Surgical Treatment of Pediatric Upper Limb Spasticity: The Shoulder

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Abstract

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The shoulder joint is essential for placing the hand in a functional position for reach and overhead activities. This depends on the delicate balance between abductor/adductor and internal/external rotator muscles. Spasticity alters this equilibrium, limiting the interaction of the upper limb with the environment. Classically, pediatric patients with upper limb spasticity present with an adduction and internal rotation contracture of the shoulder. These contractures are typically secondary to spasticity of the pectoralis major and subscapularis muscles and sometimes attributed to the latissimus dorsi muscle. Fractional lengthening, Z-step lengthening, or tendon release of the contributing muscle groups may help correct the adduction and internal rotation contractures. With proper diagnosis, a well-executed surgical plan, and a consistent hand rehabilitation regimen, successful surgical outcomes can be achieved.

The shoulder joint is essential for placing the hand in a functional position for reach and overhead activities. This relies on an orchestrated balance between the shoulder abductor (supraspinatus and deltoid), shoulder adductor (pectoralis major, subscapularis, latissimus dorsi, teres major), external rotator (infraspinatus, teres minor), and internal rotator (pectoralis major, subscapularis, latissimus dorsi, teres major) muscles. Spasticity alters this delicate equilibrium. Classically, pediatric patients with upper limb spasticity present with adduction and internal rotation of the shoulder (▶Fig. 1).^{1,2}

Depending on the severity, the shoulder joint contracture may produce a hygienic, cosmetic, and/or functional deformity.^{3,4} Severe adduction deformities can promote skin intertrigo and eventually lead to skin breakdown in the axilla, thus requiring wound management. Physical appearance is also an important consideration, as the internal rotation deformity represents one of the key stigmata of cerebral palsy. The functional implications of the shoulder joint contracture include limitations on reaching a wider radius of objects.

Here we will discuss the diagnostic approach, surgical options, postoperative management, and outcomes of pediatric patients presenting with upper limb spasticity at the shoulder.

Clinical Evaluation

Shoulder adduction and internal rotation contractures may be secondary to spasticity of the pectoralis major, subscapularis muscles, and latissimus dorsi muscles. In the chronically adducted and shortened position, the soft tissue structures may respond with a variable degree of contraction. This can include contraction of the axillary skin, shortening of the neurovascular structures, and tightening of the capsular ligaments. Thus, although the inciting cause may be strictly muscular, the subsequent mechanisms for contracture may be multifactorial (skin deficiency, muscular spasticity, neurovascular shortening, and capsular contracture).⁵

Proper diagnosis of shoulder adduction and internal rotation contractures relies on careful identification of each of the contributing factors. The exam begins with visual inspection of the axillary region. The quality of the surrounding skin should be evaluated for color, presence of surgical/traumatic scars, evidence of skin breakdown or intertrigo, and presence of taut musculotendinous units (▶Fig. 2). The shoulder should be noted for its resting angle and presence of increased muscular tone versus slow repetitive movements

Fig. 1 Classic posture of pediatric patients with upper limb spasticity, marked by adduction and internal rotation of the shoulder.

Fig. 2 Taut musculotendinous unit evident at the anterior axillary fold, indicative of pectoralis major involvement.

indicative of dyskinesia. Second, the anterior and posterior axillary folds should be palpated to better appreciate the degree of skin laxity (if any) and pinpoint the spastic musculotendinous units. The anterior axillary fold is comprised of the pectoralis major muscle, which originates from the clavicle and sternocostal regions and inserts onto the lateral lip of the bicipital groove. The posterior axillary fold is

comprised of the latissimus dorsi and teres major muscle complex, which originate from the thoracolumbar fascia and inferior angle of the scapula and insert onto the intertubercular groove and medial lip of the intertubercular sulcus of the humerus, respectively. Finally, tight neurovascular structures, particularly the axillary artery/vein and infraclavicular brachial plexus, are best appreciated deep within the axillary fossa and medial to the coracobrachialis muscle.

