Subscapularis Slide Correction of the Shoulder Internal Rotation Contracture After Brachial Plexus Birth Injury: Technique and Outcomes

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Abstract: Internal rotation contracture is the most common shoulder deformity in patients with brachial plexus birth injury. The purpose of this investigation is to describe the indications, technique, and results of the subscapularis slide procedure. The technique involves the release of the subscapularis muscle origin off the scapula, with preservation of anterior shoulder structures. A standard postoperative protocol is used in all patients and includes a modified shoulder spica with the shoulder held in 60 degrees of external rotation and 30 degrees of abduction, aggressive occupational and physical therapy, and subsequent shoulder manipulation under anesthesia with botulinum toxin injections as needed. Seventy-one patients at 2 institutions treated with subscapularis slide between 1997 and 2010, with minimum follow-up of 39.2 months, were identified. Patients were divided into 5 groups based on the index procedure performed: subscapularis slide alone (group 1); subscapularis slide with a simultaneous microsurgical reconstruction (group 2); primary microsurgical brachial plexus reconstruction followed later by a subscapularis slide (group 3); primary microsurgical brachial plexus reconstruction followed later by a subscapularis slide combined with tendon transfers for shoulder external rotation (group 4); and subscapularis slide with simultaneous tendon transfers, with no prior brachial plexus surgery (group 5). Full passive external rotation equivalent to the contralateral side was achieved in the operating room in all cases. No cases resulted in anterior instability or internal rotation deficit. Internal rotation contracture of the shoulder after brachial plexus birth injury can be effectively managed with the technique of subscapularis slide.

Key Words: brachial plexus, shoulder contracture, subscapularis slide

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HISTORICAL PERSPECTIVE

Brachial plexus birth injury occurs at a rate of 0.1% to 0.5% in the general population.[1,2] The resultant relative weakness of the abductors and external rotators of the shoulder is the core underlying pathology. This muscle imbalance leads to a consistent and disabling deficit in external rotation. In children without complete neurological recovery by 3 weeks, contracture of the shoulder was observed in up to 54%.[3] Even in patients with good overall functional recovery, a substantial number can present with contractures about the shoulder, of which internal rotation contracture is the most common and significant finding.[3–8] Literature supports the notion that untreated internal rotation contracture of the shoulder will progress and lead to glenohumeral deformity.[1,3,5,8–13]

Surgical management of internal rotation contracture remains a controversial subject. Several approaches have been described, including open anterior release with a subscapularis Z-lengthening, with or without a capsular release; arthroscopic anterior release; and subscapularis slide.[14–19] The subscapularis slide was initially described by Carlioz and Brahimi[15] and subsequently advocated by Gilbert et al.[16] The proposed benefits of this procedure include the ability to obtain full intraoperative correction of the contracture, while avoiding the potential pitfalls of anterior releases, such as instability, external rotation contracture, loss of internal rotation strength,[1,7,20] and axillary nerve damage.[5] At our institution, we have used a modified technique of the subscapularis slide to manage the internal rotation contracture with good results. The purpose of this investigation is to describe our indications, technique, and initial results of the subscapularis slide procedure. It is hypothesized that internal rotation contracture release by subscapularis slide consistently and safely achieves the goal of restoring passive external rotation, avoiding overlengthening and weakening the subscapularis, while maintaining the possibility of redo surgery in the event of contracture recurrence.

INDICATIONS AND CONTRAINDICATIONS

After institutional review board approval, a retrospective review was performed of all patients treated for obstetric brachial plexus injury by the 2 senior authors (J.A.I.G. and A.E.P.) during the period of 1997 to 2010. A cohort of 117 patients treated with the subscapularis slide was identified. Charts were retrospectively reviewed, and surgical and clinical data abstracted. Patients were divided into 5 groups based on previous, simultaneous, or subsequent procedures performed: subscapularis slide alone (group 1); subscapularis slide with a simultaneous microsurgical reconstruction (group 2); primary microsurgical brachial plexus reconstruction followed later by a subscapularis slide (group 3); primary microsurgical brachial plexus reconstruction followed later by a subscapularis slide combined with tendon transfers for shoulder external rotation (group 4), and subscapularis slide with simultaneous tendon transfers, with no prior brachial plexus surgery (group 5). No patients had shoulder surgery before the initial presentation.

