
ORIGINAL ARTICLE

Arthroscopic release of shoulder contracture secondary to obstetric brachial plexus palsy: Retrospective study of 18 children with an average follow-up of 4.5 years

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KEYWORDS
Arthroscopic release; Shoulder; Obstetric brachial plexus palsy; Child

Summary
Introduction: Children affected by obstetric brachial plexus palsy have an internal rotation contracture of the shoulder and a deformed glenohumeral joint. In 2003, Pearl proposed doing an arthroscopic release of the shoulder to restore external rotation and allow the glenohumeral joint to remodel. The goal of the current study was to evaluate the active and passive shoulder external rotation range of motion and glenohumeral joint remodelling in children treated with arthroscopic-directed release.

Materials and methods: Between 2004 and 2010, 18 children with passive external rotation under 10° were treated with shoulder arthroscopy to release the anterior capsule and ligaments and perform a subscapularis tenotomy; no tendon transfer was performed. The average age was 4 years, 2 months. Nine children had an injury at C5C6, four had an injury at C5C6C7 and five had a complete injury. The average follow-up was 4.5 years. The clinical evaluation consisted of active and passive external rotation (ER) with elbow at the side, active internal rotation, and the modified Mallet score. One child who required an external rotation osteotomy of the proximal humerus was excluded from the clinical outcomes. An MRI was performed on both shoulders to assess glenoid retroversion, glenoid type, degree of posterior subluxation (measured by the percentage of humeral head anterior to the middle glenoid fossa) and humeral head hypoplasia.

Results: At the latest follow-up, passive ER was 58° on average and active ER was 42°. Eleven children had regained more than 30° of active ER. The average internal rotation had decreased
after the release. The MRI assessment showed that the glenohumeral joint had remodelled in 66% of cases; the glenoid type had improved, the glenoid retroversion had diminished and the humeral head was centred. Humeral head hypoplasia was found in 28% of cases.

Discussion and conclusion: Arthroscopic release of the shoulder results in more external rotation and allows for glenohumeral joint remodelling. Tendon transfer is not always necessary to restore active external rotation.

Level of evidence: Level IV — Retrospective study.

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Introduction

Obstetric brachial plexus palsy occurs in France at a rate of about 1000 cases per year [1]. Loss of external rotation at the shoulder is the most common sequela. Imaging reveals glenoid dysplasia with humeral head hypoplasia and posterior subluxation, along with glenoid retroversion. This glenohumeral joint deformation is already apparent at 6 months of age [1,2]. To restore active and/ or passive external rotation and encourage glenohumeral joint remodelling, procedures to lengthen the subscapularis and release the anterior capsule and ligament have been proposed, with or without teres major and latissimus dorsi tendon transfer [3–7]. Pearl [8] first suggested doing the release by arthroscopy.

The goal of the current study was to provide a clinical and radiological (MRI) evaluation of the outcome of arthroscopic shoulder release for the sequela of obstetric brachial plexus palsy with an average follow-up of 4.5 years. Shoulder external rotation and glenohumeral joint remodelling were of specific interest.

Materials and methods

Patients

This was a retrospective study. Between 2004 and 2010, eighteen children (five boys, 13 girls) presenting with passive external rotation (ER) with elbow at side of less than 10°, secondary to obstetric brachial plexus palsy, were treated by arthroscopy with anterior capsule and ligament release and subscapularis tenotomy, without tendon transfer. One child had a subscapularis detachment as described by Carlloz et Brahimi [9] and then two arthroscopic release procedures. The average age at the time of release was 4 years, 2 months (range 1 year to 11 years). Nine children had an injury at C5C6, four had an injury at C5C6C7 and five had a complete injury. All the children had biceps function that allowed for active elbow flexion. In one case, an external rotation osteotomy of the proximal humerus was performed 2 years after the arthroscopic release; this patient was excluded from the clinical results.

Surgical technique

Under general anaesthesia, the child was placed in lateral decubitus. A posterior incision was made first. The glenohumeral cavity was visualized with a 2.7 mm arthroscope.

An anterior instrument portal was made and the arthroscopy pump attached to the cannula. The surgical assistant held the upper limb in neutral rotation, neutral antepulsion and 20° abduction.

