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# Isolated open anterior shoulder release in brachial plexus birth palsy

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**Background:** In children with brachial plexus birth palsy (BPBP), a shoulder joint internal contracture is commonly observed, which may result in glenohumeral osseous deformities and posterior joint subluxation. The purpose of this retrospective study was to evaluate the impact of an isolated anterior shoulder release on osteoarticular disorders and assess the subsequent clinical improvements.
**Methods:** Forty consecutive BPBP patients with glenohumeral dysplasia underwent an open anterior shoulder release. Shoulder scans (ie, magnetic resonance imaging preoperatively and computed tomography postoperatively) were conducted to assess glenoid version and the percentage of the humeral head anterior to the middle of the glenoid fossa. Clinical data including analytical shoulder range of motion and modified Mallet scores were collected.
**Results:** After a mean follow-up period of 23 months, glenoid version and the percentage of the humeral head anterior to the middle of the glenoid fossa significantly improved from –32° and 18%, respectively, to mean postoperative values of –12° ($P < .001$) and 45% ($P < .001$), respectively. Passive and active external rotation increased from –2° and –43°, respectively, to 76° ($P < .001$) and 54° ($P < .001$), respectively. The mean modified Mallet score significantly improved from 14.2 to 21.4 points ($P < .001$). In 8 children with satisfactory passive motion, a latissimus dorsi transfer was performed secondarily to obtain satisfactory active motion.
**Conclusion:** In BPBP patients with glenohumeral deformities, isolated open anterior release of the shoulder induces significant remodeling of the joint, reducing posterior joint subluxation and improving both passive and active shoulder ranges of motion. Additional latissimus transfer remains mandatory in selected cases to achieve satisfactory function.
**Level of evidence:** Level IV; Case Series; Treatment Study


**Keywords:** Birth palsy; brachial plexus; glenohumeral dislocation; obstetrical palsy; shoulder release; subscapularis tenotomy

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Because of variance in clinical care and in perinatal risk factors, the incidence of brachial plexus birth palsy (BPBP) is estimated to range between 0.4 and 4 per 1000 live births.[10] Recent studies have shown that 44% of affected children recovered incompletely, including 10% to 15% with considerable upper-limb muscle weakness.[9,11,24] In children with partial recovery, denervation muscular atrophy will occur, leading to active motion limitation.

As a consequence of the large predominance of upper root involvement (ie, C5-C6 and C5-C7 palsies), muscle imbalance of the shoulder will develop in most children, with weak abductors and external rotators but relatively intact adductors and internal rotators.[16,18,21,33] Untreated, this loss of glenohumeral axial balance may result in an anterior contracture of the joint, limiting passive shoulder external rotation and abduction.[18] Subsequently, owing to permanent hyper-pressure of the humeral head onto the posterior aspect of the glenoid surface, dysplasia of both the humeral head and the glenoid process is commonly observed; such osseous deformities usually lead to incongruity of the glenohumeral joint, which may be subluxated or even completely dislocated posteriorly in severe cases.[20,21,33]

Several surgical techniques have been described to enhance shoulder function in such cases, including anterior capsular release (ie, open or arthroscopic), internal rotator release (ie, pectoralis major and/or subscapularis tenotomy, lengthening, or slide), external rotator reinforcement (ie, latissimus and teres major tendon transfers to the infraspinatus), and humeral or glenoid osteotomies.[18] Depending on the age of the patient and the severity of the muscular imbalance, the resulting joint contracture, and the subsequent glenohumeral deformity, recommendations may vary between surgical teams regarding the best combination of these techniques to perform during the same operating time.[10,22,30]

The objective of this study was to assess the clinical and radiologic outcomes of patients with glenohumeral deformities due to BPBP treated with an isolated anterior release of the shoulder joint.

