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Optimization of the treatment of finger extensor tendon injuries in 1st zone

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Abstract

Despite the apparent simplicity of diagnosis and treatment of injuries of the finger extensor tendons, the number of unsatisfactory outcomes reaches 10-15.7 %, and 61.2 % in combined injuries. The small volume of extensor excursions (a small lever to the joint), unlike the flexors, requires a special attitude to the surgical restoration of the extensors. The accuracy of extensor length recovery is an essential factor in successful treatment. **Purpose** of the study was to develop diagnostic and surgical algorithms for the treatment and rehabilitation of hammer-like deformity of the fingers. **Material and methods** The study included two groups of patients with dropped distal phalanx of the fingers. The control group consisted of patients (n = 149) with a separation of the extensor tendon from the tuberosity of the nail phalanx. The main group (n = 163) were patients with tendon rupture at the level of the joint space. Patients in both groups underwent radiographic and ultrasound examination. Evaluation of the results was carried out using the subjective DASH criterion and objective assessment according to J.P. Crawford. **Results** Most patients in the control group were diagnosed with a tendon separation from the tuberosity of the nail phalanx. These patients were treated with a diagnosis of damage to the extensor tendons of the fingers in the 1st zone. Thus, the treatment tactics did not correspond to the diagnosis and is the reason for the deficiency of extension of the distal phalanx of the fingers of the hand after conservative therapy. According to the evaluation criterion (J.P. Crawford), the distal phalanx was observed in the majority of patients (n = 132), and according to the subjective assessment of DASH, only 45 could not fully perform these tests. In the patients of the main group at the diagnostic (ultrasound) stage, the position in the joints of the fingers of the hand was revealed, where the diastasis approached maximally between the damaged ends of the extensor tendon of the fingers of the hand in the 1st zone. Assessment of treatment results in this group of patients according to J.P. Crawford received excellent and good results, and according to DASH, all patients were able to perform these actions. **Conclusions** For the diagnosis of drooping distal phalanges of the fingers, it is necessary to apply x-ray and ultrasound examinations. Patients with an extensor tendon separation from the tuberosity of the nail phalanges should undergo surgical treatment using the blocking suture method. After surgical treatment of patients with subcutaneous rupture of the extensor tendons of the fingers in the 1st zone, immobilize the hand in the physiological position.

Keywords: extensor tendons, subcutaneous tendon rupture, mallet finger

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INTRODUCTION

"Mallet finger" is a hammer-shaped deformity of the distal phalanx of the fingers. The incidence of closed injuries to the extensor tendons of the fingers that leads to dropping (sagging) of the distal phalanx is 1.5–3.0 % of all hand injuries [1–3]. The mechanism of closed injury to the extensor tendon at the level of the distal phalanx of the finger is associated with its unexpectedly sharp flexion when the finger encounters an obstacle by rapid movement [4–8]. Thereby, a transverse rupture of the tendon occurs distal to the confluence of the lateral bundles, at the level of its attachment to the distal phalanx [6, 9, 10]. The latter acquires a flexed position in the distal interphalangeal (DIP) joint. This is explained by the predominance of the tone of the deep flexor that is attached to the palmar surface of the distal phalanx [5, 11–13]. In some cases of mallet finger, the extensor tendon of the finger remains intact, but separates from the base of the nail phalanx along with a bone fragment [4, 7, 14, 15]. Fractures of the nail phalanx at the site of attachment of the extensor tendon of the finger account for 17 % [6, 9, 14, 16] of all intraarticular fractures of finger phalanges. In both cases, hammer deformity is treated on an outpatient basis by immobilization of the distal phalanx and extention of the DIP joint with various types of splints, assuming that such a position will ensure an approximation of the injured ends of the tendon and fixation of the bone fragment [5, 12, 15, 17–19]. The results of conservative treatment are rarely analyzed. Only a few patients for whom the function of the distal phalanx is important (musicians, hairdressers, IT engineers) refer to hospitals to restore full mobility of the distal interphalangeal joint of the fingers. However, in surgical treatment, issues remain unresolved regarding the technology of differentiated treatment for both types of "mallet finger", adequate postoperative immobilization, rehabilitation and evaluation of treatment results.

