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Results of surgical hand tendon repair using a microsurgical tendon holder

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Introduction Tendon injury of the hand is one of the most frequent musculoskeletal disorders. **Objective** To improve results of surgical hand tendon repair. **Materials and methods** Outcomes of 86 patients with tendon injuries of the hand treated in municipal hospital № 4 in the city of Orenburg from 2005 to 2017 were reviewed. Tendons of 10 patients were microsurgically sutured using an original tendon holder. Disability of the Arm, Shoulder and Hand (DASH) questionnaire was used to assess functional results of treatment in addition to established clinical outcome measures. **Results** No complications were observed in patients who underwent original tendon suturing technique and they showed better functional outcomes as compared to controls. **Conclusion** The use of microsurgical tendon holder facilitated more precise and faster tendon suturing, less complication rate and higher functional outcomes.

Keywords: hand tendons trauma, tendon stitch, microsurgery, treatment

INTRODUCTION

Tendon injury of the hand is one of the most frequent musculoskeletal disorders and the problem of tendon surgery has been challenging for centuries. Despite a variety of tendon sutures, a wide range of surgical suture materials and precise technologies for tendon reconstruction surgeons are still discontent with results of reconstructive procedures using conventional techniques [1–4]. Recovery of impaired tendons of the hand poses a question that cannot be answered by orthopaedic and trauma surgeons worldwide. There are many reasons to that including high frequency of tendon injury of 20 to 50 % of all injuries; complex anatomy and tissue differentiation of the tendon and surrounding tissues; failures of treatment; increasing number of complications. The above factors lead to repeated revision procedures, increased temporary disability period and serious incapacity of the involved hand [5–8].

Surgical reconstruction of injured tendons is a technically demanding procedure that involves suturing technique with the tendon undergoing traumatization, multiple squeezing with forceps or a pinch clamp. This results in disturbed ultrastructure, blood supply, dissociated fibres, inaccurate adaptation and low strength of the sutured tendon and finally leads to deformity, thickening of the suture site that tends the sutures to cut out. Tendon regeneration is accompanied by evident scars and adhesion, and tenogenic contractures. Revision procedures (tenolysis, re-suturing) are often required and entail financial responsibilities including the costs of surgical supplies, hospital charges, medications to restore the lost function of the hand.

There is a great number of surgical instruments available for the surgeon to hold and maneuver suturing tissues in hand surgery. However, no description of the devices providing atraumatic and stable fixation of the suturing tendon has been found in the literature. The above problems necessitate development of new techniques and instrumentation that would allow us to sparingly operate on the tendon tissue and provide precise suturing, prevent complications, minimize social and economic loss and related costs.

Objective To improve functional results of surgical hand tendon repair by applying a new technique of grasping and holding suturing tendon.

Goals: a) develop a new suturing technique of hand tendon repair and an instrument to hold suturing tendon preventing pressure against the tendon and damage to the structures; b) perform operative treatment of this cohort of patients; c) evaluate outcomes of surgical treatment employing the new technique.

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MATERIAL AND METHODS

The retrospective study included outcomes of surgical reconstruction of flexor tendons of three-phalangeal fingers performed for 86 patients treated in municipal hospital № 4 in the city of Orenburg from 2005 to 2017. Patients' age ranged from 15 to 68 years (mean age 28.5 years). Patients with impaired bones, hand vessels and nerves were excluded from the review. Left-sided hand injury was diagnosed in 33 patients and 53 had right-sided trauma. The majority of participants (71.3 %) had lacerations, 26.4 % of the patients suffered avulsed wounds; stab wounds, bruises and closed injuries were quite rare. Injuries were mostly located in hand zones 2 and 3 of 45 (52.8 %) and 26 (27.7 %) patients, correspondingly.