Microsurgical reconstruction of the brachial plexus was indicated as previously described.[21,22] The indication to perform the subscapularis slide was always the presence of an internal rotation contracture of the shoulder that was unresponsive to nonoperative management. Glenohumeral joint deformity and congruency was assessed by preoperative imaging. Contraindications for the subscapularis slide included older children with advanced glenohumeral deformity that required an osteotomy for correction. Older children with or

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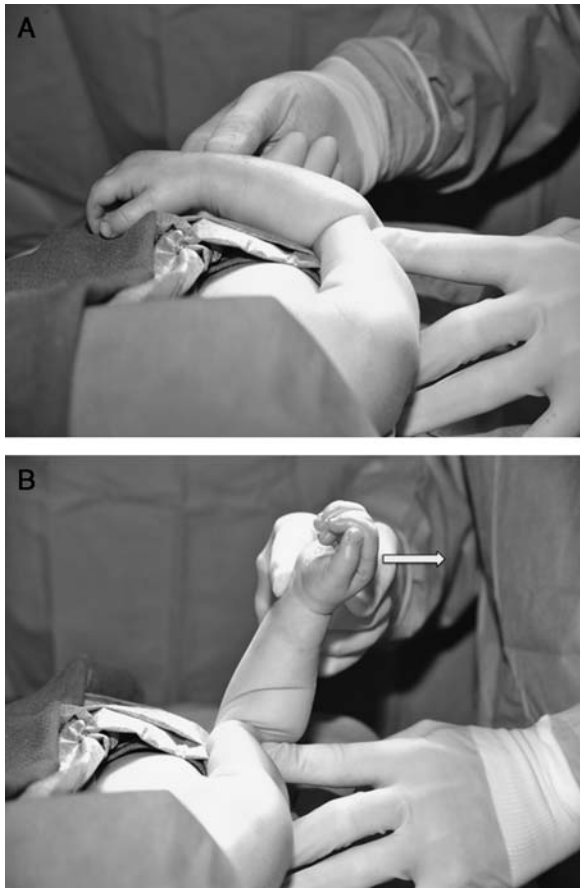

FIGURE 1. Measurement of the internal rotation contracture. A, The patient is supine, the brachium is held fully adducted, and the arm is maximally internally rotated to the chest wall (B). Ninety-degree internal rotation contracture is measured, keeping the brachium fully adducted.

without prior nerve surgery, who showed no evidence of active external rotation, were indicated for simultaneous tendon transfers.

Perioperative and postoperative complications were recorded. At the latest follow-up, the shoulder internal rotation contracture was assessed for recurrence. Patients who redeveloped an internal rotation contracture that required a repeat subscapularis slide and/or other treatment were considered recurrence.

FIGURE 2. A straight incision is placed over the scapula.

SURGICAL TECHNIQUE

The procedure is a modified technique based on the original descriptions of Carlioz and Brahimi[15] and Gilbert et al.[16] The patient is positioned supine on the operating room table. General anesthesia is induced, and perioperative antibiotics are administered. The amount of internal rotation contracture is measured with the brachium fully adducted (Fig. 1). The sterile surgical field includes the entire involved extremity, and the ipsilateral chest, head, and neck regions. The procedure is performed through a longitudinal mid-axillary incision (Fig. 2), and subcutaneous dissection is performed with loupe magnification, creating skin flaps. When an isolated subscapularis slide is performed, the procedure can be performed through a 2.5-cm incision. The latissimus dorsi muscle is identified, and further dissection is performed along the anterior edge of the muscle, with concomitant release of any adhesions. The neurovascular pedicle to the latissimus dorsi is identified and protected, and the latissimus dorsi is retracted laterally.

Next, the lateral edge of the scapula is identified, the arm is hyperabducted, and the tip of the scapula is pulled into the wound with the aid of a towel clamp. The white raphe of the subscapularis is identified (Fig. 3). It is cut with the cautery to allow a subperiosteal dissection. Using a periosteal elevator, the subscapularis muscle is dissected subperiosteally off the entire anterior surface of the scapula, as far laterally as the joint capsule (Fig. 4). The anterior shoulder structures, including the subscapularis tendon and the joint capsule, are preserved. The passive motion of the shoulder is then tested, and if full passive external rotation is achieved, the procedure is concluded.

