Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
March-April 2022 Page No. 1216-1222
Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022

Efficacy Analysis of the Silfverskiold Repair for Extensor Tendon Injury in Zones V-VII Followed by Early Active Motion Rehabilitation and Postoperative Psychological Care

Lili Geng, Can Wu*, Zenggang Chen, Jingshu Fu, Renggang Shi
Banan District People's Hospital of Chongqing, Chongqing, 401320, China
*Corresponding Author.

Abstract:

The skin on the back of the hand is thin, and extensor tendon injury in zones Ⅴ-Ⅶ is common. The traditional treatment scheme is injured limb braking for 4-6weeks after zigzag cross seam, after that rehabilitation exercise was taken, which would lead to tendon adhesion and long rehabilitation cycle. The long-term functional recovery of patients caused most patients with hand trauma have serious psychological pressure. It is necessary to explore a new treatment method to improve the long-term function of this kind of patients. It was reviewed that the Silfverskiold repair for extensor tendon injuries in zones Ⅴ-Ⅶ, followed by early active motion rehabilitation and postoperative psychological care, and good results were achieved. This paper evaluated the effect of the early active motion rehabilitation and postoperative psychological care after the Silfverskiold repair for extensor tendon injuries. To evaluate the curative effect analysis of the Silfverskiold repair for extensor tendon injuries in zones Ⅴ-Ⅶ, followed by early active motion rehabilitation and postoperative psychological care. Between March 2015 and October 2018, a total of 43 patients with 84 digital extensor tendon lacerations in zones Ⅴ-Ⅶ were included in this study. The tendon repairs used Silfverskiöld technique involving a standard modified Kessler core suture and a running cross-stitch epitendinous suture. Within seven days postoperatively, the patient began wearing a splint with the wrist in 20 degrees extension .The splint allowed patient to actively flex and extend the fingers, but blocked the MP joints from 40 degrees flexion. Exercise were carried out ten times per hour. At night, another splint was added to the main splint and positioned the MCP joints and IP joints in extension. After four weeks, the splint was discontinued, and the patients began active digital motion. Protective static splinting was continued with the interphalangeal joints in full extension during the night and outdoors for another 2 weeks. Miller's system was applied to evaluate the function postoperatively. The follow-up period ranged from 2 to 6 months, with an average of 4 months.29 of the 43 patients regained full range of motion within 8 weeks postoperatively. At the final follow- up, according to Miller's criteria, the results were graded as 'excellent' and 'good' in 96% of the digits, and as 'fair' in the remainder. There was no rupture of the repaired tendon. Early postoperative active activity has been widely used in the postoperative treatment of flexor tendon injury, but there were few reports about the application after extensor tendon repair. Previous studies had shown that early active activity can promote the regression of wound swelling and reduce tendon adhesion. The stress

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
March-April 2022 Page No. 1216-1222
Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022

generated by activity is conducive to the longitudinal arrangement of new tendon fibers, avoid tendon softening and increase the strength of tendon healing. At the same time, the early active activity scheme is relatively simple and easy to be under stood and accepted by patients, but firm tendon suture is the prerequisite to prevent tendon rupture in the process of early rehabilitation. The Silfverskiold repair for extensor tendon injuries in zones Ⅴ-Ⅶ, followed by early active motion rehabilitation yields excellent results, and is quite safe without increasing the risk of tendon rupture.

Keywords*: extensor tendon; Early active mobilisation ;Silfverskiold; dynamic splinting*

