

ORIGINAL RESEARCH

Early Active Rehabilitation After Grip Reconstructive Surgery in Tetraplegia



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Abstract

Objective: To describe and evaluate the concept of early active rehabilitation after tendon transfer to restore grip function in tetraplegia.

Design: Retrospective cohort study.

Setting: Two nonprofit rehabilitation units in Sweden and Switzerland.

Participants: All patients with tetraplegia who underwent tendon transfer to restore grip ability during 2009 to 2013 (N=49).

Intervention: Reconstructive tendon transfer surgery with early active rehabilitation to restore grip ability in tetraplegia.

Main Outcome Measures: Grip and pinch strength, grip ability test, and outcome of prioritized activities.

Results: In the 49 surgeries performed, postoperative complications included 2 patients with bleeding and 2 infections related to the surgery. There were no reported ruptures or lengthening of transferred tendons. Within 24 hours after surgery, all 47 patients (100%) with finger flexion reconstruction succeeded to activate their finger flexion. All but 1 patient with reconstructed thumb flexion successfully activated their thumb flexion (n=40). Three weeks after surgery, all patients (100%) were able to perform basic activities of daily living, and instrumental activities of daily living were achieved by 74%. One year after surgery, the maximum grip strength in restored finger flexion was on average 6.9kg (range, 1.5–15kg; n=29). The maximum pinch strength in restored thumb flexion was on average 3.7kg (range, 1–20; n=29). On average, grip ability improved from 33 to 101 (n=19) according to the COPM. Prioritized activity limitations, as measured with the COPM, equated to an average of 3.5 steps (2.5 steps preoperatively to 6 steps postoperatively). Patients' perceived satisfaction with this improvement was 4 steps (increasing from 2 steps preoperatively to 6 steps postoperatively).

Conclusions: Grip reconstructive surgery followed by early active rehabilitation can be considered a reliable procedure that leads to substantial improvements in grip and pinch strength and activity performance among patients with tetraplegia.

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Surgical reconstruction of grip function in tetraplegia has been performed since the early 1970s and has constantly been developed since. Reconstructive surgery to restore grip function may include up to 7 procedures within 1 operation.¹ Depending on the individual patient's wishes and donor muscles available for transfer, the surgery may include multiple active tendon transfers to restore finger flexion (grasp), thumb flexion (pinch), and thumb

abduction. Moreover, several additional corrections might be needed to optimize the balance in the hand such as intrinsic reconstruction (for hand opening), rebalancing of the wrist, and stabilization of selected joints (first carpometacarpal joint [CMC1] arthrodesis).¹ In combination, these procedures aim at restoring full grip function and have been described as the alpha-bet procedure.

With strong suture techniques, active training of the hand can and should be initiated directly after surgery. Studies have shown that using a side-to-side suture technique produces a significantly stronger and stiffer attachment site compared with a conventional weaving suture technique.^{2,3} The side-to-side suture techniques can stand a force of 200N to load a tendon to failure. It provides

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approximately 10 times the force produced during active range of motion (ROM).⁴ As a consequence, the postoperative rehabilitation strategies must be adapted to optimize the result of the intervention.

The initiation of grip reconstructive surgery rehabilitation protocol in tetraplegia varies around the world. This article will focus on the concept of early active rehabilitation and the importance of activity-dependent muscle reeducation. In tetraplegia hand surgery in Sweden, early mobilization of transferred tendons has been performed since 1995, and the full early active rehabilitation protocol has been used since 2008. The aim of this article is to describe the concept of early active rehabilitation after tendon transfers to restore grip function in tetraplegia and its short and long-term clinical outcomes.

Methods

Early active rehabilitation protocol

Overview

A full grip reconstruction (alphabet procedure) may include up to 7 individual operations.¹ Therefore, it is critical that the therapists are familiar with all of the surgical procedures and how they interact with one another in terms of training. Moreover, the patient must also understand the principles of the surgery and the postsurgical training in order to stay motivated and ensure that restrictions are followed. The therapists therefore play important roles in educating, supporting, and guiding the patient through the postsurgical training.

