Reconstruct Flexor and Extensor tendon in Severe Hand Injury Using Allogenic tendon: A Retrospective study

CURRENT STATUS: POSTED

Gu Heng Wang
Affiliated Hospital of Nantong University

Tian Mao
Affiliated Hospital of Nantong University

Shu Guo Xing
Affiliated Hospital of Nantong University

Ya Lan Chen
Nantong University

Yu Xuan Zhang
Affiliated Hospital of Nantong University

Corresponding Author
ORCiD: 0000-0001-8100-5097

DOI:
10.21203/rs.2.11695/v1

SUBJECT AREAS
Orthopedic Surgery

KEYWORDS
Allograft, Hand, Severe injury, Tendon
Abstract

Background

To evaluate the effective and safety of reconstruction of flexor and extensor tendon in hand using allogenic tendon with 2- to 7.6-year follow-up.

Methods

Between August 2007 and July 2014, we performed tendon allografts for 14 patients who suffered from severe hand injury with 2 or more tendon defects. 10 patients have been followed-up, 6 cases of flexor tendon rupture with defect, 3 cases of extensor tendon rupture with defect, 1 case with flexor and extensor tendon rupture with defect. Tendon allografts were used to repair tendon defects in order to reconstruct the function of flexion or extension. At the final follow-up visit, the total active motion (TAM), grip strength, pinch strength, DASH and the degree of satisfaction were measured. The WBC, C-reactive protein (CRP), Erythrocyte sedimentation rate (ESR), Total T cell and CD4+T/CD8+T were measured to evaluate the response related to immune and infection.

Results

The average follow-up period was 50.0 months (range 24-82 months). The mean motion of TAM was 129.9° (rang 12-259°), pinch strength was 0.76Kg (rang 0-4.5Kg), grip strength was 18.67Kg (rang 4-46Kg), the score of DASH was 14.25 (rang 3.3-30.8), 7 patients were satisfied and 3 patients were partially satisfied with the results. The results of WBC, CRP, ESR, Total T cell and CD4+ T/CD8+ T were mostly in normal field.

Conclusion

In severe hand injuries with multiple tendon defects, reconstruction of flexor and extensor tendon in hand using allogenic tendon is an effective and safe treatment.

Background
Patients with severe hand injury are more common in the handicraft-intensive areas, which will bring great pain to patients and take great challenge to surgeon at the same time[1]. Patients with severe hand injury often include bones fracture, tendons, skin and other tissue injuries. Among this, many of them have tendon defect. For these patients, the most ideal way is to take the autologous tendon transplantation[2], but if patients who do not want to sacrifice autologous tendon or have multi-tendon defect, allogeneic tendon transplantation may be a good choice. Allogeneic tendon grafts have been used since the 1967 and proven to be effective [3], but have not been widely used due to concerns about immunogenicity and other issues. With the development of modern medicine, allograft tendon has been used in the cruciate ligament injury[4], Acromioclavicular ligaments injury[5], Achilles tendon injury[6], hand trauma[7,8] and others widely. In this study, we report the efficacy and safety of allogeneic tendon graft used in severe hand injury patients with multiple tendon defects.

Methods

This study was approved by our institutional review board and informed consent was obtained from each participant. Between August 2007 and July 2014, we performed tendon allografts for 14 patients who suffered from severe hand injury the modified hand injury severity score[9] > 50 with two or more tendon defects. 10 patients have been followed-up, including 3 females and 7 males with an mean age of 38.0 (range, 18 to 60) years at the time of the surgery.

Among the 10 patients, 9 were industrial accident and 1 utility knife cuts. Among all the patients, 6 cases of flexor tendon rupture with defect, 3 cases of extensor tendon rupture with defect, 1 case with flexor and extensor tendon rupture with defect. Except for tendon partial defects in all patients, they also have soft tissue or bone injuries. More details about patients are presented in Table1.
The allogenic tendons were off-the-shelf products in China. They were harvested and process by a commercial company (tissue bank of the Orthopedic Institute of the People’s Liberation Army in Beijing) with strict guidelines and stored in deep-freeze environment. Before surgery, we confirmed that patients have well healed wounds, pliable skin and soft tissues, no sign of infection and joint of the hand or wrist mobility can reach as normal passively. In preoperative communication, the patient with two or more tendon defects and does not wish to donate his or her own tendons were choice to tendon allograft (determined by patient after the risks and benefits of tendon allograft were described). During surgery, the allogenic tendon was reconstituted with normal temperature saline with Gentamicin for 30 minutes before use transplantation into receptor. The rest of the surgical procedure is the same as autogenic tendon transplantation and ensure the tension of tendon suture is appropriate.

