Technical Pearls of Tendon Transfers for Upper Extremity Spasticity

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KEYWORDS

• Tendon transfers • Cerebral palsy • Tetraplegia • Wrist deformity • Wrist spasticity
• Finger spasticity

KEY POINTS

- Successful tendon transfer surgery depends on a thorough preoperative clinical evaluation, understanding of tendon transfer biomechanics, appropriate donor and recipient selection, technical execution, and postoperative rehabilitation.
- Tendon transfer pillars include matching donor and recipient work capacity, excursion, and synergy; maintaining a straight line of pull; ensuring single donor function; and minimizing tendon donor morbidity.
- Flexor carpi ulnaris to extensor carpi radialis brevis, extensor carpi ulnaris to extensor carpi radialis brevis, and flexor digitorum profundus to superficialis transfers are some of the most common tendon transfers used for patients with upper extremity spasticity.

INTRODUCTION

Patients with upper extremity spasticity due to cerebral palsy, tetraplegia, traumatic brain injury, or stroke frequently display an imbalance of muscular forces acting across their joints. The treating surgeon must carefully evaluate their function and have a thorough knowledge of the fundamentals of treatment before initiating care. Surgical treatment may be indicated depending on functional goals and the magnitude of deformity and joint range of motion. Surgical options include tendon transfer, tendon lengthening, tenotomy, tenodesis, and arthrodesis. The goal of tendon transfer surgery in this setting is the restoration of muscle balance and active muscle control. Success after tendon transfer surgery depends on a thorough preoperative clinical evaluation, an understanding of tendon transfer biomechanics, appropriate donor and recipient muscle selection, technical execution, and postoperative rehabilitation.

PREOPERATIVE PATIENT EVALUATION

Tendon transfer surgical planning requires a thorough preoperative clinical evaluation. Before examining the involved extremity, overall functional status, social infrastructure, and psychological status should be assessed. Additionally the patients' and caregivers' goals for intervention should be assessed so that appropriate treatment strategies that best fit these goals can be devised. In patients with tetraplegia, the priorities for reconstruction are (from first to last): wrist extension, pinch, grasp, release, and intrinsic reconstruction.[1] Extremity examination should be detailed and methodical,

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including observation of the skin and resting posture, joint stability and range of motion, muscle strength and activity, and neurovascular examination. Surgical indications are beyond the scope of this article; however, before considering tendon transfer surgery, several aspects of the physical examination are emphasized:

1. Joints affected by the planned procedure should be supple and without contracture. Joint stability must also be assessed because joint mobility outside of the anticipated range of motion can alter the line of pull of the tendon transfer and lead to suboptimal tensioning or joint contracture.
2. The function and activity of potential donor and recipient muscles (in addition to synergist or antagonist muscles) must be understood. Clinical examination can be supplemented with other data sources, such as dynamic electromyography, motion analysis, and video review of patients performing standardized tasks.[2–4] A thorough understanding of muscular balance is required to ensure appropriate donor and recipient muscle selection and prevent iatrogenic harm.
3. Potential donor muscle strength should be at least 4+/5 because of the anticipated loss of at least 1 grade of strength postoperatively.[5,6]
4. Tendon transfer surgery timing is generally delayed until at least age 6 years in patients with cerebral palsy and at least 1 year after injury in spinal cord injury patients.

Contraindications to tendon transfer surgery in patients with upper extremity spasticity disorders include fixed joint contractures, spasticity in the planned donor muscle beyond voluntary control (dyskinesia), and lack of social infrastructure and/or psychological ability to comply with postoperative rehabilitation.[1] It is also important to note that tendon transfers can be performed in combination with other techniques such as arthrodesis and/or tenodesis.

Patient evaluation by the surgeon or therapist may include 1 of several scales to assess baseline functional status and/or improvement. The House classification ranges from grade 0 (does not use) to 8 (spontaneous, complete use). Grades 1 to 3 are characterized by a passive assist hand, grades 4 to 6 by an active assist hand, and grades 7 to 8 by spontaneous use.[7] The Manual Ability Classification System (MACS) evaluates the patient's ability to handle objects required for activities of daily living.[8] The scale ranges from 1 (handles objects easily and successfully) to 5 (does not handle objects and has severely limited ability to perform even simple actions). In general, the MACS and House classifications are inverse scales, such that a MACS 1 corresponds to a House spontaneous use (7/8) hand and a MACS 5 corresponding to an unused (House 0) hand.[9] The Assisting Hand Assessment (AHA) evaluates bimanual hand function in patients with conditions affecting a unilateral upper extremity (eg, cerebral palsy or brachial plexus birth injury) via 15 minutes of simulated bimanual tasks.[10] Using the AHA at age 18 months, children's hand functions can be divided into high or low. The evidence suggests that children with high hand function at 18 months functionally plateau around age 3 years. Despite this, they end up at a higher functional level than patients with low hand function, who typically plateau around age 7 years.[11] Finally, the Zancolli classification evaluates the interrelationship between finger and wrist flexor spasticity and contracture by assessing at what angle of wrist flexion full passive finger extension can be achieved.[9,12] Patients with minimal flexor spasticity can achieve full passive finger extension in positions of wrist extension or neutral (Zancolli 1), whereas patients with severe spasticity can only achieve full passive finger extension in full wrist flexion (Zancolli 3). The Zancolli classification helps guide treatment strategies for tendon lengthening, tendon releases, and/or flexor digitorum superficialis (FDS) to profundus transfer to improve hand function and/or resting posture.

TENDON TRANSFER SELECTION

Appropriate tendon transfer selection is based on the following principles (**Box 1**):

1. The work capacity of the donor and recipient muscles should be matched.[13,14] Muscle fiber volume is proportional to work capacity and the muscle cross-sectional area is proportional

Box 1
Six pillars of tendon transfer surgery

1. Match work capacity of donor and recipient muscles
2. Match excursion of donor and recipient muscles
3. Transferred tendon linear vector of pull
4. One donor, 1 function
5. Acceptable morbidity of donor muscle sacrifice
6. Consider synergistic donor and recipient muscles to ease rehabilitation