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ORIGINAL RESEARCH

Rehabilitation After Spasticity-Correcting Upper Limb Surgery in Tetraplegia

Johanna Wangdell, OT, PhD,[a] Jan Fridén, MD, PhD[a,b,c]

From the [a]Center of Advanced Reconstruction of Extremities, Sahlgrenska University Hospital, Gothenburg, Sweden; [b]Department of Hand Surgery, Institute of Clinical Sciences, The Sahlgrenska Academy at Göteborgs University, Gothenburg, Sweden; and [c]Swiss Paraplegic Center, Nottwil, Switzerland.

Abstract

Objective: To describe the early active rehabilitation concept developed for spasticity-correcting surgery in tetraplegia and to report the outcomes in grip ability and change of performance and satisfaction in patients' prioritized activities 1 year postoperatively.

Design: Retrospective case-control study.

Setting: Nonprofit rehabilitation unit.

Participants: All patients who underwent surgeries for correction of spasticity in tetraplegic hands between 2009 and 2013 in the studied unit (N = 37).

Interventions: Spasticity-correcting upper limb surgery with early active rehabilitation to restore grip ability in tetraplegia.

Main Outcome Measures: Grasp and release test (GRT) and modified Canadian Occupational Performance Measure (COPM).

Results: All patients could accomplish the early active rehabilitation concept. The complication rate related to the treatment was low. Compared with preoperatively, all evaluated individuals experienced improvements in grasp ability and activity performance and satisfaction at 1-year follow-up. The performance in prioritized activities, as measured by the COPM, improved by 2.6 scale steps. Satisfaction with performance improved 3.0 scale steps postoperatively (n = 21). The grasp ability, measured by the GRT, improved significantly, from 80 preoperatively to 111 (n = 10).

Conclusions: The surgery, combined with the early active rehabilitation protocol, is a reliable and safe procedure. The ability to use the hand improved, and gains were maintained at least 1 year after surgery in all patients with respect to both the objective grasp ability and patients' subjective rating of their performance and satisfaction in their prioritized activities. The procedure should therefore be considered as an adjunct to other treatments of upper limb spasticity in spinal cord injury.

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Spasticity is a common complication after a spinal cord injury (SCI). After a cervical SCI, inhibiting spasticity has been reported in 87% to 96% of cases and is more frequent in incomplete injuries.[1-4] As a result of treatment improvements largely in the acute management of SCI, the number of incomplete injuries has increased. As a consequence, a higher proportion of the SCI population live with spasticity.[5] The pathogenesis of spasticity after SCI remains uncertain, and there is no consensus on the definition of spasticity in SCI. It involves several aspects: muscle hypertone, hyperreflexia, clonus, clasp-knife responses, long-lasting cutaneous reflexes, and muscle spasms evoked by brief nonnoxious cutaneous stimuli. After an SCI, also gradual changes in muscle properties occur: fibrosis, atrophy of muscle fibers, decrease in the elastic properties, decrease in the number of sarcomeres, accumulation of connective tissue, and alteration of contractile properties toward tonic muscle characteristics. These changes will also interact with the spasticity.[4] Tendon lengthening surgery mainly aims to reduce the muscle hypertone component of spasticity to increase the use of arm and hand in daily life. Hypertone is defined as the resistance felt when moving a limb passively through range.[6]

The treatment of spasticity is multifaceted and highly variable in terms of both treatment strategies and outcomes.[4] Physical treatment methods (eg, splints, stretching, limb positioning, electrical stimulation) are frequently used; however, the effects from these interventions have been sparsely reported. Pharmacologic management (eg, baclofen, botulinum toxin) is often

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prescribed in SCI populations.[7] Even though positive effects on spasticity after pharmacologic treatment have been reported, the overall effect is time limited, frequently variable, and unpredictable because of the medication side-effects that interfere with the reduced spasticity.[4]

Spasticity in the upper limb after an SCI typically involves shoulder adduction/internal rotators, together with elbow, wrist, finger and thumb flexors, and forearm pronators. Long-standing spasticity that keeps the arm in a flexed and pronated position makes the soft-tissue structures adapt to the shortened position and might subsequently lead to contractures, which can increase further disability. Spasticity in the hand typically leaves the person with a closed fist and difficulties related to reaching, grasping, and releasing items in an efficient way. Spasticity-reducing surgery aims to improve the ability to grasp, release, and open the hand by lengthening or releasing tendons. These procedures provide a long-term decrease of hypertone in the spastic muscles and allow for remaining functioning synergists and antagonists to reestablish a better balance.

