Modified Hoffer technique for treatment of internal rotation deformity in obstetric brachial plexus palsy

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Introduction

In the Hoffer technique, the tendons of the latissimus dorsi (LD) and teres major (TM) muscles are transferred to the rotator cuff posterior to the long head of the triceps muscle, which significantly improves external rotation and abduction range of motion in the shoulders of children with obstetric brachial plexus palsy (OBPP) with internal rotation contracture.

Patients and methods

Ten children with OBPP C5/C6 pattern were included in the study and underwent simultaneous subscapularis recession and transfer of the LD and TM tendons to the rotator cuff through a single posterior incision. The age at the time of surgery ranged from 3 years and 3 months to 14 years and 1 month, with an average age of 7 years. The age at initial evaluation ranged from 1 year and 6 months to 9 years and 8 months, with an average of 5 years and 11 months.

Results

There was significant improvement in the degree of active shoulder abduction, from a mean 72° (range 40–90°) preoperatively to 136° (range 90–180°) postoperatively. The preoperative passive shoulder external rotation averaged from 78° (range 0–100°) to 64°. The postoperative active external rotation ranged from 0 to 90°.

Conclusion

Transfer of LD and TM tendons through a single incision to the rotator cuff significantly increases the degree of abduction and external rotation in children with OBPP having internal rotation contracture.

Keywords:

abduction and external rotation, Hoffer technique, obstetric brachial plexus palsy

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Introduction

Obstetric brachial plexus palsy (OBPP) is one of the most severe complications at birth. Although most children show favorable outcome after intense physical therapy during the early period, as age advances ∼10% of the children develop severe sequelae, including contractures and bone deformities that result from paralysis [1]. The most common residual weakness in neonatal OBPP involves the shoulder muscles [2].

Children with C5/C6 palsies usually have residual weakness of the rhomboid and serratus anterior muscles, which leads to winging of the scapula. This usually is an accepted functional deformity. More important is the weakness of the deltoid and external rotators that eventually causes internal rotation deformities in these children and can lead to dislocation of the posterior glenohumeral joint [3,4].

This deformity is caused by muscle imbalance around the shoulder and the dominance of the internal rotators [5]. In a small number of children, the primary neurological lesion may lead to the development of secondary structural deformities of the shoulder despite neurological improvement [6].

Different soft-tissue releases and transfers have been described, such as the release of the subscapularis and the capsule by Fairbank (1913), release of the subscapularis and the pectoralis major by Sever (1918), and transfer and insertion of the teres major (TM) and latissimus dorsi (LD) from the anteromedial to the posterolateral part of the humerus by an osteoperiosteal flap after release of the subscapularis, pectoralis major, and capsule [7].

The Hoffer technique involves the transfer of the LD and TM tendons through a posterolateral single incision across the lateral border of the scapula to the rotator cuff posterior to the long head of the triceps and recession of the subscapularis from the posterior end through the same incision instead of anterior incision to improve the degree of external rotation and abduction [5,8–10].

Patients and methods

This was a prospective study that included 10 children with OBPP C5/C6 pattern of injury conducted from March 2006 to November 2010 who were treated at the Department of Orthopedics, Pediatric Unit at Zagazig University Hospital. All children were evaluated using the

Table 1 Preoperative data and pathological lesion

Child	Sex	Age at initial evaluation (months)	Age at surgery (months)	Side affected	Specific injury	Follow-up (months)
1	Female	58	62	R	C5/C6	24
2	Female	77	80	L	C5/C6	33
3	Female	18	42	R	C5/C6	56
4	Male	168	169	L	C5/C6	12
5	Female	21	39	R	C5/C6	48
6	Female	139	149	R	C5/C6	12
7	Male	59	60	R	C5/C6	45
8	Female	79	88	L	C5/C6	45
9	Male	79	100	R	C5/C6	44
10	Female	34	72	R	C5/C6	45
Average		5 years 11 months	7 years			36.4

modified Gilbert system [11] and the modified Mallet classification. All children were treated with simultaneous subscapularis recession and by transfer of LD and TM to the rotator cuff through a single posterior incision. The study included three boys and seven girls, all above the age of 2 years. The age at the time of surgery ranged from 3 years and 3 months to 14 years and 1 month, with an average of 7 years. The age at initial evaluation ranged from 1 year and 6 months to 9 years and 8 months, with an average of 5 years and 11 months (Table 1).

