Case Report

Staged Shoulder and Elbow Reconstruction in a Child with Obstetric Brachial Plexus Palsy: Six-year Follow-up

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Abstract

The management of obstetric brachial plexus palsy (OBPP) can be challenging, particularly in neglected patients. We report the long-term results of the surgical management of a late-presenting adolescent girl with severe left shoulder and elbow flexor paralysis secondary to OBPP. She was subjected to staged shoulder and elbow reconstruction in the form of trapezius transfer and latissimus and teres major transfer to enhance shoulder abduction and lateral rotation, and flexor-pronator transfer to the anterior distal humerus to enhance elbow flexion. Flexor-pronator plasty was successful in restoring elbow flexion and function and maintaining joint stability in the long term in a patient with severe OBPP. This further consolidates its role as a feasible secondary reconstructive procedure in carefully selected patients with elbow flexor paralysis. Shoulder function improved less remarkably, yet it augmented the overall upper extremity function and correlated with pre-operative residual shoulder function. Fulfilling the candidacy for each surgical procedure is important to a successful outcome.

Keywords: Birth injuries, elbow tendon transfer, neonatal brachial plexus palsy, obstetric paralysis, Steindler flexorplasty, trapezius muscle transfer

Introduction

Obstetric brachial plexus palsy (OBPP) is a fairly common disorder in paediatric orthopaedic practice. A considerable percentage of patients recover spontaneously with the aid of regular exercise and physical therapy.[1] Unlike other birth injuries as isolated clavicle fractures whose prognosis is satisfactory, permanent residual sequelae can arise from OBPP.[2] Primary neural reconstruction has been used to improve upper extremity function. The ulnar-to-musculocutaneous nerve transfer has particularly been used to restore elbow flexion at an early age.[3] If primary nerve repair fails to restore adequate extremity function, secondary bone and tendon reconstructive procedures come into play.[2] Nevertheless, the majority of these secondary reconstructive procedures address shoulder and hand dysfunction in OBPP.[2] Unsurprisingly, literature on secondary elbow reconstruction in OBPP is relatively scant, especially long-term studies. Despite being uncommon, loss of elbow flexion in specific impacts function and quality of life of patients.[4] Steindler flexorplasty entails the transfer of the flexor-pronator origin to a more proximal position, thus enhancing its flexor moment across the elbow joint. Steindler flexorplasty has been used successfully to restore elbow flexion loss in children with OBPP[5,6] amongst other neuromuscular disorders.[7,8] Microsurgical free and other pedicle muscle transfers as gracilis and pectoralis major have also been employed to restore elbow flexion in OBPP children.[9,10] They represent an alternative to Steindler flexorplasty. However, their use is highly dependent on surgeon volume, technical resources, degree of elbow paralysis and availability of local muscle donors.[9,10]

Steindler flexorplasty is more suited to severe paralysis with complete loss of elbow flexion.[6] Apart from mastery of the surgical technique of Steindler flexorplasty, careful patient and disease selection criteria remain critical to the overall success and appreciable patient gains.[5,6] The presence of an associated shoulder paralysis, especially of abduction

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and lateral rotation, increases the management challenges. In general, the Hoffer procedure, in which shoulder internal rotators are transferred to the shoulder abductors and lateral rotators, has shown satisfactory functional results in the long term.[11,12] However, more pronounced or near-total loss of abduction and lateral rotation may necessitate the addition of a supplementary procedure, namely, trapezius transfer.[13,14] The objective of this study was to retrospectively report the clinical and radiological long-term outcomes of staged shoulder and elbow reconstruction in an adolescent with OBPP. In this, we report the outcomes of elbow flexorplasty and shoulder trapezius transfer associated with rotator cuff transfer over a 6-year period.

