



# Evaluation of the Outcomes of Tendon Bypass Transfer to Finger Flexors by Tensor Fascia Lata Graft in Patients With Volkmann's Contracture: A Non-Randomized Clinical Trial Without a Control Group

Behrooz Nazari<sup>1</sup>, Farzad Farokhi<sup>1</sup>, Mohammadreza Moharrami<sup>1\*</sup>

## Abstract

**Objectives:** Free muscle transfer in Volkmann's contracture surgery is the most difficult method for achieving good results. The aim of the present study was to evaluate the outcomes of tendon bypass transfer to finger flexors by tensor fascia lata graft in patients with Volkmann's contracture.

**Materials and Methods:** This non-randomized clinical trial was conducted on 15 patients (based on a relevant study, census sampling) during 2015-2019 in Shohada hospital, Tabriz. The patients underwent surgery in two stages. In the first stage, muscle release and nerve neurolysis were performed, and in the second stage, the tendon was prepared and connected to the bypass in the volar forearm at the proximal and to finger flexors at the distal joint. Hand grip strength, finger and wrist range of motion, hand dexterity, and daily activities were assessed using the considered tools, and finally, the data were compared using SPSS 20.  $P < 0.05$  was considered statistically significant.

**Results:** The preoperative status of the subjects regarding the studied variables was extremely unfavorable, however, hand grip strength ( $81.35 \pm 10.18$ ), Fugl-Meyer ( $29.49 \pm 05.25$ ), hand dexterity ( $08.59 \pm 01.83$ ), and daily activities ( $81.10 \pm 07.43$ ) showed a highly favorable and significant improvement after the surgery ( $P = 0.001$ ).

**Conclusions:** The tendon bypass transfer to finger flexors by tensor fascia lata graft in patients with ischemic Volkmann's contracture resulted in acceptable improvements after the surgery.

**Keywords:** Ischemic Volkmann's contracture, Surgery, Tensor fascia lata graft

## Introduction

The compartment is called the compartment of nerves, vessels (arteries and veins), muscles, and bones covered by the fascia thin layer. However, if, for any reason, it causes pressure buildup in the compartment, the blood supply to the damaged muscles and the tissues of the affected area is not performed well. This is called compartment syndrome (1-3). Ischemic Volkmann's contracture is a complication of untreated or poorly treated compartment syndrome, in which necrotic muscles and nerves are replaced by the fibrosis tissue (3,4).

Compartment syndrome is caused by various factors such as crush injuries, long external pressure, internal bleeding, fractures, intense exercise, burns, snakebite, intra-arterial injection, and infection. The early diagnosis and appropriate treatment of compartment syndrome are critical since late diagnosis or inappropriate treatment can lead to Volkmann's contracture (1,3).

The ischemic Volkmann's contracture is characterized by elbow flexion, pronation of the forearm, wrist flexion, index finger abduction, metacarpophalangeal joint

extension, and finger flexion (1,4). Ischemic Volkmann's contracture is divided into mild, moderate, and severe types according to the involved areas (3,5).

Mild or localized ischemic Volkmann's contracture refers to partial deep ischemia usually affecting fingers 2 and 3 with slight or no neurological symptoms. The moderate type not only affects finger flexors but also wrist flexors and median and ulnar nerves are involved as well. Eventually, flexor and extensor muscles and nerves and the skin (scars) are involved in severe Volkmann's contracture (5,6).

Based on the affected areas, different treatments have been suggested for ischemic Volkmann's contracture, including contracture release, resection of the necrotic muscle, neurolysis of the involved nerve, elongation, tendon or free muscle transfer, arthrodesis, or proximal row carpectomy (7-10).

Free muscle transfer is one of the treatments that is currently used with favorable outcomes, however, it has been associated with some contraindications and its performance is technically highly difficult.

Received 12 January 2020, Accepted 6 May 2020, Available online 25 May 2020

<sup>1</sup>Department of Orthopedics, Shohada Medical Research & Training Hospital, Faculty of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran.

\*Corresponding Author: Mohammadreza Moharrami, Tel: +989143159306, Email: M\_Moharrami@yahoo.com



## Key Messages

- ▶ In severe Volkmann's contracture, the flexor and extensor muscles and nerves and also skin are involved.
- ▶ Free muscle transfer is one of the treatments in Volkmann's syndrome.
- ▶ The tendon bypass transfer to finger flexors led to a favorable improvement in Volkmann's contracture.

Given the severity of disability in patients with severe ischemic Volkmann's contracture and the lack of an approved surgical procedure for treating this syndrome, the aim of the present study was to evaluate the results of tendon bypass transfer to finger flexion by tensor fascia lata graft in patients with Volkmann's contracture. Tendon bypass transfer is a type of surgery in which the bone joint of one active tendon is transferred from one bone to another to resume lost movement.