## Materials and methods

### Population selection and surgical indications

A retrospective chart review was conducted in a consecutive series of patients with upper BPBP (ie, C5-C6 or C5-C7 palsies) who underwent anterior release of the shoulder at our institution between December 2003 and January 2014. Patients without imaging evidence of dysplasia of the glenoid process or glenohumeral incongruity on preoperative assessment were excluded from analysis, along with patients who had undergone a prior shoulder surgical procedure or treatment other than physical therapy regarding their BPBP.

The indications for surgical release were established in patients aged 1 year or older if (1) external rotation with the arm at the side was less than 0°, (2) palpable and irreducible posterior displacement of the humeral head was noted, or (3) evidence of osseous deformities of the glenohumeral joint was noted on initial shoulder imaging.

### Surgical technique and postoperative care

All children were operated on by the same senior surgeon. With the patient in the supine position and under general anesthesia, surgery was performed through a deltopectoral incision. After identification of the pectoralis major muscle medially and the deltoid muscle laterally, the cephalic vein was retracted, along with the pectoralis major, to access the coracoid process. The release started with the coracohumeral ligament, which was identified at the cranial aspect of the incision and excised. The conjoint tendon was retracted medially and anteriorly with the brachial plexus secondary trunks, allowing access to the subscapularis tendon's superficial layer, which was released medially from all adherences; great precaution was taken on its inferior aspect to identify and gently retract the axillary nerve inferiorly during the release. The superior third of the subscapularis tendon was then cut, allowing an anterosuperior glenohumeral capsulotomy, starting superiorly from the rotator interval to the medial glenohumeral ligament inferiorly; the long head of the biceps tendon was respected. Finally, with a wide access to the glenohumeral joint, the deep surface of the subscapularis was released from all adherences medially to the glenoid neck. Intraoperative testing was conducted at the end of the release to assess postoperative external rotation with the arm adducted; external rotation over 60° was considered sufficient. Intra-articular viewing allowed appreciation of the reduction of the glenohumeral joint in maximal external rotation. During testing, a lateralized and hypertrophied coracoid process was noted in all cases, which was anteriorly hindering the passive mobilization of the humeral head. Subsequently, to prevent any impingement on the humeral head, a subperiosteal osteotomy of the hypertrophied coracoid process was systematically performed, with preserving at most the insertions of the conjoint tendon anteriorly and coracoacromial ligament superiorly (Fig. 1). To perform the subperiosteal osteotomy, the coracoid periosteum was incised on the superior aspect of the coracoid process and released laterally. The excess bone was cut away, and the periosteum flap was placed back in its original position, along with the coracoacromial ligament insertion. The surgical incision was finally closed without any drain in a layered subcuticular fashion. No tendon transfer (ie, latissimus dorsi and/or teres major) to the rotator cuff was performed during the same operating time in any patient.

An upper-extremity spica cast was made in the operating room by the operating assistant with the patient under general anesthesia while the operator was maintaining the joint in a reduced position at all times, to position the shoulder with 60° to 90° of external rotation, depending on intraoperative testing (Fig. 2). The cast was removed after 3 weeks, and occupational therapy and self-rehabilitation exercises were started immediately to maintain passive range of motion, as well as strengthen the abductors and external rotators.

### Data collection

Investigations were conducted according to the 1964 Declaration of Helsinki ethical standards and the MR-003 reference