Purpose of the study To improve the results of diagnostic examination and surgical treatment of patients with injuries to the extensor tendons of the fingers in the 1st zone

Tasks:

1) To evaluate the results of conservative treatment of patients with mallet finger deformity;

2) To determine the tactics of surgical treatment in injuries to the extensor tendons of the fingers in the 1st zone.

MATERIALS AND METHODS

Two groups of patients were studied at the clinic of the Research Institute for Microsurgery (Tomsk) within the period of 2014–2020.

The injuries sustained by the patients resulted in mallet finger due to the distal phalanx.

The first group (control group) was 149 subjects that passed conservative treatment. All were treated by immobilization of the distal finger phalanx in overextension with various types of fixation materials.

The gender and age of patients in the control group were as follows: 84 (56.4 %) males, 65 (43.6 %) females. The age of the patients varied from 18 to 74 years, the mean age was 41.30 ± 13.36 years. The structure of injuries of the extensor tendons of the fingers in patients of the control group, depending on the involved (right or left) hand in the pathological process, is presented in Table 1.

The main group consisted of 163 patients with closed injuries of the extensor tendons of the fingers in the 1st zone (167 fingers) treated surgically at the Institute for Microsurgery (Tomsk) within the period from 2014 to 2020. The age of patients varied from 19 to 72 years, the average age was 44.90 ± 11.67 years; the group consisted of 95 (58.2 %) males and 68 (41.8 %) females.

The structure of injuries of the extensor tendons of the fingers in patients of the main group, depending on which particular (right or left) hand was involved in the pathological process, is presented in Table 2.

In order to enroll patients in the study, inclusion and exclusion criteria were developed:

Group 1 (control):

• inclusion criterion: avulsion of the extensor tendon from the base of the nail phalanx according to J.R. Doyle (type 1 injury);

• exclusion criterion: open injuries of the extensor tendons in the 1st zone.

Group 2:

• inclusion criterion: subcutaneous rupture of the extensor tendon in the 1st zone (fingers I–V);

• exclusion criteria: open damage to the distal phalanx;

• chronic damage to the extensor tendons in the 1st zone.

All patients with hammer-like deformity of the nail phalanx of the fingers underwent X-ray and ultrasound examination to verify the diagnosis and enrollment into the groups (Fig. 1).

Table 1

Location of finger injuries in the control group (n = 149)

Hand	Number of finger										Total	
	I		II		III		IV		V			
	n	%	n	%	n	%	n	%	n	%	n	%
Left	4	4.3	11	11.8	28	30.1	23	24.7	27	29.0	93	62.4
Right	1	1.8	8	14.3	15	26.8	15	26.8	17	30.4	56	37.6
Total	5	3.4	19	12.8	43	28.9	38	25.5	44	29.5	149	100

Table 2

Location of finger injuries in the main group (n = 163)

Hand	Finger										Total	
	I		II		III		IV		V			
	n	%	n	%	n	%	n	%	n	%	n	%
Right	3	4.9	1	1.6	30	49.2	17	27.9	10	16.4	61	37.4
Left	4	3.9	11	10.8	29	28.4	36	35.3	22	21.6	102	62.6
Total	7	4.3	12	7.4	59	36.2	53	32.5	32	19.6	163	100

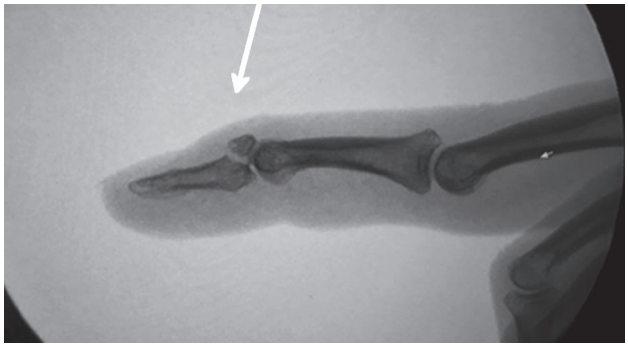

Fig. 1 X-ray of the third finger in a patient of the control group. Fracture of the base of the nail phalanx (mallet finger). The arrow shows the fracture of the base of the nail phalanx

