Orthopaedics & Traumatology: Surgery & Research (2010) **96**, 334—339

ELSEVIER MASSON
Available online at ScienceDirect www.sciencedirect.com
Elsevier Masson France EM|consulte www.em-consulte.com
Orthopaedics & Traumatology Surgery & Research

ORIGINAL ARTICLE

Brachial plexus birth palsy shoulder deformity treatment using subscapularis release combined to tendons transfer

G. Cohen[a,*], V. Rampal[a], F. Aubart-Cohen[b], R. Seringe[a], P. Wicart[a]

[a] *Orthopedic Surgery Dept, Cochin-Saint-Vincent-de-Paul Hospital, Paris Hospitals Group, University of Paris Descartes, France*
[b] *Pharmacology Dept, Pitié-Salpétrière Hospital, France*

Accepted: 2 February 2010

KEYWORDS
Obstetrical brachial plexus birth palsy;
Tendon transfer;
Subscapularis release

Summary
Introduction: One possible sequela of obstetric brachial plexus palsy (OP) is impaired external rotation (ER) of the shoulder which, in addition to its functional consequences, can generate a posterior humeral head subluxation or dislocation. The goal of the present study was to assess medium-term clinical and radiological results of release of the subscapularis muscle with transfer of the latissimus dorsi and teres major muscles.
Patients and methods: From 1985 to 1995, a continuous series of 32 OP patients underwent subscapularis muscle release, associated in 24 cases to muscle transfer. Mean age was 2.5 years (range, 1—9.2 years). Shoulder function was assessed by measurement of passive ER and graded according to the modified Mallet classification at 1, 5 and 10 years' follow-up or before revision. The evolution of the glenohumeral deformity was assessed on CT images of glenoid retroversion and the humeral head subluxation (% of humeral head covered), before and 5 years after surgery.
Results: Mean postoperative follow-up was 9.5 ± 5.6 years. Treatment brought significant improvement in passive ER (mean preoperative and 1-year follow-up values: $-10°$ and $52°$, respectively). This explained the good modified Mallet score at 1 year: mean = 18.4/25. Subsequent significant progressive degradation was noted: 10 years postoperatively, mean ER amplitude and modified Mallet score were respectively $13°$ and 15.8. The CT study showed correction of the glenoid retroversion (mean preoperative and 5-year follow-up values: $29°$ and $18°$, respectively), and of the humeral head subluxation (mean preoperative and 5-year follow-up values: 25 and 39%, respectively). Surgical revision was indicated six times (five patients): two latissimus dorsi and teres major transfers (not performed initially) and four derotational humeral osteotomies. Three-quarters of the patients who did not initially have muscle transfer had to be reoperated or else showed ER insufficiency at last follow-up.

* Corresponding author. Orthopedic Surgery Dept, Georges-Pompidou European Hospital, 20, rue Leblanc, 75908 Paris cedex 15, France. Tel.: +33 1 56 09 32 73; fax: +33 1 56 09 23 96.
E-mail address: gilles_fcohen@hotmail.com (G. Cohen).

doi:10.1016/j.otsr.2010.02.004

Discussion and conclusion: Surgical treatment produces objective functional gain, even if this diminishes over time. Moreover, it prevents or corrects posterior subluxation of the shoulder. It is indicated when passive ER amplitude is negative. It seems advisable to associate release to muscle transfer.
Level of evidence: Level IV Retrospective study.

Introduction

Obstetric brachial plexus palsy (OP) affects 0.1 to 0.4% of births [1]. Half of these cases show spontaneously favorable evolution. Some children, however, are left with significant impairment of shoulder function due to an active external rotation (ER) deficit. Such failure of muscle recovery may cause glenohumeral joint deformity [2—7].

Ideally, management consists in preventing ER amplitude reduction by orthopedic means such as rehabilitation and Lerique nocturnal braces [8] in external rotation, elbow to body. However, this may be difficult to achieve, and may fail in certain severe cases. A deficit in passive ER is an indication for surgery to restore ER amplitude, with proximal release of the subscapularis muscle on the anterior face of the scapula [9], possibly associated to the transfer of the humeral insertions of the teres major and latissimus dorsi muscles on the greater tuberosity. To the best of our knowledge, there have been no reports of medium-term results for this procedure.