The early active rehabilitation protocol includes 2 parts: early mobilization of transferred tendons and a muscle reeducation rehabilitation program subsequently described.

Early mobilization after tendon surgery is a common treatment strategy in various types of hand surgery (eg, flexor tendon surgery⁵⁻⁷) and has been used after grip reconstruction in tetraplegia since 1995. The benefits of early mobilization include reduced risk of adhesions, joint stiffness, muscular atrophy, and swelling.⁷ It also helps to maintain the neuromuscular and contractile function of transferred muscles, shorten postoperative rehabilitation periods, and improve outcomes.⁷

The second cornerstone in early active rehabilitation is the muscle reeducation approach to promote active use of the transferred muscles. An activity-dependent approach enhances patient empowerment by letting them be actively engaged in their own rehabilitation and helps them to gain confidence in their ability to manage their everyday lives. Some patients hesitate to undergo surgery because of the decreased degree of independence that follows the postsurgical phase.^{8,9} In general, they have often worked hard to maximize their level of independence and regain roles in their families and are afraid to impair their acquired quality of life, even for a limited period of time.⁹ For these patients, minimal restrictions are critical in the process of deciding

whether they will undergo surgery. Even if restrictions are imposed after surgery, patients are encouraged to be as active as possible in their daily lives. In this way, general fitness and independence are maintained to the greatest extent possible.

Preoperative preparation

Grip reconstruction is a combination of intricate procedures that requires the patients to be actively engaged in the rehabilitation process. Patient education is therefore a prioritized part of the early active rehabilitation concept. It also requires frequent communication between the surgeon and therapists. Therefore, rehabilitation planning starts prior to surgery. Patients need to be well informed about the surgical procedure and the postsurgery rehabilitation strategies to ensure they are prepared, focused, and actively engaged in the training. A slightly adopted version of the Canadian Occupational Performance Measure (COPM)¹⁰ is used to inform about patients' expectations and serves as a guideline for postoperative activity training. It is also used as a patient rated activity outcome.

Preparations are made to address maintenance of important daily activities by means of environmental adaptations, changed techniques to facilitate for example transfers, altered technical aids, and temporary increased levels of assistance.

First days postsurgery

At this stage, the essential components of the rehabilitation program are edema control, protection of the transferred tendons, and controlled mobilization of the operated areas to prevent adherence of the healing tissue. The day after surgery, the surgical dressings are changed, and a smooth compression wrapping is applied with the aim to prevent edema without restricting active movement. A custom-made splint (subsequently described) holds the wrists and digits in a position that aims to unload the attachment sites and produces effective compression. Activation of the transferred muscles and passive movement of tenodesis functions are performed with careful instructions from the therapist several times per day, starting within 24 hours after surgery.

Splinting

The optimal position of the hand in the splint depends on the combination of surgical procedures used. The general aim is to position the structures in a relaxed but lightly stretched position to minimize stress to the transferred tendons. There is, however, no need to restrict elbow extension even if the brachioradialis (BR) (still working as an elbow flexor) is transferred. Studies have demonstrated that the attachment site of the sutured BR has a safety factor of at least 10 times the expected load resulting from active contraction, independent of the position of the elbow and wrist.⁴ To support the venous blood flow, the splint is applied on the volar side of the forearm with elastic bands over the dorsal aspects of the fingers, hand, and lower arm. This arrangement facilitates higher compression on the volar aspects of the hand, resulting in fluid being pressed dorsally, where most of the venous blood flow from the hand is located. At rest, and during periods of the day involving lower levels of activity, patients are encouraged to place the arm in an elevated position to control postsurgical edema. The splint is adapted to enable activities (eg, independently putting it on and removing it, driving a wheelchair, typing on a computer, assisting during catheterization) (fig 1).

List of abbreviations:

ADL	activities of daily living
BR	brachioradialis
CMC1	first carpometacarpal joint
COPM	Canadian Occupational Performance Measure
ROM	range of motion

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