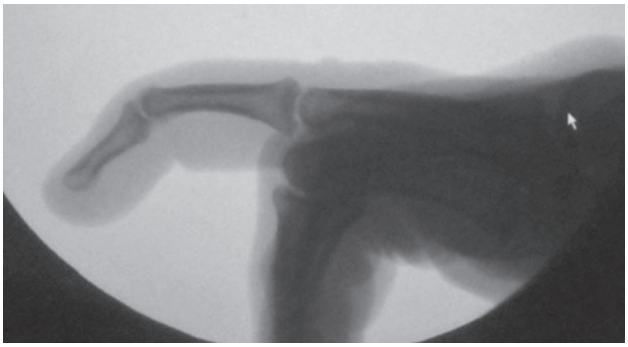

Fig. 2 X-ray of the third finger in a patient of the main group. The bones of the third finger are not broken (mallet finger)

To determine the effectiveness of the presented methodology, we used the DASH criteria for subjective assessment and for objective assessment according to G.P. Crawford. Upon six weeks after treatment, patients were examined for the presence/absence of deficiency in extension of the distal finger phalanx (Fig. 3 a, b). The study of this parameter was carried out taking into account the criteria of G.P. Crawford (Table 3) using an angulometer (Fig. 3c) [20].

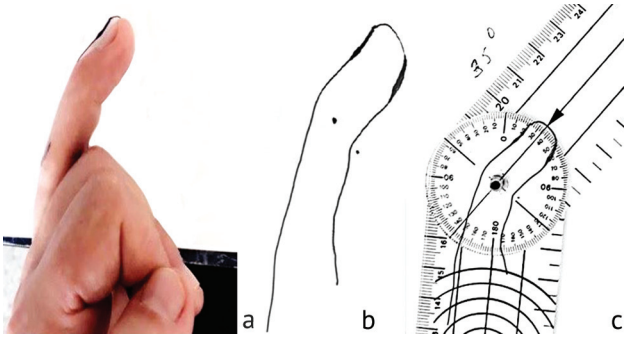

Fig. 3 Measurement of extension deficiency of the distal phalanx with an angulometer

Table 3

Evaluation of distal finger phalanx function (G.P. Crawford)

Result	Description
Excellent	Full flexion and extension, no pain
Good	0–10° deficit of extension, full flexion, no pain
Fair	10–25° deficit of extension, mild deficit of flexion, no pain
Poor	More than 25° deficit of extension, persistent pain

Patients of the main group were assessed according to the subjective data of the DASH questionnaire before and after surgical treatment. They independently examined the function of their hand for two weeks. The score in the questionnaire was calculated using the formula: DASH = (sum of n answers / n–1) × 25, where n is the number of completed answers.

Statistical methods

Comparison of the groups by quantitative indicators was carried out using non-parametric criteria. Significance levels are indicated as absolute values or (in the case of exponential values) as $p < 0.0001$.

The analysis of quantitative scales for the normality of distribution was carried out according to the Kolmogorov-Smirnov D-test and the Shapiro-Wilk W-test. Statistical analysis was carried out using the IBM SPSS Statistics software package (version 25.0).

The *primary endpoint of the study* was formulated as rate of responses in treatment results expressed as Crawford success rate at 6 months post-treatment.

This indicator is frequency variable and is a variant of the Crawford scale reduced to the following: "poor" and "fair" outcomes are regarded as an "unacceptable" outcome, and "excellent" and "good" outcomes are regarded as a "successful" outcome. This indicator was evaluated using Fisher's exact test in all patients who completed the study according to the planned design.