Passive and active shoulder range of motion (ROM) measurements should then be obtained with a goniometer. Maximum passive shoulder abduction should be evaluated, to better highlight the major contributing factors to the adduction contracture. Passive external rotation can also aid in identifying the contributing forces, depending on the shoulder position. Spasticity of the pectoralis major muscle is best appreciated on passive external rotation with the shoulder in the abducted position (►Fig. 3). In contrast, spasticity of the subscapularis muscle is best observed on passive external rotation with the shoulder in the adducted position (►Fig. 4). Capsular contracture can be deduced from the situation where other soft tissue components are not sufficiently taut enough to explain the severity of the contracture.

Fig. 3 Spasticity of the pectoralis major muscle is best evaluated on passive external rotation with the shoulder in the abducted position.

Fig. 4 Spasticity of the subscapularis muscle is best observed on passive external rotation with the shoulder in the adducted position.

Surgical Indications and Timing

Proposed guidelines for surgical release of the shoulder include (1) impairment of custodial care, whether for hygiene or dressing; and (2) skin breakdown problems in the axilla. Specific degrees of the deformity are typically not considered in the surgical indications.⁶ That being said, for lesser degrees of contracture, nonsurgical options include serial abduction splinting and/or botulinum toxin A (BoNT-A). A relative contraindication includes the presence of athetosis, which manifests as fluctuations in tone and opens the possibility for reconstructive overcorrection.⁷

In relation to the timing of surgery, reliance on strict age criteria should be avoided. Although the effects of cerebral palsy are often recognized in the perinatal period, it is wise to defer surgery until a clear evaluation of upper extremity function can be performed. Additionally, there is merit in delaying surgery until predominant patterns of upper extremity use become apparent. These two points often coincide during childhood age, between 5 and 12 years of age. That being said, some authors have advocated for earlier surgical correction around 18 months to 5 years of age. While the optimal surgical age remains up for debate, there is a clear consensus that surgery remains a viable option for the older pediatric patient. It is not uncommon for a patient to be referred in their teenage years. In such cases, there still remains a role for surgery, albeit with a lower expectation for functional improvement.

Treatment

Physical/occupational therapy, BoNT therapy, and/or surgical reconstruction can help rebalance these abnormal muscular forces. Although not the topic of this article, splinting and BoNT therapy are useful as stand-alone or as adjunctive modalities for treating spasticity about the shoulder. However, surgical strategies for addressing the shoulder will be explored here.

When addressing a shoulder adduction and internal rotation contracture, the surgical plan must take into account the multifactorial potential etiologies: skin deficiency, muscular spasticity, neurovascular shortening, and capsular contracture. Therefore, one must be prepared for local flap resurfacing of the axillary fossa, musculotendinous lengthening of the involved units (pectoralis major, subscapularis, latissimus dorsi), and anterior shoulder capsulotomy performed to the limits of neurovascular tension and within the confines of shoulder stability.

Depending on the musculotendinous units contributing to the deformity, the surgical incisions can vary. If the subscapularis muscle is not involved, the surgical procedure begins with either two separate curvilinear incisions centered over the anterior and posterior axillary folds (►Fig. 5) or one complete incision across the axillary fossa for added exposure (►Fig. 6). The dissection then proceeds deep to the skin overlying the anterior axillary fold. The skin and subcutaneous tissues are elevated; the tendon of the pectoralis major muscle can be verified by its glistening white surface above and below. The soft tissue is then cleared off the tendon in an anterograde fashion toward its insertion onto the humerus and in a retrograde fashion up to the musculotendinous

Fig. 5 Two separate curvilinear incisions centered over the anterior and posterior axillary folds can be used to approach the pectoralis major and latissimus dorsi musculotendinous units, respectively.

Fig. 6 Alternatively, one complete incision across the axillary fossa can be used for added exposure.

junction. The tendon is then circumscribed, carefully isolating its deep surface from the surrounding long head of the biceps. During this process, the clavicular and sternal tendinous contributions can be separately appreciated. Depending on the severity of the deformity and the desired release, either a fractional lengthening, Z-step lengthening, or complete tendon release is performed (►Fig. 7). Fractional lengthening is

Fig. 7 Depending on the severity of the deformity and the desired release, either a fractional lengthening, Z-step lengthening (*right dotted lines*), or complete tendon release (*left dotted lines*) of the pectoralis major can be performed.

performed by transecting the posterior tendinous fibers where they overlap with the muscular belly.⁸ In the more common moderate or severe situation, a Z-step lengthening is performed. The lengthening should be performed across as much length of the tendon as possible. This will ensure the ability to repair the lengthened tendon ends with maximal contact, allowing for optimal healing. In the patient with a severe contracture and no volitional control, the pectoralis major tendon can simply be released.