I. INTRODUCTION

The back of the hand and forearm has thin skin, so common injuries occur on the back of the hand and its proximal extensor tendon (extensor tendon injury in zones V-VII) [1]. The traditional treatment plan is to immobilize for 4-6 weeks after the figure-of-eight suture, followed by rehabilitation exercise, which will lead to tendon adhesion and a longer recovery cycle. Howell et al. [2] found in a long-term follow-up study that after 4 weeks of immobilization following extensor tendon injury, the excellent and good rate was only 64% for simple injuries and 45% for complex injuries. Early postoperative active activities have been widely used in the postoperative treatment of flexor tendon injuries, but are less reported in application after extensor tendon repair. Studies have shown that early active activity can accelerate reduction in wound swelling, reduce tendon adhesion, and the stress generated in activity can contribute to longitudinal arrangement of new tendon fibers, avoid tendon softening, and increase tendon healing strength. At the same time, relatively simple early active activity program is easy to understand and accept by patients. However, firm tendon suture is a prerequisite for preventing tendon re-rupture during early rehabilitation. The extensor tendon is flat and loose in structure, lacking cross-linked fiber between the tendon fibers. Although the figure-of-eight suture is relatively simple, its suture direction is parallel to the tendon fibers, so when force is applied, the suture is easily cut out of the tendon, resulting in loose stump or re-rupture. Silfverskiold[3] suture consists of two parts, with modified Kessler suture in the central part and crisscross suture in the periphery. Perpendicular to the tendon fibers, the suture has multiple gripping points on the tendon, which renders its much higher biomechanical strength compared to figure-of-eight suture and Kessler suture. In addition, the suture location far away from the injury area enables a good grasp of the extensor tendon that becomes loose due to contusion.

Therefore, to enable early functional exercise after the extensor tendon repair and improve injured limb function, we combine Silfverskiold suture with greater suture strength with early postoperative function rehabilitation to treat the extensor tendon laceration in zones V-VII . From June 2015 to December 2018, our department treated a total of 43 patients with 84 finger extensor tendon ruptures in zones V-VII, with good results achieved. The report is as follows.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
March-April 2022 Page No. 1216-1222
Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022

II. MATERIAL AND METHODS

2.1 General Materials

There were 43 cases in this group, a total of 84 fingers; 28 males and 15 females. Aged 27-52 years old, the patients had an average age of 41 years old. Causes of injury: 36 cases had sharp injuries (including knives, glass, and iron sheets), 7 cases had chainsaw injuries. 23 cases involved index fingers, 27 cases involved middle fingers, 20 cases involved ring fingers, and 14 cases involved little fingers. The time from injury to surgery lasted 1-10h, all cases received emergency repairs. Partial lacerations of the extensor tendons, defects, children, combined fractures or patients whose skin failed in primary closure were excluded, and thumb cases were also excluded (with different anatomical structures and biomechanics).

2.2 Surgical Method

Brachial plexus anesthesia. After debridement, make an arc extension along the original wound, expose the tendon stump, reset the proximal end of the extensor tendon, fix it with a needle, passively straighten the finger, and suture the tendon. Silfverskiold method was taken for tendon repair: modified Kessler suture was performed with 3-0 tendon suture (Ethicon), and then crisscross suture of the tendon surface was made with 5-0 tendon suture (Ethicon) at 1 cm from the tendon stump. Needle insertion had a width of approximately 2mm. Perform toroidal suture to the beginning and tie a knot (Figure 1a). For zone V, it was difficult to suture the contralateral side due to the presence of sagittal tract, so the tendon surface was only sutured from the operator's side to the assistant's side, and then knotted. For tendon ruptures near the extensor retinaculum, open part of the retinaculum or form Z-shaped retinaculum intraoperatively to facilitate tendon repair or tendon sliding. Perform passive full-range flexion and extension of the fingers 5-6 times. After the suture was evenly stressed, cut the tendon surface and the core suture tail. After electrocoagulation completely stopped the bleeding, close the wound.

2.3 Postoperative Treatment

In early stage, use plaster slab to fix 2-5 fingers in the straight position. Within one week after the surgery, the wound was usually dry, so switch to splint protection, and begin rehabilitation exercises. With palmar splint maintaining the wrist joint at 20° dorsal extension, the patient actively flexed and stretched fingers under the splint protection. The metacarpophalangeal joints could be flexed up to 40°, and the interphalangeal joints were open. Practice 10 times every 2 hours (Figure 1b- 1d). The patient could wear an extended splint between exercises and at night to maintain fingers in a straight position. After the stitches were removed, a local scar massage was performed. The splint was removed at 4th week postoperatively, so that the patient actively flexed and extended fingers without resistance. The number of exercises was not limited. The straightening splint was used for 2-week continuous protection at night and during outdoor activities. At the end of 6th week, if there was limited flexion of the finger joints, progressive passive flexion exercises could be performed. After 8 weeks, patient could use the grip ball for strength exercises, starting from the lowest magnitude and gradually increasing it.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
March-April 2022 Page No. 1216-1222
Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022

2.4 Evaluation criteria

Miller criteria was used for functional evaluation [4]. This criteria analyzes the recovery of the total range of motion of the metacarpophalangeal joints, the near interphalangeal joints and the distal interphalangeal joints, which is divided into four levels: excellent if flexion and extension are completely normal, fine if total extension loss angle ≤ 10° or total flexion loss angle ≤20°, acceptable if total extension loss angle is between 11°-45° or total flexion loss angle is between 21°-45°, poor if total flexion loss angle or extension loss angle ≥45°.

