Subscapularis release and tendon transfer in treatment of posterior shoulder dislocation in obstetric brachial plexus palsy

Yousuf M. Khira, Elsayed El-Etewy Soudy

Department of Orthopedic Surgery, Faculty of Medicine, Zagazig University, Egypt

The Egyptian Orthopaedic Association 2013, 48:220–228

Background
Muscle imbalance of the shoulder results in weak external rotation and abduction. Active internal rotation and adduction can cause glenohumeral joint deformity with late posterior dislocation.

Patients and methods
This prospective study conducted from 2004 to 2009 included 34 patients, 18 girls and 16 boys, with a mean age of 4 years (1–7 years). The right side was affected in 19 patients, whereas the left side was affected in 15 patients. All patients suffered from obstetric brachial plexus palsy with internal rotation contracture and defective shoulder abduction plus posterior dislocation or subluxation of the humeral head. These patients were treated by soft tissue release (subscapularis slide and anterior soft tissues release) with or without tendon transfer (latissimus dorsi and teres major to infraspinatus).

Conclusion
Subscapularis release provided an objective functional benefit; however, it degraded over time. Teres major and latissimus dorsi to infraspinatus transfer is a useful procedure for correction of defective shoulder abduction and external rotation in obstetric brachial plexus palsy as it increases the stabilizing action of the rotator cuff, thus allowing the deltoid to act with maximal force.

Egypt Orthop J 48:220–228

1110-1148

Introduction

The incidence of obstetric brachial plexus palsy (OBPP) is one to four per 1000 live births, and about 50% of these cases have good recovery without late deformity. Partial recovery of the C5, C6, and C7 roots results in muscle imbalance, and delay of recovery causes bicep muscle contracture [1–3]. The residual muscle imbalance of the shoulder in the form of weak external rotation and abduction with active internal rotation and adduction can cause glenohumeral joint deformity with late dislocation posteriorly [4–6]. Advances in microvascular surgery and early reconstruction of the brachial plexus have resulted in a reduced need for palliative treatment such as rehabilitation by physiotherapy and use of orthosis and braces, which are difficult to apply at such a young age and fail in severe cases [7].

There are many surgical options for treatment of this deformity, such as anterior release of contractures in internal rotators and adductors of the shoulder, such as in the Sever operation [8]. L'Episcopo[9] enhanced the efficacy of this technique by introducing tendon transfer of the latissimus dorsi and teres major to the lateral aspect of the humerus. Thereafter, Hoffer *et al*. [10] suggested the transfer of the latissimus dorsi and teres major to the rotator cuff. Bone procedures such as derotational osteotomy of the proximal humerus are used to correct these deformities. Pedicle and free muscle transfers in patients with paralytic shoulder are other options. The criteria for selection of a specific procedure were based on the age of the patient and the degree of glenohumeral deformity on the preoperative computed tomography (CT) scan or MRI. As long as the glenohumeral joint is congruent, tendon and muscle transfers can be performed at a later date; however, they should be considered at the earliest to maximize functional recovery [11]. Shoulder reconstruction is expected to improve both arm appearance and some of the hand functions such as reaching the head or mouth and raising the hand above the shoulder [3].

The aim of this prospective study was to evaluate the results in 34 patients with OBPP treated surgically by anterior release and tendon transfer of teres major and latissimus dorsi.

Patients and methods

This prospective study conducted from 2004 to 2009 included 34 patients, 18 girls and 16 boys, with a mean age of 4 years (1–7 years). The right side was affected in 19 patients, whereas the left side was affected in 15 patients. All patients suffered from OBPP with internal rotation contracture and defective shoulder abduction with posterior dislocation or subluxation of the humeral head. These patients were treated by soft tissue release (subscapularis slide and anterior soft tissues release) with or without tendon transfer (latissimus dorsi and teres major to infraspinatus).

