects of other physical agents (thermotherapy, and electrotherapy) as an introduction to active methods of therapy, may account for a significant share of the overall treatment of contractures.

References

Ayadi, K., Trigui, M., Tounsi, N., & Ellouze, Z. (2006). Supracondylar fractures of the humerus in children. *Revue de Chirurgie Orthopédique et Réparatrice de l'Appareil Moteur*, *92*(7), 651-6.

Arena, S., Vermiglio, G., Terranova, A., Vermiglio, M., & Arena, P. (2006). Trattamento ortopedico e riabilitativo nelle fratture sovracondiloidee di omero in età evolutiva. *Acta Chirurgica Mediterranea, 22,* 169-173.

Banović, M. D. (1989). Traumatologija koštano-zglobnog sistema. Gornji Milanovac: Dečije novine.

Bombaci, H., Gereli, A., Kucukyazici, O., & Gorgec, M. (2005). A new technique of crossed pins in supracondylar elbow fractures in children. *Orthopedics, 28*(12), 1406-1409.

Carmichael, K. D., & Joyner, K. (2006). Quality of reduction versus timing of surgical intervention for pediatric supracondylar humerus fractures. *Orthopedics, 29*(7), 628-632.

Čekanauskas, E., Degliute, R., & Kalesinkas, R. J. (2003). Treatment of supracondylar humerus fractures in children, according to Gartland classification. *Medicina, 39*(4), 379-383.

Čolović, H., Stanković, I., Dimitrijević, L., Živković, V., & Nikolić, D. (2008). Značaj modifikovanog DASH upitnika u proceni funkcijskog stanja lakta nakon suprakondilarnih fraktura humerusa kod dece. *Vojnosanitetski pregled, 65*(1), 27-32.

De Coulon, G., Ceroni D., De Rosa, V., Pazos J. M., & Kaelin, A. (2005). Nonoperative treatment of displaced supracondylar fractures in children: Rigault type 2 fractures. *Acta Orthopaedica, 76*(6), 858-861.

De Pellegrin, M., Brivio, A., Pescatori, E., & Tessari, L. (2008). Frattura sovracondiloidea di omero in età infantile. Osteosintesi percutanea in posizione prona. *G.I.O.T, 34*, 199-204.

Divjaković, M., Mikov, A., & Gajdobranski, Đ. (2010). Effect of physical therapy on treatment of contractures of elbow after supracondylar humerus fractures in children. *Medicina danas, 9*(1-3), 90-97.

Foead, A., Penafort, R., Saw, A., & Sengupta, S. (2004). Comparsion of two methods of percutaneous pin fixation in displaced supracondylar fractures of the humerus in children. *Journal of Orthopedic Surgery, 12*(1), 76-82.

Gadgil, A., Hayhurst, C., Maffulli, N., & Dwyer, J. S. M. (2005). Elevated, straight-arm traction for supracondylar fractures of the humerus in children. *Journal of Bone and Joint Surgery, 87*(1), 82-87.

Gajdobranski, Đ., Marić, D., Tatić, M., Đurić-Nosek, D. i Mikov A. (2003). Osteosinteza Kiršnerovim iglama u lečenju dislociranih suprakondilarnih preloma humerusa kod dece. *Medicinski pregled, 56* (7-8), 355-361.

Griffin, K. J., Walsh, S. R, Markar, S., Tang, T. Y., Boyle, J. R, & Hayes, P. D. (2008). The pink pulsless hand: a review of the literature regarding management of vascular complications of supracondylar humeral fractures in children. *European Journal of Vascular and Endovascular Surgery, 36*(6), 697-702.

Gris, M., Van Nieuwenhove, O., Gehanne, C., Quintin, J., & Burny, F. (2004). Treatment of supracondylar humeral fractures in children using external fixation. *Orthopedics, 27*(11), 1146-1150.

He, B. X., Zhang, B., & Tan, Y. J. (2009). Comparsion of clinical effects of various external fixation for the treatment of humeral supracondylar fracture. *Zhongguo Gu Shang*, *22*(3), 190-192.

Jandrić, S. Đ. (2007). Terapijski efekat fizikalnih procedura na kontrakture lakta kod djece sa suprakondilarnom frakturom humerusa. *Acta Chirurgica iugoslavica, 54*(2), 39-43.

Kaiser, M. M, Kamphaus, A, Massalme, E., & Wessel, L. M. (2008). Percutaneous closed pin fixation of supracondylar fractures of the distal humerus in children. *Operative Orthopädie und Traumatologie. 20*(4-5), 297-309.

Karapinar, L., Ozturk, H., Altay, T., & Kose, B. (2005). Closed reduction and percutaneous pinning with three Kirschner wires in children with type III displaced supracondylar fractures of the humerus. *Acta Orthopaedica et Traumatologica Turcica*, *39*(1), 23-29.

Keppler, P., Salem, K., Schwarting, B., & Kinzl, L. (2005). The effectiveness of physiotherapy after operative treatment of supracondylar humeral fractures in children. *Journal of Pediatric Orthopedics*, *25*(3), 314-316.

Patrice Eiff, M., & Hatch, R. L. (2004). Doctor/Pediatria/Ortopedia Retrieved from www.medweb.it

Platt, B. (2004). Supracondylar fracture of the humerus. *Emergency Nurse*, *12*, 22-30.

Sibinski, M., Sharma, H., & Bennet, G. C. (2006). Early versus delayed treatment of extension type-3 supracondylar fractures of the humerus in children. *Journal of Bone and Joint Surgery*, *88*(3), 380-381.

Slongo, T., Schmid, T., Wilkins, & K., Joeris, A. (2008). Lateral external fixation: A new surgical technique for displaced unreducible supracondylar humeral fractures in children. *Journal of Bone and Joint Surgery American Volume, 90*, 1690-1697.

Solazzo, V., Bertolani, G., & Traina, F. (2000). Le complicanze vasculo-nervose nelle fratture sovracondiloidee di omero nel bambino: nostra esperienza. *G.I.O.T.*, *26*, 196-200.

Tanno, M., Tanaka, H., Mukai, E., Hayashi, Y., & Takenouchi, K. (2008). Supracondylar and condylar fracture of the humerus. *Clinical Calciium, 18*(9):1332-1338.

Temple, A., Bache, C. E., & Gibbsons, P. J. (2006). Fractures of the elbow : supracondylar fractures. *Trauma*, *8*, 123-130.

Tiwari, A., Kanojia, R. K, & Kapoor, S. K. (2007). Surgical management for late presentation of supracondylar humeral fracture in children. *Journal of Orthopedic Surgery, 15*(2), 177-182.

Submitted November 3, 2010

Accepted December 14, 2010