

ORIGINAL RESEARCH

# Multicenter Survey of the Effects of Rehabilitation Practices on Pinch Force Strength After Tendon Transfer to Restore Pinch in Tetraplegia



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## Abstract

**Objective:** To identify key components of conventional therapy after brachioradialis (BR) to flexor pollicis longus (FPL) transfer, a common procedure to restore pinch strength, and evaluate whether any of the key components of therapy were associated with pinch strength outcomes.

**Design:** Rehabilitation protocols were surveyed in 7 spinal cord injury (SCI) centers after BR to FPL tendon transfer. Key components of therapy, including duration of immobilization, participation, and date of initiating therapy activities (mobilization, strengthening, muscle reeducation, functional activities, and home exercise), were recorded by the patient's therapist. Pinch outcomes were recorded with identical equipment at 1-year follow-up.

**Setting:** Seven SCI rehabilitation centers where the BR to FPL surgery is performed on a routine basis.

**Participants:** Thirty-eight arms from individuals with C5-7 level SCI injury who underwent BR to FPL transfer surgery (N=34).

**Intervention:** Conventional therapy according to established protocol in each center.

**Main Outcome Measures:** The frequency of specific activities and their time of initiation (relative to surgery) were expressed as means and 95% confidence intervals. Outcome measures included pinch strength and the Canadian Occupational Performance Measure (COPM). Spearman rank-order correlations determined significant relations between pinch strength and components of therapy.

**Results:** There was similarity in the key components of therapy and in the progression of activities. Early cast removal was associated with pinch force (Spearman  $\rho = -.40$ ,  $P = .0269$ ). Pinch force was associated with improved COPM performance (Spearman  $\rho = .48$ ,  $P = .0048$ ) and satisfaction (Spearman  $\rho = .45$ ,  $P = .0083$ ) scores.

**Conclusions:** Initiating therapy early after surgery is beneficial after BR to FPL surgery. Postoperative therapy protocols have the potential to significantly influence the outcome of tendon transfers after tetraplegia.

Archives of Physical Medicine and Rehabilitation 2016;97(6 Suppl 2):S105-16

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Individuals with cervical spinal cord injuries (SCIs) have limited hand function because of paralysis of the muscles that provide strength for grasp and pinch functions. One of the most common methods for restoring lateral pinch strength to individuals with a complete cervical SCI is to surgically transfer the tendon of a strong brachioradialis (BR) muscle to the tendon of a paralyzed flexor

pollicis longus (FPL).<sup>1,2</sup> This surgery is recommended for individuals who are classified according to the International Standards for Neurological Classification for SCI with C5-7 level injuries, are at least 1 year postinjury, have strong wrist extension and a strong BR muscle (manual muscle test [MMT]<sup>3</sup> grade 4), and agree to comply with postoperative care. A systematic review of surgical outcomes after BR to FPL surgery reported that on average 2kg (range, 1–4kg) of pinch strength may be restored.<sup>4</sup> Adequate force to accomplish many daily living tasks is achieved<sup>5</sup>; however, pinch strength is not restored to the levels reported for the noninjured population (10.8kg for men and 7.3kg for women).<sup>6,7</sup>

The surgical literature supplies general guidelines that apply to all tendon transfer procedures for postoperative care, but are not specific

The research described here was supported by the Department of Veterans Affairs, Veterans Health Administration, Rehabilitation Research and Development Service. Award number A4069-R, Vincent R Hentz, Surgical Service, Palo Alto Health Care System. Supported also by Searle Funds of the Chicago Community Trust.

Publication of this article was supported by the American Congress of Rehabilitation Medicine.

Disclosures: none.

for BR to FPL transfer recipients.<sup>8</sup> This includes 4 to 6 weeks of immobilization to protect the transfer until healing is complete, and then range of motion and light activities to mobilize the transfer. Several sources suggest biofeedback or electrical stimulation may be used to augment postoperative training.<sup>9-11</sup> Activating the transferred muscle in its original function, sometimes referred to as triggering, is used to demonstrate its new functional capability.<sup>12</sup> For example, because the BR is an accessory elbow flexor, after BR to FPL transfer, resisting elbow flexion will produce thumb flexion because of the new surgical attachment of the BR tendon to the FPL tendon. Once the patient can demonstrate voluntary activation of the transferred muscle, individuals are often discharged because of limitations in hospital stay. If the opportunity for supervised directed therapy is limited, then learning to use the transferred BR in pinch activities will depend on the individual's motivation to perform activities at home to the greatest extent possible.