### Materials and Methods

This clinical trial was conducted on 15 patients hospitalized in the Shohada hospital affiliated to Tabriz University of Medical Sciences during 2014-2019. The patients met the inclusion and exclusion criteria of the study selected by census and available sampling. The inclusion criteria included suffering from severe ischemic Volkmann's contracture and being a candidate for surgery. On the other hand, the exclusion criteria were an unwillingness to participate in the study and a history of severe systemic infectious diseases. The number of patients referring for surgery during a year was included due to the limited number of people affected by the syndrome. On the other hand, the minimum sample size was estimated as 12 patients according to the study by Meena et al (11), and finally, this study was conducted on 15 patients.

All patients were in the intervention group so that patients were hospitalized three days before the surgery, were 'nothing by mouth' from the night before the surgery, and then admitted to the operating room the following morning. Patients were subjected to a two-stage surgical procedure under general anesthesia (as routine) following signing a hospital consent form. After prep and dropping in sterile conditions and preparation for starting the surgery in the first stage, the volar forearm was opened (using surgical blade) and underwent muscle release and neurolysis, and in the case of severe wrist contracture, it was subjected to wrist arthrodesis. The length of the tensor fasciae lata graft toward the bypass distal graft and then finger flexors was measured as well. In the next step, the lateral apical tendon tensor fascia lattice with 4 cm width, and the required length was removed according to the patient. Then, the proximal area was connected to the bypass and distal to the flexor after the preparation of the tendon in the forearm.

Patients' hand grip strength was measured and recorded with a dynamometer, and the Fugl-Meyer tool (12) was used to assess the fingers and wrist range of motion.

Further, dexterity was evaluated by Sollerman hand function test pre- and post-operation. This questionnaire is used to evaluate fine motor skills and higher scores indicate better fine motor skills (13). Barthel questionnaire was also applied to investigate daily activities. This questionnaire measures the status of doing daily activities such as dressing, washing the face, eating, and the like and is scored from zero to 100. Higher scores represent greater independence in individuals (14). All questionnaires were completed using a pen before and three weeks after the intervention by an orthopedic residency (as a member of the research team) in the hospital.

Following data collection (correctly and accurately) by the researcher (After consulting with a statistical consultant, the data were entered into SPSS 20 and analyzed by a paired *t* test (To check hand grip, Fugl-Meyer, dexterity, and daily activities) considering a *P* value of less than 0.05 statistically significant.

### Results

The mean (standard deviation) age of the participants was 19.18 ( $\pm 03.78$ ) years and the majority of them were males ( $n=9$ , 60%). The mean of hand grip strength ( $06.55 \pm 01.43$ ), Fugl-Meyer ( $15.59 \pm 02.89$ ), hand dexterity ( $01.11 \pm 00.49$ ), and daily activities ( $65.19 \pm 05.29$ ) indicated their preoperative poor condition while hand dexterity ( $08.59 \pm 01.83$ ) and daily activities ( $81.10 \pm 07.43$ ) demonstrated significant improvements ( $P=0.001$ ). Table 1 presents the results of the studied variables.

Based on the results, the subjects showed an improvement in the studied variables after the surgery compared with the preoperative period and this difference was statistically significant pre- and post-operation. In other words, all participants in the intervention had a significant improvement in terms of the hand grip, Fugl-Meyer, and dexterity variables and daily activities compared to preoperative surgery, and surgical outcomes were reported to be positive. It should be noted that the best outcome of the intervention was related to participant 13 (21 years old) who achieved a good improvement in all variables (Table 2).

### Discussion

The present study aimed to evaluate the results of tendon bypass transfer to finger flexion by tensor fascia lata graft in patients with Volkmann's contracture. This syndrome

**Table 1.** Comparison of the Mean and Standard Deviation Scores of the Studied Variables Pre- and Post-operation

Variable	Pre-operation	Post-operation	<i>P</i> Value
Hand grip strength	06.55 $\pm$ 01.43	75.35 $\pm$ 10.18	0.001
Fugl-Meyer	15.59 $\pm$ 02.89	29.49 $\pm$ 05.25	0.001
Hand dexterity	01.11 $\pm$ 00.49	08.59 $\pm$ 01.83	0.001
Daily activities	65.19 $\pm$ 05.29	81.10 $\pm$ 07.43	0.001

Paired *t* test.

