

TWO-STAGE REPAIR OF FINGER FLEXOR TENDONS IN CHILDREN WITH CHRONIC TENDON RUPTURES IN FIBRO-SYNOVIAL CANALS

Alexandrov AV^{1,2} ✉, Rybchenok VV², Lvov NV¹, Aleksandrova NE¹, Palinkash AM²

¹ N. F. Filatov Children's Municipal Clinical Hospital No. 13, Moscow, Russia

² Pirogov Russian National Research Medical University, Moscow, Russia

Two-stage repair is a well-developed method that is commonly used to repair chronic ruptures of flexor digitorum profundus tendons. However, its use in pediatric hand surgery is limited due to the absence of tendon implants adapted for children. The article describes a modified Paneva-Holevich/Hunter technique for two-stage tendon reconstruction using original, oval, Lavan-reinforced silicone prosthetic implants of four sizes (depending on patients' age). The surgery was performed in 34 children aged 1.5–17 years. Long-term outcomes were assessed in 12 patients (8 boys and 4 girls) using the Total Active Motion scale. The follow-up period was 30 months. The average active range of motion accounted for 178.8° in boys and 218.8° in girls. The results of treatment (TAM %) were considered good in all the girls (average score of 84.3 %), and in those boys who received surgery for fingers IV and V (average score of 80.0 %). The boys who received tendon repair for fingers II and III had “good” and “poor” results (average score of 67.0 %). The proposed method of two-stage tendon repair of chronic tendon ruptures in fibro-synovial channels in children was shown to provide good results with minimal complication rates and acceptable donor site deficiency.

Keywords: two-stage tendon repair, tendon silicone prosthetic implants, tendons of flexor digitorum profundus, chronic ruptures

✉ **Correspondence should be addressed:** Aleksander Alexandrov
ul Sadovaya-Kudrinskaya, d. 15, Moscow, Russia, 123001; alexmicrosur@mail.ru

Received: 28.09.2016 Accepted: 17.10.2016

ДВУХЭТАПНАЯ ТЕНДОПЛАСТИКА СУХОЖИЛИЙ СГИБАТЕЛЕЙ ПАЛЬЦЕВ КИСТИ У ДЕТЕЙ С ЗАСТАРЕЛЫМИ ПОВРЕЖДЕНИЯМИ В ЗОНЕ ФИБРОЗНО-СИНОВИАЛЬНЫХ КАНАЛОВ

А. В. Александров^{1,2} ✉, В. В. Рыбченко², Н. В. Львов¹, Н. Е. Александрова¹, А. М. Палинкаш²

¹ Детская городская клиническая больница № 13 имени Н. Ф. Филатова, Москва

² Российский национальный исследовательский медицинский университет имени Н. И. Пирогова, Москва

Двухэтапная тендопластика — хорошо разработанный метод лечения застарелых повреждений сухожилий глубоких сгибателей пальцев кисти, однако его применение в детской кистевой хирургии ограничивается отсутствием адаптированных для детей эндопротезов сухожилий. В статье описана модификация метода двухэтапной тендопластики Паневой-Холевич и Hunter с использованием оригинальных силиконовых эндопротезов овального сечения, армированных лавсановой лентой, четырех типоразмеров, соответствующих различным возрастным группам. Были прооперированы 34 ребенка в возрасте 1,5–17 лет, у 12 из них (8 мальчиков и 4 девочек) были оценены отдаленные результаты лечения по шкале Total Active Motion (срок наблюдения — 30 мес.). Средний активный объем движений поврежденного пальца в группе мальчиков составил 178,8°, в группе девочек — 218,8°. Хорошие результаты лечения (ТАМ %) были отмечены у всех девочек (в среднем 84,3 %), а также у мальчиков, которым оперировали IV и V пальцы (в среднем 80,0 %). У мальчиков, которым оперировали II и III пальцы, наблюдали хорошие и плохие результаты (в среднем 67,0 %). Предложенный метод двухэтапной тендопластики при застарелых повреждениях сухожилий в области фиброзно-синовиальных каналов у детей позволяет достичь хорошего результата с минимальными осложнениями и приемлемым донорским дефицитом.