Flexor digitorum profundus was sutured alone in case of the tendon impaired in critical zones with an adjusting suture applied to improve tendon sliding properties using either nylon or prolene 6/0 and atraumatic needle. The procedures were performed under anesthesia or regional nerve block. Pneumatic tourniquet was applied in the middle third of the humerus to maintain a bloodless surgical field. The wound was sutured at the end of the surgery with rubber tubes and aseptic dressings applied. Magnet therapy was administered at the site of the wound early after procedure. The hand was immobilized in a functionally favourable position with dorsal plaster cast for 3 weeks and exercise therapy initiated.

Primary suture was performed for 56 patients and primary delayed suture produced for 30 individuals. Skin plasty with local tissues was produced for two cases with skin defects. Rozov tendon suture was applied for 30 patients (group I), Cuneo suture was used for 24 patients (group II), Tsuge suture employed for 22 observations (group III) and 10 patients had original microsurgical suture (group IV) using the patented tendon holder (patent of RF 'Microsurgical tendon holder for tendon suture', priority of 02.10.2017) (**Fig. 1**).

A needle fixator with the diameter less than that of tendon bundles was first used as a new component of the tendon holder to keep the tendon and produce surgical maneuvers. The tendon is minimally exposed allowing for less surgical field. The tendon holder is practical for gripping the tendon and freely move the suturing pieces (flex, rotate and pull the tendon acutely) providing compact reduction and accurate adaptation of tendon ends. There is no need to hold the tendon with forceps and multiple entrapments minimizing intraoperative injury to the tendon, avoiding compression gripping and twisting and reducing surgical time. The device allows for limited surgical field and can be used for any conventional sutures including microsurgical sutures.

Figure 2 shows slides of experimental tendon specimen after conventional suturing technique and suturing with microsurgical tendon holder.

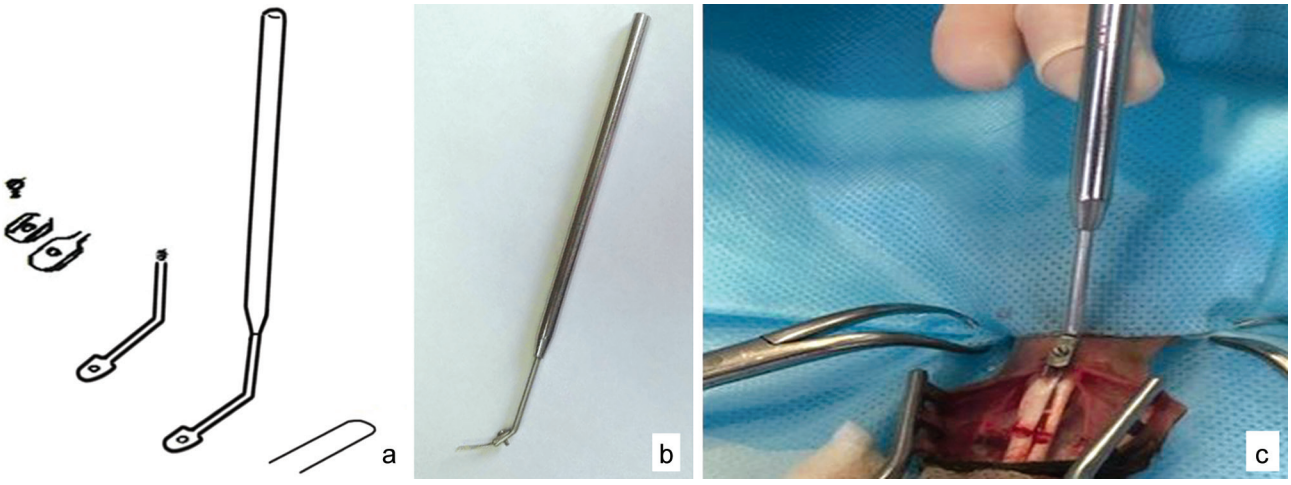

Fig. 1 Microsurgical tendon holder for tendon suturing: (a), layout view of the instrument; (b), test component; (c), intraoperative photograph