Sixteen patients (47%) were delivered at the hospital, whereas 18 (53%) were delivered at home. Fifteen patients (44%) had a definite history of difficult labor and five (14.7%) had a breech delivery. Two patients (5.9%) had an associated fractured clavicle. In nine patients (26.5%), the baby was the first child of his/her parents. Birth weight in 17 patients (50%) was over 4 kg (3.6–4.5 kg), which appears to be the most important risk factor. Thirty-two patients (94.1%) had not undergone previous surgery and were treated by physiotherapy. Only two patients (5.9%) had undergone primary microsurgical repair of the plexus. Complete paralysis (C_5, C_6, C_7, C_8, and T_1 roots affected) was observed in 21 patients (61.8%) at the time of birth, and 13 patients (38.2%) had partial paralysis (only C_5 and C_6 affected). All 34 patients had medial rotation contracture: 21 (61.8%) had dislocation and 13 (38.2%) had subluxation. Standard plain radiographs of the shoulder and CT scans were routinely obtained for all patients for precise assessment of the deformity (glenoid retroversion and degree of posterior subluxation of the humeral head). Follow-up CT scans of both shoulders were obtained for all 34 patients postoperatively. We used the Mallet [12] grading system and the modified Gilbert system [13] for assessment of shoulder function (Fig. 1; Tables 1 and 2).

Rationale of treatment

The aim of the operation was to relocate the dislocated glenohumeral joint and to alleviate secondary deformities arising from incomplete recovery following nonsurgical management or residual deformities following primary reconstruction.

All 34 patients underwent subscapularis release. Additional tendon transfers were needed in 21 patients. Posterior capsulorrhaphy was performed in three patients for residual glenohumeral subluxation.