Ключевые слова: двухэтапная тендопластика, сухожильные силиконовые эндопротезы, сухожилия глубоких сгибателей пальцев кисти, застарелые повреждения

✉ **Для корреспонденции:** Александров Александр Владимирович
ул. Садовая-Кудринская, д. 15, г. Москва, 123001; alexmicrosur@mail.ru

Статья поступила: 28.09.2016 Статья принята к печати: 17.10.2016

Chronic ruptures of the flexor digitorum profundus tendons in children remain a pressing issue of pediatric hand surgery. This is a relatively uncommon injury [1], but its consequences are extremely negative for children. Long-term results of treatment remain unsatisfactory for a number of reasons: complexity of the initial diagnostic assessment, a large number of missed tendon injuries (up to 30 %); a small diameter of tendons, which hinders the use of multifilament sutures and does not allow the reconstructed tendon to achieve the desired strength. In addition, the lack of cooperation and motivation in young patients precludes early active rehabilitation [2, 3].

The most challenging is the injury of flexor digitorum tendons in zone 2. This zone extends from the distal palmar crease (proximal end of the first annular ligament, or A1 pulley) to the middle of the middle phalanx. In this zone flexor digitorum superficialis and flexor digitorum profundus tendons criss-cross and glide into a narrow fibro-synovial canal. Injuries in zone 2 are associated with a high risk of scarring after surgical repair, which prevents normal sliding of tendons [4–6]. Bunell [7] called this zone “critical” and “no-man's-land” (Fig. 1).

Two-stage repair is a well-established method of flexor digitorum profundus tendon repair in cases of extensive scarring in the area of the fibro-synovial canal. Various modifications of this method have been proposed [8–17]. However, the use of this method in pediatric hand surgery is impeded due to the absence of prosthetic implants adapted for children. Using our experience in tendon repair according to Paneva-Holevich [9, 10] and Hunter [8, 12] techniques, we have developed an original method of two-stage repair with silicone oval Lavsan-reinforced implants (developed jointly with Medsil, Russia). The implants are available in four sizes for children of different age. The use of these implants allows for the adaptation of the existing protocols of postoperative passive and active rehabilitation for children. Currently, a state patent for these implants is being filed.

The aim of the study was to assess the efficacy of treatment of chronic flexor digitorum profundus tendon ruptures in children using a modified two-stage repair and original implants.

METHODS

In 2010–2016, in the Department of Reconstructive Microsurgery of N. F. Filatov Children’s Municipal Clinical Hospital No. 13 (Moscow), there were 34 patients aged 1.5 to 17 years with chronic ruptures of flexor digitorum profundus tendons in the fibro-synovial canal. Most tendon injuries were caused by knives (n = 18), an edge of a metal fence (n = 11) and glass (n = 5). The time of injury was approximately 54–90 days before admission.

Two-stage repair of flexor digitorum profundus tendons was performed in all children. At the first stage we used a Brunner zigzag skin incision (Fig. 2) that provided wide access to the fibro-synovial canal. The canal was opened; scar tissues and tendon remnants were excised. A-2 and A-4 pulleys were retained or reconstructed. As opposed to Paneva-Holevich and Hunter techniques, the proximal stumps of the flexor digitorum superficialis and flexor digitorum profundus tendons were retrieved and then sutured side-to-side and to the fibrous tissues with moderate tension at the base of the proximal phalanx. This enabled us to increase elasticity, improve the contractile function of the injured flexors, and avoid the “muscle tenotomy” effect. A silicone prosthetic implant was placed under the retained or repaired pulleys. Its distal end was fixed to the distal phalanx under the stump of the flexor digitorum profundus tendon, and the proximal end was placed freely under the flexor tendons on the palm (Fig. 3). For immobilization, the patients wore the dorsal plaster splint for 4 weeks. Passive range of motion exercises were started to achieve the full range of passive flexion immediately after the first stage of repair.

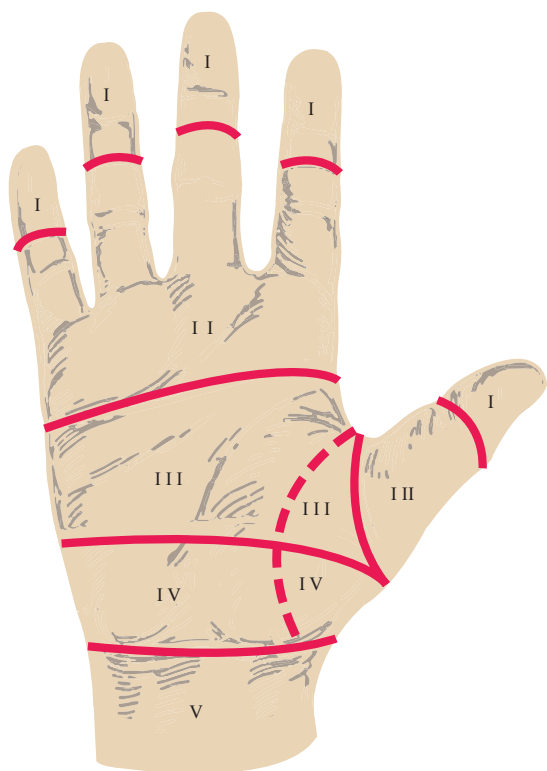


Fig. 1. Location of zone 2 (no man's land)