In flexor tendon graft, the tension should allow the repaired finger to appear slightly more flexed than the normal cascade and during the time of wrist flexion the finger can straight freely. When repaired the extensor tendon, we should keep the digit and wrist straighten and permit the finger flex as the wrist dorsal flexion.

Postoperative care
In Extensor tendon graft repair, the joint of wrist was dorsiflexion about 30° and the metacarpophalangeal(MCP) joint was straight with volar splint. In flexor tendon graft repair, the wrist and MCP joints were flexed about 30° and the joint of finger were slight flexion with dorsal splint. If flexor and extensor tendons were repaired at the same time, the wrist was fixed in neutral position.

After tendon graft, surgeon, patient, and rehabilitation physician have to be in regular cooperation to ensure the best outcome. We encourage patients to do limited range of passive motion 3 to 5 days after surgery. After 3 weeks, full range of passive motion and
limited range of active motion began. Full range of active motion began after 6 weeks.

Outcome assessment

The total active motion (TAM) system[10] was used to evaluate the functional outcomes. The motion of MCP, proximal (PIP) and distal interphalangeal (DIP) joints may be all affected in our series, so the active motion of three joints were measured for each injured finger. The TAM outcome use the sum of MCP, PIP joint and DIP joint flexion (in attempted fist position) minus the extensor lag at these joints (in thumb, TAM is the sum of MCP and interphalangeal joint flexion minus the extensor lag at these joints).

We also measured the grip strength of injured hand and pinch strength of injured finger. The white blood cell (WBC), C-reactive protein (CRP), Erythrocyte sedimentation rate (ESR), Total T cell and CD4+ T/CD8+ T[11] were measured to evaluate the response related to immune and infection. At last, the degree of satisfaction with functional recovery of tendon allografts was asked (satisfied, partially satisfied, or not satisfied).

Results

The average follow-up period was 50.0 months (range 24-82 months) and wounds were well healed. No deep infection, infectious disease transmission or obvious immune rejection was found in these series. The mean motion of TAM was 129.9° (rang 12-259°), pinch strength was 0.76Kg (rang 0-4.5Kg), grip strength was 18.67Kg (rang 4-46Kg), the score of DASH was 14.25 (rang 3.3-30.8), 7 patients were satisfied and 3 patients were partially satisfied with the results (Table 2). 5 patients received an immune-related blood test WBC, CRP, ESR, Total T cell and CD4+ T/CD8+ T. The results related to immune were mostly in normal field and details were presented in Table 3.

Discussion

The process of treatment for sever hand injury is complexity. Sometimes we usually have
to do several surgeries in order to recover the function of the hand. Before tendon graft, we may do surgery like internal fixation, Vascular nerves or wound repair. After initial surgery we need to prevent the occurrence of infection, 1 case in our series was infected and after treated we do functional reconstruction. Generally speaking, functional reconstruction was usually taken 3 months after the wound healed.

The patients with severe hand injury may have several tendon defects, and we have to reconstruction it with tendon graft[7]. Weather to use allegnic tendon for reconstruction, we choose it according to the patient's intention. Some patients may choose allegnic tendon graft for worrying about their own normally functioning decreased after sacrifice tendon. Use allogeneic tendon can restore the continuity of tendon defective quickly and without restrict of the number autologous tendon can offer.

However, tendon allografts are not without some disadvantages[12]. Tendon allografts have the risk of rejection and disease transmission and this is one of the reasons that allogeneic tendons have not been widely used. But with the advances in tissue processing such as acellularization and extensive donor screening for transmissible diseases, it is time for us to address the reconstructive needs of patients with allogeneic tendon for multiple tendon defects. We used allograft tendons provided by the professional tissue transplant library and they use γ sterilization treatment which can mostly eliminate the spread of the disease. Before the allograft tendon was implanted into the receptor, it was invade in gentamicin water for 30 minutes. At the same time, no signs of transmission of infectious diseases were found in our study. In results of Tang et al[13] published, no infectious disease transmission, deep infection, or obvious immune rejection occurred in 24 patients who received tendon allografts. In addition, no evidence of immune reactions or disease transmission in Harner’s[14] study with 3 to 5 years fellow-up. CD4+ T/CD8+ T which was considered related to tendon immune[11] was mostly normal as we measured.
Other measurement related to immune such as WBC, CRP and ESR were mostly in normal field of 5 measured patients. Therefore, we believe that it is safe to use allogeneic tendons. Besides, DeGeorge et al[15] and Drake et al[1] were also hold optimistic opinion about the application prospect of allogenic tendon.

