A subscapularis-preserving arthroscopic release of capsule in the treatment of internal rotation contracture of shoulder in Erb's palsy (SPARC procedure)

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The purpose of this study was to evaluate a minimally invasive subscapularis-preserving arthroscopic release of capsule in the treatment of internal rotation contracture of the shoulder due to Erb's palsy. We performed our procedure (subscapularis-preserving arthroscopic release of capsule) in 10 paediatric shoulders with an average age of 20.2 months and followed them for an average period of 41.5 months. All the patients were assessed clinically and radiologically preoperatively and postoperatively at regular intervals. The Mallet scoring system was used for analysing the results. The average gain in passive external rotation was 50°. The active internal rotation was preserved in all the cases. With the mid-term follow-up, there was no loss of the gained external rotation or the recurrence of internal rotation contracture of the shoulder. Our hypothesis has achieved its goal in preserving subscapularis, active internal rotation and treatment of internal rotation contracture of the shoulder. The success of this procedure lies in the early identification of starting of internal rotation contracture and early surgical intervention to prevent progressive permanent glenohumeral osseocartilaginous deformity. *J Pediatr Orthop B* 21:469–473 © 2012 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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Introduction

Erb's palsy has been well studied and documented since Hippocrates' period. Internal rotation contracture of the shoulder is seen in 25% of Erb's palsy [1,2]. It is important to understand the nature of starting of the pathology of internal rotation contracture of the shoulder. Muscular imbalance between the weak external rotators (due to C5, C6 +/− C7 involvement) and the strong internal rotators forms the basis of deformity [3–5]. The consequence of progression of the internal rotation contracture into glenohumeral deformation is well studied. The continued position of internal rotation during infancy will lead to starting of the glenohumeral deformity as early as 6 months of age and is progressively well established by 2 years of age. This is characterized by increased glenohumeral retroversion and posterior subluxation [6–9]. Around a century back, Fairbank [10] and Sever [11] proposed capsulo-tenotomy of subscapularis. Carlioz and Brahimi [6] introduced the concept of proximal muscular release of subscapularis from the scapula. All these early described procedures [12,13] release internal rotator muscles of the shoulder and transfer muscles to improve active external rotation. More recently, Pearl [14,15] published arthroscopic tenotomy of the subscapularis and anterior capsular release with the loss of active internal rotation of the shoulder. Pedowitz *et al.* [16] also propose arthroscopic near-total subscapularis tenotomy with varying degrees of loss of active internal rotation. All known procedures in the literature described to date achieve active external rotation by sacrificing active internal rotation, by weakening of the subscapularis (tenotomy or muscle slide). We hypothesized that it is not required to sacrifice the subscapularis to achieve active external rotation and thus lose active internal rotation. We report our experience with a subscapularis-preserving arthroscopic release of the capsule (SPARC procedure) in the treatment of internal rotation contracture, to preserve active internal rotation and to improve active external rotation by simultaneous latissimus dorsi muscle transfer.

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Materials and methods

During the period from 1999 to 2008, 16 paediatric shoulders were operated for internal rotation contracture due to residual Erb's palsy. The internal rotation contracture was released arthroscopically and latissimus dorsi transfer to rotator cuff was performed (modified Hoffer procedure [13]). In case of arthroscopic release failure, classic open Carlioz procedure [6] with latissimus dorsi transfer [13] was carried out.

There were 11 unilateral cases involving C5, C6 roots and five cases involving C5, C6 and C7 roots. There were nine boys and seven girls. The average age of the children was 20.2 months (range 10–54 months). All were treated by

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functional rehabilitation from 3 weeks of life. In all the cases, an active and effective flexion of the elbow recovered between 3 and 6 months. No surgery for the nerves/plexus (neurolysis or neurotization) had been performed before or after the SPARC procedure.

A monthly clinical follow-up with recording of range of movements of both shoulders was carried out in all children. A combined movement of abduction and anterior flexion was measured while the child was playing. For rotation assessment, only the passive range was taken into account as it is difficult to quantify the active movements in children. Passive external rotation was measured preoperatively and postoperatively with the arm by the side of the body.