A bipolar diathermy unit (VAPR®, DePuy Mitek, Raynham, MA, USA) was used to release the anterior capsule, cut the middle glenohumeral ligament and cut the intra-articular portion of the subscapularis until muscle fibres were visible. If the intraoperative passive external rotation was less than 45° after the anterior capsule and middle glenohumeral ligament were cut, the release was extended either upwards (by cutting the superior glenohumeral ligament, rotator interval and coracohumeral ligament) or downwards (by cutting the inferior glenohumeral ligament). A shoulder spica cast was put into place before the child awoke and used for 6 weeks. The shoulder was positioned in maximum external rotation and a few degrees of abduction.

Clinical evaluation

The preoperative clinical evaluation was based on medical records. The passive external rotation and internal rotation (IR) values were recorded. Because of the age of the children before the surgery, active external rotation was not available. The patients were seen again after an average of 4.5 years (range 1 to 7 years). The active and passive external rotation and internal rotation were evaluated with the Mallet score [1] and modified Mallet [10] functional score.

Imaging

Sixteen children had received a preoperative MRI: 15 bilateral and one unilateral. An MRI was performed on both shoulders of the 18 included patients at the follow-up. The same protocol was used and the same radiologist did the interpretation. Transverse cross-sectional cuts were made through the major axis of the glenoid on respiration-triggered T2-weighted fast spin echo (FSE) sequence and/or T2*-weighted gradient recalled echo (GRE), two-dimensional spoiled gradient echo (SPGR).

The following radiological criteria were analysed:

• Glenoid type [11] (Fig. 1):
  • centred concentric: humeral head curvature is centred over the glenoid cavity,
  • posterior concentric: glenoid trends towards increased retroversion; humeral head is centred over glenoid, but asymmetric; glenoid surface is irregular,
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• Concentric (centered)
• Flat
• Biconcave
• Concentric (posterior)

Figure 1 Diagram showing the various glenoid types.

- flat: near complete loss of the glenoid curvature,
- biconcave: central ridge dividing the glenoid in anterior and posterior facets, with the latter having the same version relative to the scapula,
- minimal pseudoglenoid: central ridge dividing the glenoid in anterior and posterior facets but retroversion of glenoid posterior facet is increased relative to scapular axis, with an angle less than 30°,
- moderate pseudoglenoid: retroversion of posterior glenoid facet between 30° and 60°,
- severe pseudoglenoid: retroversion of posterior glenoid facet greater than 60°;
- retroversion [4] of both sides of the glenoid: angle formed between the scapular axis (line passing from the medial edge of the scapula, to the body and middle of the glenoid) and the glenoid axis. When the labrum was visible, the glenoid axis passed through the anterior and posterior edges of the labrum. If the labrum was not visible, the glenoid axis corresponded to a tangent line to the articular surface of the glenoid. In cases of joint dysplasia (biconcave or pseudoglenoid), the scapular axis passed through the ridge dividing the anterior and posterior facets; the glenoid axis corresponded to the line passing through the dividing ridge and posterior edge of the glenoid. Once these two lines were drawn, the posteromedial angle was measured and 90° subtracted from the measurement. If this angle was negative, the glenoid was considered retroverted; if it was the positive the glenoid was anteverted (Fig. 2);
- PHHA (percentage of humeral head anterior) to middle of glenoid fossa [4]: the scapular axis was drawn in the same way as for the determination of retroversion, then a line perpendicular to this axis was drawn that passed through the largest diameter of the humeral head. The PHHA corresponded to the ratio between the length of the humeral head in front on this perpendicular line and the diameter of the humeral head. If the PHHA was 50%, the head was centred; if it was between 25% and 50% posterior subluxation was minimal; if it was between 0 and 25%, the subluxation was moderate; if it was less than 0% the head was completely dislocated (Fig. 3);
- humeral head hypoplasia measured as the ratio of the largest diameter of the diseased humeral head to the largest diameter of the healthy humeral head. Hypoplasia was present when this ratio was less than 0.9.

Because of the small sample size, only descriptive statistics (averages) were calculated.

Figure 2 Left retroversion: 64°–90° equal to −26°; Right retroversion: 85°–90° equal to −5°.

Figure 3 Left percentage of humeral head anterior to middle of glenoid fossa (PHHA): 0.3 equal to 30%.

