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5.1 Which tissues contribute to the internal rotation contracture in the BPBP shoulder?

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Internal rotation contracture with or without concomitant incongruence of the shoulder joint is a major sequel of brachial plexus birth palsy. In the early twentieth century authors gave considerable attention to pinning down exactly which anatomical structures caused the contracture. Since then many surgical techniques have been proposed, but there is still no consensus regarding the optimal treatment of these children. The main purposes of this study were; to investigate which anatomical structures are responsible for the contracture, what it takes to release it and to present a detailed account of the method used in our center for 20-some years.

Nineteen consecutive patients with a mean age of three years (9 months-14 years) were enrolled, the indications and procedure remaining unchanged to our previously published method. As the surgery proceeded, an assistant to the senior surgeon used a goniometer and a ruler to measure the progress in outward rotation of the shoulder in adducted and abducted position as well as the lengthening in the subscapularis (SS) tendon and the passive excursion of the SS tendon.

Excision of the enlarged part of the coracoid process, division of the coracohumeral ligament and division of the cranial half of the SS tendon had a marginal effect on the contracture. Adequate release was achieved only when the entire SS tendon had been divided. Additionally a limited capsulotomy was required only in cases where the humeral head was relocated.
5.2 Shoulder and Elbow Function following the Sup-ER Protocol in Children with Birth Related Brachial Plexus Injuries: A Pilot Study

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Background: Consensus regarding the optimal management of birth-related brachial plexus injuries (BRBPI) has not been achieved with various treatments including physiotherapy, occupational therapy, and surgery. Our group developed a protocol that repositions the shoulder into supination and external rotation (Sup-ER), which helps restore supination and external rotation by two years of age. However, the longer-term outcomes of internal and external rotation have not been reported.

Methods: This cross-sectional cohort study examined 16 children older than 4 years of age with severe BRBPI who were treated with the Sup-ER splint. Shoulder and elbow function were measured by the ABC loops and a modified Mallet scale. Additionally, the passive and active range of motion of internal rotation, external rotation, supination, pronation, elbow flexion and elbow extension, as well as internal and external rotation strength were examined.

Results: All active movements were statistically significantly lower in the affected arm compared to the unaffected arm, except for elbow flexion. Passively, there were no statistically significant differences between the affected and unaffected arms in internal rotation and supination. Strength in internal and external rotation was weaker in the affected arm, with internal rotation having a relatively larger strength deficit.

Conclusions: Despite differences in anatomic ranges of motion between the affected and unaffected arms, the ranges were within functional limits. The relative weakness in internal rotation is less than what is described in the literature.
5.3 A new surgical technique for internal shoulder contractures secondary to obstetric brachial plexus injury: an anterior coracohumeral ligament release

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Background: Obstetric brachial plexus injuries (OBPI) result from traction injury during delivery, 30% of these children sustain persisting functional limitations related to an external rotation deficit of the shoulder. The aim of this study was to compare the intraoperative gain in external rotation after a posterior subscapular release and an anterior coracohumeral ligament release.

Methods: A prospective study on 102 children with an internal rotation contracture of the shoulder who received either a posterior subscapular release (posterior skin incision along the medial border of the scapula of 3-5cm) or an anterior (5mm skin incision) coracohumeral ligament release between 1996 and 2010. After general anesthesia, abduction and external rotation, in adduction and abduction, were measured before and after the surgical release.

Results: After a posterior subscapular release, the Intraoperative external rotation in adduction improved with a mean of 64 degrees (95%CI: 54 – 74, 0.001) and with 41 degrees (95%CI: 32-49, 0.001) in abduction. After an anterior coracohumeral ligament release, external rotation in adduction increased with a mean of 61 degrees (95%CI: 56 – 66, 0.001) and increased 42 degrees in abduction (95%CI: 39-45, 0.001). Differences between these two groups were not statistically different.

Conclusion: The anterior release technique shows comparable results as the posterior subscapular release. And since it is performed through a smaller incision of 5mm, this is our preferred method to increase passive external rotation.
5.4 Minimally Invasive Subscapularis Release: A Novel Technique and Results

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Introduction: Subscapularis is considered as the prime element of internal rotation contracture in patients with residual Brachial Plexus Birth Palsy. We describe here a novel minimally invasive technique of Subscapularis release & its results.

Material & Methods: Between 2013 to 2016, Forty-five patients underwent Subscapularis Slide through a centimetre incision along the medial border of scapula. Procedure was termed as "Minimally Invasive Subscapularis Release"( MISR). A concomitant conjoined Latissimus Dorsi and Teres Major transfer was performed. Thirty-three patients (average age - 5.6 years) with minimum follow up of one year were included in this study. Axial imaging to assess Glenohumeral deformity were available for twenty patients. Average clinical follow up of patients was 3 years.