The Mallet classification has been shown to be a reliable instrument for assessing upper extremity function in children with brachial plexsus birth palsy [17]. These scores were recorded for age-specific patients who could comply with testing by verbal cueing or enticing [18]. Hence, the passive internal rotation here and other features were assessed using the Mallet score, which is different from the described original score [19] (Table 1). The SPARC surgical procedure was carried out when the passive external rotation was less than or equal to 0°.

Operative technique

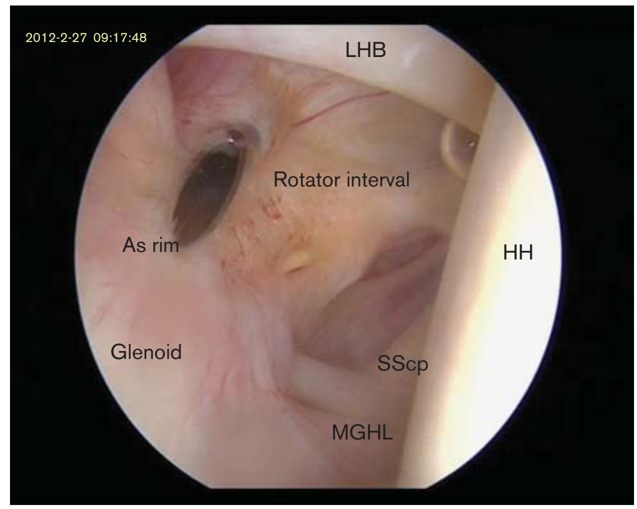
The passive mobility was reassessed under general anaesthesia in the supine position without any traction apparatus. Through the standard arthroscopic soft point posterior portal, the glenohumeral joint was visualized to assess the articulation. A 2.7-mm, 30° short arthroscope was used routinely for all the procedures. Dynamic arthroscopic examination of the shoulder joint was carried out and it was noted that on gradual external rotation of the shoulder, the glenohumeral (middle and superior) ligaments and the coracohumeral ligament (CHL) were tightened and doubled in internal rotation (Fig. 1). The capsular release was carried out at the foot of the corocoid process [20] using a standard electrode vapour introduced by a lateral portal (rotator interval) and continued by shaver (Fig. 2). The release was carried out to release the internal rotation contracture at the rotator interval till the lower portion of the superior glenohumeral ligament (SGHL). This is supplemented by release of the corocoid process insertion of CHL (Fig. 3).

At this stage, the gain in passive external rotation is assessed, and if it is not symmetrical to the other side, one can proceed to release the middle glenohumeral ligament. The tendon of the subscapularis and the inferior glenohumeral ligament are respected and left untouched. At this stage, the arthroscopic arthrolysis ends. In the second phase, the modified Hoffer's technique (double incision) of latissimus dorsi tendon transfer to the footprint of the supraspinatus tendon is performed in all the cases. The postoperative immobilization is by means of a plaster maintained in 90° of abduction and in maximum external rotation for 6 weeks. Rehabilitation is started as soon as the plaster is removed [(SDC), view supplemental video].

Table 1 **Measurement of internal rotation by the Mallet score (functional parameter)**

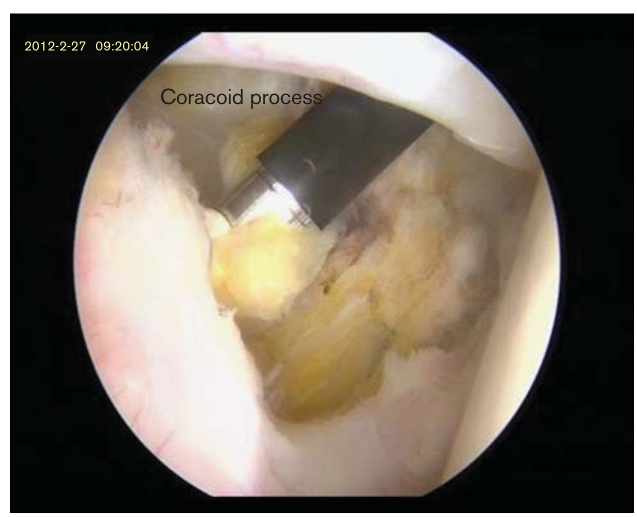
Hand to great trochanter	1 point
Hand to buttocks	2 points
Hand to L4	3 points
Hand to T12	4 points
Hand to T6 (normal)	5 points

Fig. 1



Limits of the rotator interval [see humeral head (HH), long head biceps (LHB) and glenoid]. AS rim, anterosuperior rim; MGHL, middle gleno humeral ligament; SScp, subscapularis.