Case Report

A 6-year-old girl presented with an inability to use the left upper extremity and bring the hand to mouth dating since birth. She had previously undergone physical rehabilitation without success. She had an unremarkable medical history. Examination revealed a near-flail left shoulder. Wasting of the shoulder girdle musculature was noted with prominent bony prominences. The patient was able to initiate indirect – pendulum and swinging – shoulder movements through swaying of her trunk. According to the Medical Research Council grading system,[15] examination of her left elbow flexion revealed no active contraction, namely, (grade M0) paralysis [Figure 1]. Active elbow extension against gravity and resistance was demonstrated but with reduced strength (grade M4+). She had complete forearm rotation and normal hand function. There were neither associated contractures nor sensory abnormalities nor pain. Active shoulder protraction against resistance was possible indicating that the trapezius muscle was intact. Based on the above findings, the patient was scheduled for staged shoulder and elbow reconstruction. The shoulder reconstruction or the first stage included trapezius muscle transfer supplemented by a Hoffer procedure, namely, transfer of the latissimus dorsi and teres major to the infraspinatus tendon. The elbow reconstruction or second stage included a Steindler flexorplasty, namely, proximal transfer of the common flexor origin to the anterior surface of the distal humerus. The two stages were performed 9 months apart. The CAse REport guidelines checklist was adopted https://www.care-statement.org/checklist.

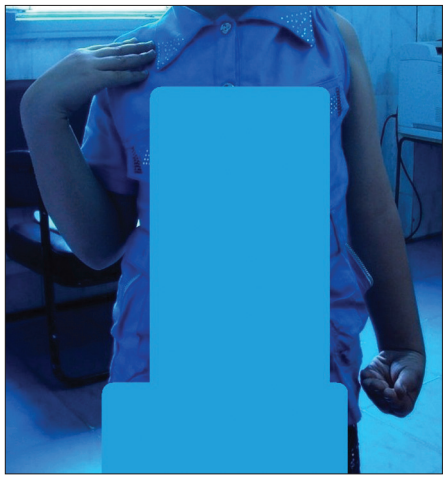


Figure 1: Pre-operative clinical photo of the patient. Note the complete inability to actively flex the elbow, whereas the ipsilateral wrist shows active flexion

Surgical technique

The technique of trapezius transfer to the proximal-lateral surface of the humerus was performed in accordance with Saha, in 1967.[16] Trapezius transfer was performed before the Hoffer procedure which entailed a combined transfer of the latissimus dorsi and teres major to the lateral rotator cuff, namely, infraspinatus. The deltoid was freed from its acromioclavicular and scapular spine attachments. The trapezius with its acromioclavicular insertion was mobilized bluntly towards the root of the neck to gain sufficient length. It was then secured to the proximal humerus by two 4-mm cancellous screws after positioning the shoulder in 90° of lateral rotation and 120° of abduction. A shoulder spica cast was applied in the aforementioned position for 7 weeks.

The technique of elbow flexorplasty was performed as follows. A curvilinear incision was made over the anterior-medial distal humerus and extended to the medial aspect of the proximal forearm passing just anterior to the medial epicondyle. After the division of the subcutaneous tissue, the ulnar nerve was identified and retracted. The biceps brachii tendon was palpated, and the median nerve was identified and retracted, thus protecting the vascular structures just lateral to it. The flexor-pronator tendon was identified as it inserts into the medial epicondyle which was exposed subperiosteally and osteotomised so as to leave a bone fragment of roughly 2 cm width × 2 cm thickness. The flexor-pronator mass was freed and mobilised so as to allow for transfer proximal to the elbow. The atrophied brachialis muscle was divided, and the anterior-medial surface of the distal humerus was exposed subperiosteally [Figure 2a-d]. A point on the mid-anterior distal humerus – approximately 5 cm above the elbow joint line – was chosen to reattach the osteotomised fragment of the medial epicondyle with the donor flexor-pronator mass. A small fragment screw was taken over a washer and through the pre-drilled medial epicondyle fragment and humeral cortices at the above-noted point without being fully tightened. The desired tension in the transferred flexor pronator mass was obtained by suspending the forearm freely so as to achieve an elbow flexion angle of 90°. The final threads of the screw were advanced around the washer. The ulnar nerve was relocated and stabilised by suturing the capsular remnants around it. The patient was placed in an above-elbow posterior slab – spanning the wrist – at 110° of elbow flexion and neutral rotation for 6 weeks.

Post-operative rehabilitation

Following the removal of the shoulder spica, the patient underwent a post-operative rehabilitation programme that consisted of gradual assisted active, active and resisted active exercises aimed at strengthening and re-educating the

transferred trapezius to act as a shoulder abductor. Moreover, it aimed at strengthening and re-educating the transferred latissimus and teres major to act as abductors and lateral rotators. The patient was provided with a removable shoulder abduction and external rotation brace − 90° ×90° – to use in between rehabilitation sessions for 3 weeks and then at night time for another 3 weeks. Following the removal of the elbow posterior slab, the patient was subjected to a post-operative rehabilitation programme that included gradual assisted active, active and resisted active exercises aimed at strengthening the elbow flexor moment of the transferred/donor flexor-pronator mass. Initially, no attempt was made to correct the last 20° of the elbow extension passively.