The present study sought to assess the interest of this technique for shoulder function in the short term and for function and also for glenohumeral joint architecture over the medium term.

Patient and methods

Patients

This was a single-center retrospective study. All patients operated on for shoulder ER deficit associated with OP between 1985 and 1997 were consecutively included.

Surgery was indicated for passive and active ER deficit despite orthopedic treatment with a nocturnal brace holding the limb in external rotation and rehabilitation performed by a physiotherapist.

Clinical data were retrieved from medical records, and X-rays and CT scans were analyzed.

All patients underwent preoperative standard shoulder X-ray; when bone deformity was found or suspected, a preoperative shoulder CT scan was performed for precise assessment of the deformity.

Thirty-two patients (18 boys, 14 girls) met the inclusion criteria and were operated on. Mean age at surgery was 2.5 years (range, 0.9—9.2 yrs). Lesion topography was C5/C6 (26 cases), C5C6C7 (two cases), C5C6C7C8 (two cases) or C5C6C7C8D1 (two cases). The right shoulder was affected in 15 cases and the left in 17. Hornblower sign was present in all cases, with associated internal rotator muscle hypertonia. In 19 cases (59%), there was also clinical posterior subluxation of the humeral head.

Mean preoperative ER was -10° (-45° to 0°) and mean abduction 113° (30° to 180°).

The modified Mallet score [10,11] was not systematically calculated preoperatively, given the very young age of several patients.

Standard AP and lateral shoulder X-ray disclosed 20 posterior subluxations of the humeral head (62.5%) and seven glenoid deformities (25%: glenoid cavity blunting found on axillary lateral view when available and interpretable). The seven preoperative CT scans showed seven glenoid deformities: three flat cavities and three with convex aspect due to posterior edge blunting. Finally, one cavity was biconcave, with a vertical groove between the posterior neoformation and the true anterior glenoid cavity. Mean glenoid retroversion was 29° (5°—40°). Mean posterior subluxation of the humeral head was 25% (10—50%).

Surgical technique

Surgery consisted in exposing the scapula by a posterior inverted-U approach, along the anterior edge of the latissimus dorsi muscle and on to the posterior side of the arm. The subscapularis muscle was released posteriorly at its anterior scapular insertion. This extraperiosteal release restored a mean ER of 45° (30—70°). In case of preoperative active ER deficit, the procedure was completed by teres major and latissimus dorsi tendon transfer at the humeral insertion on the rotator cuff (greater tuberosity), or more precisely on the infraspinatus. Postoperative thoracobrachial cast immobilization with the limb in 45° external rotation, elbow to body, was maintained for a period of 3 to 6 weeks, depending on the surgeon in charge.

All 32 patients underwent subscapularis release, completed by tendon transfer in 24 cases. In three cases, the procedure was completed by posterior capsulorraphy for residual glenohumeral subluxation.

Assessment criteria and follow-up

Postoperative follow-up comprised regular consultations, with systematic measurement of passive and active elbow-to-body ER and of active shoulder abduction. Modified Mallet scores were calculated at 1, 5 and 10 years postoperatively.

All patients had postoperative standard shoulder X-ray.

Seven CT controls were performed in the patients who had had preoperative scans, and analyzed following Waters et al. [12,13] to assess posterior subluxation of the humeral head (percentage head, measured at its

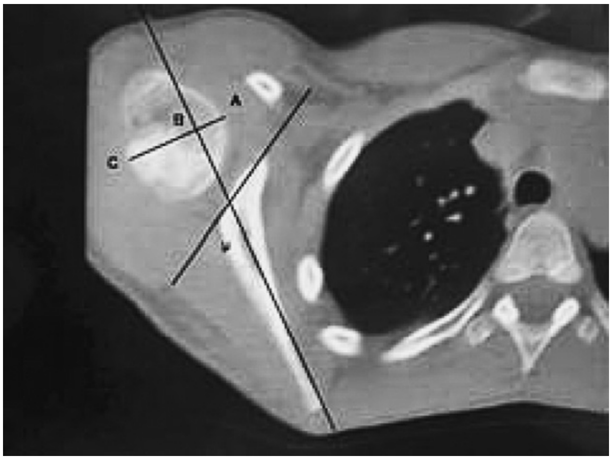

Figure 1 Analysis of glenoid retroversion and posterior humeral head subluxation on computed tomography. Humeral head posterior subluxation: (AB/AC) $\times$ 100 (%). Glenoid retroversion: ($90 - \mu$) (°).