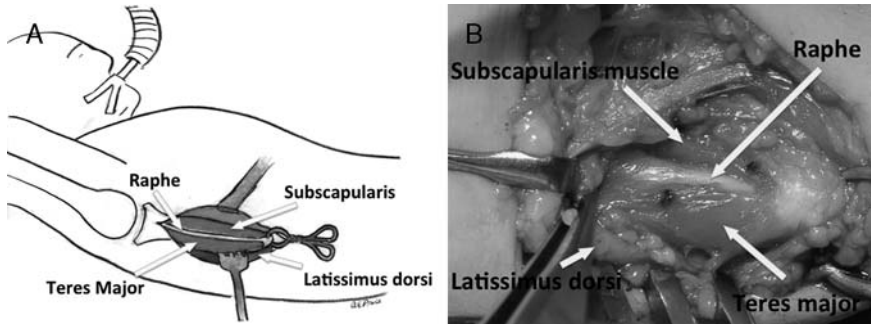

FIGURE 3. A and B, The scapula is being pulled into the operative field, and the subscapularis muscular raphe is identified.

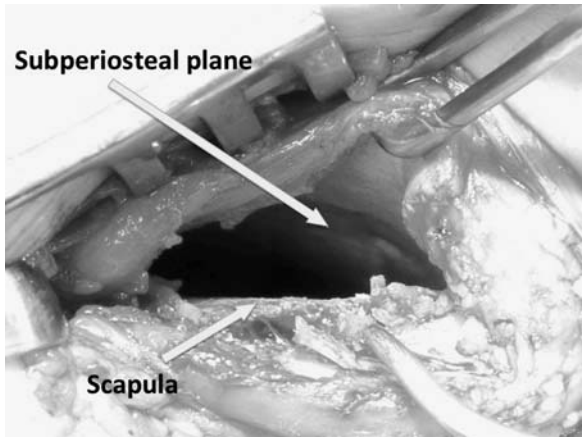

FIGURE 4. Subperiosteal plane is fully released.

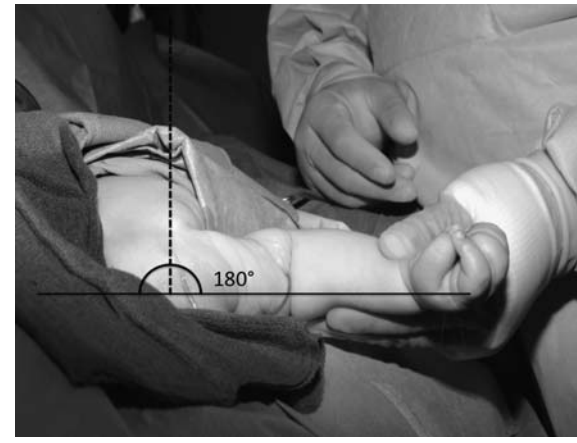

FIGURE 6. Full passive external rotation is achieved.

Usually residual tightness occurs and further release is sequentially performed, with passive motion reassessed at each step. First, periosteal fasciotomy of the subscapularis is performed if it is still tight (Fig. 5). The pectoralis major tendon is assessed, and if tight, it is fractionally lengthened intramuscularly. If full reduction of the humeral head in the glenoid cannot be achieved due to overgrown corocoid, the coracohumeral ligament is released with a partial coracoidectomy performed to achieve full reduction into the true glenoid (Fig. 6). Anterior release of the joint capsule and, thus, disruption of the subscapularis/capsular relationship is never performed.

After copious irrigation, fibrin glue is injected in the subscapularis fossa and on any exposed muscle to prevent adhesion formation. Botulinum toxin is always injected into the subscapularis and pectoralis major muscles, and, if not transferred, the latissimus dorsi and teres major. The wound is closed in layers, and the skin is closed with an absorbable subcuticular suture. Local anesthetic is injected along the incision to facilitate postoperative pain control. A sterile dressing is applied, and the arm is placed in a modified shoulder spica cast with arm in 45 degrees of abduction and 60 degrees of external rotation.

Postoperatively, the child is given routine prophylactic antibiotics and is typically discharged the day after surgery.