Figure 1

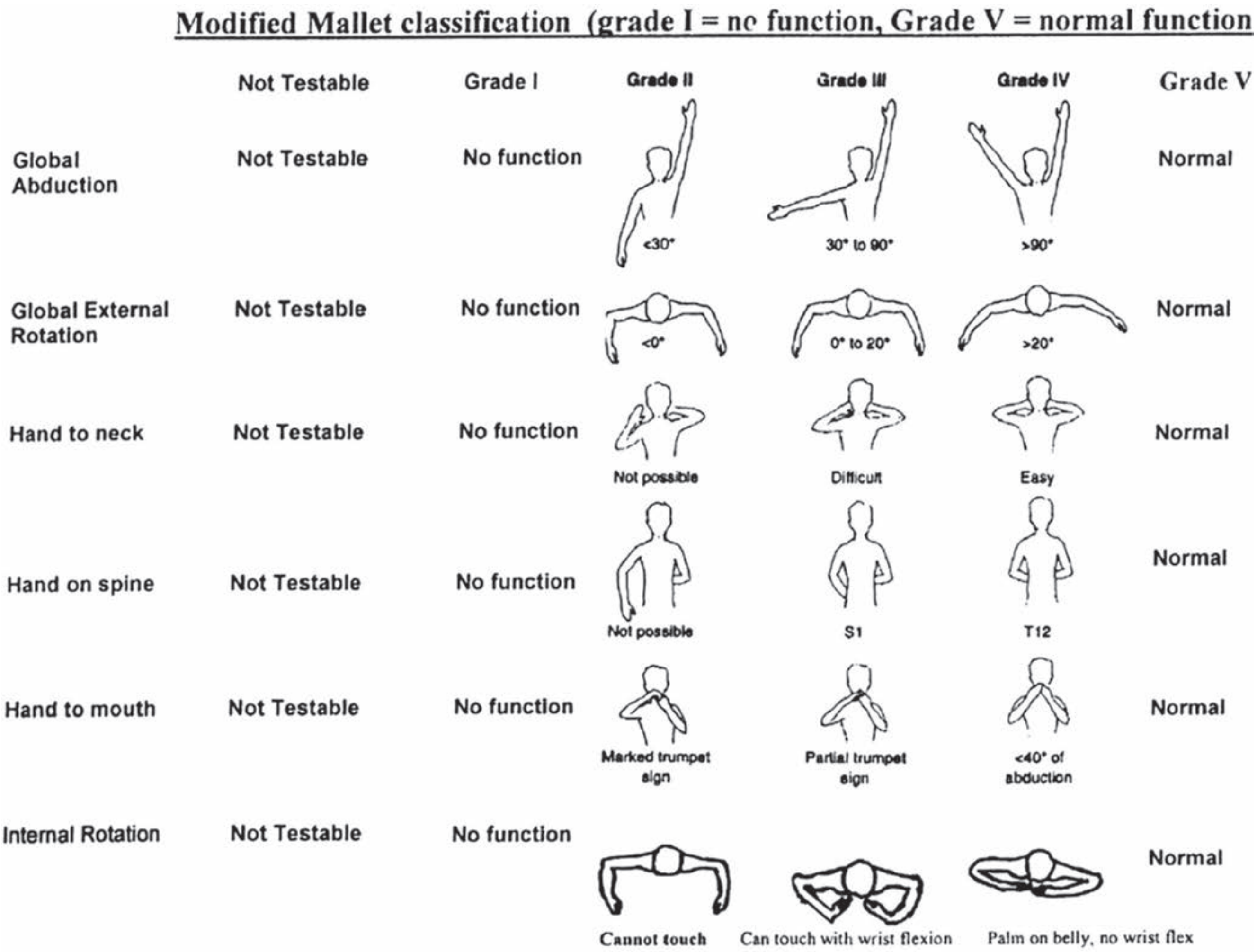


Illustration of the Mallet classification. A score of 1 represents no function and a score of 5 represents full function.

Table 1 Mallet grading of functions of the shoulder joint

Mallet grading	Description
Grade I	Flail shoulder
Grade II	Active abduction < 30° Zero degrees of external rotation Hand to back of neck impossible Hand to back impossible Hand to mouth with marked trumpet sign
Grade III	Active abduction of 30–90° External rotation up to 20° Hand to back of neck difficult Hand to back with difficulty Hand to mouth possible with partial trumpet sign
Grade IV	Active abduction over 90° External rotation over 20° Hand to back of neck easy Hand to back easy Hand to mouth easy with less than 40° of shoulder abduction
Grade V	Normal shoulder

Grade II gives 1 point, grade III gives 2 points, and grade IV gives 3 points. Excellent function, 15 points; good function, 9–12 points; and poor function, <9 points (Nicolas *et al.*, 2004).

Table 2 Modified Gilbert system

Stage	Function
Stage 0	Flail shoulder
Stage I	Abduction or flexion to 45°, no active lateral rotation
Stage II	Abduction < 90°, lateral rotation to neutral
Stage III	Abduction = 90°, weak lateral rotation
Stage IV	Abduction < 120°, incomplete lateral rotation
Stage V	Abduction > 120°, active lateral rotation
Stage VI	Normal

Technique for subscapularis release

The patients were placed in the lateral decubitus position. The affected shoulder and trunk were prepared to the mid-line anteriorly and posteriorly. A longitudinal incision was made along the lateral border of the scapula, and dissection was performed down to the latissimus dorsi muscle, which was retracted inferiorly, and the inferior angle of the scapula was identified and stabilized using towel clips. The subscapularis muscle is readily identified and elevated in its entirety from the anterior surface of the scapula by electrocautery or using a periosteal elevator.

Dissection was then performed in a subperiosteal manner, progressing from the inferior angle upward. An external rotation force was applied gently on the humerus throughout the release to confirm adequate release of the muscle and elimination of contracture. Care must be taken to avoid injury of the subscapular artery and nerve running anteromedial to the glenoid neck, anterior to the subscapularis muscle, and over the scapular notch. After complete release of the subscapularis muscle, the wound was closed over a suction drain.

Technique for tendon transfer

The patient was placed in the lateral decubitus position, with the arm abducted 120° and externally rotated. A curved, wide, C-shaped incision was made along the lateral border of the scapula and posterior margin and deltoid, 2–3 cm posterior to the posterior axillary fold to avoid a tethering scar. After dissection of the deep fascia, the tendons were identified, and the latissimus dorsi tendon was released at its insertion at the proximal humerus. In our study, the tendon of latissimus dorsi was thin and weak in three patients (<2 years of age), in whom the transfer of the latissimus dorsi was augmented by terse major muscle transfer as described by Edward *et al.* [14].

To avoid injury of the neurovascular bundles, care was taken to avoid excessive dissection on the under surface of the latissimus dorsi and teres major. The interval between the posteroinferior margins of the deltoid muscle and the rotator cuff was then developed, and with the arm maximally abducted and externally rotated, the released tendons of teres major and latissimus dorsi were sutured as superior as possible to the infraspinatus tendon. We kept in mind that the tension of the transferred tendons should keep the arm slightly abducted and externally rotated.