Criteria for performing the surgery

The inclusion criteria were: OBPP in children above 2 years of age, having a functional elbow and hand, radiologically determined nondysplastic glenoid, functional LD and TM muscles, and supple range of motion around the shoulder joint. Preoperative physiotherapy was advised to all children in the form of a passive and active range of motion exercises [7].

Ten children with OBPP having the above-mentioned indications were included for management of internal contractures of the shoulders using the modified Hoffer technique by transferring the LD and TM to the rotator cuff and by recession of the subscapularis tendon.

Preoperative and postoperative active and passive range of motion, degrees of abduction, and external rotation were measured and recorded during shoulder abduction and external rotation, and Mallet scores (Fig. 1) were also determined. The degree of abduction was measured in the standing position, and external rotation was measured in the prone position with 90° shoulder abduction and 90° elbow flexion. Most of the time, preoperative physical examination revealed weakness of the deltoid muscle and external rotators and co-contraction of the pectoralis major, LD, and TM muscles at the anterior and posterior margin of the axillary fossa during shoulder elevation (Fig. 2; Table 2).

Figure 1

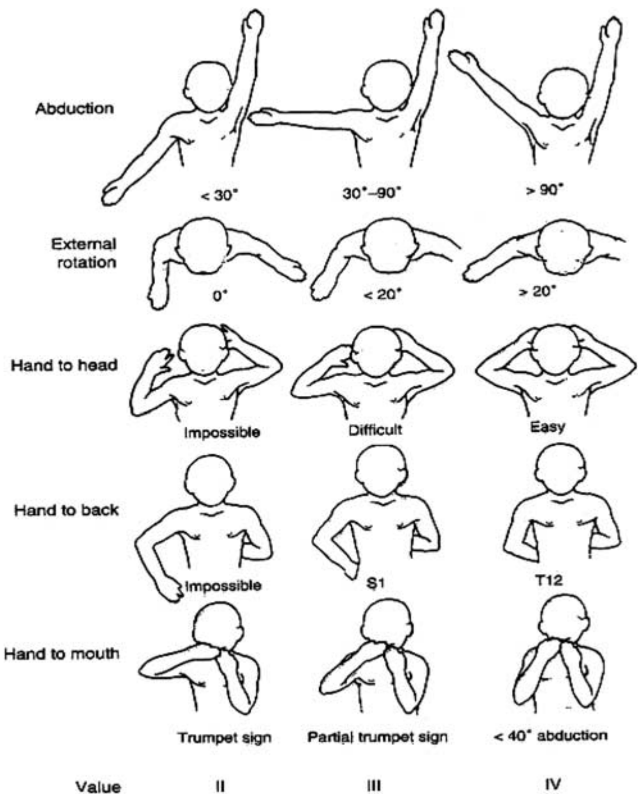


Illustration of the modified Mallet classification. A score of 1 represents no function and a score of 5 represents full function. Scores 2 through 4 have been shown. Values for global abduction, global external rotation, and hand-to-mouth ability are measured in degrees (Water and Peljovich [12]).

