

# Evaluating the outcome of different reconstructive surgical options for the management of shoulder deformity following obstetrical brachial plexus injury due to Erb's palsy

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## ABSTRACT

**Background:** Obstetrical brachial plexus paralysis (OBPP) refers to an injury to all or part of the brachial plexus occurring at the time of delivery. Injuries associated with the upper brachial plexus are termed Erb's palsy, while those associated with the lower brachial plexus are referred to as Klumpke palsy. Obstetrical brachial plexus injuries are often associated with large birth weight and shoulder dystocia. **Aim:** This study aims to evaluate the outcomes of different secondary reconstructive surgical options for the treatment of OBPP. **Methods:** This prospective study was conducted at Basra General Hospital from October 2022 to November 2023. Sixty-eight patients (43 males and 25 females) were included, with 49 patients experiencing right-side involvement and 19 with left-side involvement. All patients had Grade 2 OBPP according to the modified Mallet score. Secondary reconstruction involved subscapularis release for 48 patients, derotation osteotomy for 12 patients with fixation using plates and screws, and tendon transfer for eight patients in the form of trapezius transfer to the upper humerus. **Results:** In the subscapularis release group, 42 out of 48 patients (87.5%) reported satisfaction with the surgical outcome, noting improvements in their ability to eat and drink. In the derotation osteotomy group, 11 out of 12 patients (81.7%) were satisfied with the result of surgery, while the trapezius transfer group expressed dissatisfaction with the surgical outcome. **Conclusion:** Subscapularis release surgery is suitable for early and flexible OBPP, yielding satisfactory results, while derotation osteotomy is appropriate for fixed OBPP in toddlers and older children, also demonstrating good results. Trapezius tendon transfer showed unsatisfactory outcomes.

**Keywords:** Obstetrical brachial plexus paralysis, derotation osteotomy, trapezius tendon transfer

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**DOI:** <https://doi.org/10.37319/ignim.7.1.16>

Received: 16 JUN 2024

Accepted: 18 OCT 2024

Published online: 15 JAN 2025

## INTRODUCTION

Every year in the United States alone, over 5,400 newborns suffer damage to their brachial plexus,<sup>1</sup> with an incidence ranging from 0.4 to 5.1 per 1,000 live births

worldwide.<sup>2</sup> Most patients with obstetric brachial plexus palsy experience improvement by the age of three months, with up to 92% showing recovery.<sup>3</sup> However,

recent research indicates a less encouraging recovery rate of between 52% and 83%.<sup>4</sup> In a study by Noetzel et al., 53 out of 80 patients (66%) achieved full recovery; however, shoulder contracture was a common consequence of obstetrical brachial plexus palsy.<sup>5</sup>

Therefore, patients who do not achieve sufficient shoulder function by three months of age should consider brachial plexus repair.<sup>6</sup> Spontaneous recovery typically favors the internal rotators and adductors, leading to lifelong shoulder abnormalities in cases of uncorrected upper plexus lesions (C5 and C6 roots, with or without C7).<sup>7</sup> Internal rotation contracture arises from paresis, or paralysis of the shoulder's external rotators and abductors, allowing the internal rotators and adductors to contract without resistance. Patients, when trying to bring their hands near their mouth, often exhibit the "trumpet sign"—a compensatory movement indicating limited shoulder mobility.<sup>8</sup> Significant functional impairment may eventually result from glenohumeral subluxation or posterior dislocation.<sup>9,10</sup> These abnormalities can be surgically corrected using various techniques, including bone surgeries and muscle releases and/or transfers.<sup>11</sup>

Shoulder deformities are less common in the global context of obstetrical brachial plexus palsy, as the arm is flaccid and in a neutral position when the upper roots are avulsed.<sup>12</sup> Pedicle and/or free muscle transfers have been employed in late cases and in patients whose shoulder function remained inadequate after nerve repair.

Therefore, to improve shoulder stability and function, patients with obstetrical brachial plexus palsy had secondary reconstructions in the present study. The aim was to: (1) evaluate the effects of several secondary surgeries in reconstruction cases and (2) determine which of these secondary procedures yields the best results for shoulder function.

## MATERIALS AND METHODS

This prospective study was conducted in the orthopedic department at Basra Teaching Hospital from October 2022 to November 2023. Sixty-eight patients (43 males and 25 females) with obstetrical brachial plexus palsy (established deformity) were included. Their ages ranged from 2 to 18 years (mean age: 10 years). Fifty-four patients had right-side involvement, while 14 had left-side (upper root C5 and C6) Erb's palsy. There was no history of primary reconstruction in any patient.

Patients were evaluated preoperatively based on prenatal, antenatal, and postnatal history; maternal medical history; physical examination results; nerve conduction studies; electromyograms; and radiographic evaluations of the shoulder to exclude fractures and dislocation.