REHABILITATION

The cast is continued for 4 to 6 weeks depending on the age of the child. Once the cast is discontinued, aggressive occupational and physical therapy is instituted as described previously.[23]

RESULTS

Of 117 patients treated with the subscapularis slide between 1997 and 2010, 71 patients [25 male (35%) and 46 female (65%)] had postoperative follow-up for a minimum of 2 years (mean 60.6 mo) and were included in this analysis. Forty-nine patients (69%) had a C5-C6 injury, 10 patients (14%) had an injury involving the C5, C6, and C7 roots, and 12 patients (17%) had global brachial plexus involvement. Average age at the time of subscapularis slide was 39.2 months.

Patients were divided into 5 groups according to the index procedure performed (Table 1). Full intraoperative correction of the contracture was obtained in all patients, without the need for anterior capsular release.

COMPLICATIONS

No wound complications, other immediate postoperative complications, cases of axillary nerve damage, or instances of overcorrection occurred. No patients lost the ability to perform active internal rotation at least to their abdomen, and no treatment was required to restore active internal rotation.

Recurrence of the contracture is the most common complication of this procedure. By the time of final follow-up, a total of 21 patients (30%) were noted to have a recurrence of the internal rotation contracture that required either a revision subscapularis slide or a humeral osteotomy (Table 1). Group 3 had the highest rate of recurrence (50%). Conversely, no recurrences occurred in group 5. When analyzed individually, recurrence of the contracture was related to lack of timely restoration of muscle balance and not to the success of the initial procedure. When analyzed by the level of injury, only 1 of the 12 patients (8%) with global involvement developed recurrence of the

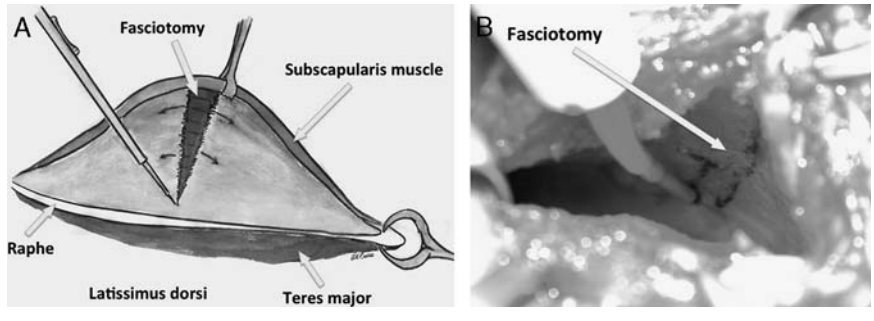

FIGURE 5. A and B, Y fasciotomy on the undersurface of the periosteum further releases the contracture.

TABLE 1. Indications for Subscapularis Slide

			C5-C6 Injury		C5-C7 Injury		Global Injury	
	Total Patients N	Surgical Failure N (%)	Total N	Surgical Failure N (%)	Total N	Surgical Failure N (%)	Total N	Surgical Failure N (%)
Group 1								
Primary subscapularis slide alone	6	2 (33%)	6	2 (33%)	0	NA	0	NA
Group 2								
Primary subscapularis slide with simultaneous nerve reconstruction	39	14 (36%)	27	11 (41%)	5	2 (40%)	7	1 (14%)
Group 3								
Primary nerve reconstruction followed by later subscapularis slide	8	4 (50%)	5	2 (40%)	3	2 (67%)	0	NA
Group 4								
Primary nerve reconstruction followed by later subscapularis slide combined with tendon transfers	10	1 (10%)	3	1 (33%)	2	0 (0%)	5	0 (0%)
Group 5								
Primary subscapularis slide combined with tendon transfers, with no prior brachial plexus surgery	8	0 (0%)	8	0 (0%)	0	NA	0	NA
Total	71	21 (30%)	49	16 (33%)	10	4 (40%)	12	1 (8%)

NA indicates not available.

contracture. The best results were seen in cases with associated tendon transfers for external rotation. Of the 18 patients (groups 4 and 5) who underwent tendon transfers at the time of the subscapularis slide, only 1 (6%) required reoperation.