Even with optimum surgical treatment and physical therapy, postoperative adhesion formation especially in allograft is also the fundamental problem which continue to challenge the hand surgeon[16]. In our series, one patient was adhesion and do release with flap shaping after 3 months, but the final function is still poor. Therefore, postoperative effective rehabilitation exercise, to prevent adhesion is extremely important. Even though we have always stressed the importance of rehabilitation exercises to patients, but when some patients discharge from hospital it is difficult to achieve it.

Before we decide to transfer the tendon, we must make sure the condition of tissues is permitted and the joint of the finger are not stiffness. Severe hand injury are often accompanied by multiple tissue injuries. So, the tendon transfer were usually performed in a two-stage procedure[16][17], with separate consideration given to the recovery of soft-tissue coverage. In Severe hand injury, the tendon graft was usually taken after the skin defect was covered 3 month later[17]. At the same time, the patient should exercise to avoid the joint stiffness. In our study, we performed the surgery 3.5months after wound healed and induct patient do exercise to avoid the joint stiffness during this period. The goal of surgery is to restore hand function. We hope that patients will able to flex and extend their fingers freely. Although 3 cases of functional recovery were poor in our follow-up cases, we can hold the opinion that tendon allografts can restore the patient's function at some extent on the whole. Of course, the functional recovery of patients with severe hand injury is affected by many factors. In our study, some patient's injury was
indeed serious and has to receive multiple operations. For example, one case had internal fixation for phalangeal or metacarpal fracture, amputation of middle and ring at DIP level and anterolateral thigh flap repaired the wound at first stage. And then, the allogeneic tendon was transplanted at second stage. Finally, due to the serious injury, functional recovery is not ideal. In addition, patients with poor postoperative compliance and functional rehabilitation are not in place, which is also a problem. These tips require our clinicians to fully understand their strengths and weaknesses about tendon allografts before use it. It is very important to grasp the indications. If the patient have severe injury or unable to cooperate after surgery, use it with caution. In patients who have used allogeneic tendon repair, they must have regular follow-up visits and timely and effective functional exercise.

Conclusion

In severe hand injuries with multiple tendon defects, reconstruction of flexor and extensor tendon in hand using allogenic tendon is an effective and safe treatment.

Abbreviations

MHISS: the modified hand injury severity score; MCP: metacarpophalangeal; TAM: total active motion; PIP: proximal interphalangeal; DIP: distal interphalangeal; WBC: white blood cell; CRP: C-reactive protein; ESR: Erythrocyte sedimentation rate;

Declarations

Ethics approval and consent to participate

All patients received information about the study and gave written consent. The retrospective study design and all investigation protocols were approved by the Ethics Committee of Affiliated Hospital of Nantong University.

Consent to publish
Informed consent was obtained from the patient whose data are provided.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

No funding was received.

Authors' Contributions

GH Wang Project development, Data analysis, Manuscript writing. T Mao and SG Xing Project development. YL Chen and YX Zhang Data management, Data collection. RG Xie designed the retrospective study and Manuscript editing. All authors have read and approved the manuscript.

Acknowledgements

Dr. Yi Feng Gao and Xing Wang have helped in reviewing the patient data in this paper.

References

1. Drake DB, Tilt AC, DeGeorge BR. Acellular flexor tendon allografts: a new horizon for tendon reconstruction. J Hand Surg Am 2013; 38: 2491-2495.
   https://doi.org/10.1016/j.jhsa.2013.03.039

2. Türker T, Hassan K, Capdarest-Arest N. Extensor tendon gap reconstruction: a review. J Plast Surg Hand Surg 2016; 50: 1-6. https://doi.org/10.3109/2000656X.2015.1086363