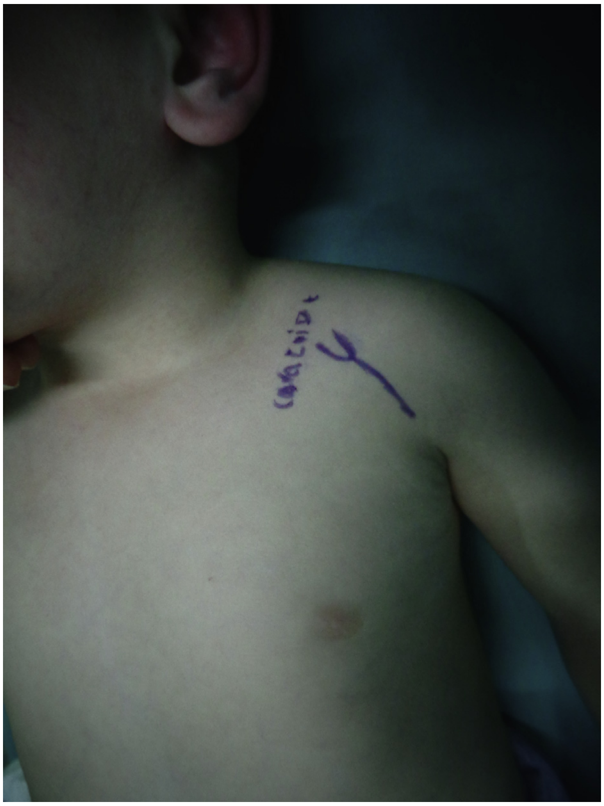

**Figure 1** Schema of subperiosteal osteotomy of coracoid process.


**Figure 2** Upper-extremity spica cast positioning shoulder in reduced position.

methodology.[13] Chart review yielded patients' demographic characteristics along with clinical and imaging data before surgery and at the last follow-up visit. Preoperatively, thorough medical histories were obtained and radioclinical evaluations were conducted. The modified Mallet score[1] was used to comprehensively evaluate the upper-extremity function and particularly active shoulder motion[3]; in 8 cases, this score could not be used because of the young age of the patients. Special attention was given to passive and active shoulder abduction and external rotation with the arm at the side, measured by the operating surgeon with a goniometer; these measurements were made while patients were awake to ensure comparability with postoperative values. Shoulder magnetic resonance imaging and computed tomography (CT) scans were conducted preoperatively and postoperatively, respectively, to assess joint deformities. On the basis of an axial view passing under the coracoid process and the spinoglenoid notch,[14] a single investigator made 2 quantitative measures using IMPAX 6 software (AGFA, Mortsel, Belgium): glenoid version (with retroversion of the glenoid being indicated with negative values) and the percentage of the humeral head anterior to the middle of the glenoid fossa (PHHA).[7]

### Statistical analysis

To compare preoperative and postoperative Mallet scores, range of motion, and radiographic measurements, the Shapiro-Wilk test was used on all data and confirmed their normal distribution; paired Student *t* tests were subsequently used. A subgroup analysis was then conducted to compare the radioclinical outcomes of patients who underwent surgery before the age of 4 years versus older patients; comparisons of their respective mean values for postoperative radioclinical outcomes were carried out with unpaired *t* tests. Results were presented as mean ± standard deviation (range) unless otherwise stated. The level of significance was defined as $P < .05$ for all tests.

## Results

### Series characteristics

After we excluded 15 patients (30%) who did not have evidence of dysplasia on initial shoulder imaging, 40 patients met our inclusion criteria, including 25 male and 15 female children (Table I). Twenty-seven patients had C5-C6 palsies, and 13 had additional involvement of the C7 root. The mean age was 50 ± 29 months (range, 16-154 months) at the time of surgery, including 24 patients younger than 4 years.

### Clinical outcomes

After a mean follow-up period of 23 ± 8 months (range, 12-49 months), all patients showed significant improvements in active abduction and external rotation as measured based on the modified Mallet score, which improved from 14.2 ± 2.5 points (range, 9-20 points) preoperatively to 21.4 ± 1.8 points (range, 17-24 points) postoperatively ($P < .001$). Passive and active external rotation significantly improved as well, from mean preoperative values of –2° ± 9° (range, –30° to 10°) and –43° ± 20° (range, –80° to –10°), respectively, to mean postoperative values of 76° ± 6° (range, 60°-80°; $P < .001$) and 54° ± 33° (range, –50° to

**Table I** Cohort details

| | Data |
|---|---|
| Patients | 40 |
| Sex ratio: M/F | 25/15 |
| Age at surgery, mo | 50 ± 29 (16-154) |
| Age <4 yr/≥4 yr | 24/16 |
| Type of palsy: C5-C6/C5-C7 | 27/13 |
| Affected side: R/L | 25/15 |
| Follow-up, mo | 23 ± 8 (12-49) |

*M*, male; *F*, female; *R*, right; *L*, left.
Data are presented as mean ± standard deviation (range) or number of patients (absolute value).