DISCUSSION

Full correction of the contracture was achieved in all patients in our series, without need for anterior capsular release. These results are in agreement with others, who also reported excellent correction of deformity with the subscapularis slide.[16–24] Although Pearl and Edgerton[5] found that 20% of the children in their series required formal anterior release in addition to the subscapularis slide, this seemed to be associated with older age at surgery. We did not observe such correlation, possibly due to use of additional releases (subscapularis subperiosteal fasciotomy, pectoralis major lengthening, coracohumeral ligament release, and partial coracoid resection) in our technique. Our results demonstrated a 70% success rate at final follow-up with the use of the subscapularis slide for the correction of the internal rotation contracture of the shoulder. Previously, we reported outcomes of 19 children treated with combined plexus reconstruction and subscapularis slide and found that the internal rotation contracture was corrected without need for revision surgery in 13 patients (68%), with a mean follow-up of 43.5 months.[25] In the current study, group 2 corresponds to the same cohort, and with the longer mean follow-up of 63 months, the results are largely equivalent (64% success rate). This suggests results remain durable for 5 years posttreatment. These results are in line with Gilbert et al[16] who reported on the results of subscapularis release in 66 children, with a postoperative gain of 70 degrees of external rotation in patients below the age of 2 years and reported that the correction of the contracture was maintained for a minimum of 5 years.

In our series, the best results were seen when the primary subscapularis slide was combined with tendon transfers. In patients who underwent isolated subscapularis release without transfers, we saw a recurrence rate ranging from 33% (group 1) to 50% (group 3). A similar trend was noted by Cohen et al[26] who reported 32 patients treated with the subscapularis slide. In their series, subscapularis release restored external rotation to a mean of 45 degrees postoperatively, although they noted a slight deterioration with long-term follow-up of 9.5 years. The overall rate of poor results in their patients managed with isolated subscapularis slide was high at 75%, compared with only 17% requiring osteotomy when subscapularis release was combined with tendon transfers.[26] This is in contrast to results reported by Newman et al[27] who achieved good results with anterior subscapularis tenotomy without tendon transfers at a mean follow-up of 3.5 years in 13 children. Similarly, Gilbert et al[16] recommended against routine muscle transfers in younger patients, because nearly half of them recovered active external rotation. In their series, failure occurred in just 18% of patients and was attributed to either the presence of intra-articular deformities or absence of postoperative physical therapy.[16] Nonetheless, muscle transfers have demonstrated good and moderately durable results in improving external rotation when indicated to restore external rotation power.[6,17,28,29]

Of the 12 patients in our study with global involvement of the brachial plexus, only 1 patient developed a significant recurrence of the internal rotation contracture, a surprisingly low rate of recurrence. A possible explanation is that the extensive brachial plexus injury in these patients causes a weakness of the internal rotators in addition to the typical external rotation paralysis. This weakness of the internal rotators therefore limits the recurrence of the internal rotation contracture.

Loss of internal rotation power has been reported as a complication of the traditional or arthroscopic anterior release.[1,20] In our study, we did not observe this complication. Using magnetic resonance imaging, subscapularis muscle was found to be atrophic in 55% of children with obstetric brachial plexus birth injury.[30] It is possible that anterior release can further weaken the already compromised muscle-tendon unit, leading to weakness and external rotation contracture. The subscapularis slide is an intramuscular release of the contracture without affecting the length of the muscle-tendon unit, which may help prevent this complication. In contrast, subscapularis slide has been associated with histologic evidence of

ischemic contracture of the subscapularis muscle.[24] The implications of this finding are unclear, but careful protection of the neurovascular pedicle is important during the release.

Use of botulinum toxin seems to be beneficial in maintaining correction of the internal rotation contracture and has been shown to lead to an improved outcome at a mean follow-up of 3 years in patients undergoing subscapularis slide with concomitant muscle transfers.[31] In addition, botulinum toxin injections may minimize the development of the exaggerated internal rotation contracture seen after microsurgical brachial plexus reconstruction.[32] The suggested mechanism for botulinum toxin type A is that it weakens the medial rotators through its action on the motor endplates, thereby reducing their afferent input to the motor cortex and allowing cortical recruitment of injured nerves to increase.[2,31]

We did not assess the progression of glenohumeral deformity in our study. However, literature suggests that with correction of the internal rotation contracture, an improvement in glenohumeral subluxation and glenoid retroversion may be expected at a mean of 5-year follow-up.[26]

Our results support the conclusion that subscapularis slide is a valuable and safe procedure for correction of shoulder internal rotation contracture associated with obstetric brachial plexus injury. Longer-term follow-up is needed, and further research could elucidate factors associated with recurrence. In cases in which more severe and long-standing contractures occur, simultaneous associated procedures are required to complete the release. Satisfactory shoulder outcomes depend on the timely recovery or restoration of muscle balance around the shoulder, and secondary procedures may be required.

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