Table 1  Passive external rotation before and during surgery, and passive and active external rotation at the last follow-up.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Preoperative Passive ER</th>
<th>Intraoperative Passive ER</th>
<th>Passive ER at follow-up</th>
<th>Active ER at follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excluded</td>
<td>Excluded</td>
<td>Excluded</td>
<td>Excluded</td>
</tr>
<tr>
<td>2</td>
<td>-20</td>
<td>45</td>
<td>85</td>
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<td>18</td>
<td>0</td>
<td>80</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Average</td>
<td>-1°</td>
<td>51°</td>
<td>58°</td>
<td>42°</td>
</tr>
</tbody>
</table>

ER: external rotation with elbow at side, in degrees.

Table 2  Average external rotation with elbow at side as function of age.

<table>
<thead>
<tr>
<th>Children</th>
<th>Preoperative Passive ER</th>
<th>Intraoperative Passive ER</th>
<th>Passive ER at follow-up</th>
<th>Active ER at follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4 years</td>
<td>-3°</td>
<td>54°</td>
<td>64°</td>
<td>47°</td>
</tr>
<tr>
<td>≥4 years</td>
<td>1°</td>
<td>48°</td>
<td>50°</td>
<td>36°</td>
</tr>
</tbody>
</table>

ER: external rotation with elbow at side, in degrees

Results

One child who required an external rotation osteotomy of the proximal humerus was excluded from the clinical results.

The average passive ER was -1° (range -20° to 10°) before the surgery; 51° (range 30° to 80°) during the procedure, and 58° (range 5° to 90°) at the last follow-up. At the last follow-up, passive ER was stable in two of the cases; it was less in six cases and greater in nine cases. There were two average results (passive ER between 0 and 30°), six good results (passive ER between 30° and 60°), and nine excellent results (passive ER > 60°). At the last follow-up, the average passive ER was 64° in the subgroup less than 4 years of age and 50° in the subgroup above 4 years of age. The average active ER was 42° (range -10° to 90°) with six average, four good and seven excellent results. Eleven children (65% of cases) had active external rotation equal to or greater than 30° with the release only, since no primary or secondary tendon transfer was performed (Tables 1–3; Fig. 4).

Internal rotation using the Mallet score was 3.2 out of 5 before the surgery and 2.1 out of 5 at the last follow-up, on average. The modified Mallet functional score at the last follow-up was 16 out of 25 on average (range 5 to 25).

The number of concentric glenoids (centred or retroverted) increased from 37% before the surgery to 61% at the last follow-up. Before the surgery, two patients presented with posterior dislocation of the humeral head associated with a severe pseudoglenoid type glenoid. At the last follow-up, these shoulders were still dislocated.

On the preoperative MRI, the average glenoid retroversion in the diseased shoulder was $-27°$ (range $-56°$ to $-9°$) and $-6°$ (range $-14°$ to $+1°$) in the healthy shoulder. At the last follow-up, the retroversion was $-18°$ (range $-71°$ to $-2°$) on the injured side and $-3°$ (range $-8°$ to $+4°$) on the healthy side.

The average PHHA was 31% before the surgery and 41% at the last follow-up (Fig. 5). In 54% of cases, humeral head hypoplasia was present before the surgery; at the last follow-up, 24% of cases showed hypoplasia (Table 4).

Table 3  Average passive external rotation with elbow at side before the surgery and at the last follow-up as a function of glenoid type: concentric (centred or retroverted) or non-concentric (flat, biconcave, pseudoglenoid).

<table>
<thead>
<tr>
<th>Glenoid type</th>
<th>Preoperative Passive ER</th>
<th>Passive ER at follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentric</td>
<td>-3°</td>
<td>64°</td>
</tr>
<tr>
<td>Non-concentric</td>
<td>-1°</td>
<td>48°</td>
</tr>
</tbody>
</table>

ER: external rotation with elbow at side, in degrees

posterior, infraspinatus, teres minor) that are paralysed [7,12,13]. When passive external rotation is greatly reduced (near 0°), surgery is proposed to release the external rotation and allow the glenohumeral joint to remodel [1,3,4,7,8,13]. This muscle imbalance leads to glenoid dysplasia, which is characterised by posterior subluxation of the humeral head (often dysplastic) due to a retroverted glenoid [12].

MRI was deemed the best modality to evaluate glenohumeral dysplasia since the cartilage structures of the shoulder can be evaluated [14].