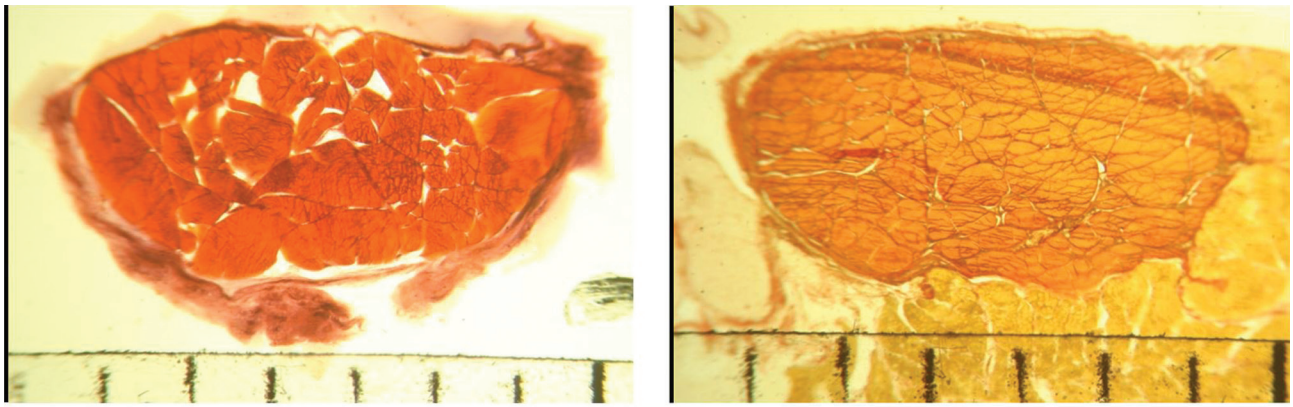

Fig. 2 Transverse histotopograms of tendons showing (a) tendon structure impaired with forceps; (b) tendon structure after applying tendon holder. Stained with Van-Gizone technique. Photo via MBS-10. Ok. 8, ob. 2

The procedure with the usage of microsurgical tendon holder is conducted with a patient being in supine position under combined anesthesia. Upper limb is abducted at an angle of 90 degrees and placed on a side table. Pneumatic tourniquet was applied to the middle third of the humerus, operation field treated with antiseptic solution three times and operation approach to injured tendon produced. The ends of the tendon are exposed and mobilized. U-shaped needle nozzle of appropriate size is attached to the clamp of tendon holder. Two tendon holders can be used at the same time. The pierced tendon ends are strung on the U-shaped needle nozzle of the tendon holder embedding the needles into the tendon along the axis approximating the tendon ends and accurately reducing them. The suturing tendon can be held and shifted without compression forces avoiding injury to the structures. A tendon suture is applied and the instrument is removed. Hemostasis is performed, and the wound is stitched by layers. In addition to established clinical outcome measures the Disability of the Arm, Shoulder and Hand (DASH) score was used to evaluate functional results of tendon suture. Statistical data analysis was performed using Statistica for Windows – 6.0 computer program. The differences were statistically significant with confidence interval of 95 % and higher ($p < 0.05$). Written informed consent was obtained from all the patients. The study was reviewed and approved by institutional review board (Protocol of Ethical Committee FGBOU VO OrGMU Minzdrava № 138 dtd 01.04.2016).

RESULTS

No infection and inflammatory complications were observed in the groups. Four patients developed failed tendon suture from 4 to 6 weeks. Three of them had Cuneo suture (group II), revision surgery showed the suture cut off through tendon thickness, primarily in the proximal portion. This could be associated with disturbed tendon structure during suturing and impaired strength. One patient (group I) developed failed Rozov suture after 15 postoperative days. Revision surgery showed torn suture due to incompliance, neglected immobilization or early loading on the hand. Two patients with torn tendon underwent tendon plasty repair and one had tendon re-suture. One patient refused from revision procedure.