Results: Mean improvement in passive external rotation was 64° and in active external rotation was 53° (p 0.001) at 3 months, which was maintained at final follow up. Average shoulder abduction improved from pre-operative 101° to post-operative 142°. Aggregate five-point Mallet Score improved from 13 points (range, 11-16) preoperatively to 18.8 points (range, 17-22) post operatively. No patient developed external rotation contracture. The results were comparable to other existing techniques. Safety zones to avoid injury to important neurovascular structures while performing MISR were determined through cadaveric dissection.
5.5 Management of shoulder internal rotation limitation in obstetrical palsy

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Muscle imbalance in a growing child can lead to bone and joint deformities. Obstetric palsy patients with incomplete recovery have glenohumeral joint problems because of imbalance between shoulder adductor and internal rotator (IR) muscles; abductor external rotator(ER) muscles.

Since to improve shoulder abduction and ER, tendon transfers are commonly used, postoperative transient loss in internal rotation is expected. But some patients could not get preoperative IR functions, long after the operations. Also there are some nonoperated patients whose main problem is internal rotation limitations. We operated on these two group of patients to achieve better internal rotation function.

Fourteen patients had operation to improve shoulder ER and Abduction but 15 patients did not have neither nerve nor palliative any operation before and had IR limitations preoperatively. During operation, posterior incision above spine of the scapula was performed, supraspinatus, infraspinatus and teres minor muscles, and acromion bone were encountered. We did not cast or use orthosis for the patients postoperatively. At 3rd day postoperative rehabilitation program active range of motion exercises were initiated. Average age of the children was 6,3 years and The average follow-up period was 21 months. The preoperative values in terms of IR were 2º and postoperatively 20º. Degree of abduction was mean 136 before the surgery. After surgery, it decreased to 105º but with therapy it caught up preoperative values and all children improved shoulder IR function. We operated on patients with limited shoulder IR, and achieved better hand to midline and back functions.
5.6 Shoulder release and tendon transfer for neonatal brachial plexus palsy: gains, losses, and midline function

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Persistent deficits of external rotation are often treated by shoulder release and tendon transfer. Gains in external rotation have previously been emphasized whereas losses of internal rotation are poorly documented. Given that inability to reach midline has functional consequences the losses associated with surgery need to be better understood. The purpose of this study was to assess changes in movement, function, and self-reported outcome after surgery.

Methods: Retrospective review of prospectively collected measures for 30 consecutive patients was conducted. Mean follow-up was 48 months. Significant changes were assessed by t-test and Wilcoxon rank sum (0.05).

Results: Active motion increased for external rotation (AMS 1.5 to 2.9 and AROM 2 to 38) and abduction increased (AMS 5.5 to 6.2 and AROM 105 to 140); while internal rotation decreased (AMS 7.0 to 5.7 and AROM 73 to 67). The total arc of motion was unchanged. While there were increases in all other domains of the Mallet scale, there was no change in hand-to-spine and there was a decrease in hand-to-belly (3.8 to 3.1). There were improvements in Brachial Plexus Outcome Measure (BPOM) task-based domains and in self-reported outcomes of appearance and function (18.3 to 23.0) Inability to reach midline occurred in 3 patients with more severe palsies (type 2 or worse). No specific predictors could be identified.

Conclusions: Increases in external rotation were accompanied by losses of internal rotation with inability to reach midline occurring in 10%. Despite the losses there were overall improvements in function based upon Mallet and BPOM scores.
5.7 Tendon and muscle anomalies around shoulder

A. Aydin, Turkey
Istanbul medical faculty, Istanbul, Turkey

Our algorithm concerning shoulder external rotation (ER) limitation in a obstetric palsy patient, under 1 year of age, comprises MRI study of the shoulder, and clinical testing. If the glenohumeral joint is subtle and limitation is less than 30 degrees we perform botulinium injestion to subscapularis, latissimus dorsi and pectoralis major muscles. If the we observe posterior subluxation, glenoid displasia and ER limitation is advaced, we perform anterior and posterior release.

During surgery of the children of whom we perform posterior release or tendon transfer; we observe muscle/tendon anomalies and variations occasionally. Tendon anomalies were mostly originate from conjoint tendon and heading to humerus looking like thickenned facial bands. These anomalies are far common than muscle anomalies and we came across one third of surgical cases. But they definately limits shoulder abduction and cannot be addressed by botulinium toxin injection.

The muscle anomalies can be aberrant muscle from latissimus dorsi to pectoralis major and this muscle also prevents passive full range shoulder abduction. We observed 8 cases out of hundreds of operations.