The lack of well-documented rehabilitation and consistent outcome measures is a limitation for objective comparison of new or novel therapy programs with conventional techniques. Multicenter trials offer a way to compare rehabilitation across centers and therefore gain an understanding of how different treatment protocols may influence surgical outcomes. A multicenter trial, conducted by the Veterans Affairs Palo Alto Health Care System, has been investigating the influence of surgical attachment length on the outcome of BR to FPL tendon transfer procedures (appendix 1). As part of the multicenter trial, each of the 7 participating centers was also instructed to complete a checklist documenting the key components of the rehabilitation protocol. Although the multicenter study was not designed to test the effects of different therapy protocols, the importance of concomitantly identifying differences in the availability, prescription, and timing of postoperative therapy across centers that could also influence pinch force outcome was recognized.

The opportunity to survey postoperative therapy protocols in a population who received similar surgeries and identical measurements of pinch outcome provides a basis for defining conventional therapy after BR to FPL transfer. The aims of this study were (1) to measure the outcome of BR to FPL surgery after conventional therapy in SCI centers using the same outcome measures, (2) to use the multicenter survey of postoperative therapy to identify the number and sequence of activities that defined the site-specific protocol related to BR to FPL transfers, and (3) to evaluate whether any of the key components of therapy were associated with pinch strength or functional outcome. This knowledge base is critical for future studies that aim to compare novel treatment approaches to conventional therapy.

## Methods

### Overview

Seven SCI rehabilitation centers, where the BR to FPL surgery is performed on a routine basis, participated in the multicenter

#### List of abbreviations:

<b>BR</b>	<b>brachioradialis</b>
<b>CI</b>	<b>confidence interval</b>
<b>COPM</b>	<b>Canadian Occupational Performance Measure</b>
<b>FPL</b>	<b>flexor pollicis longus</b>
<b>IC</b>	<b>International Classification for Surgery of the Hand in Tetraplegia</b>
<b>MMT</b>	<b>manual muscle test</b>
<b>SCI</b>	<b>spinal cord injury</b>

survey of postoperative rehabilitation. Candidates for BR to FPL surgeries were identified during routine clinic visits as part of their ongoing medical care. Patients who elected to have BR to FPL surgery were invited to participate in the multicenter trial. The surgery and postoperative rehabilitation was performed according to each site's established protocol. For those who enrolled in the study, quantitative measures of postoperative outcomes were obtained, and the therapist responsible for postoperative rehabilitation was asked to complete a survey that identified the key components of therapy 1 year after surgery. Each center was responsible for maintaining institutional review board approval throughout the study period and to obtain informed consent for each participant.

### Demographic data and preoperative status

Prior to surgery, the therapist recorded demographic data (age, sex, time since injury, International Standards for Neurological Classification of Spinal Cord Injury classification, and surgical history), performed manual muscle testing for the upper limb, and documented the patient's surgical history. A standardized evaluation and survey of therapy form was used by all therapists (appendix 2). The International Classification for Surgery of the Hand in Tetraplegia (IC) was used to classify an individual's motor resources (ie, the number of muscles available for transfer). Patients in IC group 2 or higher are candidates for BR to FPL surgery. Additional reconstructive procedures were performed simultaneously with the pinch reconstruction, but individuals were not included if they had multiple transfers to the thumb. Table 1 summarizes the demographics and classification of the participants.

### Survey forms for therapy

The therapy survey was divided into 3 general time periods: immobilization (cast and splint schedule), directed therapy (participation and date of initiating movement, muscle reeducation and strengthening, functional activities, and modalities), and home exercise. Therapists completed the survey forms during the inpatient hospital stay after surgery to document the postoperative therapy protocol. If patients were discharged to the community to receive therapy, the forms were sent to the patient's local therapists that were either familiar with the postoperative care recommended by the surgeon, or were provided with their standard protocol. The therapist was instructed to use the checklist to

**Table 1** Summary of concurrent procedures to restore hand function and elbow extension

Restored Function	Procedure	n
Active thumb flexion	BR to FPL	38
Active finger flexion	ECRL or PT to FDP	20
Stabilization of thumb CMC joint	CMC arthodesis	10
Stabilization of thumb IP joint	FPL to EPL split	27
Hand opening	Extensor tenodeses	22
MP flexion	Intrinsic balance	5
Elbow extension strength	Biceps to triceps	11

Abbreviations: CMC, carpometacarpal joint; ECRL, extensor carpi radialis longus; EPL, extensor pollicis longus; FDP, flexor digitorum profundus; IP, interphalangeal joint; MP, metacarpophalangeal joint; PT, pronator teres.

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