III. RESULTS

All 43 patients were followed up for 2-6 months, with an average of 4 months. The wound of all patients was healed by first intention. No patient had tendon re-rupture. 29 patients resumed normal activities within 8 weeks after surgery. At the last follow-up, patients were evaluated according to Miller's functional assessment criteria: 67 fingers were excellent, 14 fingers were fine, 3 fingers were acceptable, and 0 finger was poor. The excellent and good rate was 96.4% (81/84 fingers). Typical cases (Figure 2a-2d for case 1; Figure 3a-3d for case 2) are shown below.

Figure 1: a: Schematic diagram of restoration;
b-c: The patient actively flexes and stretches his fingers;
d: Finger extension splint at night

Figure 2: a: Intraoperative extensor tendon rupture in zone VII;
b: Intact fist tendon stump at 10°wrist flexion during surgery;
c-d: follow-up for 3 months

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
March-April 2022 Page No. 1216-1222
Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022

Figure 3: a: Extensor tendon rupture in zone V;
b: 2-4 intraoperative finger extensor tendon repair;
c-d: 10 weeks' follow-up after surgery

IV. DISCUSSION

At present, the traditional treatment for the hand back and proximal extensor tendon injury is to immobilize the fingers and wrist joints in the extension position for 4-6 weeks, and then restore finger flexion function via active and passive activities [5]. Immobilization can cause adhesions between the injured tendon and surrounding tissues, especially for extensor tendon injury at the retinaculum, where the extensor tendon is wrapped in the sheath. Immobilization in the extension position of the metacarpophalangeal joint can still cause collateral ligament contracture of joint and joint stiffness. Excessive external force to restore the flexion function after immobilization may even cause incompletely healed tendon relaxation and re-rupture. In view of these problems, some scholars [6-7] use dynamic finger extension splint to treat extensor tendon injury in zones V-VII. Despite certain achieved effects, the following problems still exist: (1) Dynamic finger extension is a passive activity not necessarily able to push the extensor tendon to the proximal end, because the tendon will slide only when it receives traction; (2) The patient needs to overcome the traction force of the rubber strip when actively flexing, which is similar to strength exercises in rehabilitation. Excessive traction can induce extensor contraction, so there is a risk of re-rupture of the extensor tendons; (3) The splint is bulky and affects the patient's daily life, while the rubber strip traction will make the patient uncomfortable. These will make it difficult for the patient to wear it on a long-term basis.

Early postoperative active activities have been widely used in the postoperative treatment of flexor tendon injuries [8-9], but are less reported in application after extensor tendon repair. Studies have shown [10-11] that early active activity can accelerate reduction in wound swelling, reduce tendon adhesion, and the stress generated in activity can contribute to longitudinal arrangement of new tendon fibers, avoid tendon softening, and increase tendon healing strength. At the same time, relatively simple early active activity program is easy to understand and accept by patients. However, firm tendon suture is a prerequisite for preventing tendon re-rupture during early rehabilitation. The extensor tendon is flat and loose in structure, lacking cross-linked fiber between the tendon fibers. Although the figure-of-eight suture is relatively simple, its suture direction is parallel to the tendon fibers, so when force is applied, the suture is easily cut out of the tendon, resulting in loose stump or re-rupture. Silfverskiold suture consists of two parts, with modified Kessler suture in the central part and crisscross suture in the periphery. Perpendicular to the tendon fibers, the suture has multiple gripping points on the tendon, which renders its much higher biomechanical strength compared to figure-of-eight suture and Kessler suture [12]. In addition, the suture location far away from the injury area enables a good grasp of the extensor tendon that becomes loose due to contusion. We have also observed clinically that using this suture method does not incur tendon stump fracture formation or re-rupture when patient passively makes a fist with the wrist joint in the flat extension position.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
March-April 2022 Page No. 1216-1222
Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022