80°; $P < .001$), respectively (Fig. 3). Furthermore, significant improvements were noted regarding passive and active shoulder abduction, from mean values of 93° ± 16° (range, 70°-140°) and 78° ± 15° (range, 30°-120°), respectively, preoperatively to mean values of 121° ± 14° (range, 90°-140°) and 110° ± 16° (range, 80°-140°), respectively, postoperatively (Table II). No postoperative internal rotation limitation was reported.

### Radiologic outcomes

Glenoid version was significantly improved after surgery, from a mean value of –32° ± 14° (range, 3°-63°) preoperatively to –12° ± 7° (range, 0°-33°) at final follow-up ($P < .001$) (Tables III and IV). Likewise, PHHA was increased from a mean value of 18% ± 14% (range, 0%-52%) preoperatively to 45% ± 9% (range, 22%-59%) postoperatively ($P < .001$) (Fig. 4).

### Comparisons by age group (<4 years vs. ≥4 years)

Comparisons of both clinical and radiographic outcomes of patients younger than 4 years and patients who were older at the time of surgery showed no significant differences except regarding postoperative values of passive and active abduction, which were greater in older patients (Tables III and IV).

### Perioperative complications and complementary surgical procedures

Nine patients underwent additional surgical procedures. In 8 cases, postoperative passive range of motion was satisfactory but active external rotation (n = 7) and abduction (n = 1) were weak or absent; the latissimus dorsi tendon was transferred secondarily to the humeral head, at the posterior and superior rotator cuff insertion areas, respectively, after a mean delay of 17 ± 5 months (range, 12-24 months). This subgroup of patients had a mean age of 36 months (range, 26-47 months), with 5 being younger than 4 years and 3 being aged 4 years or older. Unfortunately, we failed to identify any noticeable difference, both preoperatively and intraoperatively, between this subset of patients and those who did not require an additional transfer to obtain active motion.

In addition, because of nonobservance of postoperative instructions (ie, postoperative physical therapy), a recurrence of the contracture developed in one 3-year-old boy, with passive external rotation limited to –20° at 3 months after the initial operation. A new anterior release of the shoulder was performed and followed by appropriate postoperative care, yielding 70° of passive external rotation 19 months after the second surgical procedure. No neurovascular complications or surgical-site infections were reported.

## Discussion

In this study, we assessed the impact of an isolated anterior shoulder release on glenohumeral remodeling and functional outcomes in patients with BPBP and preoperative radiographic evidence of articular incongruity. We observed that both passive and active abduction and external rotation were significantly improved after such a procedure, with a mean augmentation of the Mallet score of 6.9 points. Likewise, radiographic parameters were improved, with a mean glenoid version correction of 20° and a mean PHHA augmentation of 27%. We believe that such improvements can be explained by the restitution of the glenohumeral passive axial balance, which could be a mandatory step to restore active function.

If the core principle of anterior shoulder releases remains the same, technical variations may be observed between series. Most commonly, it involves the anterior capsule, glenohumeral ligaments (ie, inferior, middle, and/or superior), coracohumeral ligament, rotator interval tissue, and subscapularis muscle.[5,12,19] In our series, all patients benefited from the same standardized procedure, involving a wide anterosuperior capsulotomy, a release of the subscapularis tendon with a partial superior tenotomy, and a selective subperiosteal osteotomy of the coracoid process. If the first 2 key points are well described, the coracoid osteotomy in addition to the resection of the coracohumeral ligament is another major step of this procedure. As identified by Birch et al,[4] the coracoid process is usually found to be enlarged and bent in a posteroinferior direction in patients with anterior contracture. In our experience, we most commonly observed during intraoperative testing that this hypertrophic coracoid process was a limitation to glenohumeral reduction, with a manifest conflict between the posterior aspect of the coracoid tip and the anterior aspect of the glenohumeral head. In 39 patients with BPBP, Nath et al[15] identified a high correlation


