Long Head of the Triceps Muscle Transfer for Active Elbow Flexion in Arthrogryposis

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Abstract: Arthrogryposis is a condition characterized by symmetric, nonprogressive joint contractures and weak or absent musculature that is present at birth. The amyoplasia form is the most common, and in this group, the elbow is frequently involved, typically in an extension contracture bilaterally. Active elbow flexion is weak or absent, but active extension is spared. This elbow dysfunction poses a significant disability for affected children. Sensation and cognitive development is normal in children with arthrogryposis, and as a group they demonstrate a remarkable degree of adaptability to their deformities. The goal of any treatment is to facilitate the child's functional independence. This article describes the surgical technique of transfer of the long head of the triceps into the proximal ulna to provide active elbow flexion in children with arthrogryposis. The goal of the procedure is to reliably achieve antigravity active flexion while preserving active extension. It has the advantages of technical simplicity and minimal donor site morbidity. By adding this procedure to the existing options for treating this challenging condition, a surgeon is better able to tailor intervention to an individual child's strength and available donor muscles.

Key Words: arthrogryposis, elbow, functional muscle transfer, long head triceps

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HISTORICAL PERSPECTIVE

The diagnosis and overall management of children with arthrogryposis have been recently reviewed.[1] In the upper limb, the elbow is key to functional independence. Children with rigidly extended elbows require assistance in performing activities of daily life that involve reaching their face, head, and upper body.[2] Achieving passive elbow flexion to 90 degrees, either by stretching and splinting or by surgical capsular release and triceps lengthening, allows children to use compensatory maneuvers such as table push, trunk sway, and cross-arm support to reach their face and head.[3] The addition of active elbow flexion further improves their functional independence without the need for conspicuous and potentially socially embarrassing maneuvers.[4] Accordingly, several transfers to achieve active elbow flexion have been described for this population.

The Steindler flexorplasty[5] transfers the flexor pronator origin from the medial epicondyle to a more proximal and lateral position on the humerus. Originally described in 1919 "for the relief of flail elbow in infantile paralysis,"[6] it has been subsequently used in the management of arthrogryposis.[4,6–8] The drawbacks of this procedure are that it is potentially a weak transfer, causes an elbow flexion contracture, and may increase the flexion deformity of the wrist and fingers, especially when there is no wrist extensor power to allow the transfer power to be directed toward the elbow.[9,10] Of note, Goldfarb et al[4] have shown good functional results with this procedure in a carefully selected group of arthrogypotic patients with active finger flexion and good digital strength against resistance.

The pectoralis muscle can provide active elbow flexion as either unipolar[11] or bipolar transfer.[12,13] In a unipolar transfer, the inferior portion of the sternal head is detached, tubulated, and reattached to the distal biceps, sometimes necessitating tendon graft for length. This results in a strong adduction force instead of elbow flexion unless the limb is supported horizontally.[10] It also creates a webbed appearance of axillary fold.[13] In a bipolar transfer, the entire pectoralis muscle is rotated on its neurovascular pedicle. Several reviews have noted achievement of active flexion, some loss of extension, and overall subjective functional improvement.[6,8,13,14] This transfer can provide strong elbow flexion when the pectoralis is of good quality, but it is difficult to assess preoperatively, making the outcome unpredictable.[14] Extensive dissection is required. Additionally, it can result in an aesthetically displeasing scar and asymmetry of the chest wall, factors that have discouraged its use in female patients. Lahoti and Bell[15] reported deteriorating results in the long term in transfers that initially seemed successful. With an average follow-up of 11.5 years (7-19 y), 8 of 10 elbows developed a recalcitrant flexion deformity of greater than 90 degrees.

The latissimus dorsi muscle[16,17] can be transferred similarly to the bipolar pectoralis. This transfer is strong when present, but it is also quite difficult to ascertain its strength and quality preoperatively. It is often underdeveloped in children with arthrogryposis, appearing fibrotic, or atrophied, and infiltrated with fat on visual inspection.[10,14]

Originally mentioned in 1951 by Bunnell[18] and described in 1952 by Carroll,[19] the transfer of the entire triceps is the most reliable flexion transfer in the short term. It is a strong muscle that is consistently present in arthrogryposis and can be accurately assessed preoperatively. It requires a less extensive dissection and is technically easier than the previous options. With passive range and gravity assist for extension, it was felt to be a procedure with minimal morbidity. In many comparative reviews of short-term results, it was the active transfer of choice. However, over time a significant flexion contraction develops with complete loss of passive elbow extension.[4,8,10,14] At 10 years of follow-up, Williams[20] reported that nearly all transfers had lost function due to progressive loss of arc of motion and development of disabling flexion deformity.

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The long head of the triceps has been used as pedicled musculocutaneous flap for coverage of soft tissue defects in the upper chest[21] and axilla.[22] It has been successfully used for reconstruction of elbow flexion in 2 case reports, an adult brachial plexus injury and an adult traumatic amputation at the supracondylar level of the humerus.[23] Its use in arthrogryposis was first reported by Ezaki.[10] Electromyography studies have shown that the long head functions as an adductor of the arm in its native state. Additionally, it is able to function independently of the rest of the triceps,[23] allowing elbow flexion without sacrificing active extension.

INDICATIONS/CONTRAINDICATIONS

Treatment must be individualized and should take into account the whole child, including ambulatory status, adjacent joint limitations, and compensatory maneuvers. Originally the authors only selected patients who did not rely on their upper extremities to ambulate with assistive devices, perform transfers, or rise from the floor. As no patient has had less than 4/5 triceps strength posttransfer, we have expanded our indications for this procedure, although still carefully considering each individual's needs.

