



6-1-1999

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#### Recommended Citation

Chen, Chih-Kuang; Tang, Fuk-Tan; Chen, Meao-Ming; and Chu, Ngok-Kiu (1999) "Functional Improvement of Upper Extremity in Cervical Spinal Cord Injured Patient After Tendon Transfer : A casereport," *Rehabilitation Practice and Science*: Vol. 27: Iss. 2, Article 7.

DOI: <https://doi.org/10.6315/3005-3846.2071>

Available at: <https://rps.researchcommons.org/journal/vol27/iss2/7>

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# Functional Improvement of Upper Extremity in Cervical Spinal Cord Injured Patient After Tendon Transfer : A Case Report

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Traumatic tetraplegia is a devastating malady caused by cervical spinal cord injury, leading to motor and sensory impairment of the four limbs. Loss of the upper extremities function severely impacts life quality of the victim. Early and comprehensive rehabilitation can provide good functional recovery and prevent long-term complications. Furthermore, the advanced reconstructive hand surgery that has been developed in the past two decades has become a viable alternative to enhance the function of paralyzed upper extremities. However, this surgical procedure is still rarely performed on tetraplegic patients in Taiwan. This article describes a cervical spinal cord injured patient receiving a tendon transfer from right brachioradialis to flexor digitorum profundus. Consequently, the patient markedly improved in daily activities and wheelchair mobility. After optimal candidate selection, we believe that reconstructive surgery should be considered as a part of comprehensive rehabilitation programs. (J Rehab Med Assoc ROC 1999; 27(2): 85 – 90 )

**Key words:** tetraplegia, spinal cord injury, tendon transfer

## INTRODUCTION

Traumatic tetraplegia occurs most frequently in active and previously healthy young adults, leading to various degrees of paralysis and sensory impairment of the upper extremities. Comprehensive rehabilitation promotes the function of upper limbs and prevents long-term complications<sup>[1,2]</sup>. Nevertheless, some patients still suffer from unsatisfactory life quality due to a complete and irreversible lesion of the cervical spinal cord. The fact that the activities of daily living and

mobility heavily depend on their upper extremities accounts for why any effort to restore the upper extremity functions should be considered as a part of rehabilitation.

Surgical reconstruction of the upper extremity is an effective means of helping patients achieve maximal physical and functional independence. After World War II, Bunnell originally suggested flexor tenodesis of the thumb and finger flexors to enhance paralytic hand functions in tetraplegic patients<sup>[3]</sup>. Reliable surgical techniques, however, were not accepted until two decades later when Moberg developed a simple key grip procedure by flexor pollicis longus tenodesis. Moberg

Submitted date: Feb. 3, 1998

Revised date: Mar. 18, 1999

Accepted date: Apr. 25, 1999

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contended that 60% of all tetraplegic patients could benefit from surgery on the upper extremities [4]. Meanwhile, Zancolli reported encouraging results of reconstructive surgery, including tendon transfer procedures in his study of ninety seven tetraplegic patients [5]. Thereafter, tendon transfer procedure has found increasing applications [6-13]. This reconstructive surgery attempts to extend the functional level by transferring the tendon of selected active muscles to that of paralyzed muscles. Following a detailed assessment of the specific motor strength of each upper extremity muscle and sensation of the hand with respect to two-point discrimination, neurologically stabilized and highly motivated candidates with a realistic expectation of surgery can benefit from tendon transfer and subsequent rehabilitation to extend the upper extremity function and improve quality of life. However, this procedure has not been widely accepted in Taiwan, particularly in rehabilitation medicine. Therefore, this article reports on a case to demonstrate the functional effectiveness of tendon transfer for tetraplegia.

## CASE REPORT

A 28-year-old male patient in our hospital, C6 burst fracture due to falling down from 5-floor height, received open reduction of C6 fracture, bone fusion with iliac bone graft and Caspar plate fixation from C5 to C7 on December 24, 1993. After serial rehabilitation programs, the neurological level stabilized and was classified as C7 spinal cord injury, Frankel A, according to the Frankel classification [14]. He is a right-handed individual and better motor recovery was achieved in his right upper extremity. The sensory examination by two-point discrimination test revealed adequate sensation (<10mm) on his both palms (Table 1). He was highly motivated and remained very cooperative during rehabilitation. However, some common tasks such as precision grip for cup holding and wheelchair propulsion still remained difficult for him in the absence of assistive devices. Following discussion with the plastic surgeon, we predicted that the patient would gain functional improvement in daily activities and mobility with the assistance of a wheelchair if tendon transfer could restore finger flexion. The patient was briefed on expected functional gain, potential risks,

proposed surgical procedure and subsequent rehabilitation programs. Approximately one year after the initial injury, the patient received tendon transfer surgery with right brachioradialis (BR) to flexor digitorum profundus (FDP) tendon on November 9, 1994.