**Figure 3** Preoperative clinical evaluation (**A**) and postoperative clinical evaluation at 2 years' follow-up (**B**) in a 4-year-old girl.

between the spatial orientation of the coracoid process and the glenohumeral deformity; in fact, patients with severe posterior subluxation of the humeral head and glenoid version presented with shorter coracoscapular distances, smaller coracoscapular angles, and greater coracoid overlap. Nath et al hypothesized that such coracoid deformity may interfere with the success of repositioning the posteriorly subluxated humeral head anteriorly to articulate with the glenoid. According to those findings and our experience, we would recommend systematically adding this osteotomy to the soft-tissue release in such cases.

Regarding the subscapularis tenotomy, only the superior part of the tendon should be incised to prevent any iatrogenic loss of internal rotation. In a series of 19 patients, van der Sluijs et al[27] observed 8 cases of postoperative "severe, functionally disturbing external rotation contracture of the shoulder" after a complete tenotomy and lengthening of the subscapularis with similar indications. With a partial tenotomy, we did not observe such a complication in any of our patients. Bae et al[3] also recommended lengthening the pectoralis major tendon in cases of external rotation limitation with the arm abducted 90°. We did not have to perform this additional tenotomy in our patients despite achieving improvement in external rotation and abduction. Moreover, since the description of an arthroscopic anterior release by Pearl[19] in 2003, several reports have outlined encouraging outcomes using this approach.[4,26] As an example, Pedowitz et al[23] reported on obtaining reduction of glenohumeral joint subluxation using this technique in all of their 22 patients; furthermore, they observed significant improvements in both the PHHA and glenoid version, from mean preoperative values of 15.6% ± 13.5% and –37° ± 15°, respectively, to mean postoperative values of 46.9% ± 11.2% ($P < .001$) and –8° ± 8° ($P < .001$), respectively.[26] However, considering that the authors performed latissimus dorsi and teres major tendon transfers concomitantly with the release in 15 cases, including 5 with failure of previous transfers, comparability to our results may be compromised. The results of our study, when confronted by this short literature overview, seem to demonstrate that there is still gray area regarding the optimal method to treat such complex cases, most likely because of the lack of prospective and comparative studies.

The aims of an anterior release and latissimus dorsi transfer are to correct glenoid deformity and to achieve active external rotation. The timing of the BPBP surgical procedure is a controversial topic. In a magnetic resonance imaging study, van der Sluijs et al[28] reported that 70% of patients younger than 5 years had normal glenohumeral joints whereas 80% of patients aged 5 years or older had radiographic deformity. They advocated that muscle imbalance might be the rationale for such

**Table II** Overall outcomes of cohort

| | Preoperative value | Postoperative value | *P* value |
|---|---|---|---|
| Clinical outcomes | | | |
| Range of motion, ° | | | |
| Passive external rotation | −2 ± 9 (−30 to 10) | 76 ± 6 (60-80) | <.001 |
| Active external rotation | −43 ± 20 (−80 to −10) | 54 ± 33 (−50 to 80) | <.001 |
| Passive abduction | 93 ± 17 (70-140) | 121 ± 14 (90-140) | <.001 |
| Active abduction | 78 ± 15 (30-120) | 110 ± 16 (80-140) | <.001 |
| Modified Mallet score (of 30 points) | 14.4 ± 2.4 (9-20) | 21.3 ± 2.0 (17-24) | <.001 |
| Radiographic outcomes | | | |
| Glenoid version, ° | 32 ± 14 (3-63) | 12 ± 7 (0-33) | <.001 |
| PHHA, % | 18 ± 14 (0-52) | 46 ± 11 (22-87) | <.001 |

*PHHA*, percentage of humeral head anterior to glenoid fossa.
Data are presented as mean ± standard deviation (range).