Results

At 1-year follow-up, the patient achieved minimal (~20°) active combined shoulder and scapulothoracic abduction against gravity. Overhead activities of daily living were not possible without assistance. She achieved 80° of active shoulder lateral rotation against gravity. She achieved the full range of the arc of active elbow flexion against gravity. In addition, she was able to achieve slightly less than half the range of active elbow flexion against gravity and resistance (M4-). Consequently, hand-to-mouth reach, dressing and self-care amongst other related activities of daily living were possible independently. Lifting heavy objects was though problematic. The patient retained the pre-operative full and passive range of elbow flexion-extension motion (no elbow extension loss). Furthermore, she neither developed secondary contractures of the wrist and digital flexors nor did she develop weakness of the hand grip strength.

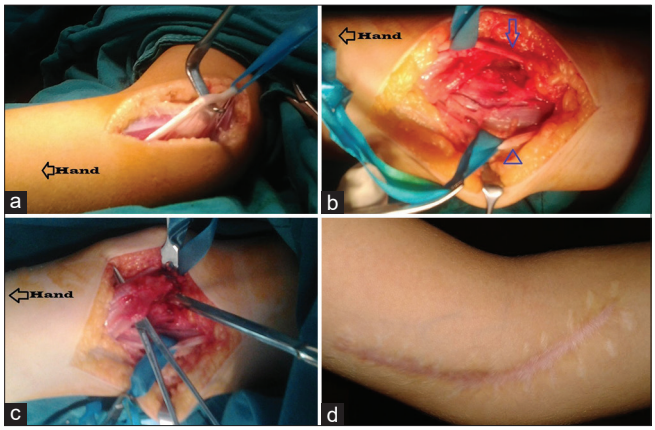


Figure 2: Operative procedure of left elbow reconstruction, Steindler flexorplasty. Incision, identification and retraction of the ulnar nerve (a). Note the identification and retraction of the ulnar (triangle) and median nerve (arrow) and the atrophic brachialis with surrounding fibro-fatty tissue in between (b). Mark the preparation for osteotomy of the medial epicondyle fragment with the origin of the flexor-pronator mass (c). Mark the curvilinear incision following wound healing (d)

All of the above-noted objective and functional gains plateaued at 1-year follow-up, in spite of receiving semi-regular rehabilitation therapy over the following years at the patient's home town [Figures 3a-c and 4a, b]. Nonetheless, these objective and functional gains were maintained at a 6-year follow-up. Final follow-up radiographs are shown [Figure 5a-c]. She did not experience pain, especially in relation to the resected lateral end of the clavicle, yet she experiences occasional tolerable discomfort. Apart from occasional tingling sensations of the lesser fingers, no troublesome ulnar nerve manifestations were experienced. There were no clinical or radiological indicators suggestive of elbow instability [Figure 6: Graphical abstract and study highlights in Supplementary Figure].

Discussion

Patient and deformity selection is a critical determinant in the success of shoulder and elbow reconstruction in children and adolescents with OBPP. This is because a multitude of factors must be taken into consideration, such as age, specific environmental or social context, functional and motor status of the adjacent joints/muscles, availability of donor muscles, surgeon expertise and so forth. In our patient, we predicted that a Steindler procedure would be successful in that she had a stable/non-dislocated shoulder, a normal hand grip and wrist extension, near normal elbow extension and importantly normal secondary elbow flexors or flexor-pronator mass. In this respect, we opted for shoulder



Figure 3: Post-operative clinical results at 1-year follow-up. Note the mild active abduction and marked improvement in lateral rotation of the left shoulder (a). And, full restoration of active left elbow flexion and hand-to-mouth reach (b and c)