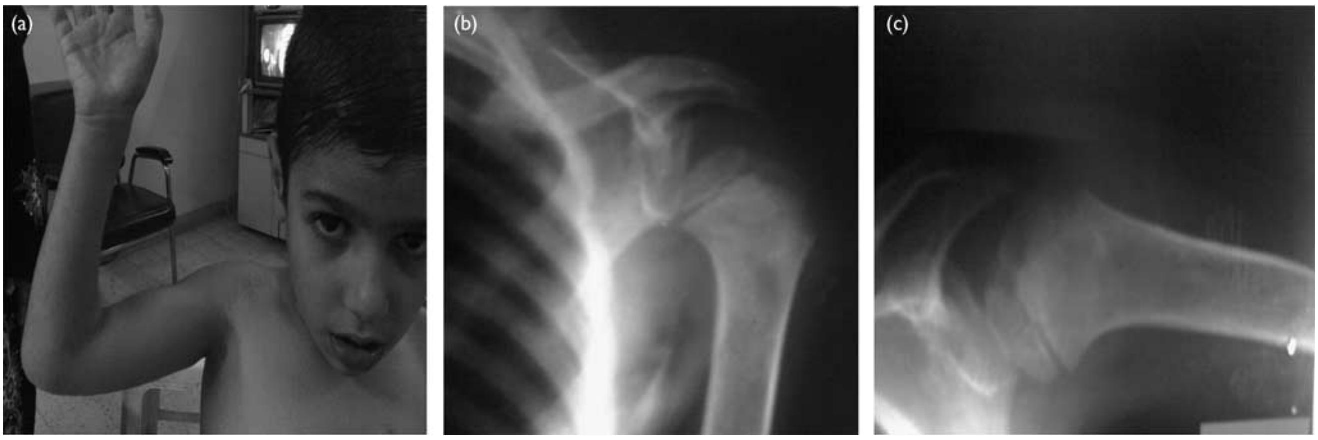
Technique

An incision is made from the inferior angle of the scapula to the axillary border proximal to the scapular spine, curving it posteriorly along the posterior aspect of the humerus. The interval between the long head of the triceps and posterior part of the deltoid muscle is explored, and recession of the subscapularis muscle through the same incision at its origin from the scapula is performed. This technique avoids anterior instability of the shoulder.

The LD and TM tendon (conjoint tendon) was dissected and stay sutures were applied and cut at its insertion near the bone and passed under the long head of the triceps muscle. A dissection was made in the interval between the posterior part of the deltoid and the rotator cuff, the infraspinatus muscle was split, the conjoint tendon was passed through the slit and sutured on itself while the shoulder was in maximum abduction and external rotation position.

The wound was closed in layers using absorbable sutures, and a shoulder spica was applied for all children while the arm was in maximum abduction and external rotation position.

Figure 2



(a) Preoperative range of motion in a child with a right-sided lesion. (b) Preoperative radiograph AP view. (c) Preoperative radiograph during abduction.

Table 2 Modified Gilbert system [11]

Stages	Function
Stage 0	Flail shoulder
Stage I	Abduction or flexion up 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

After 6 weeks, the spica was removed and a night splint was applied to maintain 90° of abduction and external rotation. Instructions were given to the child and the parents to use the arm within tolerable limits; passive movement of the arm by parents was forbidden. After 3 months, a well-programmed rehabilitation program was started by initiating passive abduction and external rotation exercises during the first 2 weeks, and then an active range of motions was started and the child was encouraged to use the affected side as he/she could.

The children were prospectively evaluated on the basis of preoperative active shoulder abduction and passive external rotation with the arm at the side compared with postoperative active abduction and active external rotation with the arm at the side (Fig. 3).

Results

All children showed improvement in the medial rotational deformity. Abnormal contour (asymmetry) of the shoulder deformity (posterior dislocation) showed improvement clinically. All children with clinical shortening showed an improvement from 1 to 1.5 cm in relation to the normal side (Fig. 4).

Marked improvement was observed in abduction and external rotation after the modified Hoffer technique. The children showed an improvement in active shoulder abduction from a mean of 72° (range 40–90°) preoperatively to 136° (range 90–180°) postoperatively. Preoperative passive shoulder external rotation improved from an average of 78° (range 0–100°) to postoperative active external rotation with an average of 64° (range 0–90°).

There were no neurovascular complications, and all wounds healed without infection. Keloid and scar formation was observed in one child and there was no recurrence of the previous deformity. The results are summarized in Table 3.

There was an association between age at the time of surgery (in months) and improvement in shoulder abduction and external rotation (postoperative range–preoperative range). The higher the age at the time of surgery, the less was the improvement in shoulder abduction and external rotation.

Loss of the last degrees of internal rotation occurred in 10 children (29.4%), which was evident when the child was asked to put his/her hand on his/her abdomen. However, this loss carried little functional impairment. Exercises performed by the parents, including holding the scapula against the ribs while flexing and internally rotating the arm, were generally useful in treating this deformity.