3. Peacock EE Jr, Madden JW. Human composite flexor tendon allografts. Ann Surg 1967; 166: 624-629
4. Bottoni CR, Smith EL, Shaha J, Shaha SS, Raybin SG, Tokish JM, Rowles DJ. Autograft Versus Allograft Anterior Cruciate Ligament Reconstruction: A Prospective, Randomized Clinical Study With a Minimum 10-Year Follow-up. Am J Sports Med 2015; 43: 2501-2509. https://doi.org/10.1177/0363546515596406

5. Wang G, Xie R, Mao T, Xing S. Treatment of AC dislocation by reconstructing CC and AC ligaments with allogenic tendons compared with hook plates. J Orthop Surg Res 2018; 13: 175. https://doi.org/10.1186/s13018-018-0879-x

6. Huang X, Huang G, Ji Y, Ao Rg, Yu B, Zhu YL. Augmented Repair of Acute Achilles Tendon Rupture Using an Allograft Tendon Weaving Technique. J Foot Ankle Surg 2015; 54: 1004-1009. https://doi.org/10.1053/j.jfas.2014.12.029

7. Xie RG, Tang JB. Allograft tendon for second-stage tendon reconstruction. Hand Clin 2012; 28: 503-509. https://doi.org/10.1016/j.hcl.2012.08.011

8. Tang JB. Uncommon methods of flexor tendon and tendon-bone repairs and grafting. Hand Clin 2013; 29: 215-221. https://doi.org/10.1016/j.hcl.2013.02.004

9. Urso-Baiarda F, Lyons RA, Laing JH, Brophy S, Wareham K, Camp D. A prospective evaluation of the modified hand injury severity score in predicting return to work. Int J Surg 2008; 6: 45-50. https://doi.org/10.1016/j.ijsu.2007.09.001

10. Kleinert HE, Verdan C. Report of the Committee on Tendon Injuries (International Federation of Societies for Surgery of the Hand). J Hand Surg Am 1983; 8: 794-798

11. Zhang YL. Research direction and current status of tendon allografts Zhonghua Shou Wai Ke Za Zhi 2006; 22: 129-130
12. Robertson A, Nutton RW, Keating JF. Current trends in the use of tendon allografts in orthopaedic surgery. J Bone Joint Surg Br 2006; 88: 988-992

13. Tang L, Chen H, Cui T, Cheng G, Fang G, Ding X. Long-term effectiveness of tendon allograft for repairing tendon defect. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 2011; 25: 341-343

14. Harner CD, Olson E, Irrgang JJ, Silverstein S, Fu FH, Silbey M. Allograft versus autograft anterior cruciate ligament reconstruction: 3- to 5-year outcome. Clin Orthop Relat Res 1996; 324: 134-144

15. DeGeorge BR Jr, Rodeheaver GT, Drake DB. Operative technique for human composite flexor tendon allograft procurement and engraftment. Ann Plast Surg 2014; 72: S191-197. https://doi.org/10.1097/SAP.0000000000000091

16. Viegas SF. A new modification of two-stage flexor tendon reconstruction. Tech Hand Up Extrem Surg 2006; 10: 177-180. https://doi.org/10.1097/01.bth.0000232868.82782.ff

17. Derby BM, Wilhelmi BJ, Zook EG, Neumeister MW. Flexor tendon reconstruction. Clin Plast Surg 2011; 38: 607-619. https://doi.org/10.1016/j.cps.2011.08.006

Table

Table 1 Data of the 10 evaluated patients
| Patient | Sex | Age | Mechanism of injury | Side       | Soft tissue and bone injuries | MHISS | Initial surgery                                                        | Operation Interval |
|---------|-----|-----|---------------------|------------|-------------------------------|-------|-----------------------------------------------------------------------|------------------|
| 1       | M   | 52  | Industrial accident | Right hand | Bones, blood vessels, nerves, tendon, skin | 138   | Internal fixtation, flap, digital amputation of middle and ring       | 3                |
| 2       | M   | 37  | Industrial accident | Left hand  | Blood vessels, nerves, tendon, skin | 90    | Blood vessels and nerves repair                                      | 3                |
| 3       | M   | 38  | Industrial accident | Right wrist | Bones, blood vessels, nerves, tendon | 340   | Replantation surgery at the wrist                                    | 2                |
| 4       | M   | 33  | Industrial accident | Right index/middle/ring/little finger | Bones, blood vessels, nerves, tendon | 230   | Replantation surgery of the index, middle, ring, little finger        | 6                |
| 5       | M   | 33  | Utility knife       | Left palm  | Bones, blood vessels, nerves, tendon | 116   | Replantation surgery at the palm                                    | 12               |
| 6       | F   | 22  | Industrial accident | Right forearm | Bones, blood vessels, nerves, tendon | 270   | Replantation at the wrist                                            | 6                |
| 7       | F   | 39  | Industrial accident | Right hand | Bones, tendon                  | 67    | Internal fixtation                                                   | 3                |
| 8       | M   | 18  | Industrial accident | Right hand | Bones, tendon, skin            | 80    | Internal fixtation                                                   | 6                |
| 9       | M   | 60  | Industrial accident | Right hand | Bones, blood vessels, tendon   | 69    | Internal fixtation and blood vessels repair                           | 10               |
| 10      | F   | 48  | Industrial accident | Right hand | Bones, tendon, skin            | 89    | Internal fixtation, flap and digital amputation of ring               | 3                |
Table 2 Outcome assessment of function