Literature reporting active activities advocates that the wrist joint should be extended at 40°-45° [13]. In view of the greater biomechanical strength of Silfverskiold suture, we placed the wrist joint at 20° dorsal extension after the surgery as lowering the flexor tendon tension helps patient actively straighten fingers after surgery. Of course, no matter how firm the tendon is sutured, its strength is much lower than that of a normal tendon. Therefore, postoperative frequency and amplitude of finger movements are limited, and only controlled active activities can be performed. In the first 4 weeks after surgery, the patient's active range of motion was 0°-40°in metacarpophalangeal joint, producing 5mm extensor tendon slippage that could effectively avoid tendon adhesions [14] still within the safe range observed intraoperatively. In addition, during exercises and at night, fixing fingers in an extension position can avoid stress creep at the stump of the tendon.

V. CONCLUSION

Silfverskiold suture method combined with early postoperative active activities can quickly and safely restore the hand function of patients with extensor tendon injury in zones V-VII. Despite the slightly time-consuming surgery, the spent time is worth it in view of the "long" recovery period after traditional treatment.

REFERENCES

[1] Amirtharajah M, Lattanza L. Open extensor tendon injuries. J Hand Surg Am. 2015 Feb; 40(2):391-7
[2] Howell JW, Peck F. Rehabilitation of flexor and extensor tendon injuries in the hand: current updates. Injury. 2013 Mar; 44(3):397-402.
[3] Silfverskiold KL, May EJ. Flexor tendon repair in zone II with a new suture technique and an early mobilization program combining passive and active flexion. J Hand Surg [Am], 1994, 19:53–60.
[4] Miller H. Repair of severed tendons of the hand and wrist. Statistical analysis of 300 cases. Surg Gynecol Obstet. 1942, 75:693–698.
[5] Howell JW, Peck F. Rehabilitation of flexor and extensor tendon injuries in the hand: current updates. Injury. 2013 Mar; 44(3):397-402.
[6] Rabbani MJ, Amin M, Khalid K, Khan H, Shahzad I, Rabbani A, Nasrullah M, Tarar MN, Rabbani S. Early Active Mobilization Vs Immobilization Following Modified Kessler Repair Of Extrinsic Extensor Tendons In Zone V TO VII. J Ayub Med Coll Abbottabad. 2019 Jul-Sep; 31(3):320-325.
[7] Patil RK, Koul AR. Early active mobilisation versus immobilisation after extrinsic extensor tendon repair: A prospective randomised trial. Indian J Plast Surg. 2012 Jan; 45(1):29-37.
[8] Moriya K, Yoshizu T, Maki Y, Tsubokawa N, Narisawa H, Endo N. Clinical outcomes of early active mobilization following flexor tendon repair using the six-strand technique: short- and long-term evaluations. J Hand Surg Eur Vol. 2015 Mar; 40(3):250-8.
[9] El-Shebly A, El Fahar M, Mohammed H, Bahaa Eldin A. Outcomes of repair of the lacerated A2 pulley with extensor retinaculum during primary flexor tendon repair. J Hand Surg Eur Vol. 2017 Nov; 42(9):903-908.
[10] Niu XF, Yi JH, Zha GQ, Hu J, Liu YJ, Xiao LB. Vacuum sealing drainage as a pre-surgical adjunct in

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
March-April 2022 Page No. 1216-1222
Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022

the treatment of complex (open) hand injuries: Report of 17 cases. Orthop Traumatol Surg Res. 2017 May; 103(3):461-464

[11] Cooper L, Khor W, Burr N, Sivakumar B. Flexor tendon repairs in children: Outcomes from a specialist tertiary centre. J Plast Reconstr Aesthet Surg. 2015 May; 68(5):717-23.

[12] Fujihara Y, Ota H, Watanabe K. Utility of early active motion for flexor tendon repair with concomitant injuries: A multivariate analysis. Injury. 2018 Dec; 49(12):2248-2251.

[13] Bazancir Z, Fırat T. A potential factor in the pathophysiology of lateral epicondylitis: The long sarcomere length of the extensor carpi radialis brevis muscle and implications for physiotherapy. Med Hypotheses. 2019 Sep; 130:109278.

[14] Fujihara Y, Ota H, Watanabe K. Utility of early active motion for flexor tendon repair with concomitant injuries: A multivariate analysis. Injury. 2018 Dec; 49(12):2248-2251.