The best functional outcomes were obtained in adolescences, young patients, patients with incised wounds, tendon injuries in zones 1, 3 and 5; the worst results were observed in patients older than 60 years, avulsed wounds and injuries located in zones 2 and 4. Tsuge suture repair showed good results in 19 out of 22 patients (85.5 %), whereas Rozov suture demonstrated similar outcomes in 22 out of 30 (72.6 %) patients. Cuneo group showed good results in 15 out of 24 (61.5 %) cases. Functional result was significantly better ($p < 0.05$) in Group IV with original suture repair using tendon holder. Tendon injury in the group was located in zone 2 ($n = 6$) and in zone 4 of the hand ($n = 4$). No poor outcomes were noted, good and excellent results were achieved in 40 and 60% of the patients, correspondingly.

Clinical instance. A 45-year-old patient B. presented with delayed injury to flexor digitorum profundus of the left-sided 4th and 5th fingers. The patient sustained an injury with glass at the level

of 4th and 5th carpal-phalangeal joints one year ago. Primary surgical treatment of the wound was performed with no suture, and the wound healed with primary intention.

Zig-zag cuts were produced on the palm of the 4th and 5th fingers from nail phalanx to the base of fingers under regional anesthesia. Distal tendon ends of superficial and profound flexors of the 4th and 5th fingers were excised leaving stumps of profound flexors of 1.0 cm at fastening to the distal phalanx. Proximal tendon ends were sutured end-to-end with major intrastem four-wire microsurgical suture using tendon holder. Silicone implants were placed in tendon beds and stitched to the tendon stumps of profound flexor of the 4th and 5th fingers. The wounds were stitched and healed with primary intention.

The second stage of plasty was produced 3 months later этап with the method described above. Revision of microsurgical suture was performed intraoperatively. The suture appeared to be good with tendon ends healed end-to-end without visible gap. Neither scars no adhesion noted in the proximity of the suture with good sliding noted. The procedure was accomplished with sutures applied to the wound. The hand was immobilized with plaster cast for 3 weeks. Passive motion were permitted on day 3 postoperatively, and active motion starting from week 2. Postoperative period was uneventful. Magnet therapy, exercise therapy and massage were administered postoperatively. The patient was seen at 6-month follow-up with complete hand function and could return to his job as a turner

DISCUSSION

Surgical reconstruction of tendon ruptures is a technically challenging and demanding procedure. There are a variety of tendon sutures, precise techniques and modern rehabilitation modalities available for tendon repair. The existing methods of reconstruction often neglect microanatomy of the hand tendons and the surrounding tissues and can be quite traumatic. There are no specialized instruments available in hand surgery that would allow for holding the suturing tendon avoiding compression against the tendon [1, 4, 8]. Forceps and clamps used for the purpose can cause additional intraoperative injury that leads to disturbed adaptation of tendon ends, deformity and thickening at the suture site and, finally, impaired tendon regeneration, evident scars and adhesion, disordered tendon function, temporary or consistent disability [2, 3, 7].

The technique offered for tendon suturing with tendon holder allowed us to reduce surgery timing, reduce postoperative complication rate and revision procedures as well as financial costs involved with the treatment of the patients. As compared to forceps and clamps for tendon fixation the tendon holder offered is practical to provide:

a) gradual sparing approximation of tendon ends and the accurate adaptation;

b) the possibility with tendon compression free fixation throughout surgical procedure;

c) minimal trauma to tendon tissues avoiding pressure, bending and injury to mesenterium;

d) reduced timing of suture application due to less number of unreasonable manipulations;

e) the possibility to perform procedure without an assistant.

CONCLUSION

Retrospective analysis of outcomes of hand injury treated at our hospital indicated to the relevance of the problem. Issues with recovery of lost hand functions to be addressed by the surgeon remain unsettled. Poor results were observed in 19 cases from the total number of patients operated on. Poor outcomes were associated with high rate of tenogenic contractures and failed tendon sutures. The use of microsurgical tendon holder facilitated more precise and faster tendon suturing, lower complication rate and higher functional outcomes.

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