There are significant differences in glenoid retroversion between the healthy and injured shoulder in children with brachial plexus paralysis [12,15]. Breisher et al. [12] reported that the injured side had an average of −29.5° of retroversion and the healthy side had −6.9°. Kozin [16] reported −24° for the injured side and −8° for the healthy side. The preoperative data in the current study (average retroversion of injured side equal to −27°, healthy side equal to −6°) were consistent with these values. Mintzer et al. [17] evaluated glenoid retroversion in 111 children free of any injury. The glenoid had a physiological retroversion, which was maximal at 2 years of age. After 2 years of age, this retroversion decreased and settled into its adult value towards the end of the first decade of life.

The PHHA measurement revealed posterior subluxation of the humeral head. Kozin [16] reported that the average PHHA for sequel of obstetric brachial plexus palsy was 28 ± 13.8%. In the current study, the average preoperative PHHA was 31%.

The glenoid shape improved in 11 cases and did not change in five cases. The most significant remodelling occurred in cases with moderate pseudoglenoid type glenoids. No remodelling was observed in the most deformed glenoids (severe pseudoglenoid type). In our opinion, this presentation is a contraindication to arthroscopic release since it is accompanied by posterior dislocation. Pearl found that 12 of 15 glenoids had remodelled after 2 years, based on preoperative and postoperative imaging [5]. Kozin reported that only one of the 19 patients with a pseudoglenoid type glenoid before the surgery still had the same glenoid type at 1 year of follow-up [4].

The glenoid type, amount of retroversion and posterior subluxation of the humeral head are interrelated [11,12,16]. These data are consistent with findings from the current study. At the last follow-up, the average PHHA was 35.5%, and the average retroversion was −19° for concentric glenoids (centred or retroverted). For non-concentric

### Table 4 MRI date before surgery and at the last follow-up.

<table>
<thead>
<tr>
<th></th>
<th>Preoperative MRI</th>
<th>Postoperative MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentric glenoid</td>
<td>37% of cases</td>
<td>67% of cases</td>
</tr>
<tr>
<td>Non-concentric glenoid</td>
<td>63% of cases</td>
<td>33% of cases</td>
</tr>
<tr>
<td>Retroversion (average)</td>
<td>−27°</td>
<td>−18°</td>
</tr>
<tr>
<td>PHHA (average)</td>
<td>31%</td>
<td>41%</td>
</tr>
<tr>
<td>Humeral head hypoplasia</td>
<td>54% of cases</td>
<td>28% of cases</td>
</tr>
</tbody>
</table>

PHHA: percentage of humeral head anterior to middle of glenoid fossa.

Discussion

Limited shoulder external rotation is the most common sequelae in children affected by obstetric brachial plexus palsy. This internal rotation posture is the result of imbalance between the contraction of internal rotation effector muscles (subscapularis, teres major, latissimus dorsi, pectoralis major, serratus anterior) that are more or less still active, and the external rotation muscles (serratus

Figure 4  Clinical appearance of shoulder external rotation 4 years after the procedure (sequela of left brachial plexus).

Figure 5  Sequela of left brachial plexus paralysis: a: preoperative MRI: left glenoid is the moderate pseudoglenoid type, left retroversion equal to −38°, right retroversion equal to −14°, PHHA equal to 17%; b: MRI 4 years after surgery: left glenoid is the flat type, left retroversion equal to −12°, right retroversion equal to −2°, PHHA equal to 24%.

glenoids (flat, biconcave and pseudoglenoid), the PHHA and retroversion were 27.5% and −32°, respectively. In pseudoglenoid type glenoids, the retroversion is greater and the PHHA less, which results in more posterior subluxation. The loss of external rotation and amount of glenohumeral dysplasia are correlated [11,16]. In our study, the average passive external rotation was 65° in the subgroup with concentric glenoids and only 48° in the subgroup with non-concentric glenoids. Conversely, there is no relationship between external rotation and humeral head hypoplasia [16].

Many surgical procedures have been described in the published literature to restore external shoulder rotation in these children and allow the glenohumeral joint to remodel during growth. Cohen et al. detached the subscapularis from the anterior aspect of the scapula with or without teres major and latissimus dorsi tendon transfer [3]. The external rotation went from −10° before the surgery to 52° 1 year later. Hui and Torode performed an open reduction and lengthened the tendons of the internal rotation effector muscles [15]. Waters and Bae proposed a decision tree based on the severity of the dysplasia [7]:

- minor dysplasia: latissimus dorsi and teres major transfer onto the rotator cuff with subscapularis and pectoralis major lengthening;
- moderate dysplasia: latissimus dorsi and teres major transfer onto the rotator cuff with subscapularis and pectoralis major lengthening, along with open reduction ± capsulorrhaphy;
- severe dysplasia: external rotation osteotomy of the proximal humerus.