**Table III** Outcomes by age at surgery

| | Preoperative value | Postoperative value | *P* value |
|---|---|---|---|
| Age < 4 yr (n = 24) | | | |
| Clinical outcomes | | | |
| Range of motion, ° | | | |
| Passive external rotation | −4 ± 10 (−30 to 10) | 75 ± 6 (60-80) | <.001 |
| Active external rotation | −44 ± 22 (−80 to −10) | 53 ± 30 (0-80) | <.001 |
| Passive abduction | 91 ± 15 (70-140) | 117 ± 14 (90-140) | <.001 |
| Active abduction | 77 ± 13 (60-110) | 105 ± 16 (80-140) | <.001 |
| Modified Mallet score (of 30 points) | 14.3 ± 2.4 (9-18) | 20.9 ± 2 (17-24) | <.001 |
| Radiographic outcomes | | | |
| Glenoid version, ° | 31 ± 14 (3-63) | 13 ± 8 (0-33) | <.001 |
| PHHA, % | 19 ± 15 (0-52) | 45 ± 13 (22-87) | <.001 |
| Age ≥ 4 yr (n = 16) | | | |
| Clinical outcomes | | | |
| Range of motion, ° | | | |
| Passive external rotation | 1 ± 6 (−10 to 10) | 77 ± 6 (60-80) | <.001 |
| Active external rotation | −41 ± 16 (−70 to −20) | 55 ± 37 (−50 to 80) | <.001 |
| Passive abduction | 97 ± 19 (70-140) | 128 ± 12 (100-140) | <.001 |
| Active abduction | 78 ± 19 (30-120) | 116 ± 15 (90-140) | <.001 |
| Modified Mallet score (of 30 points) | 14.6 ± 2.3 (10-20) | 21.8 ± 1.9 (17-24) | <.001 |
| Radiographic outcomes | | | |
| Glenoid version, ° | 33 ± 14 (14-60) | 11 ± 7 (0-25) | <.001 |
| PHHA, % | 16 ± 13 (0-38) | 47 ± 8 (23-59) | <.001 |

*PHHA*, percentage of humeral head anterior to glenoid fossa.
Data are presented as mean ± standard deviation (range).

glenohumeral deformity; according to this hypothesis, early correction of this muscle imbalance should decrease the internal rotation contracture rate and prevent osseous deformity.[5,16] In our study, we compared outcomes between 2 groups (<4 years or ≥4 years) according to the recommendations of Gilbert et al.[8] Considering the radiologic findings, we reported no statistical difference between these 2 groups ($P > .05$).

Gilbert et al[8] recommended additional latissimus dorsi transfer in children older than 4 years. Similarly, according to his clinical experience, Pearl[19] modified his original protocol and recommended isolated release in children younger than 3 years, whereas for children aged 3 years or older with passive external rotation with the arm at the side of less than neutral (0°), he preferred to combine anterior arthroscopic release with latissimus dorsi transfer. If tendon transfers have been shown to be successful in restoring active shoulder external rotation and abduction, the impact of these dynamic procedures on osteoarticular alterations remains minor.[6,13,17] Thus, we

**Table IV** Outcome comparison based on age at surgery

| | Age < 4 yr (n = 24) | Age ≥ 4 yr (n = 16) | *P* value |
|---|---|---|---|
| Clinical outcomes | | | |
| Range of motion, ° | | | |
| Passive external rotation | 75 ± 6 (60-80) | 77 ± 6 (60-80) | .34 |
| Active external rotation | 53 ± 30 (0-80) | 55 ± 37 (−50 to 80) | .88 |
| Passive abduction | 117 ± 14 (90-140) | 128 ± 12 (100-140) | .01 |
| Active abduction | 105 ± 16 (80-140) | 116 ± 15 (90-140) | .03 |
| Modified Mallet score (of 30 points) | 20.9 ± 2.0 (17-24) | 21.8 ± 1.9 (17-24) | .16 |
| Radiographic outcomes | | | |
| Glenoid version, ° | 12 ± 8 (0-33) | 11 ± 7 (0-25) | .60 |
| PHHA, % | 45 ± 13 (22-87) | 47 ± 8 (23-59) | .45 |

*PHHA*, percentage of humeral head anterior to glenoid fossa.
Data are presented as mean ± standard deviation (range).