A good passive arc of elbow motion is a prerequisite for an active muscle transfer, preferably 80 to 90 degrees of passive flexion. The triceps must be strong, with 4/5 or 5/5 strength on manual muscle testing. The long head's independent function can be easily confirmed with surface electromyography, although the authors do not routinely do this preoperatively. The child should be old or mature enough to train the transfer postoperatively, usually 7 to 8 years of age or older.

A relative contraindication to transferring the long head of the triceps may be prior capsular release and triceps lengthening to achieve a passive arc of motion. The concern is that a previously lengthened tendon will be scarred and inadequate to transfer satisfactorily. Experience has shown that this concern can be mitigated by the use of a fascia lata prolongation graft, thereby bypassing the scarred distal triceps tendon and allowing the long head to still be used as a motor for elbow flexion.

ANATOMY

The long head of triceps originates from the infraglenoid tubercle of the scapula and inserts into a fibrous band within the belly of the medial head of the triceps. Its power is transferred to the olecranon through a common tendon with the medial and lateral heads. The long head has a separate muscle belly with an independent nerve and blood supply, which has been extensively studied. Haninec and Szeder,[24] in an anatomic study of 10 cadavers, found the branch to the long head (which is the first motor branch from radial nerve, branching 10.4 cm distal to the acromion) consistently present and sufficiently mobile for pedicled transfer. Lim et al[25] dissected 23 cadavers investigating the long head for free functioning muscle transfer. They reported that the long head receives a single branch from the radial nerve, 7 cm in length, which enters the muscle at the junction of the proximal one-third and distal two-thirds, approximately 70 mm from the muscle origin. There is a constant and proximal vascular pedicle from the profunda brachii, and a perfusion study in 6 specimens confirmed the adequacy of perfusion of the entire muscle head.

TECHNIQUE

Surgery is performed with the patient either supine or in a lateral decubitus position and the arm prepped around the axilla and draped free. Epinephrine solution in Marcaine is infiltrated along the planned incision to minimize bleeding and provide a field block. With the arm flexed, a long longitudinal incision is made in the midline of the posterior arm (Fig. 1), from the lateral end of the posterior axillary fold to a few centimeters distal to the olecranon, along the posterior subcutaneous border of the proximal ulna. The incision is gently curved medially around the olecranon tip to avoid a suture line directly over that bony prominence. The dissection is carried down to triceps muscle fascia and tendon along its length.

The ulnar nerve is identified, released from the cubital tunnel and transposed anteriorly subcutaneously. A medial subcutaneous flap is developed for the transfer.

The long head of the triceps is identified at the proximal end of the incision, where the individual muscular heads are clearly separate. The long head is released distally using gentle dissection. It is not necessary to dissect or mobilize the neurovascular pedicle of the long head of the triceps. A separate tissue plane separates the long head from the underlying medial head.

Once the common triceps tendon is reached, the release is continued sharply, taking the medial third to half of the distal tendon. It is important to take a contiguous strip of extensor carpi ulnaris fascia to have enough length for transfer (Fig. 2).

FIGURE 1. Incision for long head triceps transfer.

FIGURE 2. Intraoperative view of the long head of the triceps. The white vessel loop is around the ulnar nerve. The muscle is ready for insertion into the ulna.

Alternatively, a tendon graft can be used for additional length, our preference being fascia lata.

Once released, the long head distal tendon is tubed upon itself with 3-0 Ethibond suture. It is transferred around the medial border to the anterior aspect of the arm. The insertion point is the proximal anterior ulna, distal to the coronoid process. The ulnar nerve is carefully protected and positioned to prevent impingement from the transfer. The distal tendon is fixed to the ulna with a 2.5 mm suture anchor approx 3.5 cm distal to the olecranon, with the elbow in 90 degrees of flexion. The incision is then closed in layers after meticulous hemostasis is achieved.

Alternatively, the end of the prolongation graft can be split longitudinally, and each tail placed around the proximal ulna in a subperiosteal tunnel. The tails are brought out on the dorsum of the proximal ulna through a separate incision. After the closure of all other wounds, tension is adjusted, and the tails of the tendon or graft are secured back onto themselves and the ulna. Tension of the transfer is set with the elbow at 90 degrees and the shoulder adducted with minimal tension on the graft. Passive extension to minus 30 degrees should be easy, but tight beyond that.

COMPLICATIONS

Injury to the radial or ulnar nerves could occur if they are not carefully protected. The transferred long head may not be strong enough to initiate flexion from a position of extension, but generally will be strong enough to hold an elbow flexed against gravity after it is brought into flexion by compensatory mechanisms such as swinging the arm. In the weakest result, the muscle may not be of sufficient size and strength to move the elbow joint against gravity postoperatively. However, just achieving active flexion from 90 degrees of shoulder elevation (elbow flexion with gravity eliminated) is a functional improvement over needing overhead arm position and gravity flexion to reach the face.

Another potential complication is loss of active elbow extension, which the authors have not encountered in their own series. Others who have used the long head for coverage have noted no significant loss of active elbow extension.[21,22] There is usually a loss of terminal passive extension of 20 to 30 degrees. The change in passive arc of motion is balanced by the creation of an active arc of motion.

REHABILITATION

The arm is immobilized in 90 degrees of elbow flexion for 3 weeks. Then a removable, long arm posterior splint is fabricated. The splint is worn until the child can actively contract the transferred muscle (Fig. 3). The child can train the transfer for elbow flexion by trying to adduct arm to his side. Active and active-assisted exercises in both flexion and extension are easiest with the arm at the horizontal. At 6 weeks, passive elbow range of motion is resumed. A sling is worn for a total of 3 months.

FIGURE 3. Active flexion against gravity after long head of the triceps transfer.

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