| Patient | Finger | TAM(°) | Pinch(Kg) | Grip strength(Kg) | DASH | Degree of satisfaction |
|---------|--------|--------|-----------|-------------------|------|-----------------------|
| 1       | Thumb  | 12     | -         | 6                 | 30.8 | Partially satisfied   |
|         | Index  | 48     | 0         | -                 | -    | Satisfied             |
|         | Little | 30     | 0         | -                 | -    | Satisfied             |
| 2       | Index  | 193    | -         | -                 | 4.2  | Satisfied             |
|         | Little | 152    | -         | -                 | -    | Satisfied             |
| 3       | Thumb  | 92     | -         | 19.3              | 3.3  | Satisfied             |
|         | Index  | 192    | 3         | -                 | -    | Satisfied             |
|         | Middle | 206    | 1         | -                 | -    | Satisfied             |
|         | Ring   | 204    | 0.2       | -                 | -    | Satisfied             |
|         | Little | 174    | 0         | -                 | -    | Satisfied             |
| 4       | Index  | 86     | 3.1       | 41.5              | 5    | Satisfied             |
|         | Middle | 94     | 2.433     | -                 | -    | Satisfied             |
| 5       | Middle | 36     | 4.5       | 4                 | 22.5 | Satisfied             |
|         | Ring   | 37     | 0         | -                 | -    | Satisfied             |
|         | Little | 25     | 0         | -                 | -    | Satisfied             |
| 6       | Thumb  | 67     | -         | 5.3               | 4.2  | Satisfied             |
|         | Index  | 208    | 0         | -                 | -    | Satisfied             |
|         | Middle | 212    | 0         | -                 | -    | Satisfied             |
| Ring | 208 | 0 |
|------|-----|---|
| Little | 238 | 0 |
| **7** | **Middle** | 253 | 0.35 | 16.2 | 7.5 | Partially satisfied |
| Ring | 237 | 0 |
| **8** | **Index** | 149 | - | - | 17.5 | Partially satisfied |
| Middle | 127 | - |
| Ring | 113 | - |
| **9** | **Index** | 51 | 0 | 10 | 19.2 | Satisfied |
| Middle | 39 | 2 |
| **10** | **Index** | 100 | 1.467 | 7.2 | 28.3 | Satisfied |
| Middle | 57 | 0.167 |

TAM = total active flexion - total extension deficit (MCP, PIP, DIP)

"-" have not measured

Skin means patient has skin defect; ‘m’ means month; ‘w’ means weekMHISS: the modified hand injury severity score.

Table 3 Outcome assessment of blood test
| patient | WBC10^9L | CRP(mg/L) | ESRmm/h | Total t cell% | CD4+T/CD8+T |
|---------|----------|-----------|---------|---------------|--------------|
| 1       | -        | -         | -       | -             | -            |
| 2       | -        | -         | -       | -             | -            |
| 3       | 4.7      | 1.84      | 1       | 63.36         | 1.58         |
| 4       | -        | -         | -       | -             | -            |
| 5       | 6.5      | 5.24      | 5       | 73.85         | 1.57         |
| 6       | 5.6      | 2.15      | 7       | 66.02         | 0.91         |
| 7       | 7.6      | 1.22      | 2       | 60.37         | 1.53         |
| 8       | -        | -         | -       | -             | -            |
| 9       | 3.7      | 1.49      | 14      | 76.29         | 1.51         |
| 10      | 4.9      | 4.58      | 8       | 64.54         | 1.81         |

"-" have not measured