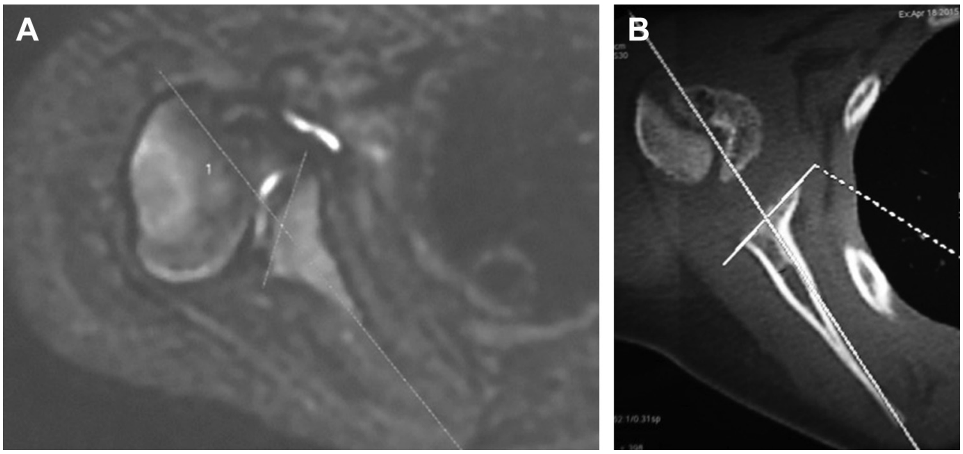


**Figure 4** Preoperative axial view of magnetic resonance imaging (**A**) and postoperative axial view of computed tomography scan at 1-year follow-up (**B**).

believe that a 2-stage surgical procedure allows adequate evaluation of active motion limitation after restoration of passive motion. Indeed, if active external rotation can be assessed—for example, with botulinic toxin injection in the subscapularis muscle—an isolated anterior release of the subscapularis can first be performed. Then, if effective active external rotation is not achieved, latissimus dorsi transfer can be performed, as we did in 8 cases in this series. Similarly, for children with brachial plexus palsy but no evidence of glenoid dysplasia, representing 30% of children with BPBP in our practice, we also performed isolated anterior shoulder release to first regain the joint passive range of motion. Then, we more accurately assessed the need for an additional transfer to achieve active mobilization. According to some authors, extra-articular soft-tissue rebalancing or isolated tendon transfers cannot remodel the glenohumeral deformity in patients with long-standing BPBP.[31] Some authors even believed that soft-tissue releases may lead to iatrogenic anterior instability[2] and advocated that derotation humeral osteotomy may improve function. Ruchelsman et al[25] achieved mean external rotation of 64° with improvement in the Mallet score from 13 to 18 points at a mean follow-up of 3.7 years. They did not report nonunion, but they showed a persistence of glenohumeral dysplasia.

Our study was limited by the short follow-up. Growth could lead to deterioration of clinical and anatomic results. Moreover, the small number of patients and the retrospective nature of the study did not allow us to properly compare groups of patients with different ages. A prospective comparative study could be performed to evaluate comparable groups and to draw recommendations. Another limitation of this study was the postoperative radiologic evaluation of the shoulder deformity in children. Because the joint remains predominantly cartilaginous, the shoulder may be suboptimally visualized with CT before 5 years of age.[29,32] However, with a mean age of 50 months at surgery and a mean follow-up period of 23 months, most of our patients were aged 5 years or older at the time of the CT scan.

## Conclusion

Anterior release was shown to increase the passive motion of the joint and center the humeral head in front of the glenoid process, leading to remodeling of the bony deformities and correction of the glenohumeral joint incongruity. In some patients, however, active external rotation restoration was secondarily necessary. Repeating the evaluation at the end of their growth should allow measurement of the true benefit of the procedure.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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