Keloid and ugly scar formation occurred in one child (10%). This is more common in dark skinned and older children. Superficial infection occurred in one child (10%); however, it was controlled with dressing and antibiotics. One child showed postoperative recurrence of posterior dislocation and was treated with humeral osteotomy.

Discussion

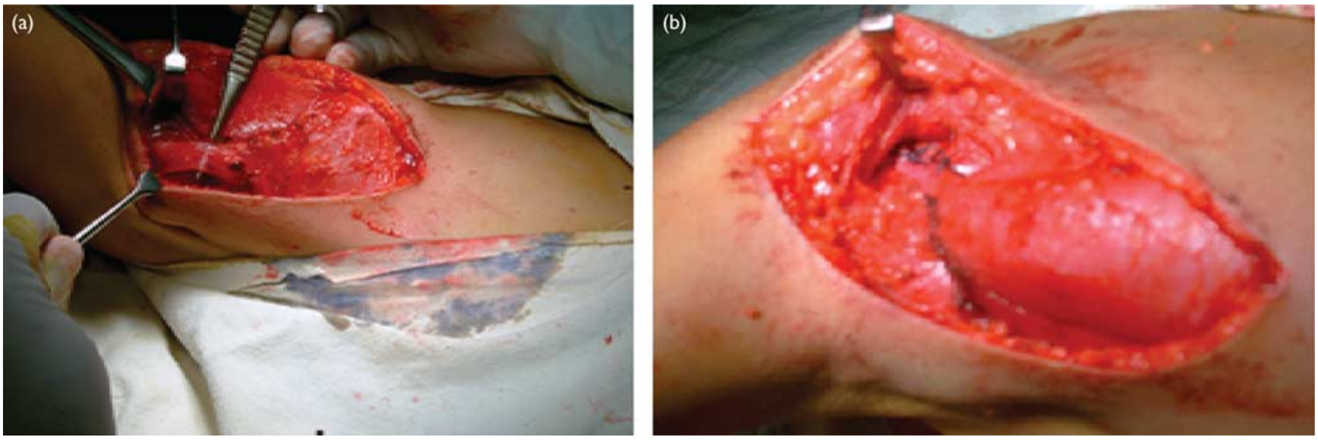
OBPP remains a great challenge despite the advances in obstetrical care, which lowered its incidence to around 1/1000 live births. OBPP commonly occurs in situations of difficult labor because of large baby, breech presentation, and shoulder dystocia [13].

There are many risk factors for OBPP, as reported by Gilbert and Birch. These include factors related to the mother and baby. From this study, we found that high birth weight and midwives performing the delivery were the most common risk factors. This observation coincides with the fact that occurrence of a birth lesion during breech delivery is severe and often bilateral; Birch *et al.* [14] reported a high incidence of preganglionic injuries, particularly of the higher spinal nerves.

A baby with high birth weight and born with cephalic presentation is at risk. Zancolli and Zancolli [15] reported that 90% of children with OBPP weighed more than 4 kg at birth (the mean birth weight was 4.55 kg). Gilbert reported a mean weight of 4.3 kg [16].

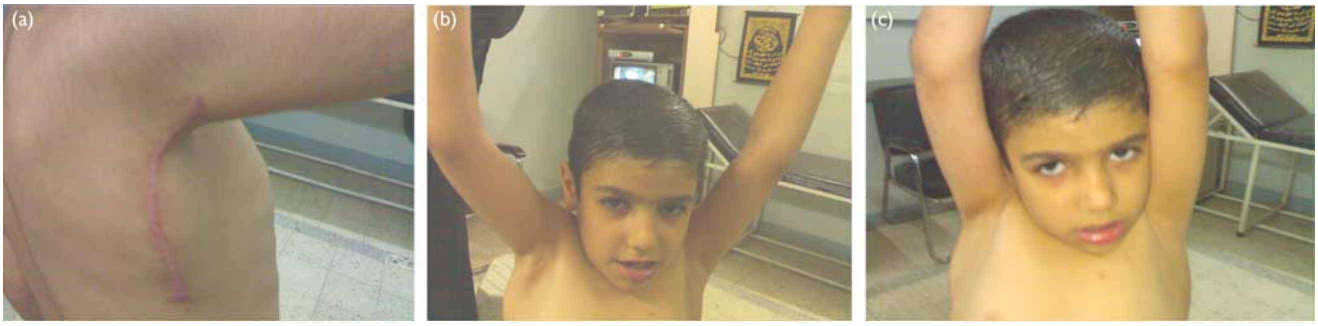
OBPP is subdivided into clinical types, the most common of which is Duchenne-Erb palsy, which affects the upper trunk and has better prognosis compared with total plexus palsy [17]. Complete recovery within the first year can be expected in about 75–90% of children [18]. However, incomplete recovery leads to residual deformity that may