Literature mentions about muscle variations around shoulder like axillopectoral muscle, axillary arch muscle etc and brachial plexus surgeons but be aware of these extra anatomic structures which can be the cause of botulinium injection or tendon transfer failure.
5.8 25-Year Experience with the Subscapularis Slide for Correction of Internal Rotation Contracture in Brachial Plexus Birth Palsy

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The subscapularis slide involves the release of the subscapularis muscle off of its scapular origin while avoiding the need for additional anterior releases. We report on our 25 year experience with this technique. 104 patients (57 female, 47 male) underwent the subscapularis slide procedures for internal rotation contracture in neonatal brachial plexus palsy over a 25-year period from 1992 to 2017. This was performed in association with other procedures including microsurgical brachial plexus reconstruction, tendon transfers for external rotation, botulinum toxin injections, and or humeral osteotomies. Patients were followed up for an average of 5.1 years post operatively. Mean age at operation was 3.8 years. Records were assessed for final range of motion and need for any additional procedures.

At initial presentation, patients had an average of 101 degrees of forward elevation (range 30-170) and 13 degrees of external rotation (range 20-90). 20 patients (19%) had prior brachial plexus reconstruction, 23 patients (22%) had concurrent brachial plexus reconstruction, and 61 (59%) did not have any brachial plexus surgery. Intraoperatively, full passive range of motion as compared to the contralateral shoulder was achieved in all cases. At final follow up, average external rotation was 43 degrees (range 0-85) and forward elevation was 133 degrees (range 45-180). The subscapularis slide technique can be effectively used in the management of internal rotation contracture after brachial plexus birth injury. A functional range of forward elevation and external rotation can be reasonably achieved in these patients with the use of this technique.
5.9 Gleno humeral inferior release combined with latissimus dorsi transfer to restore shoulder abduction on brachial plexus obstetrical palsy

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At the end of the recovery period in obstetric palsy of the brachial plexus, the shoulder abduction deficit remains frequent. A stiffness of abduction at the glenohumeral joint by retraction of the axillary elements is associated in the majority of cases. I achieved for 3 years in 47 cases an inferior release of the gleno humeral joint associated with a transfer latissimus dorsi muscle. The lower release has the following steps: - Axillary Approach and section of fibrous bands between triceps and latissimus dorsi muscles - Dissection of the latissimus dorsi muscle which is separated from the teres major and its severed tendon at its humeral insertion - Section of teres major muscle - Section of the insertion of the long portion of the triceps - Opening of the inferior capsule - axillary Z-plasty perform a transfer of latissimus muscle on the posterior side of humeral head the shoulder is immobilized with thoracic and shoulder brachial splints in maximum abduction position for 15 days. Physiotherapy is started immediately after removal of the immobilization with repeated movements several times a day at home and at the physiotherapist for results, important improvement of abduction is obtained in 31 cases and abduction didn’t change in 7 cases will show videos of pre and post operative status of patients and a review of literature.
Obstetrical brachial plexus injuries, a long-term prospective study on the outcome of external rotation plasties of the shoulder

Leiden University Medical Center, Leiden, Netherlands

Background: Obstetric brachial plexus injuries (OBPI) result from traction injury during delivery, 30% of these children sustain persisting functional limitations related to an external rotation deficit of the shoulder. Our aim was to evaluate different soft tissue procedures to improve external rotation during 5-year follow-up.

Methods: 105 children with an internal rotation contracture of the shoulder received either I) an internal contracture release or II) an internal contracture release in combination with a tendon transfer for active external rotation. Prospective functional assessment of the shoulder was performed preoperatively and postoperatively at 6 weeks, 3 months and annually thereafter.

Results: The internal contracture release showed an improvement in passive external rotation in adduction and abduction of 29 degrees and of 17 degrees at one year follow-up and of 25 degrees and 15 degrees at five years.

The internal rotation contracture release combined with an active tendon transfer showed an improvement, compared to the preoperative state: active external rotation in adduction and abduction were: 75 degrees and 50 degrees at one year follow-up; 65 degrees and 40 degrees at five years.

Conclusion: Young children with OBPI without spontaneous functional recovery of the shoulder benefit from soft tissue procedures according to the presented strategy. The policy of only a passive correction of the internal rotation contracture release resulted in improved active external rotation in 54% of the youngest age group. In the older age group, improvement of both active and passive range of motion were clinically relevant and sustained during 5-year follow-up.
5.11 Twenty-year experience of arthroscopic subscapularis release for internal rotation contractures secondary to neonatal brachial plexus injury: clinical and radiographic outcomes

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Intro:
The internal rotation contracture (IRC) secondary to neonatal BPI is common and alters glenohumeral development in most cases. A variety of treatment options have been reported on with clinical success. It remains unclear which surgical approach optimally improves function and glenohumeral development. This report reviews a 20 year experience of arthroscopic contracture release looking to identify factors associated with good/excellent results and differentiate them from those that seemingly exchanged one problem for another or even made patients worse.