Fig. 2

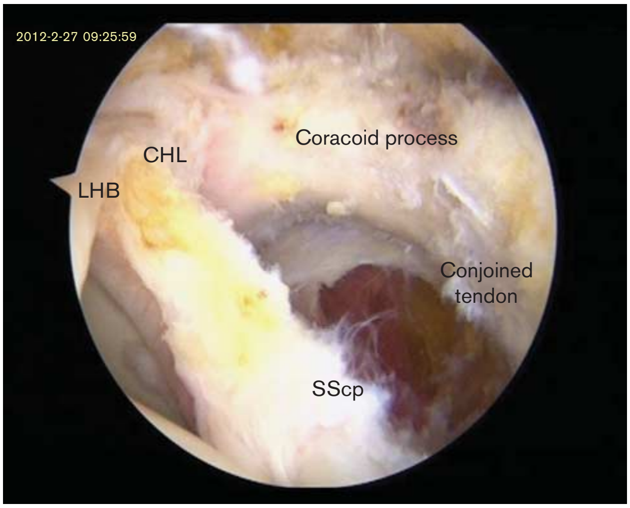


Intraarticular arthroscopic view during rotator interval release.

Results

The SPARC procedure failed for the two first cases in 1998 because of the learning curve. Four other cases had a posterior dislocation of the glenohumeral joint in

Fig. 3



Intraarticular arthroscopic view after rotator interval and coracohumeral ligament (CHL) total release (see coracoid process). LHB, long head biceps; SScp, subscapularis.

whom the SPARC procedure was not proposed. In these six cases, the classic open Carlioz procedure [6] with latissimus dorsi transfer were executed and excluded from this series.

In the remaining 10 cases, we performed the SPARC procedure, and they were assessed by the Mallet score [19] (Table 1). These 10 children were followed up for an average period of 41.5 months (12–59 months). The average preoperative external rotation was -11.5° (0 to -20°), the internal rotation according to Mallet's score was on average 2.3 points and the average abduction and forward flexion was $+62^\circ$ (50–90°). In the immediate postoperative period, the passive external rotation was $+65.5^\circ$ (60–70°), with an average gain of $+77^\circ$ (70–90°). On follow-up, the external rotation was $+54.5^\circ$ (45–80°), internal rotation remained unchanged and the gain in abduction and forward flexion averaged $+150^\circ$ (130–170°). No complications were observed in this series. There was no case of recurrence of internal rotation contracture even after 41.5 months follow-up.

Discussion

Internal rotation contracture of the shoulder is the most frequently encountered sequelae in Erb's palsy. Even though the neurological recovery is complete, one frequently finds some degree of limitation of external rotation. The internal rotation attitude persists and leads to early deformation of the glenohumeral articulation (dysplasia) gradually progressing to subluxation and finally posterior dislocation of the humeral head [7–9,21,22]. The frequency of glenohumeral deformities estimated in the literature ranges from 62 to 75% [21,22]. The earliest age at which the deformity can be recognized is 5 months and by the age of 2 years the deformities in persistent internal rotation contracture lead to glenoid retroversion and posterior humeral head subluxation [8,21].

Van der Sluijs *et al.* [21] in their MRI study on infants shoulder state that the glenohumeral deformations start at an age as early as 5 months. The deformity progresses with the age and the internal rotation contracture develops if passive external rotation is not maintained. Early surgical intervention rather than conventional treatment is advocated to prevent dysplasia.