Figure 3



(a) Tendon dissection. (b) Sutures to the rotator cuff muscles.

Figure 4



(a) Postoperative scar at the lateral edge of the scapula. (b) Postoperative abduction at 5 months. (c) Postoperative abduction at 9 months.

Table 3 Preoperative/postoperative range of abduction and external rotation

Child	Preoperative active abduction (degrees)	Postoperative active abduction (degrees)	Preoperative passive ER (degrees)	Postoperative active ER (degrees)
1	60	110	70	45
2	90	155	100	90
3	40	160	0	45
4	80	90	0	0
5	60	150	40	80
6	90	145	0	90
7	60	90	80	80
8	60	130	90	80
9	90	180	90	90
10	90	150	80	40
Mean	72	136	78	64

ER, external rotation.

affect the shoulder, elbow, wrist, or hand. Shoulder deformity in OBPP usually results from muscle imbalance around the shoulder and leads to weak shoulder abduction and external rotation, which causes dysfunction in daily living activities or recreational activities that require arm use above the level of the shoulder [16].

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 an anterior subscapularis tendon lengthening. Once passive external rotation is improved, the child is assessed for muscle transfers to reconstruct active external rotation, if necessary [19].

According to Chang *et al.* [20] there are two types of residual muscle impairment after recovery in OBPP: motor recovery with cross-innervation and paralysis or paresis. Contractures of the pectoralis major, TM, brachialis, and biceps muscles, which are most frequently observed, cause the deformity of the shoulder and elbow. The reconstructive strategy includes release of the antagonistic muscles (elongation of the pectoralis major and LD muscles) and augmentation of the paretic muscles (transfer of the TM to the infraspinatus muscle for augmentation of shoulder external rotation and abduction, and reinsertions of both ends of the clavicular part of the pectoralis major laterally for deltoid augmentation).

The importance of transferring the TM and LD as one conjoined tendon and anchoring it into the posterior aspect of the greater tuberosity at the insertion of the infraspinatus, similar to the Hoffer method, is augmentation of the weakened infraspinatus. Transfer using this technique instead of rerouting around the humeral neck enables a stronger external rotator power because of the increased mechanical advantage with its insertion into the humeral head as opposed to the humeral shaft. The reason for the dramatic improvement in shoulder abduction after latissimus muscle transfer is probably because the transfer enhances the stabilizing effect of the rotator cuff, which enables the deltoid to act more effectively; this phenomenon was called the 'force couple' effect by Phipps and Hoffer [9].

In many centers, muscle release procedures are performed before the age of 2 years; however, for older children, tendon transfer to restore abduction and external rotation is performed additionally [21]. It is accepted that the corrective procedures to rebuild the muscle equilibrium are best undertaken before permanent bony deformity occurs at the age of 3–4 years [22].

Gilbert *et al.* [16] suggested that release of the subscapularis is indicated if external rotation does not improve by more than 20°. On the basis of his 5-year follow-up, Gilbert reported excellent results after subscapularis release, especially in children younger than 2 years of age. Raimondi also anticipated improvement in active external rotation due to reinforcement of the weak external rotator muscles after subscapular muscle release during early age. However, as recovery of the external rotators cannot be expected, he preferred simultaneous tendon transfer and muscle release in children older than 4 years of age [23].