On completion of the operation, the arm was held in the appropriate position and a plaster body jacket, prepared before the operation, was applied, above which an elbow cast was applied and attached to the body jacket with the shoulder in 90° of abduction, with full external rotation and 20° of forward elevation to take the pressure off the brachial plexus. One month postoperatively, a splint was applied full time to maintain the arm in the abduction and external rotation position for 1.5 months, removing it only to bathe and for gentle range-of-motion exercises, which were initiated at 6 weeks. Thereafter, the patient was asked to wear the splint only at night for an additional 1.5 months, which was discontinued 6 months postoperatively (Fig. 2).

Statistics

Statistical analysis was carried out using the SPSS 17 program for Windows (SPSS Inc., Chicago, Illinois, USA). Results are expressed as mean ± SD for quantitative variables and percentages for qualitative variables. The paired *t*-test was used to determine the effect of surgery on shoulder motion.

Results

The follow-up period ranged from 24 to 62 months, with an average of 30 months. The mean shoulder abduction in all patients was improved from 85.9° (±18.9 SD) preoperatively to 132.0° (±18.7 SD) postoperatively. The mean shoulder external rotation in all patients was improved from −17.9° (±16.6 SD) preoperatively to 66.5° (±14.9 SD) postoperatively ($P \geq 0.001$). The mean improvement in external rotation of the shoulder was 84.4°; thus, the average gain in external rotation of the shoulder was 37%. The improvement in both abduction and external rotation was statistically significant (Table 3). On correlating age at surgery (in months) with improvement in shoulder abduction and external rotation postoperatively, we found a highly significant negative correlation ($P \geq 0.001$) between the age at surgery and average improvement in shoulder abduction and external rotation (Chart 1; that is, the greater the age at surgery, the lesser the improvement in shoulder range of abduction and external rotation; Figs 3 and 4).

The mean global Mallet score [12] improved from 7.1 ± 1.0 SD (range from 6 to 9) preoperatively to 13.2 ±

Figure 2

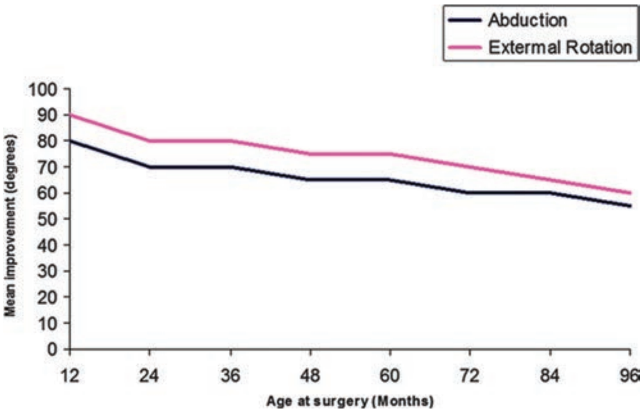
Some stages in the operative technique: (a) position of the patient; (b) posterior exposure of the tendons; (c) plaster jacket; (d) shoulder abduction splint.

Table 3 Preoperative and postoperative range of motion (abduction and internal rotation)

	Preoperative (deg.)	Postoperative (deg.)	Paired *t*	*P*-value
Mean abduction ± SD	85.9 ± 18.9	132.0 ± 18.7	15.3	≤0.001
Range	60–130	90–170		
Mean external rotation ± SD	− 17.9 ± 16.6	66.5 ± 14.9	17.14	≤0.001
Range	− 45 to 20	40–90		

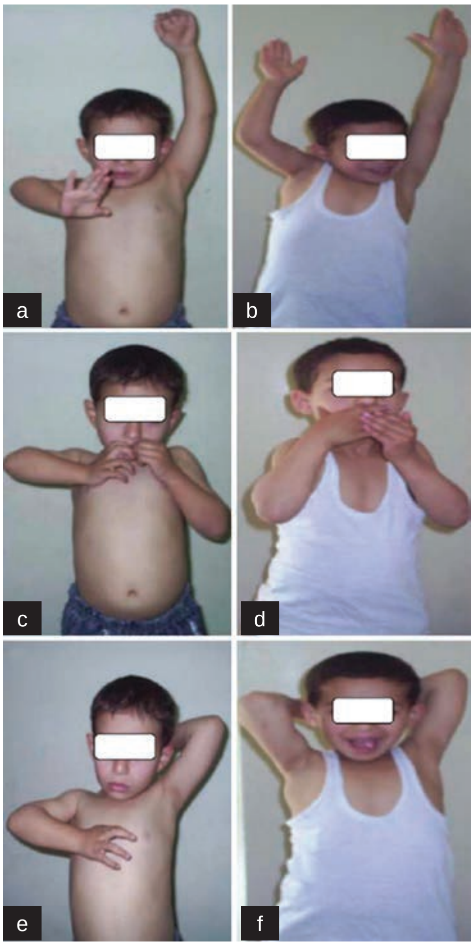
0.8 SD (range from 11 to 15) postoperatively. Of the patients, 29 had excellent scores, five had good scores, and none had poor scores postoperatively, whereas 30 had poor scores, four had good scores, and none had excellent scores preoperatively (Table 4).