Several surgical techniques are described to release the contracted soft tissue. Fairbanks in 1913 [10] noted that the section of subscapularis tendon, pectoralis major, associated with capsulotomy improved passive external rotation. However, this procedure also needs the release of conjoint tendon for adequate exposure of the shoulder joint. Sever in 1918 [11] noted a functional and aesthetic improvement in 60 patients after pectoralis major and subscapularis tendon section. L'Episcopo in 1934 [12] has noted recurrence in internal rotation contracture after Sever procedure, and proposed to transfer latissimus dorsi and teres major to the posterior humeral head to obtain active external rotation. Then, technical modifications were proposed by subscapularis muscle release from the scapula [6], tendon transfer of latissimus dorsi and teres major on top of the rotator cuff muscles associated with a section of pectoralis major tendon [13]. During these last 15 years, many authors noted that the L'Episcopo [12] technique more or less improved active external rotation and abduction of the shoulder in children, but there was loss of active internal rotation and sometimes even external rotation contracture on long-term follow-up. However, all these results confirm the need for a muscle transfer (latissimus dorsi and/or teres major) when there is paralysis of external rotators of the shoulder.

In most of the procedures, the external rotation is obtained by tenotomy, lengthening or release of subscapularis or pectoralis major muscles, which are the prime internal rotators of the shoulder. After the transfer of latissimus dorsi and teres major, there are no internal rotators of the shoulder left for active internal rotation, which can lead to an unstable shoulder after capsulotomy.

Strecker *et al.* [23] followed up 16 cases treated according to the L'Episcopo–Sever technique for 39 months and noted an average reduction in active internal rotation of 31°. The release of subscapularis muscle from the body of the scapula leads to recurrence of internal rotation contracture [23].

Ferrari [24] and Harryman *et al.* [25], following a cadaver study, showed that the internal rotation of the shoulder relaxes the rotator interval and capsuloligamentous structures, indirectly stating that they are the main restraints for external rotation.

Pearl [14] published the technique of arthroscopic section of capsule, rotator interval, middle and inferior glenohumeral ligaments along with subscapularis tenotomy. They also noted that isolated capsulo-tenotomy without latissimus dorsi or teres major tendon transfer has recurrence. In all these cases, there is diminished active and passive internal rotation.

The precise role of the release of the shoulder contracture in the care of children secondary to birth palsy, however, is complex and still in need of better clarity. Some authors recommend leaving the subscapularis intact, either entirely or at least at the insertion [13,26]. Others routinely recommended detaching the subscapularis tendon at its insertion through a large extensile approach [10,27]. It is also unclear as to which children should receive a muscle transfer in addition to a release at the primary operation. Furthermore, it is not well known as to which joint deformities have sufficient potential for remodelling and which joint deformities have a sufficient potential for remodeling and which do not [7]. In the face of these questions and disparate treatment protocols at various centres, arthroscopic release may offer a reasonable approach to this complex problem.

Rollnick *et al.* [28] in their study stated the use of botulinum toxin in the treatment of Erb's palsy in the biceps and triceps with satisfactory results and good increase in the elbow range of movement. Price *et al.* [29] injected botulinum toxin into the pectoralis major as a surgical adjuvant and concluded that the benefits that are sustained beyond the period for which the toxin is recognized to be active. They suggest that by temporarily weakening some of the power of the internal rotation, afferent signals to the brain are reduced and cortical recruitment for the injured nerves is improved. Prof. Gilbert (personal communication, May 2009, Paris) used botulinum toxin in the subscapularis muscle at 3- to 6-month intervals to improve the external rotation as a first method before subscapularis release.