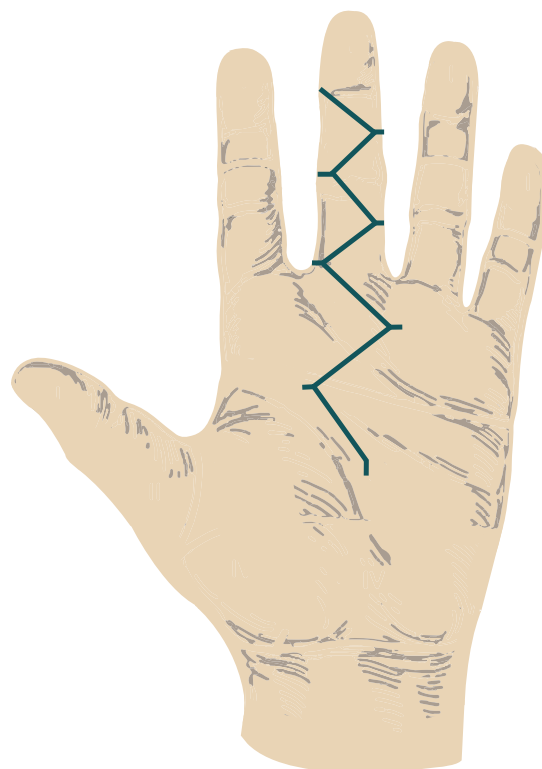


Fig. 2. Brunner zigzag incision

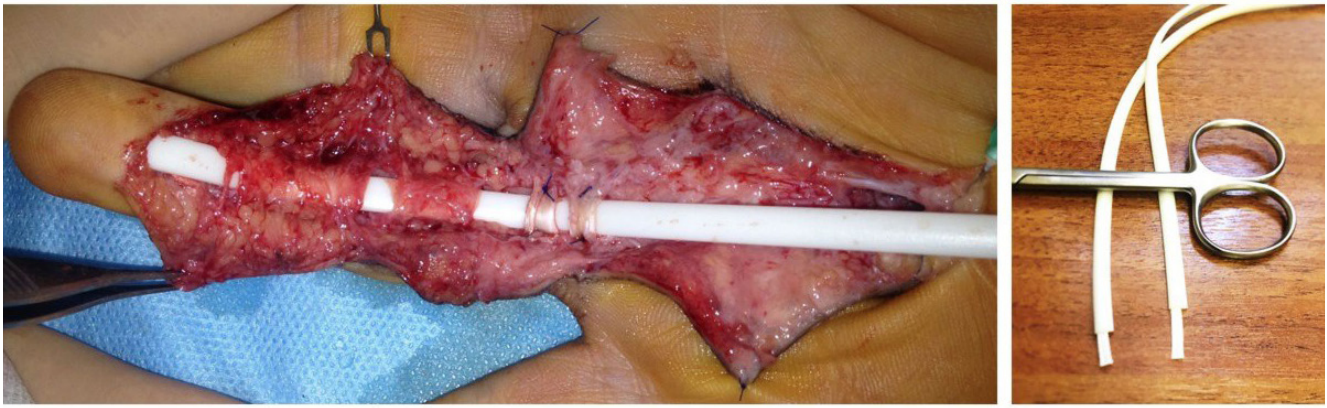


Fig. 3. The first stage of flexor digitorum profundus tendon repair: fixation of the silicone prosthetic implant