Chart 1



The mean improvement in abduction and external rotation of the shoulder in relation to age.

Figure 3



Case no. 7: (a, c, e) preoperative range of motion; (b, d, f) movements of the same patient after 2 years of follow-up.

Follow-up CT scans of both shoulders were obtained 1 year postoperatively to measure the glenoid version and the degree of subluxation of the humeral head. On statistically correlating the relationship between the age at surgery and CT changes, we found a highly significant negative correlation ($P \leq 0.001$) between the age at surgery and glenoid retroversion (i.e. the greater the age at surgery, the higher the degree of retroversion of the glenoid; Figs 5 and 6); however, there was no

Table 4 Global Mallet score changes

	Preoperative	Postoperative	Paired *t*	*P*
Mean abduction ± SD	85.9 ± 18.9	132.0 ± 18.7	15.3	≤0.001
Range	60–130	90–170		
Mean external rotation ± SD	−17.9 ± 16.6	66.5 ± 14.9	17.14	≤0.001
Range	−45 to 20	40–90		

Figure 4

Case no. 9: (a, c, e) preoperative range of motion; (b, d, f) movements of the same patient after 2 years of follow-up.

significant correlation between the age at surgery and the degree of posterior subluxation or dislocation of the humeral head.

On successive CT scans, the development of the glenohumeral joint was characterized by the amount of glenoid version and the degree of humeral head subluxation in relation to the axis of the scapular spine. Preoperatively, the mean glenoid retroversion of the affected shoulder was 47.8° ± 8 SD (range,–60 to –35°) and the mean humeral head subluxation was 8.82 ± 7.7% (range, 0–25%). At the end of the follow-up period, the mean glenoid retroversion of the affected shoulder was −8.7° ± 2.5 SD (range, −10 to –6°) and the mean humeral head subluxation of the affected shoulder was 46.6 ± 1.3% (range, 45–49%). The mean improvement in the glenoid version was 39° (range, –60 to –35°; P = 0.012), and the mean improvement in humeral head subluxation was 37% (P = 0.03).