Secondary endpoints of the study:

1. DASH score, measured 3 months after treatment

This indicator is a quantitative variable. The comparison was carried out using the non-parametric Mann-Whitney test (for intergroup comparison), and the Wilcoxon method (for intragroup analysis).

2. Deficit of extension of the distal finger phalanges, measured in degrees, 3 months after conservative therapy.

This indicator is a quantitative variable. The comparison was carried out using the non-parametric Mann-Whitney test.

RESULTS

Out of 149 patients in the control group, 132 had varying degrees of distal phalanx extension deficiency. Forty-five subjects (34.1 %) experienced difficulty in everyday life as this deficit caused them discomfort in their professional activities. Of these, 11 patients with injuries to the third finger of the right (dominant) hand, despite the achieved good result according to J.P. Crawford, had functional limitation in the activity. Fifteen patients with fair outcomes (two of them with the dominant left hand) had an extension deficit of 12–16° in the second finger. Poor outcomes according to Crawford was revealed in 21 patients with injuries to the fourth and fifth fingers of the right hand (all patients with the dominant right hand), and the deficit of extension of the distal phalanx exceeded 25°.

Thus, the results of conservative treatment of injuries of the extensor tendon of fingers I–V (zone 1) in patients of the control group, assessed by J.P. Crawford and according to the DASH questionnaire, turned out to be ambiguous. According to an objective indicator of the deficit of extension of the distal phalanx, the worst results were obtained after the restoration of the tendon of the fifth finger of the working right hand, in which the extension deficit exceeded 25° on average. The fingers were arranged in the following order of decreasing extension deficit: V, IV, III, II, I; the extension deficit of the distal phalanges was 7–20°. Subjective data assessed using the DASH questionnaire showed that 87 patients with varying distal phalanx extension deficits did not feel any discomfort, neither in terms of self-service, nor in terms of the professional activities. And only 45 out of 132 patients were not satisfied with

the result of treatment. These were persons for whom the restoration of the function of the DIP joint was of fundamental importance (musicians, hairdressers, office workers).

Case reports of the conservative therapy in the control group are presented in Figure 4.

The results of the assessment according to the Crawford criterion of extension deficit in the distal phalanges of the fingers to are shown in Figure 5.

The results of ultrasound examination of the affected finger in patients of the main group, conducted to determine the diastasis between the ends of the damaged extensor tendon in the 1st zone, showed that the convergence/divergence of the ends depends on the position of the finger joints. In full extension in the joints of the finger, the diastasis between the damaged ends increased (Fig. 6).

In the physiological position (Fig. 7 a), flexion in the metacarpophalangeal joint of 60°, 40° in the PIP joint, and 0° in the DIP joint led to the maximum convergence of the ends of the damaged extensor tendon in the 1st zone (Fig. 7, b).

Fig. 4 Clinical examples Photos of the hand: a - patient L., 25 years old, disruption of the extensor tendon of the 1st finger of the left hand in the 1st zone; b – patient Sh., 47 years old, disruption of the extensor tendon of the second finger of the left hand in the 1st zone; c – patient B., 47 years old, disruption of the extensor tendon of the third finger of the right hand in the 1st zone; d – patient O., 71 years old, disruption of the extensor tendon of the IV finger of the right hand in the 1st zone

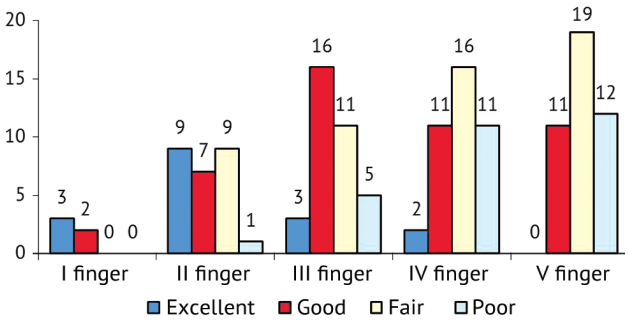

Fig. 5 Distribution of patients in the control group according to the deficiency of extension of the distal phalanges of the fingers (J.P. Crawford)