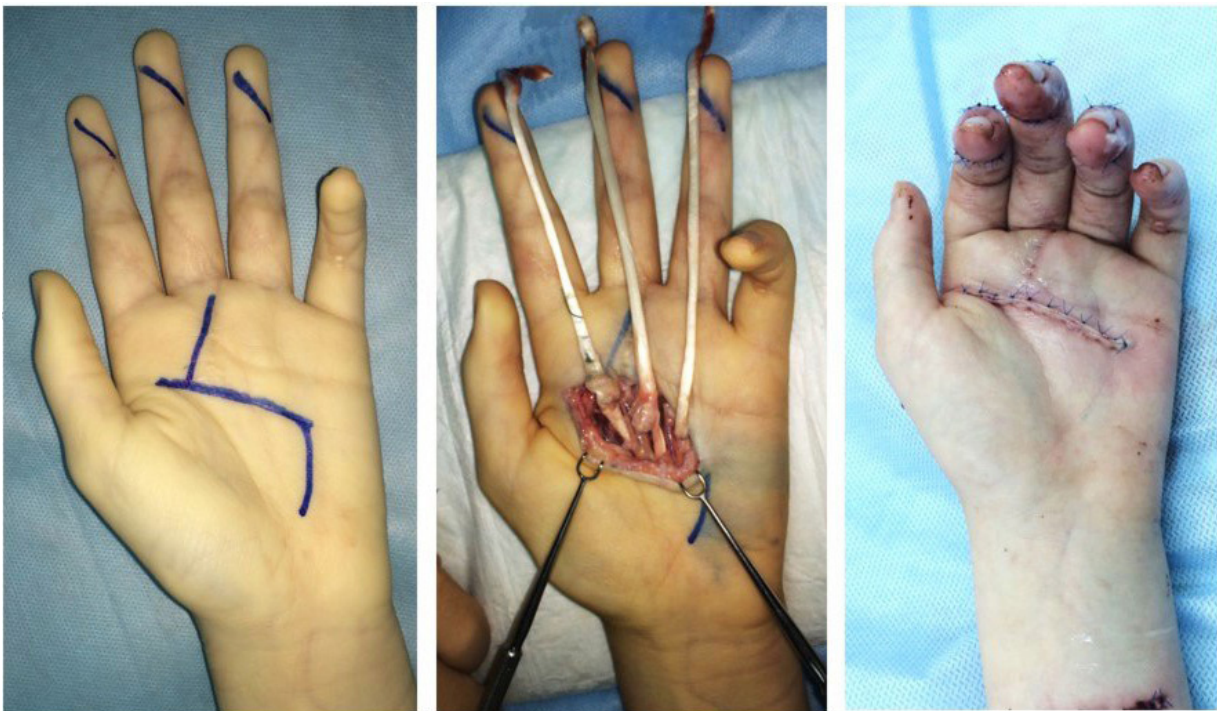


Fig. 4. The second stage of flexor digitorum profundus tendon repair: fixation of the autograft

The second stage of repair was performed 2–2.5 months later. Incisions were made in the distal phalanx, palm and middle third of the forearm (Fig. 4). The flexor digitorum superficialis tendon was retrieved from the middle third of the forearm, cut and transferred to the palm. Using the prosthetic implant as a guide, the autograft was passed through the canal to the distal phalanx and fixed transosseously. The excess of the fibro-synovial canal was dissected proximally to allow free movement of the autograft. Proximal tendon suturing was performed using the Pulvertaft technique. The graft tension was adjusted so that the repaired finger was at less angle of flexion than adjacent ulnar finger.

In the postoperative period, patients wore the dorsal plaster splint (flexion at the radiocarpal joint was 30°, flexion at the metacarpophalangeal joints was 70°) for 5 weeks. Range of motion exercises and physiotherapy were started on day 3 after the surgery. We used early active-passive mobilization in our rehabilitation program.

The results of treatment were assessed with the scale (Total Active Motion) scale. The total range of motion was determined

as the sum of the angles of active flexion in the operated finger joints. The score was calculated as the ratio of the damaged finger TAM to the healthy finger TAM multiplied by 100 %. A score of 100 % was considered “excellent”; a 75–99 % score was considered “good”; a 50–74 % score was considered “satisfactory”, less than 50 % score was considered “poor”. The long-term results were evaluated in 12 of 34 patients (30 months of the follow-up).