Complications

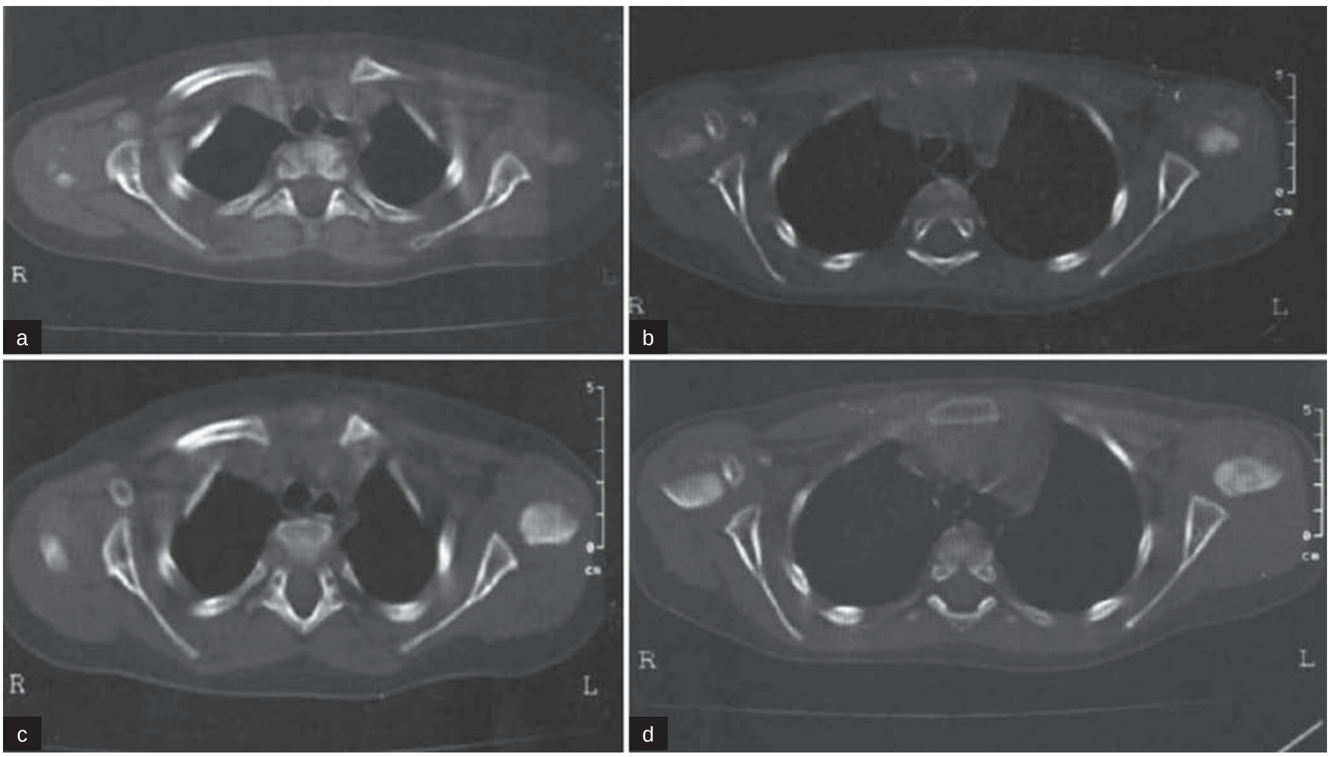
Loss of the last degrees of internal rotation occurred in 10 patients (29.4%), which was evident when the patient was asked to put his/her hand on his/her abdomen. However, this losscaused little functional impairment. One patient (0.3%) developed a keloid and an ugly scar. Superficial infection developed in one patient (0.3%); however, it was controlled with dressing and antibiotics. One patient showed postoperative recurrence of posterior dislocation and was treated by proximal humeral osteotomy.

Discussion

Posterior subluxation and dislocation occurs in about 20% of children with OBPP, and more than one-third of patients in groups 2 and 3 of the study by Narakas *et al.* [15] are affected. Internal rotation contracture is the most frequent and important secondary deformity of the shoulder in birth palsy. The problem is sometimes addressed by muscle release procedures such as the posterior subscapular slide or the anterior subscapularis tendon lengthening operation. Once passive external rotation is improved, the child is assessed for muscle transfers to re-establish active external rotation if necessary [16].