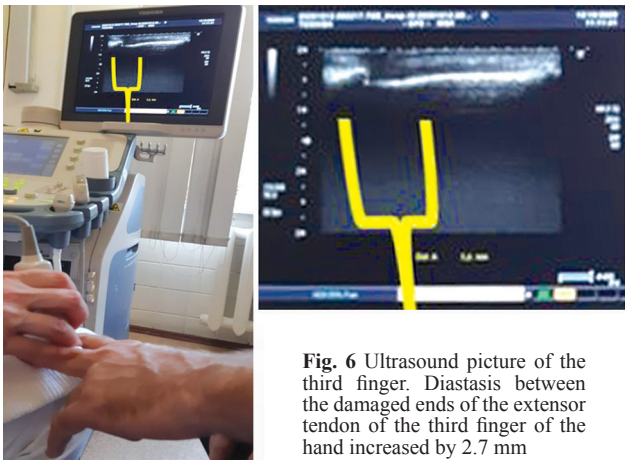

Fig. 6 Ultrasound picture of the third finger. Diastasis between the damaged ends of the extensor tendon of the third finger of the hand increased by 2.7 mm

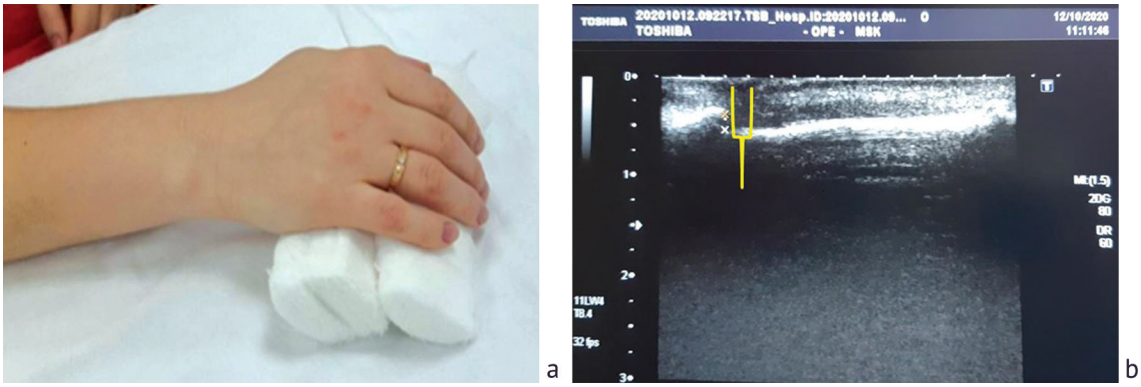

Fig. 7 Ultrasound examination of the injured finger of the right hand of patient L.: a physiological position of the hand; b maximum convergence of the damaged ends of the tendon by 1.4 mm

The next step was surgical treatment. After arrest of the blood flow to the finger, regional anesthesia was performed with 1 % Lidocaine solution (5 ml). A skin incision in the shape of the letter "U" was made above the distal DIP joint to access the area of tendon injury (Fig. 8 a). After bringing the fingers of the hand into the physiological position, the damaged ends of the tendon approached as close as possible (Fig. 8 b).

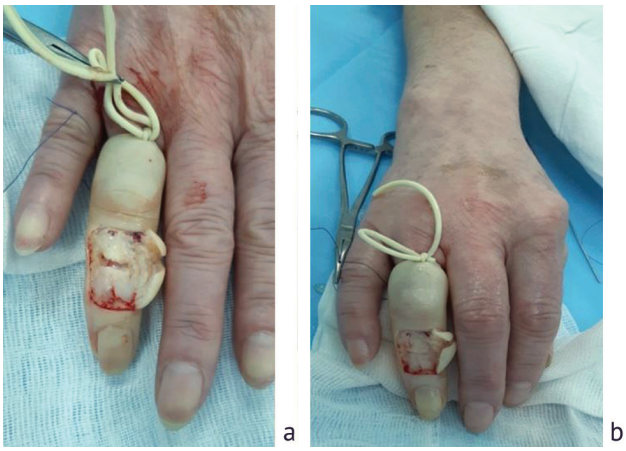

Fig. 8 Intra-operative determination of diastasis between the damaged ends of the extensor tendon of the fourth finger of the right hand in patient S.: a damaged ends of the tendon diverge; b the physiological position of the finger, the damaged ends are as close as possible