Pearl [8] proposed a new arthroscopy technique consisting of subscapularis tenotomy and anterior capsule and ligament release. In children older than 4 years, the latissimus dorsi was also transferred. As with open techniques, the technique improves external rotation and glenohumeral joint remodelling [5–8]. Abid et al. preferred to perform an arthroscopic release of the anterior capsule and ligaments but not touch the subscapularis, to reduce the risk of anterior instability [1]. However, a latissimus dorsi tendon transfer was performed systematically.

Our technique differs from the ones described previously because we performed an anterior capsule and ligament release with tenotomy of the intra-articular portion of the subscapularis, without tendon transfer. Passive external rotation (ER > 30°) improved in 15 cases and active ER improved in 11 cases (65% of patients) even though no tendon transfer was performed. By releasing the internal rotation contracture, the external rotation muscles regain their tone, which eventually allows for active external rotation. The average gain was 59° after 5 years of follow-up. Abid reported 76.5° after 3 years [1]. Pearl reported an average passive external rotation of 67° after 2 years in the patient group treated with release only; the best results occurred in the concentric glenoid (centred or retroverted) subgroup [5]. The group treated with release and latissimus dorsi transfer had the best passive external rotation, 81°. Kozin reported that passive external rotation went from −26° before the surgery to 47° 1 year later [4]. In the current study, the average passive external rotation was 58° after nearly 5 years follow-up; Cohen et al. reported only 35° [3].

There is no consensus as to the need for tendon transfer. Pearl [8] reported doing it systematically in children above 4 years of age. Abid et al. [1] always did it, no matter the age of the child. Pedowitz et al. [6] and Kozin [4] take age, amount of deformation, nerve regeneration capacity and family context into account before deciding on the transfer. Cohen et al. [3] transfer the teres major and latissimus dorsi tendons when there is no active external rotation. Cohen’s results were better when a transfer was also performed; Pearl [5] also found no recurrence of the internal rotation contracture after latissimus dorsi transfer. In the current study, a tendon transfer was not performed with the release and the active external rotation was greater than 30° in 65% of cases, thus a useless tendon transfer was avoided in nearly two third of cases. We prefer to perform a tendon transfer in children with an active external rotation deficit when the passive external rotation is nearly normal.

As reported by Kozin [4], internal rotation was reduced following the procedure. Pearl found no such reduction when the teres major and latissimus dorsi were simultaneously transferred [5]. Abid et al. [1] found no reduction in internal rotation. This is probably due to the release only being performed on the capsule and ligaments, whereas the subscapularis is not incised. However, this loss in internal rotation must be considered in view of the increased function that resulted from restoring the external rotation.

One of the challenges with this type of injury is determining when to perform the surgery. Many studies have shown that glenohumeral deformation occurs at an early age, worsens with age and is correlated to the internal rotation position of the shoulder [14–18]. Thus, these children should be operated early on when the deformation is still moderate and the potential still exists for growth-driven joint remodelling. Most published reports are consistent in saying that external rotation less than 10° requires a surgical intervention [1–11]. Age is also taken into consideration by some surgeons. Better results can be expected in younger children [3,4]. But this finding was not confirmed in the current study. The two oldest children (8 and 11 years) had good clinical results (active ER of 20° and 70°, passive ER of 45° and 75°), in contrast with the two cases with poor clinical and radiological results that were operated on at 4 and 5 years of age, respectively. These patients had significant dysplasia with a severe pseudoglenoid type glenoid and complete posterior dislocation. Currently, they have no active external rotation and the passive external rotation is 5°; there has been no remodelling of the glenohumeral joint.

Botulinum toxin injection is a new treatment alternative. Although this would have no effect on capsular and ligament joint structures, it could be used in combination with a surgical procedure to maximize the effectiveness of the procedure, such as arthroscopic release [19].

**Conclusion**

Arthroscopic release without tendon transfer for the sequelae of obstetric brachial plexus palsy restored the active and passive external rotation the shoulder and was associated
with glenohumeral remodelling. The current study confirmed that the improvement in external rotation was maintained after nearly 5 years of follow-up.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References