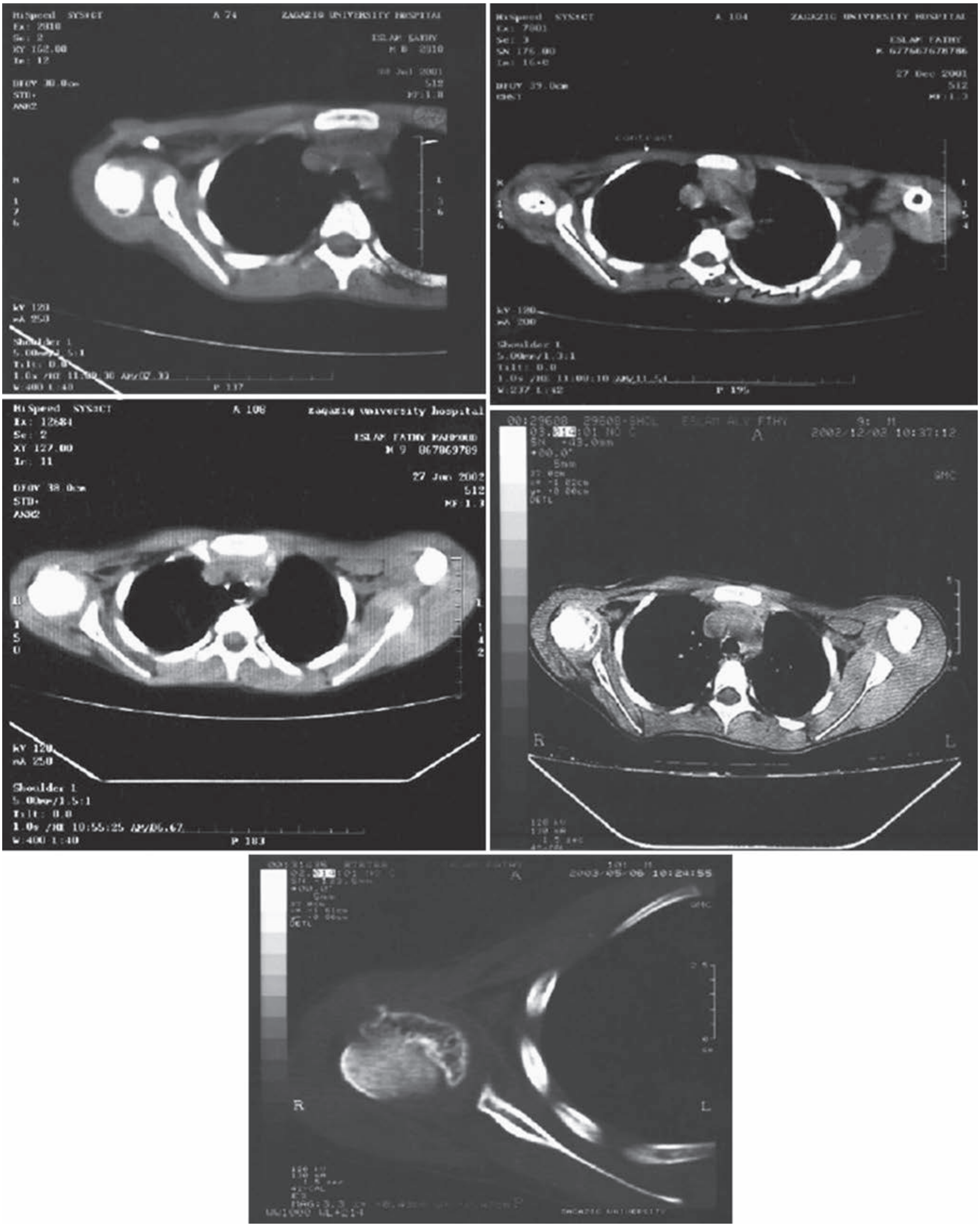
In this study, we observed good functional and clinical improvement on subscapularis muscle release with latissimus dorsi and teres major transfer. The mean global Mallet score [12] improved from 7.1 ± 1.0 SD (range from 6 to 9) points preoperatively to 13.2 ± 0.8 SD (range from 11 to 15) points postoperatively. Of the patients, 29 had excellent scores, five had good scores, and none had poor scores postoperatively, whereas 30

Figure 5



Computed tomography (CT) scans of patient no. 13. (a, c) Preoperative CT scans; (b, d) CT scans obtained 1 year postoperatively.

Figure 6



Serial computed tomography (CT) examination of patient No. 17. (a, b) CT scans obtained 6 months postoperatively; (c, d) CT scans obtained after 1 year of follow-up; (e, f, g) CT scans obtained after 3 years of follow-up.

had poor scores, four had good scores, and none had excellent scores preoperatively.

Some authors reported a decrease in the postoperative gain over 10 years of follow-up; the final values were still higher than those in untreated patients because of the greater loss of external rotation and deterioration in glenohumeral congruence [17].

Loss of external rotation and internal rotation deformity are

indications for surgery that involves releasing the subscapularis muscle first to restore the external rotation range [18]. Some authors have reported that tendon transfer of teres major and/or insertion of the latissimus dorsi into the proximal humerus or the infraspinatus muscle inhibits internal rotation but cannot recover significant basic active external rotation [9,10,13]. El-Gammal *et al.* and Chuang *et al.* added to this procedure lengthening of pectoralis major muscle 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 [19,20]. External derotational osteotomy of the humerus is indicated only when glenohumeral incongruence prevents recovery of adequate joint mobility [21,22].

Newman *et al.* [23], on follow-up of 13 patients with isolated subscapularis release for a mean of 4.7 years, reported results comparable with those obtained on associated tendon transfer. In this study, isolated subscapularis release gave poorer results: six of eight patients showed ER and modified Mallet scores below the mean values of the series as a whole, and two required surgical correction later.