Methods:
Twenty-five children for whom pre-operative and long term clinical and MRI follow up were available before and after arthroscopic subscapularis release were retrospectively reviewed. Conventional measures of range of motion and glenohumeral anatomy on imaging were analyzed. Surgical release of the tendinous portion of the subscapularis, the anterior joint capsule and rotator interval tissue inclusive of the coracohumeral ligament was performed on all children, with or without transfer of the latissimus dorsi tendon to the posterior greater tuberosity (9/25).
The mean age at surgery was 3.7 years old, range 0.7 to 8.3 years old. Passive external rotation (ER) with the arm adducted by the side measured under general anesthesia (intra-op) was -30°. All children had near full passive elevation (mean 135°) under anesthesia. Active elevation pre-operatively averaged 110° (range 40° to 150°). Pre-operatively, 21 children had pseudoglenoids of varying severity and four had Posterior/Concentric glenohumeral joints on MRI.

Results:
All children showed gains to near normal range in active and passive ER, both with the arm at the side and in an elevated position. All children showed reduced range of internal rotation (IR) after release that was functionally well compensated in 15 cases, challenged midline function in 10 cases, and led to an internal rotational osteotomy of the humerus in one case. Active elevation was not changed from pre-op except in one child who lost 30° elevation after combined arthroscopic release and latissimus transfer at age 4.6 yo for a -60° internal rotation contracture and severe pseudoglenoid. For children with the longest follow up (> 5 years), range of motion changed considerably over time resulting in decreased ER, improved IR and usually reduced elevation.

Follow up MRI or CT (two cases) was done at an average of 3.3 years post index surgery.
Glenohumeral alignment (PHHA) normalized in all but one shoulder that was essentially unchanged.
Glenohumeral morphology also improved in all but that one child, resulting in rounder humeral heads articulating with glenoids of improved concavity. Glenohumeral contact patterns and orientation essentially reversed from pre-op, repositioning the humeral articular surface so that its posterior aspect, rather than anterior aspect, articulated with the glenoid. This re-orientation of the
humeral head normalized half (13) of the glenohumeral joints. In the other 12 children, the reoriented position of the humerus was in maximal external rotation. This was functionally well compensated in most but resulted in functionally disabling external rotation contractures in a few, the majority of whom were operated after age three years old.

Conclusion:

This review found that most children with IRC from birth palsy were improved by arthroscopic release. Clinical outcomes were excellent in some, clearly improved in others but with an apparent exchange of ER range and function for IR range. This exchange of ER for IR occurs at, and can be visualized, at the glenohumeral joint. External rotation consistently improves from arthroscopic release, as does the appearance of glenohumeral anatomy. Together these improvements will score highly on conventional clinical and radiographic measures – Mallet score, PHHA, etc. Active elevation was not appreciably altered from preop, although improved ER led to a marked improvement of the child’s ability to reach overhead.

No clear factors were identified in this cohort to predict which patients would have the best outcome. Younger age at the time of surgery was beneficial. In order to advance our understanding and treat patients more effectively continued efforts are necessary to better differentiate patterns of injury and sequela that may represent different patient populations better treated by different methods.
5.12 Short and Long Term Outcomes after Treatment of Shoulder Subluxation in Birth Brachial Plexus Palsy

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Background: Methods vary for timing of evaluation shoulder subluxation, modality used for detection and type of intervention. The purpose of this study is to describe the incidence and clinical outcomes after early detection and intervention for shoulder subluxation.

Methods: Retrospective chart review with 64 patients included. Patients divided into three groups based on alpha angles from shoulder ultrasound: normal, abnormal + no intervention, and abnormal + intervention. Intervention group received onabotulinum toxin A +/- casting. Outcome measures included passive range of motion external rotation (PROM-ER), Active Movement Scale (AMS), alpha angle, Waters score on MRI, and need for tendon transfer.

Results: Initial ultrasound performed at mean 16.6 weeks of age. Shoulder subluxation found in 89%. Mean alpha angle for normal group was 24.5°, abnormal + no intervention was 40.2° and abnormal + intervention was 56.4°. Only abnormal PROM-ER predicted abnormal alpha angle. Eighty-seven percent of abnormal + intervention group had normal alpha angle after intervention (mean alpha angle 25.8°). Fifty percent of normal group, none of abnormal + no intervention group, and 32% of abnormal + intervention group required tendon transfer. Pre-operative MRIs were compared and 50% of normal group compared to 54% abnormal + intervention group had Waters score = 3.

Conclusions: Shoulder subluxation occurs in the majority of patients by 4 months of age and in the absence of clinical signs. This is adequately treated with botulinum toxin and casting, but this does not appear to have an effect on the long term development of the glenohumeral joint.