reconstruction first. However, we acknowledge the average result of the shoulder reconstruction, that is, insignificant improvement in active shoulder abduction despite significant improvement in lateral rotation. This may be explainable by the near-total loss of pre-operative shoulder abduction. This corroborates the interpretation of Rühmann *et al*., in 2005, who attributed the inferior post-operative results of shoulder abduction following trapezius transfer to the originally poor pre-operative abduction or flail shoulders as opposed to patients who had considerable residual pre-operative abduction.[17] Although their study sample was overwhelmingly composed of adults with traumatic brachial plexus palsy that was subjected to isolated trapezius transfer – without latissimus transfer to lateral rotators – conceptual correlations could be drawn.[17] Unsurprisingly, Rühmann *et al*., in 2005, did not report improvement in the post-operative shoulder lateral rotation.[17] It is possible, at least in theory, that the point of insertion of the transferred trapezius into the humerus might have influenced its post-operative function – abduction versus lateral rotation. However, we assume that the transferred trapezius which is partially functioning as a shoulder abductor can at least improve the dynamic muscular balance across the shoulder, guard against or delay shoulder dislocation and disuse osteoporosis of the upper extremity. Provisionally, we believe that the patient is a good candidate for shoulder arthrodesis. We assume that this can put her elbow and hand at a functional advantage.

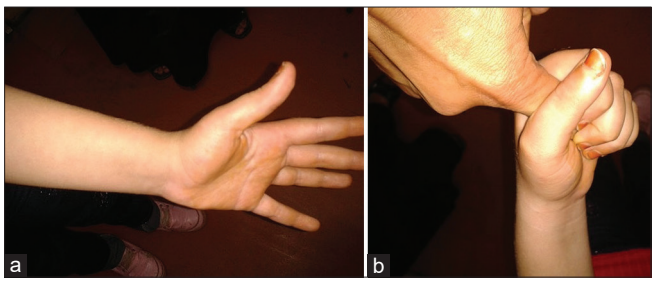


Figure 4: Post-operative hand function. Note the absence of digital flexor contraction of the ipsilateral hand (a) and maintained hand grip power (b)

The overall satisfactory outcome of our patient is consistent with the literature on reconstructive tendon surgery for loss of elbow flexion in OBPP, provided that there is careful patient selection.[5,6] Because the literature on combined shoulder and elbow tendon reconstruction is uncommon and not exclusively addressed, it is difficult to draw meaningful correlations.[2,13] The long-term follow-up of our patient further strengthens the results, especially respecting the absence of elbow instability. In the surgical technique, we were cautious not to compromise elbow stability by excessive bone resection of the medial epicondyle. Practically said, we resected/osteotomised enough bone to allow for secure fixation of the transferred medical epicondyle without compromising elbow stability. Standardised post-operative physical rehabilitation programmes within a multidiscipline context are crucial to optimise the outcomes of tendon transfer procedures in OBPP. In this respect, the overall outcome of our patient might have been influenced by the fact that she underwent the post-operative rehabilitation programme at a distant local facility with infrequent follow-up visits to our centre.

It is noteworthy that although elbow flexorplasty, as a form of secondary reconstructive tendon procedure, has been successful in restoring elbow flexion, some primary neural procedures performed in infancy may save patients more extensive (reconstructive) surgeries and guard against secondary bone and joint changes later on in life.[2,3] Therefore, multidiscipline management with the provision for early referral to hand or neurosurgical specialised centres and public health awareness programmes is of importance in the management of neonates and infants with suspected or confirmed OBPP.