Figure 2 Image of young patient before surgery, with Hornblower sign.

largest diameter, forward of the tangent of the scapular spine) and glenoid retroversion (Fig. 1). The CT scans also enabled precise description of glenoid morphology. The mean postoperative interval to CT was 5.3 years (1—9 yrs).

In case of revision surgery, the indication and type of procedure were recorded.

Statistics

Results were expressed as mean $\pm$ standard deviation for quantitative variables, and as percentages for qualitative variables. Mallet scores and postoperative ER values at 1, 5 and 10 years' FU were compared by parametric ANOVA for repeated measures. Ten-year results were not in all cases available, and analysis was made excluding patients with missing values. CT data were compared by non-parametric Wilcoxon test. The significance threshold was set at $p < 0.05$ in all tests.

Results

Mean follow-up for the 32 patients was 9.5 ± 5.6 years (range, 2 to 23 yrs).

Clinical results

Hornblower sign was present at 1 year in 35% of cases, at 5 years in 67% and at 10 years in 70%. Residual humeral head posterior subluxation was palpable in five patients (16%).

ER gain (from a mean −10° (−45° to 0°) to 52° (5° to 90°); Figs. 2 and 3) was observed in all patients at 1-year FU, and

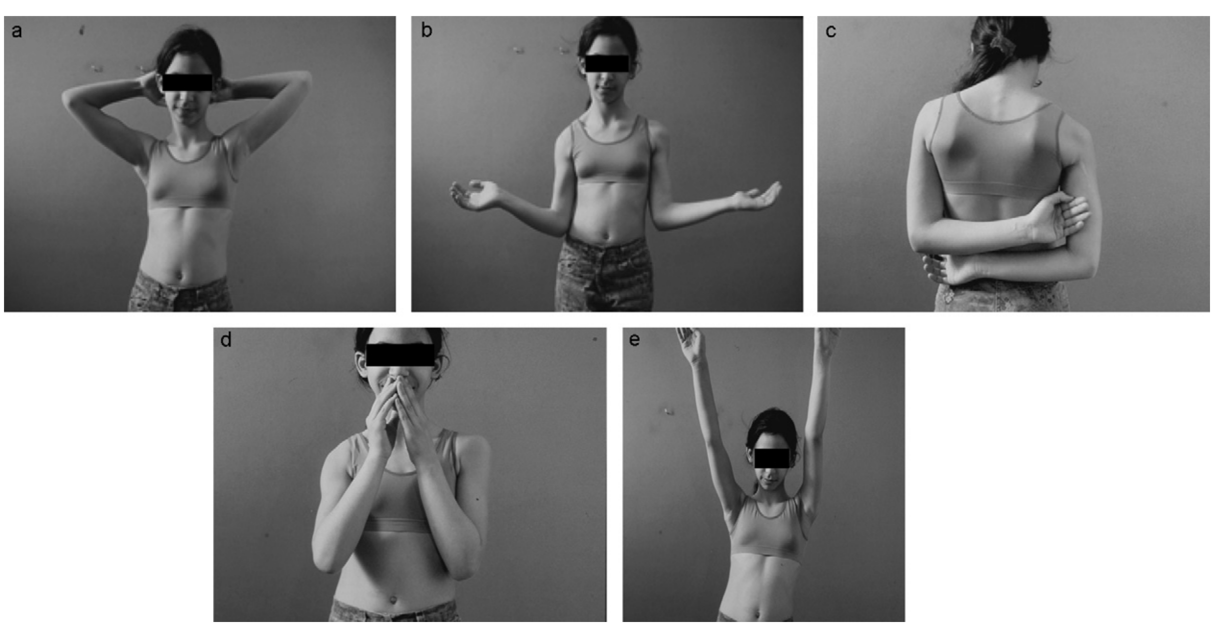

Figure 3 Clinical result nine years after surgery.