After obtaining the maximum convergence of the ends, the continuity of the extensor tendon of the fingers in the 1st zone was restored with a U-shaped suture using a Vicryl 4.0 thread. Interrupted sutures were applied to the skin with a monofil 4.0 thread followed by aseptic dressing. Plaster immobilization of the joints of the fingers in the physiological position was mandatory. Immobilization lasted for 6 weeks. Upon the end of the immobilization period, ultrasound examination was performed to determine the maturity of the tendon regenerate. The patients of the main group also independently trained movements in the joints of the fingers. The evaluation of the results of the study in patients of the main group was carried out no earlier than 3 months later.

Thus, the intra-operative study confirmed the ultrasound data: the convergence of the damaged ends of the extensor tendon in the 1st zone occurred in the physiological position of the fingers. The divergence of the injured ends of the extensor tendon of the fingers in the 1st zone occurred in fixation of the DIP joint in the extension position and with each movement (flexion/extension) in the MCP and PIP joints.

Results of statistical study

For the primary endpoint of the study, we recorded a statistically significant difference between the groups of patients in the rate of successful (total of "excellent" and "good") treatment outcomes based on the estimates with the Crawford scale. In the main group, the proportion of such outcomes was almost 2.36 times higher than in the control group, 151 cases versus 64 ($p < 0.00001$ for Fisher's exact test), respectively (Fig. 10)

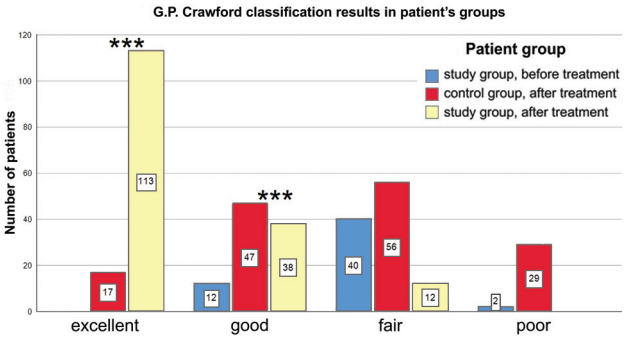

Fig. 10 Diagram of outcome evaluation by Crawford; *** – $p < 0.00001$ for exact Fischer test

In the main group, the total score on this scale was more than 5.7 times lower than that in the control group ($Z = -9.029$; $p < 0.00001$) and tended to near-zero values, which are characterized as the most favorable type of result according to the principles of interpretation of this scales (Fig. 11).

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interpretation of this scales (DASH) (Fig. 12).

The dependence of the values of the DASH scale on the Crawford scale in groups of patients according to the Kruskal-Wallis test showed the presence of statistically significant differences in the total scores on the DASH scale in both groups, depending on the assessment assigned to the patient on the Crawford scale (Kruskal-Wallis H-test = 16.140; p = 0.000313 for the main group and Kruskal-Wallis H-test = 70.736; p < 0.0001 for the control group). The result of the DASH scale changed in one direction or another in proportion to the result of evaluating a particular patient with the Crawford scale.