RESULTS

Table shows the long-term results of treatment of 12 children with chronic ruptures of flexor digitorum profundus tendons measured by the range of active motion using the TAM scale. According to the absolute TAM value, the active range of motion was by 40° greater in boys than in girls. Excellent results were seen in boys who had received repair of finger tendons IV and V (average score of 80 %), good and poor results were seen in patients who had received repair of finger

Long-term results of surgical treatment of children with chronic ruptures of flexor digitorum profundus tendons by two-stage repair using tendon silicone prosthetic implants (assessed with Total Active Motion scale)

No.	Age	Finger	TAM°	TAM %
Boys				
1	3.0	III	115.0	44.0
2	3.0	II	210.0	67.0
3	3.3	III	180.0	69.0
4	4.0	IV	190.0	79.0
5	5.0	IV	185.0	86.0
6	12	II	195.0	72.0
7	15	V	195.0	75.0
8	17	II, III	160.0	44.0
M	7.8	–	178.8	67.0
Girls				
9	2.3	IV	200.0	81.0
10	4.0	II, III	195.0	75.0
11	4.5	V	230.0	85.0
12	12	III	250.0	96.0
M	5.7	–	218.8	84.3

tendons II and III (average score of 67 %). Good results (84 %) were observed in all girls.

DISCUSSION

Two-stage repair of chronic ruptures of flexor digitorum profundus tendons in adults is a well-established method with detailed postoperative rehabilitation protocols. However, this method has not been properly adapted for children. A characteristic anatomical feature of children is a small size of the flexor tendons and the fibro-synovial canals. In addition, young children have a low ability for cooperation. We believe

that our original Lavsan-reinforced tendon silicone prosthetic implants matching patients' age allowed us to successfully adjust the existing protocols of postoperative rehabilitation to low cooperative abilities of children.

CONCLUSIONS

A modified two-stage repair with the original tendon silicone prosthetic implants, adaptation of rehabilitation protocols to the behavioral characteristics of children, and close postoperative monitoring provided good long-term results of treatment regardless of patients' age and sex.

References

- Nietosvaara Y, Lindfors NC, Palmu S, Rautakorpi S, Ristaniemi N. Flexor tendon injuries in pediatric patients. *J Hand Surg Am.* 2007 Dec; 32 (10): 1549–57.
- Höllwarth M, Haberlik A. [Flexor tendon injuries in childhood]. *Z Kinderchir.* 1985 Oct; 40 (5): 294–8. German.
- Fitoussi F, Lebellec Y, Frajman JM, Penneçot GF. Flexor tendon injuries in children: factors influencing prognosis. *J Pediatr Orthop.* 1999 Nov–Dec; 19 (6): 818–21.
- O'Connell SJ, Moore MM, Strickland JW, Fraizer GT, Dell PC. Results of zone I and zone II flexor tendon repairs in children. *J Hand Surg Am.* 1994 Jan; 19 (1): 48–52.
- Berndtsson L, Ejeskär A. Zone II flexor tendon repair in children. A retrospective long term study. *Scand J Plast Reconstr Surg Hand Surg.* 1995 Mar; 29 (1): 59–64.
- Birnie RH, Idler RS. Flexor tenolysis in children. *J Hand Surg Am.* 1995 Mar; 20 (2): 254–7.
- Bunnell S. *Surgery of the hand.* 3rd ed. Philadelphia: JB Lippincott; 1956. p. 712.
- Hunter JM, Salisbury RE. Flexor-tendon reconstruction in severely damaged hands. A two-stage procedure using a silicon-Dacron reinforced gliding prosthesis prior to tendon grafting. *J Bone Joint Surg Am.* 1971 Jul; 53 (5): 829–58.
- Paneva-Holevich E. Two-stage reconstruction of the flexor tendons. *Int Orthop.* 1982; 6 (2): 133–8.
- Paneva-Holevich E. Dvukhetapnaya sukhozhil'naya plastika po metodu Panevoy-Hunter. In: *Trudy IV Vsesoyuznogo s"ezda travmatologov-ortopedov.* Moscow; 1982. P. 231–3. Russian.
- Wehbé MA, Mawr B, Hunter JM, Schneider LH, Goodwyn BL. Two-stage flexor-tendon reconstruction. *J Bone Joint Surg Am.* 1986 Jun; 68 (5): 752–63.
- Amadio PC, Wood MB, Cooney WP 3rd, Bogard SD. Staged flexor tendon reconstruction in the fingers and hand. *J Hand Surg Am.* 1988 Jul; 13 (4): 559–62.
- Amadio PC. Staged flexor tendon reconstruction in children. *Ann Chir Main Memb Super.* 1992; 11 (3): 194–9.
- Soucacos PN. Two-stage flexor tendon reconstruction using silicone rods. In: *Vastamaki M, editor. Current Trends in Hand Surgery.* Amsterdam: Elsevier; 1995. P. 353–7.
- Soucacos PN. Secondary flexor tendon repair. In: *Duparc S, editor. Textbook on Techniques in Orthopaedic Surgery and Traumatology.* Paris: Elsevier SAS; 2000. P. 55–340.
- Beris AE, Darlis NA, Korompilias AV, Vekris MD, Mitsionis GI, Soucacos PN. Two-stage flexor tendon reconstruction in zone II using a silicone rod and a pedicled intrasynovial graft. *J Hand Surg Am.* 2003 Jul; 28 (4): 652–60.
- Deykalo VP. Meditsinskaya reabilitatsiya postradavshikh s zastarelymi povrezhdeniyami sukhozhil'nykh plastiki. *Novosti khirurgii.* 2005; 13 (1–4): 65–9. Russian.