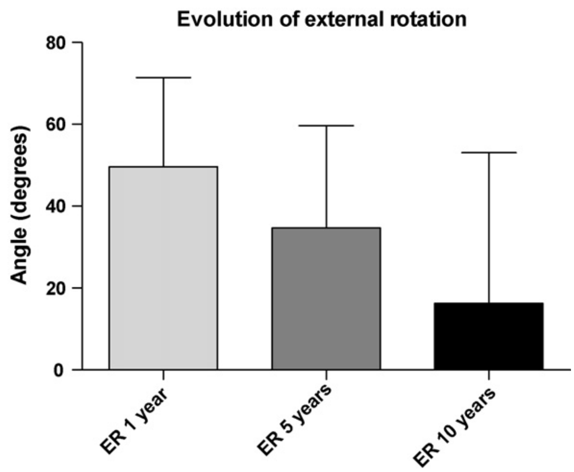

Figure 4 Evolution of external rotation. On ANOVA for matched series, the difference was significant ($p < 0.001$).

was conserved at 5 and 10 years in all cases but one (mean ER at 5 years: 35° (−5° to 80°); and at 10 years: 13° (−50° to 80°)). This progressive reduction in ER was significant on ANOVA test ($p < 0.001$; Fig. 4).

Mean abduction also improved over the first 5 years, from 113° (30° to 180°) preoperatively to 128° (40° to 160°) at 1 year and 133° (40° to 180°) at 5 years; thereafter, however, there was a slight fall-off, with a mean abduction at 10 years of 120° (40° to 180°).

Mean modified Mallet score was 18.4 at 1 year, 17 at 5 years and 15.8 at 10 years, the progressive reduction being significant on ANOVA test ($p < 0.0001$; Fig. 5).

Two of the eight patients undergoing isolated subscapularis release required surgical revision (one tendon transfer, and one tendon transfer associated to humeral derotation). Three of the other six patients showed shoulder mobility and function below average for the series as a whole (mean ER = 10° at 10 years; mean modified Mallet score = 16.5 at 1 year, 16 at 5 years and 15.5 at 10 years).

Four patients were at least 5 years of age at surgery; mobility and function were below average for the series as a whole (mean ER = 30° at 1 year, 20° at 5 years and −3° at 10 years; mean modified Mallet score = 17 at 1 year, 15.5 at 5 years and 15 at 10 years). Lack of power ($n = 4$) precluded any significant difference being shown on ANOVA.

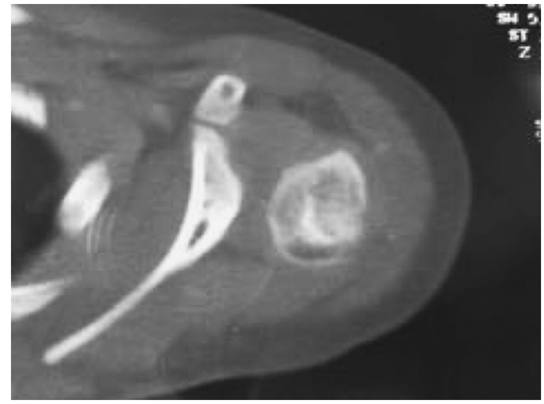

Figure 6 Glenoid retroversion and humeral head posterior subluxation before surgery in CT scan examination in a six year-old child. Clinical external rotation is −30°.

Finally, four patients showed fixed abduction, unable to position their arm in adduction; abduction values ranged from 20° to 70°, which to the best of our knowledge has never previously been reported.

Radiologic results

Postoperatively, the clinically suspected posterior subluxation of the humeral head was confirmed on standard X-ray in 80% of cases.

Glenoid deformity was found on standard X-ray in 46.15% of cases.

