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

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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]. Whether to use allogenic tendon for reconstruction, we choose it according to the patient's intention. Some patients may choose allogenic 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 follow-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.

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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.

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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	Flexor tendon (zones)	Extensor tendon (zones)	follow-up
1	M	52	Industrial accident	Right hand	Bones, blood vessels, nerves, tendon, skin	138	Internal fixation, flap, digital amputation of middle and ring	3m	Thumb, index, little finger (I,II,III)		82m
2	M	37	Industrial accident	Left hand	Blood vessels, nerves, tendon, Bones, blood vessels, nerves, tendon	90	Blood vessels and nerves repair	3w	Index, middle finger (I,II,III)		62m
3	M	38	Industrial accident	Right wrist	Bones, blood vessels, nerves, tendon	340	Replantation surgery at the wrist	2m	Thumb, index, middle, ring, little, (I,II,III)	Index, middle, ring, little (IIII)	54m
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	6m	Index, middle finger(II)		91m
5	M	33	Utility knife	Left palm	Bones, blood vessels, nerves, tendon	116	Replantation surgery at the plam	12m	Middle, ring, little finger (I,II)		30m
6	F	22	Industrial accident	Right forearm	Bones, blood vessels, nerves, tendon	270	Replantation at the wrist	6m	Thumb, index, middle, ring, little (II)		32m
7	F	39	Industrial accident	Right hand	Bones, tendon	67	Internal fixation	3w		Middle, ring, little (IIII)	26m
8	M	18	Industrial accident	Right hand	Bones, tendon, skin	80	Internal fixation	6m		Index, middle, ring, little (IIIIII)	39m
9	M	60	Industrial accident	Right hand	Bones, blood vessels, tendon	69	Internal fixation and blood vessels repair	10m	Right index, middle (I,II)		24m
10	F	48	Industrial accident	Right hand	Bones, tendon, skin	89	Internal fixation, flap and digital amputation of ring	3m		Index, middle (IIII)	60m

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			
	Little	30	0			
2	Index	193	-	-	4.2	Satisfied
	Little	152	-			
3	Thumb	92	-	19.3	3.3	Satisfied
	Index	192	3			
	Middle	206	1			
	Ring	204	0.2			
	Little	174	0			
4	Index	86	3.1	41.5	5	Satisfied
	Middle	94	2.433			
5	Middle	36	4.5	4	22.5	Satisfied
	Ring	37	0			
	Little	25	0			
6	Thumb	67	-	5.3	4.2	Satisfied
	Index	208	0			
	Middle	212	0			
	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 week. MHISS: the modified hand injury severity score.

Table 3 Outcome assessment of blood test

patient	WBC $\times 10^9/L$	CRP(mg/L)	ESR mm/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