Muhling *et al.* [21] described a common policy accepted by most of the centers. According to this, if passive external rotation of the shoulder remains less than 30°, surgical treatment is indicated. If there is no posterior displacement of the humeral head, a subscapular slide will be used. However, if there is posterior displacement of the humeral head, subscapular lengthening using an anterior approach will be preferred. Indications for tendon transfer for improving external rotation and abduction have also been determined. If the infraspinatus muscle does not show signs of reinnervation by the age of 2 years, a muscle transfer should be performed in addition to the subscapularis lengthening procedure to avoid recurrence. If there is a fixed medial rotation contracture and posterior luxation of the humeral head with deformities of the glenoid, derotational osteotomy of the humerus should be performed in addition to subscapularis lengthening.

In completely flail shoulders, despite a certain degree of innervation, the functional results of the shoulders correspond to zero, with the absence of a strong LD. In such a condition, the levator scapulae muscle is utilized as an intrinsic stabilizer of the glenohumeral joint, and the trapezius muscle is used as a prime mover for shoulder abduction, with or without LD and TM transfers [23].

In Gilbert's series of 44 children with transfer of the LD, the improvement in abduction was satisfactory in the shoulders coded preoperatively as grade III (shoulder abduction between 90 and 120°, external rotation between 0 and 30°) or more but not in those coded grade II (shoulder abduction between 45 and 90°, external rotation to neutral) or less. Therefore, he thought it may be necessary to add a concomitant transfer of the trapezius in children whose abduction of the shoulder was weak or absent [24].

Chen *et al.* [25] asserted the need for an additional trapezius muscle transfer in shoulders of children who had abduction of less than 90° to increase the success of the classic LD and TM transfer. They transferred the LD by fixing its tendon to the insertion of the infraspinatus and tenotomized the TM; they then attached it to the belly of the LD and found out in their early stage of treatment that 10 of the 18 children with abduction less than 90°, who underwent transfer of the LD and the TM, achieved no improvement in terms of abduction but achieved some recovery in external rotation, whereas five of the seven children with abduction equal to or more than 90° made significant progress in both abduction and external rotation.

Al-Qattan [26] performed LD transfer on 12 children with variable preoperative shoulder abduction (range 60–150°, mean 100°); postoperatively 10 children achieved a modified Mallet score of 4 and were able to reach the occiput easily and had a mean active shoulder abduction of 140° (range 90–170°). Therefore, the author did not find any difference among the children with weak or strong preoperative abduction.

In the children included in our study, the co-contraction between the shoulder abductors (supraspinatus, infraspinatus, and deltoid) and adductors (mainly, pectoralis major, TM, and LD) and the tightness of the subscapularis muscle caused limitations in shoulder elevation. If the antagonistic muscles (TM and LD) are transferred to the paretic muscles (infraspinatus) and the subscapularis muscle is released by preserving their shoulder stability function, these children can experience successful postoperative shoulder abduction and external rotation similar to other children. The children in our study had a postoperative mean abduction of about 136° (range 90–180°) and mean active external rotation of 64° (range 0–90°).

Extensive dissection of LD and TM muscles from the surrounding structures gave us the opportunity to utilize both muscles for transfer without any difficulty during the passage of the conjoined tendon through the tunnel that was prepared between the long head of the triceps and deltoid muscle and also during reinsertion into the humerus.

Several authors have reported recurrences of the deformity in terms of reduction of external rotation and gain of abduction. Two of the 12 children in the study by Al-Qattan [26] and three of the 35 children in the study by Phipps and Hoffer [9] had recurrence of the deformity. Al-Qattan [26] classified the possible cause of this late complication as recurrence of the internal rotation contracture (mainly in the subscapularis), gradual contracture of the TM as part of the inferior glenohumeral angle contracture, and co-contraction of the muscles. There were no cases of recurrence of the deformity in our study during the follow-up period, which may be related to the use of rigid fixation with bone anchors for reinsertion of the conjoint tendon.

Conclusion

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 anterior subscapularis tendon lengthening. Once passive external rotation is improved, the child is assessed for muscle transfers to reconstruct active external rotation if necessary. We found that the children with obstetric palsy shoulder sequelae who had preoperative abduction degrees of less than 90° could also have good functional results similar to children who had preoperative abduction degrees equal to or more than 90°, with LD and TM muscle transfer and subscapularis muscle release. Transfer of the TM and LD to the infraspinatus is a useful procedure for correction of defective shoulder abduction and external rotation in OBPP. The basic advantage of this procedure over other tendon transfers is the increased stabilizing action of the rotator cuff, allowing the deltoid to act with maximal force.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Turker O, Atakan A. Reconstruction of shoulder abduction and external rotation in obstetric brachial plexus palsy. Acta Orthop Traumatol Turc 2004; 38:161–169.