Seven CT scans were performed at a mean 5 years postoperatively; they showed five cases of flattened glenoid cavity with blunted edges, one biconcave glenoid aspect and one convex cavity. Preoperative osteoarticular abnormalities were partially corrected (Figs. 6 and 7), especially the posterior subluxation, with a significant increase in the percentage of humeral head forward of the scapular spine tangent (mean, 39% [20—50%]; $p = 0.04$). Glenoid retrover-

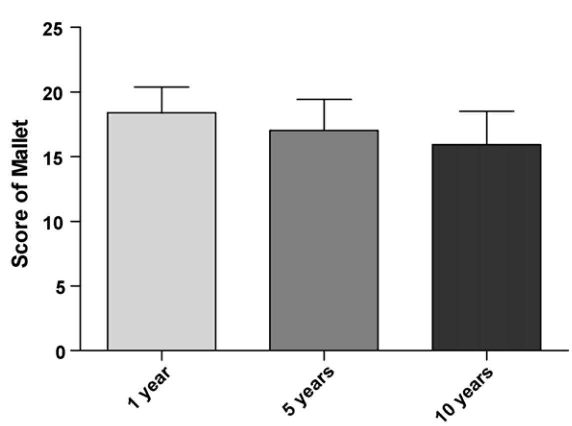

Figure 5 Evolution of Mallet modified score. On ANOVA or Friedman test for repeated measures on 24 patients with full data. Significant difference ($p < 0.0001$).

Figure 7 Five years after surgery: partial correction of glenoid retroversion and humeral head posterior subluxation in CT scan examination. Clinical external rotation is 30°.

sion was reduced to a mean 18° (4—35°), but this reduction was statistically non-significant.

Surgical revision

Six patients required surgical revision: two secondary latissimus dorsi and teres major transfers were performed in two patients having had primary isolated subscapularis muscle release. One of these two patients subsequently underwent humeral derotation osteotomy. Four other humeral derotations were performed. All five osteotomies provided clear benefit, with ER at 3 years' follow-up showing an increase from 10° to 40°, −20° to 10°, −90° to 20°, −40° to 50° and 0° to 50°, respectively.

Discussion

The present study found very clear functional and clinical improvement provided by subscapularis muscle release with latissimus dorsi and teres major transfer. Although evolution showed a fall-off in postoperative gain over 10 years' follow-up, end-point values were still higher than those observed in the absence of treatment [14], where there is greater loss of external rotation and deterioration in glenohumeral congruence. To the best of our knowledge, no previous study reported such progressive deterioration in mobility and function in the affected shoulder, although it should be borne in mind that mean follow-up never exceeded 4 years except in Pagnotta et al.'s study [15], and even there it was only 5.7 years.

The impact of surgery on impairment of glenohumeral congruence is a matter of debate. Several authors [12,16—19] reported improved shoulder mobility, accompanied by correction of osteocartilaginous deformity leading to reduction in glenal retroversion and in subluxation. Kozin et al. [20], on the other hand, found no such effects on MRI. The scans performed in the present study showed significant reduction in scapulohumeral subluxation and a trend for reduction in retroversion at a mean 5 years' follow-up.

The various functional, clinical and scan data support the short- to medium-term benefit of this surgical indication. ER deficit or defective internal rotation are indications for surgery. Step 1 consists in releasing the subscapularis muscle so as to restore satisfactory ER amplitude [9]. Transferring the distal teres major and/or latissimus dorsi insertions onto the posterolateral edge of the proximal extremity of the humerus or onto the infraspinatus muscle [21—24] basically inhibits their internal rotation rather than recovering significant active external rotation [8]. Chuang et al. [25] and El-Gammal et al. [16] associated pectoralis major muscle lengthening to teres major transfer to the rotator cuff, reinserting the two extremities of the clavicular part of the pectoralis major laterally so as to enhance abduction. Finally, Chen et al. [26] recommended associating teres major and latissimus dorsi transfer to a transfer of the trapezius muscle to the humerus in patients with less than 90° preoperative abduction. These procedures have been updated by the use of arthroscopy, enabling one-step subscapularis tenotomy or anterior capsulorraphy, with or without tendon transfer, with results equivalent to those obtained with traditional techniques [12,27—29]. External derotational osteotomy of the humerus is indicated only when glenohumeral incongruence prevents recovery of adequate joint mobility [13,15,30].