Van der Sluijs *et al.* [30] performed open subscapularis release in 19 children. Eight developed a severe, functionally disturbing external rotation contracture of the shoulder. Pearl *et al.* [15] treated 41 children with arthroscopic release of the anterior capsule and subscapularis tendon. Eighteen of the children were treated by arthroscopic release alone and 23 children underwent concomitant tendon transfer. The procedure restored passive external rotation in 40 out of the 41 children and the remaining one child whose age was 12 years did not achieve external rotation because of advanced glenoid deformity. However, the status of glenohumeral deformity was not evaluated after surgery [14]. In another series, Pearl *et al.* [15] reported follow-up on the first 33 children who underwent arthroscopic surgery. Nineteen children (all $<$ 3 years of age) underwent isolated arthroscopic release and 14 children (mean age 6.7 years) underwent concomitant tendon transfer. Improved external rotation and minimal improvement in active elevation was seen in all children except in one child of 12 years. Four children (21%) who were treated with arthroscopic release alone required repeat surgery with an additional tendon transfer. There was substantial reduction of the internal rotation after surgery although it was not measured consistently before surgery. MRI follow-up at 2 years showed marked remodeling in 12 out of the 15 children with pseudoglenoid deformity. Release without tendon transfer should be a reasonable option of management for patients in this age group [15]. Pedowitz *et al.* [16] assessed the ability of arthroscopic release to reduce glenohumeral joint subluxation. Twenty-two children (average age 3.9 years) were treated by arthroscopic surgery with or without tendon transfer in whom MRI before and after surgery was analysed. The immediate improvement in glenoid version was primarily attributed to reduction of the humeral head from the pseudoglenoid onto the native glenoid and secondary to the fast remodeling and pliable cartilage [16]. In the series of Kozin *et al.* [18] an attempt was made to analyse MRI and clinical findings in 44 patients. They noted improvement in active and passive external rotation according to the Mallet score. The addition of tendon transfer at the time of the release was found to improve active elevation, but with some impairment of midline function. According to the MRI finding, the aligned joint requires botulinum toxin in the internal rotators and a dysplastic joint requires arthroscopic release. In children less than 3 years old, arthroscopic release is advised, and in older children, arthroscopic release and tendon transfer of latissimus dorsi and/or teres major is advised depending on the strength of the internal rotators [18].

Our technique is based on the Ferrari [24] and Harryman *et al.* [25] observations that CHL and capsule are the restraining structures in shoulder external rotation. Together with the SGHL, both form a 'cord-like' structure in external rotation. Neer *et al.* [20] concluded that CHL was maximally tightened in external rotation and sectioning it alone increased external rotation by 32°. We agree in principle that obstetrical brachial plexus palsy is a nerve injury, which eventually leads to neuromuscular secondary effects. However, the secondary effects are thought to start in the ligamentocapsular tissue and hence an early release of these tissues will restore the external rotation. Our assumption is that the subscapularis muscle is not pathological to start with. The deforming force in the early stage is the ligamentocapsular structures, the early release of which will restore passive external rotation. The muscle transfer (latissimus dorsi) will restore active external rotation. The subscapularis section is unnecessary in the early stages (as soon as the external rotation is 0° in neutral position of the shoulder). SPARC as an isolated procedure may not be completely effective in cases with posterior dislocation of the glenohumeral joint. In these situations, a more extensive release of the subscapularis and the pectoralis major may be required to correct the internal rotation deformity [31] or a partial release of the subsapularis as described by Kozin *et al.* [18] to preserve the internal rotation.

Dynamic assessment can be performed by the arthroscopic procedure, for a more precise identification of CHL, SGHL and middle glenohumeral ligament, to 'à la carte' (as much as required) release. This procedure can be repeated for revision without much difficulty or scar tissue unlike open techniques. The early results of this procedure have been promising in achieving the goals of active external rotation with preservation of active internal rotation; however, we are looking forward to the long-term outcome too. These results are confirmed by the recent publication of Mehlman *et al.* [32].

The limitation of this procedure is the learning curve of the surgeon as the number of paediatric shoulder arthroscopies is very few to this date. The success of this procedure is entirely dependent on early diagnosis (as soon as the passive external rotation is 0° with the arm side to the body) and early intervention, which makes the procedure less invasive. It may prevent permanent glenohumeral deformation, which is not always reversible.

Conclusion

Our SPARC procedure addresses the primary pathology to start with, that is, the capsuloligamentous structures, and can be performed by arthroscopy. This procedure preserves the subscapularis and in turn the active internal rotation, thereby decreasing the risk of glenohumeral instability indirectly. Subscapularis-saving procedure improve the function of the shoulder in day-to-day activities by allowing the child to reach midline. The success of this procedure lies in the early identification of the internal rotation contracture and early intervention to prevent permanent glenohumeral deformation.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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