Conclusions

Flexor-pronator transfer to the anterior distal humerus

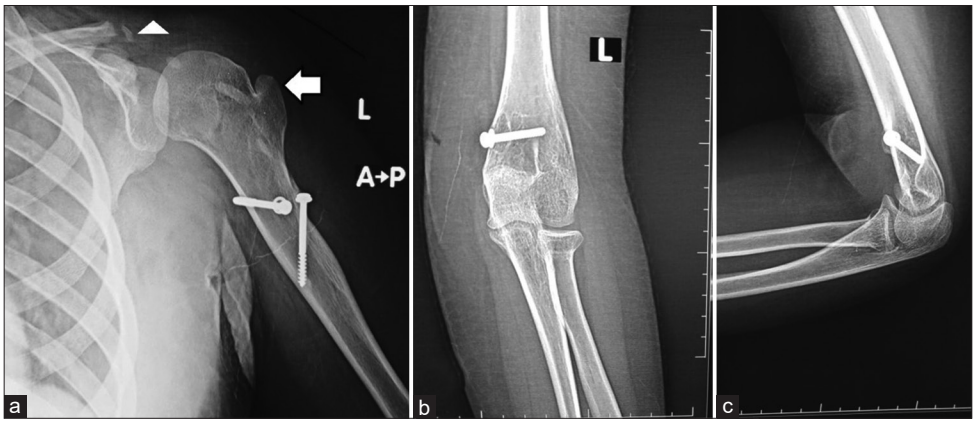


Figure 5: Post-operative radiographs at 6-year follow-up. AP view of the shoulder shows extensive bone remodelling of the transferred acromioclavicular fragment (arrow) induced by long-standing active pull of the re-educated trapezius (a). Note the distal migration of the screws used in initial fixation and the absence of inferior subluxation of the humeral head (a). Note also the resected acromioclavicular segment (triangle). AP view of the elbow shows the site of screw insertion in the distal humerus (b). Note the marked screw inclination in the lateral view presumably (c). Both views (b and c) show joint congruence

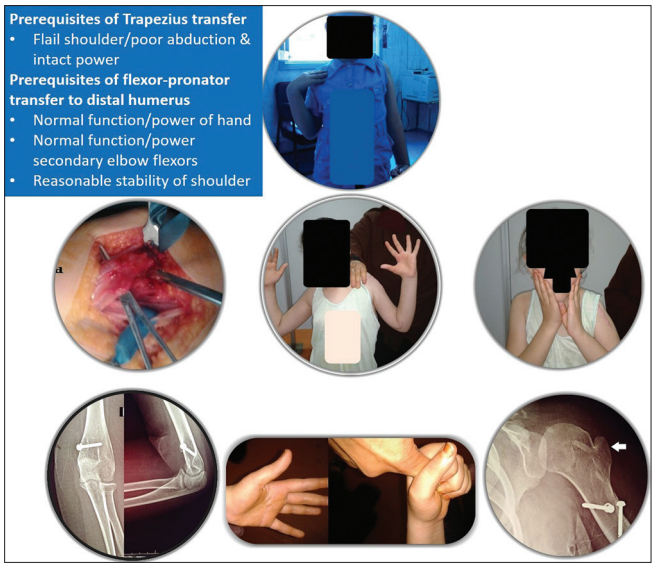


Figure 6: Graphical abstract: staged shoulder and elbow reconstruction in a child with obstetric brachial plexus palsy: Long-term results

was successful in restoring elbow flexion and function and maintaining joint stability in the long term in a patient with severe OBPP. This outcome further consolidates and strengthens the role of flexor-pronator transfer as a feasible secondary reconstructive option in carefully selected patients with elbow flexor paralysis following OBPP. In general, the outcome of shoulder reconstruction presumably correlates with the pre-operative residual shoulder function.

Supplementary files

Supplementary Figure 1, study highlights.

Ethical approval

The study was approved by the Medical Ethics Research Committee of Faculty of Medicine, Ain Shams University, FMASU R46/2023, and appropriate patient consent forms were obtained.

Data sharing

All data generated or analysed during this study are included in this published article and its supplementary information files.

Authors contributions

TAE designed the study. TAE, SSE and ASA contributed to data acquisition, analysis and interpretation. TAE wrote the manuscript. SSE and ASA revised the manuscript critically for important intellectual content and approved the version to be published. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the legal guardian has given his consent for images and other clinical information to be reported in the journal. The guardian understands that names and initials will not be published, and due efforts will be made to conceal the patient identity, but anonymity cannot be guaranteed.

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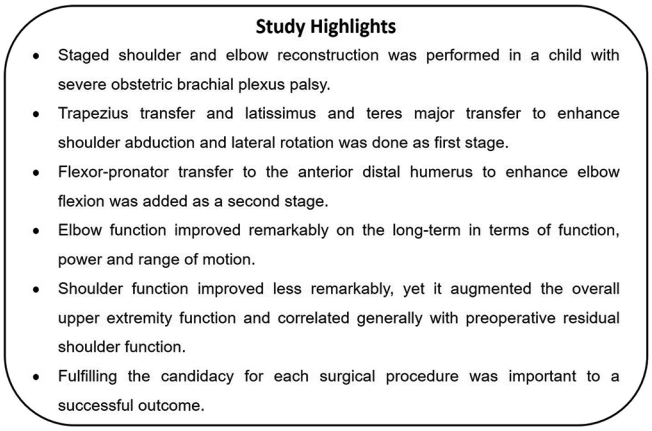
Conflicts of interest

There are no conflicts of interest.

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Supplementary Figure



Supplementary Figure 1: Study highlights: Staged shoulder and elbow reconstruction in a child with obstetric brachial plexus palsy: six-year follow-up