The need to associate tendon transfer to subscapularis release has never been clearly proven. Recently, Newman et al. [31], on a mean 4.7 years' follow-up of 13 patients with isolated subscapularis release, reported results comparable to those obtained with associated tendon transfer. In our own experience, isolated subscapularis release gave poorer results: six of the eight patients in question showed ER and modified Mallet scores below the mean values of the series as a whole, and two required iterative surgical correction; lack of power precluded statistical comparison by ANOVA, but the impossibility of predicting the impact of passive ER deficit correction on rotator muscle activity and our high rate of poor results with isolated subscapularis release lead us to recommend associating the two procedures.

Patient age at surgery is the subject of several debates. Waters et al. [12] believe that tendon transfer surgery slows shoulder joint impairment and corrects glenal retroversion and posterior subluxation. Van der Sluijs's previous MRI study [3] of 17 pathological shoulders found that 70% of patients under 5 months of age had normal shoulders, whereas 80% of those older than 5 months showed radiologic deformity. They attributed the osteocartilaginous deformity to muscle imbalance. Consequently, early correction of imbalance should usefully postpone the onset of bone abnormality [13,16]. In the present series, patients over the age of 5 years seemed to show less good results than the others, in terms both of external rotation and of modified Mallet score, although again lack of power precluded statistical demonstration.

In conclusion, subscapularis release provided objective functional benefit, even if this degraded over time. It moreover prevented or corrected posterior subluxation. It is indicated in case of negative ER amplitude. Associated muscle transfer appears to be recommended.

Conflict of interest

Nothing declared.

References

[1] Waters PM. Obstetric brachial plexus injuries: evaluation and management. J Am Acad Orthop Surg 1997;5:205—14.

[2] Pearl ML, Edgerton BW. Glenoid deformity secondary to brachial plexus birth palsy. J Bone Joint Surg Am 1998;80:659—67.

[3] Van der Sluijs JA, Van Ouwerkerk WJ, de Gast A, Wuisman PI, Nollet F, Manoliu RA. Deformities of the shoulder in infants younger than 12 months with an obstetric lesion of the brachial plexus. J Bone Joint Surg Br 2001;83:551—5.

[4] Waters PM, Smith GR, Jaramillo D. Glenohumeral deformity secondary to brachial plexus birth palsy. J Bone Joint Surg Am 1998;80:668—77.

[5] Boome RS, Kaye JC. Obstetric traction injuries of the brachial plexus. Natural history, indications for surgical repair and results. J Bone Joint Surg Br 1988;70:571—6.

[6] Hardy AE. Birth injuries of the brachial plexus: incidence and prognosis. J Bone Joint Surg Br 1981;63-B:98—101.