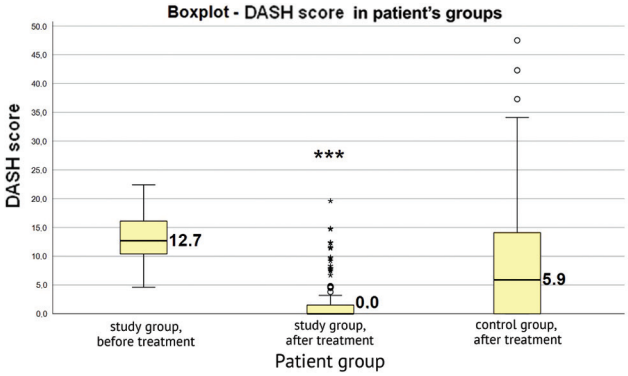

Fig. 11 Diagram of outcome evaluation by DASH score; *** – p < 0.00001 for Mann-Whytney U-test

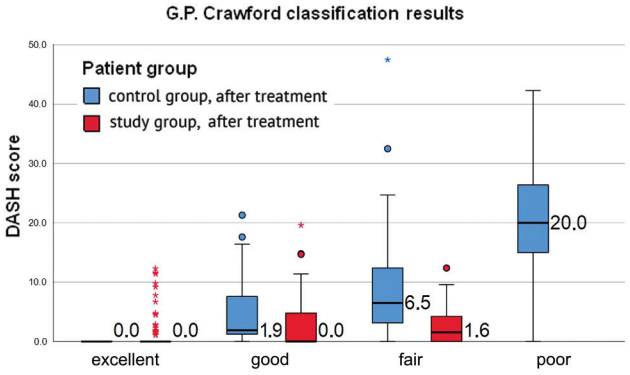

Fig. 12 Diagram of evaluation of difference between the groups using DASH and Crawford scales

DISCUSSION

In the world community of hand surgery, the DIP joint is fixed in extension after surgical treatment or conservative therapy. It is assumed that this position leads to approximation of the injured ends of the extensor tendon of the fingers in the 1st zone. In our work, we used the results of surgical treatment of patients with subcutaneous ruptures of the extensor tendons of the fingers in the 1st zone and analyzed the treatment outcomes in patients of the control and surgical groups. In the control groups, we revealed a deficiency of distal phalanx extension of varying grades in 132 (88.6 %) patients. Among them, 45 (30.2 %) patients experienced difficulty in everyday life, since the extension deficit caused them discomfort in their professional activities.

Many researchers did not search for the cause of the extension deficit in the distal phalanges of the fingers due to the evaluation of only subjective data after various types of treatment of patients with subcutaneous injuries of the extensor tendons of the fingers in the 1st zone and obtained good and excellent results. In the literature, we did not find information about the long-term results of the treatment of injuries of the extensor tendons of the fingers in the 1st zone. In a rupture of the tendon mechanism at the level of the distal phalanx, the extension force is concentrated at the proximal interphalangeal joint. Over time, especially if the palmar fibrous plate is stretched, this leads to its overextension and the occurrence of a "swan neck" deformity [3, 12, 21–23]. Therefore, even a slight deformity of the distal phalanx associated with an injury to the extensor tendon in the 1st zone requires mandatory treatment in order to further prevent deformity and dysfunction of the proximal phalanges of the fingers.

Thus, it is advisable to perform surgical treatment with fixation of the bone fragment together with the tendon to the place of attachment in the patients with extensor tendon avulsion along with a bone fragment from the base of the distal phalanx. Both by conservative treatment and in surgical treatment of patients with subcutaneous disruption of the extensor tendons of the fingers in the 1st zone, it is necessary to achieve reliable close reduction of the injured ends of the tendon.

CONCLUSIONS

1. Analysis of the treatment results in the control group of patients according to the DASH questionnaire showed that the subjective assessment of the functionality of the distal phalanges of the fingers was higher due to the low significance of fine motor skills of the hand for most patients.

2. Due to the biomechanics of finger movements, immobilization should ensure the convergence of the damaged ends of the extensor tendon of the fingers in the 1st zone and relieve tension from the tendon suture. The optimal variant of immobilization in injuries to the extensor tendon of the fingers in the 1st zone is the physiological position: (fingers II–V) flexion in the MCP joint by 50–65°, in the PIP joint by 30–40° and the DIP joint by 0°, and for the thumb: flexion and ulnar deviation of the wrist joint by 10°, flexion in the MCP joint by 20°, and DIP joint by 10°.

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