Sahlgrenska University Hospital has performed upper limb surgery to reduce the effects from muscle hypertone as a secondary complication to spastic tetraplegia since the early 1990s. One of the first articles to describe this surgery technique was published in 1992 by Treanor et al.[8] The surgery aimed to extend the active and/or passive range of motion in affected movements and thereby improve activities in daily life. The surgical technique mainly included lengthening of tendons in shortened muscles, usually by approximately 2 to 4cm, but also tenotomy or detachment from the original site are used. These techniques represent the principle approach to reduce the effects of muscle hypertone and have also been described for spasticity management in cerebral palsy and stroke.[9-11] More recently, the need for intrinsic release has been described, as a supplement to the extrinsic tendon lengthenings and releases.[12] Even though the surgery has been performed for many years, the rehabilitation after this type of surgery has not previously been described in detail.

The aim of this article is to describe the early active rehabilitation concept developed for spasticity-correcting surgery in tetraplegia and to report the outcome in complications, grip ability, and change of performance and satisfaction in patients' prioritized activities 1 year postsurgery.

Methods

Early active rehabilitation protocol

The rehabilitation concept described in this article is a modified version from the early active rehabilitation, which was developed for rehabilitation after grip reconstruction in tetraplegia.[13] The early active rehabilitation protocol includes 1 parts: (1) early active mobilization of sutured tendons and surrounding tissues and (2) maintenance of activities of daily living.

The benefits of early active mobilization include a reduced risk of adhesions, joint stiffness, and swelling. The method has frequently been used in tendon transfer rehabilitation for many years.[13-15]

The second cornerstone in early active rehabilitation is the general active approach. Patients are encouraged to be as active as possible in their daily lives, despite the restrictions after surgery. The rationale behind includes several features; active use of the arm facilitates activation of the muscle pump together with intermittent elevation, which prevents edema and improves circulation. Moreover, general fitness and independence are maintained. Some patients hesitate to undergo surgery because of the increased dependence that follows the postsurgical phase.[16,17] For these patients, reduction in restrictions in daily life are essential when deciding whether to undergo surgery or not.

List of abbreviations:

ASIA	**American Spinal Injury Association**
COPM	**Canadian Occupational Performance Measure**
GRT	**grasp and release test**
SCI	**spinal cord injury**

Preoperation

Detailed assessment on all aspects of spasticity needs to be carefully considered before the surgery. Factors (eg, fluctuations, triggers of muscle tone) are important to identify. Fluctuations in muscle tone make the surgery lengthening difficult to dose. Moreover, effect of the spasticity on daily life, both positive and negative, needs to be assessed. Useful effects of spasticity can be critical for patients' independence and has to be weighed against other expected activity improvements after surgery.

Surgery can be offered to individuals presenting with spasticity with primarily muscle hypertone in one or several muscles. The hypertone must limit the ability to perform daily activities and not be helpful in important activity performance. It is essential that the muscle hypertone is relatively stable over time, spasticity medications are optimized, and the patient is motivated to participate in the treatment before surgical treatment should be considered.

To optimize the postoperative training, the patient should be well informed regarding the rehabilitation and well prepared for the restrictions in daily life that will follow after surgery. Thereby, focus can be on rehabilitation and not worries about practical problems.

Surgery

Surgery involves tendon lengthening and/or tendon releases.[8,12] The surgery can include a single tendon if the hypertone is focal or multiple lengthenings and releases if the hypertone is more general. To avoid poor balance of the hand, tendon transfers are not performed at the same time as lengthenings and releases. If tendon transfers are considered beneficial these may be considered after the effects of spasticity has been reduced. The tendon lengthening procedures are performed by a stair-step incision technique followed by reattachment in the lengthened position using a side-to-side, cross-stitch technique. This suture technique enables immediate active training directly after surgery. The load to failure of the sutured tendon is approximately 200N, which gives a sufficient safety margin for early active mobilization of the tendons involved.[18,19]

First 1 to 3 days after surgery

Splinting

Within 24 hours after surgery, a custom-made splint is provided. The aim of the splint is to facilitate a prolonged stretch of the soft tissues and prevent postoperative edema. It is essential that the splint is custom-made in order to produce the maximal individual