[7] Waters PM. Comparison of the natural history, the outcome of microsurgical repair, and the outcome of operative reconstruction in brachial plexus birth palsy. J Bone Joint Surg Am 1999;81:649—59.
[8] Dubousset J. Paralysie obstétricale du plexus brachial. II. Traitements. Traitement des séquelles. Méthodes de prévention des attitudes vicieuses. Rev Chir Orthop 1972;58(Suppl. 1):159—64.
[9] Carlioz H, Brahimi L. Place du décollement du muscle subscapularis dans le traitement des paralysies obstétricales du membre supérieur chez l'enfant. Ann Chir Infant 1971;12:159—67.
[10] Clarke HM, Curtis CG. An approach to obstetrical brachial plexus injuries. Hand Clin 1995;11:563—80 [Discussion 580-1].
[11] Mallet J. Paralysie obstétricale du plexus brachial. II. Traitement. Traitement des séquelles. Méthodes d'expression des résultats. Rev Chir Orthop 1972;58(Suppl. 1):166—8.
[12] Waters PM, Bae DS. Effect of tendon transfers and extra-articular soft-tissue balancing on glenohumeral development in brachial plexus birth palsy. J Bone Joint Surg Am 2005;87:320—5.
[13] Waters PM, Bae DS. The effect of derotational humeral osteotomy on global shoulder function in brachial plexus birth palsy. J Bone Joint Surg Am 2006;88:1035—42.
[14] Guermazi M, Ghroubi S, Mezghanni M, Triki FE, Elleuch MH. Suivi à long terme des épaules paralytiques obstétricales (à propos de 129 cas). Ann Readapt Med Phys 2004;47:7—12.
[15] Pagnotta A, Haerle M, Gilbert A. Long-term results on abduction and external rotation of the shoulder after latissimus dorsi transfer for sequelae of obstetric palsy. Clin Orthop 2004;426:199—205.
[16] El-Gammal TA, Saleh WR, El-Sayed A, Kotb MM, Imam HM, Fathi NA. Tendon transfer around the shoulder in obstetric brachial plexus paralysis: clinical and computed tomographic study. J Pediatr Orthop 2006;26:641—6.
[17] Terzis JK, Vekris MD, Okajima S, Soucacos PN. Shoulder deformities in obstetric brachial plexus paralysis: a computed tomography study. J Pediatr Orthop 2003;23: 254—60.
[18] Edwards TB, Baghian S, Faust DC, Willis RB. Results of latissimus dorsi and teres major transfer to the rotator cuff in the treatment of Erb's palsy. J Pediatr Orthop 2000;20: 375—9.
[19] Hui JH, Torode IP. Changing glenoid version after open reduction of shoulders in children with obstetric brachial plexus palsy. J Pediatr Orthop 2003;23:109—13.
[20] Kozin SH, Chafetz RS, Barus D, Filipone L. Magnetic resonance imaging and clinical findings before and after tendon transfers about the shoulder in children with residual brachial plexus birth palsy. J Shoulder Elbow Surg 2006;15:554—61.
[21] L'Episcopo J. Tendon transplantation obstetrical paralysis. Am J Surgery 1934;25:122—5.
[22] Hoffer MM, Wickenden R, Roper B. Brachial plexus birth palsies. Results of tendon transfers to the rotator cuff. J Bone Joint Surg Am 1978;60:691—5.
[23] Gilbert A, Romana C, Ayatti R. Tendon transfers for shoulder paralysis in children. Hand Clin 1988;4:633—42.
[24] Birch R, Bonney G, Wynn Parry CB. Birth lesions of the plexus. In: Birch R, Bonney G, Wynn Parry CB, editors. Surgical disorders of peripheral nerves. Edinburgh: Churchill Livingstone; 1998. p. 209—34.
[25] Chuang DC, Ma HS, Wei FC. A new strategy of muscle transposition for treatment of shoulder deformity caused by obstetric brachial plexus palsy. Plast Reconstr Surg 1998;101:686—94.
[26] Chen L, Gu YD, Hu SN. Applying transfer of trapezius and/or latissimus dorsi with teres major for reconstruction of abduction and external rotation of the shoulder in obstetrical brachial plexus palsy. J Reconstr Microsurg 2002;18:275—80.
[27] Kany J, Abid A, Sales de Gauzy J, Cahuzac JP. Libération capsulaire arthroscopique des contractures en rotation interne dans les paralysies obstétricales. Rev Chir Orthop 2004;90:56.
[28] Pearl ML. Arthroscopic release of shoulder contracture secondary to birth palsy: an early report on findings and surgical technique. Arthroscopy 2003;19:577—82.
[29] Pedowitz DI, Gibson B, Williams GR, Kozin SH. Arthroscopic treatment of posterior glenohumeral joint subluxation resulting from brachial plexus birth palsy. J Shoulder Elbow Surg 2007;16:6—13.
[30] Kirkos JM, Papadopoulos IA. Late treatment of brachial plexus palsy secondary to birth injuries: rotational osteotomy of the proximal part of the humerus. J Bone Joint Surg Am 1998;80:1477—83.
[31] Newman CJ, Morrison L, Lynch B, Hynes D. Outcome of subscapularis muscle release for shoulder contracture secondary to brachial plexus palsy at birth. J Pediatr Orthop 2006;26:647—51.