**Table 2.** Comparison of the Results of the Studied Variables After the Surgery in Participants

Variable	Hand Grip Strength		Fugl- Meyer		Hand Dexterity		Daily Activities	
	Pre-operation	Post-operation	Pre-operation	Post- operation	Pre- operation	Post- operation	Pre- operation	Post-operation
1	03	81	12	25	0	6	61	79
2	05	82	15	30	1	7	63	81
3	06	85	15	29	1	8	66	85
4	07	91	16	31	2	9	65	88
5	01	65	11	26	0	5	60	91
6	03	78	14	29	1	6	59	90
7	05	81	15	30	1	6	55	82
8	09	89	20	35	3	9	69	95
9	03	80	14	26	0	8	61	89
10	03	79	12	25	1	6	61	87
11	01	75	10	23	0	7	55	85
12	02	81	16	31	0	8	60	87
13	02	88	15	31	0	8	59	84
14	01	81	14	27	0	6	53	81
15	04	90	15	32	2	9	61	90
Paired t-value		21.61		22.11		2.93		33.10
df		18		18		18		18
P value		0.001		0.001		0.001		0.001

is considered a debilitating syndrome, and muscles and tendons are severely weakened by this syndrome. Conservative treatment such as physiotherapy and rehabilitation will not be effective for these patients, thus surgery is a top priority. Each patient was subjected to a two-stage surgical procedure (as described in Method Section), which was effective and useful surgery for the treatment and rehabilitation in patients with ischemic Volkmann’s contracture. In the hand grip strength examination, it was found that the surgery could improve gripping in the subjects. Volkmann’s contracture is caused by complete or incomplete ischemia of finger flexor muscles in the forearm, which causes disability in gripping, and using any method (A surgery was used in this study) to restore finger extension to its original state is associated with successful surgical outcomes. The prevalence of Volkmann’s contracture is extremely rare, and only a few limited studies have focused on this syndrome, including Berggren et al (15). They reported desired outcomes by free muscle transfer in the surgical treatment of ischemic Volkmann’s contracture, which is consistent with our results. It seems that the method of muscle transfer in this ischemia can improve the condition, because muscles are extremely weak, and result in surgical success. On the other hand, assisting other muscles in this syndrome can act as the primary muscle and lead to positive and beneficial results.

The range of motion of fingers and the wrist was doubled after the surgery. In other words, surgery improved their range of motion. In ischemic Volkmann’s contracture, the muscles are surrounded by the parts or compartments created by the fascia. Therefore, swelling in these spaces for any reason can cause blood vessel obstruction resulting in anemia or ischemia, which leads to more swelling of the area. When this cycle is repeated,

it disrupts the function of the nerves and muscles, which can eventually have adverse effects on the range of the motion of fingers. However, definitive treatment will be achieved using surgery and eliminating the underlying reasons for the disease. The finger and wrist range of motion in the study by Sharma et al (5), using a similar approach to our study, showed favorable improvements in the studied cases. Considering that this ischemia is due to weakness in the wrist muscles and the tendons of the wrist, surgery should be designed and performed in such a way to increase the range of motion of fingers in order to further increase the efficiency of fingers compared to before the surgery.

In the present study, hand dexterity demonstrated the best outcome. It examines fine motor skills. Muscles and tendons of the hand (fingers) are affected by the Volkmann’s contracture and lose their function (The stiffness and elongation of the forearm muscles disrupt fine motor skills). Fine motor skills and the function of the fingers will be greatly improved following the surgery and repair of the anterior forearm muscles. The results of our study are in line with those of Gousheh (16). The results of our study suggest that this method can be used if the ischemic stroke is severe because the clinical results after the surgery are highly promising.

Favorable surgical outcomes were achieved regarding doing daily activities. Following an improvement in the function of hand muscles, and consequently, using hands in daily activities, they can be more utilized in daily routines. In other words, following the surgery and the resulted improvement in the structure of muscles and tendons affecting the hands’ optimal function, they can be more applied in doing daily activities. Unfortunately, no relevant study was found on the effect of surgery on daily activities to compare the results.

### Limitations of the Study

The limitations of the present study were the lack of patients' referral for follow-ups for more than one year and the lack of attention to the causes of the ischemic Volkmann's contracture.

### Conclusions

Tendon bypass transfer to finger flexion by tensor fascia lata graft in patients with ischemic Volkmann's contracture is associated with acceptable outcomes.

### Suggestions for Future Studies

Researchers suggest using this technique for orthopedic surgeons in people with severe Volkmann's ischemia. Physiotherapy and rehabilitation for achieving positive outcomes in the shortest possible time are also recommended to be considered in future studies.

### Authors' Contribution

Behrouz Nazari: Study design; FF: data collection, data analysis, article submission; MM: surgical supervision, data analysis, article submission.

### Conflict of Interests

Authors have no conflict of interests.

### Ethical Issues

All ethical considerations were observed, including no surgery costs, no hospital costs, timely examinations, the written informed consent to participate in the study, the approval by the Ethics Committee of Tabriz University of Medical Sciences (The ethics code: IR.TBZMED.REC.1398.858), and registration at the Iranian Registry of Clinical Trials (identifier: [IRCT20190325043107N12](https://www.clinicaltrials.gov/ct2/show/study?term=IRCT20190325043107N12)).

### Acknowledgments

This study was extracted from a thesis by Dr. Farzad Farrokhi (Orthopedic Residency) supervised by Dr. Mohammad Reza Moharrami (A faculty member). The researchers are grateful to the spiritual support provided by Tabriz University of Medical Sciences, as well as the patients who participated in the study.

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