2 Jacson St, Hoffer MM, Patrish N. Brachial palsy in the new-born. J Bone Joint Surg 1988; 70:1217–1220.

3 Troum S, Floyed WE, Waters PM. Posterior dislocation of the humeral head in infancy associated with obstetrical paralysis. J Bone Joint Surg Am 1983; 75:1370–1375.

4 Birch R, Bonny G, Wynn Parry C. Birth lesion of the brachial plexus injury. 8th ed. *Surgical disorders of the peripheral nerves.* London: Churchil Livingstone; 1998. pp. 689–691.

5 Waters PM, Peljovich AE. Shoulder reconstruction in patients with chronic brachial plexus birth palsy: a case control study. Clin Orthop 1999; 364:144–152.

6 Van Der Sluijs JA, Vanouwerkerk WJR, De Gast A, Nollet F. 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.

7 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; 20:375–379.

8 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.

9 Phipps GJ, Hoffer MM. Latissimus dorsi and teres major transfer to the rotator cuff for Erb's palsy. J Shoulder Elbow Surg 1995; 4:124–129.

10 Edwards TB, Baghian SBS, Faust DC, Willis RB. Results of latissimus dorsi and teres major transfer to the rotator cuff for in the treatment of Erb's palsy. J Pediatr Orthop 2000; 203:375–379.

11 Gilbert A, Whitaker I. Obstetrical brachial plexus lesions. J Hand Surg Br 1993; 16:489–491.

12 Water PM, Peljovich AE. Shoulder reconstruction in patients with chronic brachial plexus birth palsy: a case–control study. Clin Orthop 1999; 364:144–152.

13 Taggart M, Gidden GEB, Singh B. Risk factors for obstetrical brachial plexus palsies. J Bone Joint Surg 1994; 76:156.

14 Birch R, Bonny G, Wynnparry CB. Surgical disorders of the peripheral nerves. *Birth lesions of the brachial plexus*. London: Churchill Livingstone; 1998. p. P209.

15 Zancolli EA, Zancolli ER Jr. Palliative surgical procedures in sequelae of obstetric palsy. Hand Clin 1988; 4:643–669.

16 Gilbert A, Brockman R, Carlioz H. Surgical treatment of brachial plexus birth palsy. Clin Orthop 1991; 264:39–47.

17 Eng GJ. Brachial plexus palsy in new born infants. Paediatrics 1971; 84 **(I):** 18.

18 Adler JB, Petterson RL. Erb's palsy long time results of treatment in 88 cases. Bone Joint Surg 1967; 49A:1052–1064.

19 Al-Qattan MM. Classification of secondary shoulder deformities in obstetric brachial plexus palsy. J Hand Surg Br 2003; 28:483–486.

20 Chang 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 Muhling RS, Blaauw G, Slooff ACJ, Kortleve JW, Tonino AJ. Conservative treatment of obsterical brachial plexus palsy (OBPP) and rehabilitation. In: Gilbert A, editor. *Brachial Plexus Injuries*. London: Martin Dunitz Ltd; 2001. pp. 173–187.

22 Covey DC, Riordian DC, Milstead ME, Albright JA. Modification of the L'Episcopo procedure for brachial plexus birth palsies. J Bone Joint Surg Br 1992; 74:897–901.

23 Raimondi PL, Muse A, Saporiti E. Palliative surgery: shoulder paralysis. In: Gilbert A, editor. *Brachial plexus injuries*. London: Martin Dunitz Ltd; 2001. pp. 225–238.

24 Gilbert A. Obstetric brachial plexus palsy. In: Tubiana R, editor. *The Hand*. Philadelphia: WB Saunders; 1993. pp. 576–601.

25 Chen L, Gu Y, Hu S. 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; 18:275–280.

26 Al-Qattan MM. Latissimus dorsi transfer for external rotation weakness of the shoulder in obstetric brachial plexus palsy. J Hand Surg Br 2003; 28:487–490.