If the preoperative planning included management of the latissimus dorsi, or if the pectoralis major release was not sufficient to correct the contracture, attention is then paid to the posterior axillary fold. The skin and subcutaneous tissues are elevated and the latissimus dorsi is verified by its broad, flat surface. The soft tissue is then cleared off the muscle in an anterograde fashion toward its tendinous insertion onto the humerus. The latissimus dorsi tendon can be isolated from the teres major conjoint tendon as well as from the surrounding axillary nerve above and radial nerve below. Depending on the severity of the deformity and the desired release, either a fractional lengthening, Z-step lengthening, or complete tendon release can be performed in a similar fashion.

If the subscapularis unit is involved, the anterior access incision is placed in the deltopectoral groove for additional exposure (**Fig. 8**). The skin flaps are elevated and the location of the deltopectoral groove is confirmed by the presence of the cephalic vein. The deltopectoral interval is retracted and the coracoid process is identified. This landmark serves to identify the coracobrachialis muscle, which is retracted medially. Deep and lateral to the coracobrachialis muscle, the subscapularis tendon is found fusing to the anterior capsule of the shoulder. Depending on the severity of the deformity and the desired release, either a fractional lengthening, Z-plasty lengthening, or partial tendon release can be performed (**Fig. 9**). If tightness on passive external rotation persists, an anterior-inferior capsulotomy can be performed. Care must be taken to not over-release the capsule for fear of destabilizing the shoulder.

The shoulder is then placed into ~90 degrees of abduction and the Z-step-cut tendinous ends are then repaired in a lengthened fashion. The repair is performed using a 2-0 permanent suture, in a side-to-side fashion with a running

Fig. 8 Placement of the incision in the deltopectoral groove for additional exposure if the subscapularis unit is involved.

Fig. 9 Depending on the severity of the deformity and the desired release, either a fractional lengthening, Z-step lengthening (*black dotted lines*), or complete tendon release (*light dotted lines*) of the subscapularis can be performed.

horizontal mattress. Care is taken to place the proximal and distal tendon ends on maximal tension while holding the shoulder fixed at 90 degrees.

The skin defects at either the anterior and/or posterior axillary folds are then assessed. Depending on the degree of release, the skin can either be closed in a straight-line fashion or with the help of local flaps (**Fig. 10**).

Fig. 10 Use of local rotational flaps to address tension across the skin closure line.

Fig. 11 Fitting the left upper extremity into a hip abduction pillow, which has been converted to provide for 90 degrees of shoulder abduction.

Postoperative Care

Following surgical reconstruction of the shoulder, the patient is then fitted with a hip abduction pillow. This pillow is converted for shoulder use and is a secure method for abducting the shoulder to 90 degrees (► **Fig. 11**). The abduction pillow stays in place continuously except when sponge bathing. This promotes healing of the shoulder musculotendinous units in a lengthened position, thereby lessening the degree of relapse. Four weeks following the procedure, the patient is transitioned to nocturnal use of the abduction pillow. During the day, abduction is maintained with the use of standard pillows.

Between pillow uses, the patient is instructed on gentle active and passive ROM exercises about the shoulder. Eight weeks postoperatively, the patient is transitioned to nocturnal use of standard pillows for up to 12 months postoperatively.

Outcomes

There are few outcomes studies related to surgical release of the spastic shoulder joint in the pediatric population. Based on the work of Domzalski and colleagues, patients who undergo tenotomy of the pectoralis major can expect a 30- to 45-degree improvement in the adduction contracture without appreciable loss of adduction power.⁶ An additional 30 degrees can be achieved through release of the latissimus dorsi tendon. Of 13 patients who underwent pectoralis major plus or minus latissimus dorsi tendon release, 10 demonstrated passive abduction to > 90 degrees. Six patients (46%) demonstrated recurrent internal rotation contractures. All but one patient noted improvement, and all caregivers reported that they would recommend this surgery to another patient.⁶

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