Postoperative management began with immobilization of the affected extremity by splinting for 3 weeks, in which only gentle passive range of motion exercise was allowed. Neuromuscular reeducation to learn new motion control by the transferred muscle was initiated 3 weeks later, which was subsequently followed by graded active exercise. The patient was then taught new activities of daily living skills that he could not perform during the initial rehabilitation phase. He markedly improved in the strength of hand measured by grip dynamometer and pinch meter (Table 2), wheelchair mobility (Fig. 1) and activities of daily living. (Fig. 2). The motor function still remained steady in the following three years after operation.

Table 1. Motor examination by manual muscle test and sensory examination by two-point discrimination before tendon transfer surgery

	Right	Left
Motor		
Elbow flexion	5	5
Wrist extension	5	5
Elbow extension	5	5
Finger flexion	2	1
Finger abduction	0	0
Thumb opposition	0	0
Lower extremity	0	0
Sensory		
Palm of hand	7mm	7mm
Dorsum of hand	18mm	15mm

## DISCUSSION

Tetraplegia, by definition, is paralysis of both arms and legs attributed to cervical spinal cord injury. Hippocrates considered it "an ailment not to be treated" owing to its extremely poor prognosis. However, life

Table 2. The hand strength improved after tendon transfer procedure

	Before surgery		3months after surgery		6months after surgery	
	Right	Left	Right	Left	Right	Left
Grip(kg)	0	0	4	0	4	0
Lateral pinch(kg)	NA*	NA	0.75	0	0.5	0
3-point chuck(kg)	NA	NA	NA	NA	3.75	0.5

\*NA: no assessment due to patient's poor performance of the test

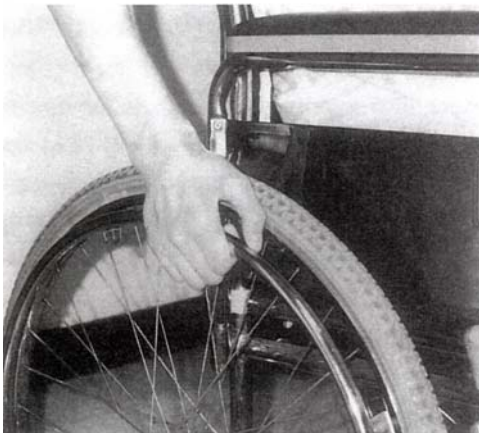


Figure 1a. The tendon-transferred right hand could grip the handrim for locomotion

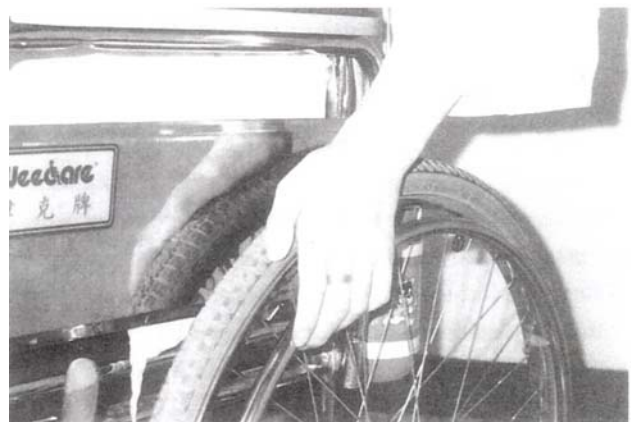


Figure 1b. The non-transferred hand gripped the handrim poorly

expectancy and functional outcome have dramatically



Figure 2. Precision grip of cup after tendon transfer

procedures

improved since the 1940s through the arduous efforts of Munro in the United States and Guttman in England <sup>[15]</sup>. In a survey of male tetraplegic patients, Hanson and Franklin found that most patients preferred restoration of the upper extremity function to the return of normal bowel and bladder function, normal use of legs, and normal sexual functions <sup>[16]</sup>. Therefore functional restoration of the upper extremities is of priority concern to enhance independence.

After World War II, some reconstructive surgeries were performed to improve the paralytic hand function in tetraplegic patients. Bunnell (1948) recommended flexor tenodesis for tetraplegic patients <sup>[3]</sup>. Tendon transfer, as a more reliable surgical procedure to enhance the upper extremity function of tetraplegia, has been developed and widely used over the past two decades <sup>[4-11]</sup>. Candidate

selection is of priority concern to maximize functional gain before surgery is planned. The contraindications include unstable neurological condition, marked spasticity, hypersensitivity or painful paraesthesia, contracture, active pressure sore, poor motivation, and psychological instability. In general, the transferred muscle should be strong enough because the effective strength of the transferred muscle decreases by one grade owing to the change in routing its tendon<sup>[17]</sup>. Moberg recommended that the stronger extremity should be operated first. If the strength was the same on both sides, the surgery was normally performed on the dominant one<sup>[4]</sup>. Cutaneous sensation is another crucial factor although visual feedback could be compensated for hand control. Weber two-point discrimination test less than 10mm in the thumb pulp is considered adequate for hand control without visual cues<sup>[18]</sup>.