Литература

1. Nietosvaara Y, Lindfors NC, Palmu S, Rautakorpi S, Ristaniemi N. Flexor tendon injuries in pediatric patients. *J Hand Surg Am.* 2007 Dec; 32 (10): 1549–57.
2. Höllwarth M, Haberlik A. [Flexor tendon injuries in childhood]. *Z Kinderchir.* 1985 Oct; 40 (5): 294–8. German.
3. Fitoussi F, Lebellec Y, Frajman JM, Penneçot GF. Flexor tendon injuries in children: factors influencing prognosis. *J Pediatr Orthop.* 1999 Nov–Dec; 19 (6): 818–21.
4. O'Connell SJ, Moore MM, Strickland JW, Fraizer GT, Dell PC. Results of zone I and zone II flexor tendon repairs in children. *J Hand Surg Am.* 1994 Jan; 19 (1): 48–52.
5. Berndtsson L, Ejeskär A. Zone II flexor tendon repair in children. A retrospective long term study. *Scand J Plast Reconstr Surg Hand Surg.* 1995 Mar; 29 (1): 59–64.
6. Birnie RH, Idler RS. Flexor tenolysis in children. *J Hand Surg Am.* 1995 Mar; 20 (2): 254–7.
7. Bunnell S. *Surgery of the hand.* 3rd ed. Philadelphia: JB Lippincott; 1956. p. 712.
8. Hunter JM, Salisbury RE. Flexor-tendon reconstruction in severely damaged hands. A two-stage procedure using a silicon-Dacron reinforced gliding prosthesis prior to tendon grafting. *J Bone Joint Surg Am.* 1971 Jul; 53 (5): 829–58.
9. Paneva-Holevich E. Two-stage reconstruction of the flexor tendons. *Int Orthop.* 1982; 6 (2): 133–8.
10. Панева-Холевич Е. Двухэтапная сухожильная пластика по методу Паневой-Хантер. В сб.: Труды IV Всесоюзного съезда травматологов-ортопедов. М.; 1982. С. 231–3.
11. Wehbe MA, Mawr B, Hunter JM, Schneider LH, Goodwyn BL. Two-stage flexor-tendon reconstruction. *J Bone Joint Surg Am.* 1986 Jun; 68 (5): 752–63.
12. Amadio PC, Wood MB, Cooney WP 3rd, Bogard SD. Staged flexor tendon reconstruction in the fingers and hand. *J Hand Surg Am.* 1988 Jul; 13 (4): 559–62.
13. Amadio PC. Staged flexor tendon reconstruction in children. *Ann Chir Main Memb Super.* 1992; 11 (3): 194–9.
14. Soucacos PN. Two-stage flexor tendon reconstruction using silicone rods. In: Vastamaki M, editor. *Current Trends in Hand Surgery.* Amsterdam: Elsevier; 1995. P. 353–7.
15. Soucacos PN. Secondary flexor tendon repair. In: Duparc S, editor. *Textbook on Techniques in Orthopaedic Surgery and Traumatology.* Paris: Elsevier SAS; 2000. P. 55–340.
16. Beris AE, Darlis NA, Korompilias AV, Vekris MD, Mitsionis GI, Soucacos PN. Two-stage flexor tendon reconstruction in zone II using a silicone rod and a pedicled intrasynovial graft. *J Hand Surg Am.* 2003 Jul; 28 (4): 652–60.
17. Дейкало В. П. Медицинская реабилитация пострадавших с застарелыми повреждениями сухожилий сгибателей пальцев кисти методом двухэтапной сухожильной пластики. *Новости хирургии.* 2005; 13 (1–4): 65–9.