The literature on the effect of the age of the patients at surgery on the final outcome was controversial. According to Waters *et al.* [16], tendon transfer surgery slows shoulder joint impairment and corrects glenoid retroversion and posterior subluxation. Van der Sluijs *et al.* [4] in an MRI study 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 deformities. They concluded that late deformities are due to muscle imbalance. Consequently, early correction of imbalance should successfully postpone the onset of bone abnormality [19,21]. In the study by Cohen *et al.* [3], patients over the age of 5 years showed lower ranges of external rotation and modified Mallet scores compared with younger patients.

Our findings are in agreement with this conclusion. In our study, we found a highly significant negative correlation ($P \leq 0.001$) between the age at surgery and glenoid retroversion (i.e. the greater the age at surgery, the higher the degree of retroversion of the glenoid). We also found a highly significant negative correlation ($P \geq 0.001$) between the age at surgery and the average improvement in shoulder abduction and external rotation (i.e. the greater the age at surgery, the lesser the improvement in the shoulder range of abduction and external rotation). In addition, we found that functional and clinical data, as well as reports from the scans, support the short-to-medium term benefit of this surgical indication.

Conclusion

Subscapularis release provided an objective functional benefit; however, it degraded over time. Teres major and latissimus dorsi to infraspinatus transfer is a useful procedure for correction of defective shoulder abduction and external rotation in OBPP. The basic advantages of this procedure over other tendon transfers are that it increases the stabilizing action of the rotator cuff, thus allowing the deltoid to act with maximal force; in addition, in this position it increases both shoulder abduction and external rotation and increases the lever arm of external rotation as the diameter of the head is larger than the diameter of the shaft.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Waters PM. Obstetric brachial plexus injuries: evaluation and management. J Am Acad Orthop Surg 1997; 5:205–214.

2 Pearl ML, Edgerton BW. Glenoid deformity secondary to brachial plexus birth palsy. J Bone Joint Surg Am 1998; 80:659–667.

3 Cohen G, Rampala V, Aubart-Cohen F, Seringea R, Wicarta P. Brachial plexus birth palsy shoulder deformity treatment using subscapularis release combined to tendons transfer. Orthop Traumatol Surg Res 2010; 96:334–339.

4 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; 83:551–555.

5 Waters PM, Smith GR, Jaramillo D. Glenohumeral deformity secondary to brachial plexus birth palsy. J Bone Joint Surg Am 1998; 80:668–677.

6 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; 70:571–576.

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; 81:649–659.

8 Clarke HM, Curtis CG. An approach to obstetrical brachial plexus injuries. Hand Clin 1995; 11:563–580.

9 L'Episcopo J. Tendon transplantation obstetrical paralysis. Am J Surg 1934; 25:122–125.

10 Hoffer MM, Wickenden R, Roper B. Brachial plexus birth palsies. Results of tendon transfers to the rotator cuff. J Bone Joint Surg Am 1978; 60:691–695.

11 Bennett JB, Allan CH. Tendon transfer about shoulder and elbow in obstetrical brachial plexus palsy. Instr Course Lect 2000; 49:319–332.

12 Mallet J. Paralysie obstétricale du plexus brachial. II. Traitement. Traitement des séquelles. Méthodes d'expression des résultats. Rev Chir Orthop 1972; 58 (Suppl 1): 166–168.

13 Gilbert A, Romana C, Ayatti R. Tendon transfers for shoulder paralysis in children. Hand Clin 1988; 4:633–642.

14 Edward 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; 20:375–379.

15 Narakas AO. Muscle transpositions in the shoulder and upper arm for sequelae of brachial plexus palsy. Clin Neurol Neurosurg 1993; 95 (Suppl): 89–91.

16 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; 87:320–325.

17 Guermazi M, Ghroubi S, Mezghanni M, Triki FE, Ellueuch MH. Suivi a long terme des epaules paralytiques obstetricales (a propos de 129 cas). Ann Readapt Med Phys 2004; 47:7–12.

18 Julia K, Terzis A, Zinon T, Kokkalis B. Primary and secondary shoulder reconstruction in obstetric brachial plexus palsy. Injury 2008; 39:S5–S14.

19 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*. 26; 2006. pp. 641–646.

20 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; 101:686–694.

21 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; 88:1035–1042.

22 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; 80:1477–1483.

23 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; 26:647–651.