Timing of the reconstructive surgery for tetraplegia is recommended at least one year after injury and patients are neurologically stable for a minimum of 6 months<sup>[7]</sup>. Waters indicated that the majority of recovery occurs within the first 9 months after injury<sup>[12,13]</sup>. Nevertheless, as widely assumed, the outcomes are less predictable if performed more than 5 years post injury<sup>[19]</sup>.

Patient classification was based mainly on the International Classification for Surgery of the Hand in Tetraplegia according to the lowest functional muscle and residual sensation. In addition, C5 level is the highest neurological level deemed appropriate for this reconstructive surgery<sup>[20]</sup>. Several different surgical procedures are available according to their different groupings, of which restoration of the active elbow extension and functional hand grip are the most common aims. Although our patient had active elbow and wrist motions, the finger flexion was insufficient. The finger flexion can be augmented by transfer of an available forearm muscle ( brachioradialis, pronator teres, extensor carpi radialis longus, or flexor carpi radialis ) to the flexor digitorum profundus. Freehafer recommended that brachioradialis (BR) is the optimal donor for finger flexion because it is a long muscle with good excursion and strength<sup>[21]</sup>. Therefore, in this study, we chose the right brachioradialis (BR) to flexor digitorum profundus (FDP) transfer to restore active finger grasp.

The factors used herein to evaluate the functional

improvement are the strength of the hand, wheelchair mobility, and daily activities. The hand strength was measured by grip dynamometer and pinch meter<sup>[22]</sup>. Grip power improved after surgery because BR to FDP transfer enhanced finger flexion. Lateral pinch by natural tenodesis effect with active wrist extension was observed preoperatively. However, the motion was so negligible that the pinch meter could not detect the strength. Furthermore, postoperative increase of the lateral pinch strength declined 6 months later, suggesting that if lateral pinch is the primary objective of reconstructive surgery, one should consider other surgical choices such as Moberg's key grip procedure by tenodesis of the flexor pollicis longus (FPL) and arthrodesis of the interphalangeal joint of the thumb<sup>[4]</sup>. The 3-point chuck performance also improved 6 months after surgery. The improvement in the non-operative left hand may be related to continuously intensive physical and occupational therapy. Spontaneous recovery is another alternative since Ditunno has reported that some neurological recovery of tetraplegic patients may occur up to 2 years after injury<sup>[23]</sup>.

C7 level, like our patient, should be independent in manual wheelchair mobility. Modifying the hand/handrim interface, however, can maximize the wheelchair propulsion efficiency. In the absence of plastic handrim or lugs, more precious and active control of the grasp and release of the handrim augmented by the tendon transfer procedure reduces the energy consumption of manual wheelchair propulsion. Cup grasping, as a part of self-care tasks, is also improved as accompanied by an increased grip power.

With any tendon transfer procedure, postoperative management and rehabilitation are the final determinants for the functional restoration. Postoperative management includes complete immobilization by splinting ( typically 3-4 weeks ), control of edema, movement of uninvolved joint, graded active exercise after immobilization, motor reeducation, and redevelopment of the proper use of the transferred muscle in light functional activities<sup>[24]</sup>.

Failure of tendon transfer procedures could also occur if the patient is still bed-ridden, unmotivated for surgery and rehabilitation, or mentally inactive<sup>[17]</sup>. Although there is potential risk of surgical failure and the benefits from surgery may be limited, it is still

worthwhile to consider the tendon transfer procedure for tetraplegia just as Bunnell said: "If you have nothing, a little is a lot." With adequate preoperative evaluation of optimal candidate in combination with proper postoperative rehabilitation, muscle tendon transfers allow for the possibility of functional restoration of the upper extremity in tetraplegia.

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## 頸脊髓損傷病患肌腱轉移手術後之上肢功能改善 ：病例報告

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外傷性四肢癱瘓是因頸脊髓損傷而造成四肢之運動及感覺神經功能障礙，其中上肢功能喪失是影響病患生活品質最重要因素。早期及完整的復健治療有助於功能恢復並預防可能發生的併發症。此外，近二十年來逐漸發展的手部重建手術亦已成為四肢癱瘓病患增加上肢功能的另一選擇，然而在台灣仍未普遍運用。在此我們報告一四肢癱瘓病患例，因接受肌腱轉移手術，而在日常生活及輪椅活動獲致明顯功能改善之病例。經由術前詳細的評估及合適病患的選擇，我們認為重建手術應被考慮作為完整復健計劃之一部份。（中華復健醫誌 1999; 27(2): 85 - 90 ）

**關鍵詞：**四肢癱瘓(tetraplegia)，脊髓損傷(spinal cord injury)，肌腱轉移(tendon transfer)