All patients underwent physiotherapy in the physiotherapy department, which included nerve stimulation and muscle strengthening exercises for several weeks, followed by home exercises performed by their parents. All patients had Grade 2 brachial plexus palsy according to the modified Mallet score, a clinical tool used to assess shoulder function in patients with brachial plexus injuries. This score evaluates five key shoulder movements: abduction, external rotation, hand-to-mouth, hand-to-neck, and hand-to-spine. Each movement is scored from 1 (no movement) to 5 (normal function), providing an overall assessment of shoulder mobility and strength. This score aids in guiding treatment decisions and tracking functional outcomes post-intervention. The patients were divided into three groups according to the Modified Mallet score:

**Group A:** Forty-eight patients with early childhood (2–8 years) and flexible Erb's deformity treated by Fairbank (subscapularis release) operation.

**Group B:** Twelve patients aged 6–18 years with Erb's rigid deformity treated by derotation osteotomy.

**Group C:** Eight patients aged 6–12 years who underwent trapezius tendon transfer in the upper end of the humerus to improve shoulder abduction.

### Group A (Fairbank Operation)

The pectoralis major tendon was separated from the humerus via an incision on the anterior portion of the shoulder in the deltopectoral groove, extending distally from the tip of the coracoid process to a location distal to the tendinous attachment of the pectoralis major muscle. The anterior edge of the deltoid was retracted laterally, and the pectoralis major medially. The inferior edge of the subscapularis tendon at its insertion on the lesser tuberosity of the humerus was identified, raised, and separated. Capsular release was performed based on the degree of capsule contraction. The wound was closed without drainage. A plaster shoulder-spica cast was applied with the shoulder in a 90-degree position of abduction and full external rotation, the elbow flexed at 90 degrees, and the forearm in complete supination. Patients were hospitalized for one day before discharge.

### Group B (Derotation Osteotomy of the Upper Humerus)

An anterolateral incision was made between the deltoid and pectoralis major musculature. Osteotomy was performed distal to the joint while the arm was abducted. Under direct visualization, the distal portion of the humerus was externally rotated, and fixation was achieved with a plate and screws. A plaster shoulder-spica cast was put on with the shoulder in a 90-degree position of abduction and full external rotation, the elbow flexed at 90 degrees, and the forearm in complete supination. Patients were hospitalized for 2–3 days; they received antibiotics intravenously in the form of ceftriaxone before being discharged on oral antibiotics.

### Group C (Trapezius Tendon Transfer)

The deltoid was detached from its acromion connection. The upper table of the acromion was osteotomized. The remaining trapezius insertions into the clavicle and scapular spine were freed, and the proximal humerus by longitudinally dividing the deltoid. The rotator cuff remained undisturbed. The acromial segment with trapezius attachment was transferred and secured to the humerus with one or two 4.5 mm cortical screws while the humerus was abducted at 90 degrees. The deltoid was then sutured over the trapezius, and the skin was closed by utilizing suction drains. A plaster shoulder-spica cast was applied with the shoulder in a 90-degree position of abduction and full external rotation, the elbow flexed at 90 degrees, and the forearm in complete supination. Radiographs were obtained the following day to confirm the position of the screws and the acromial piece. Patients received intravenous antibiotics for 2–3 days before being discharged on oral antibiotics on the third postoperative day.

After three weeks, patients from all three groups were evaluated for signs of infection, such as fever, wound irritation, plaster sores, and for the removal of stitches. After six weeks, the gypsona was removed, followed by physiotherapy focusing on muscle strengthening and joint mobilization. Follow-up lasted three to six months, with reevaluation and reclassification of patients based on the modified Mallet score.

### Ethical Considerations

Informed written consent was obtained from all patients. All surgeries were performed under general anesthesia, and antibiotics (ceftriaxone, i.v.) were administered at the time of anesthesia induction and continued for 3–5 days postoperatively.

## RESULTS

### Patient Characteristics

Sixty-eight patients with upper obstetrical brachial plexus palsy were studied. Most patients were of the age of 2–10 years (79.4%). The operation was conducted on 43 males (63.2%) and 25 females (36.8%). Forty-nine patients (72%) had right-side involvement, while 19 patients (28%) had left-side involvement. (Table 1)

**Table 1: Patient characteristics.**

Parameter		Number	Percentage
Age (years)	2–10	54	79.4%
	11–18	14	20.6%
Sex	Male	43	63.2%
	Female	25	36.8%
Side	Right	49	72%
	Left	19	28%
Total		68	100%

### Possible Risk Factors

Table 2 outlines the distribution of patients according to potential risk factors for obstetric brachial plexus palsy. Among the 68 patients, only a minority 10 (14.7%) exhibited known risk factors. Large birth weight, previous birth with brachial plexopathy, breech presentation, and maternal diabetes each contributed to a small percentage of cases (ranging from 1.47% to 4.41%). The most frequent risk factors were prolonged labor and difficult delivery (4.41%) and diabetic mothers (4.41%). Notably, the vast majority of patients (85.29%) had no identifiable risk factors, suggesting that brachial plexus palsy can occur even in the absence of traditional risk indicators.

**Table 2: Distribution of patients according to possible risk factors.**

Risk factor (s)	Number	Percentage
Large birth weight	1	1.47%
Prolonged labor and difficult delivery	3	4.41%
Breech presentation	2	2.94%
Previous birth with brachial plexopathy	1	1.47%
Diabetic mother	3	4.41%
No risk factors	58	85.29%

### Distribution of Patients According to General Criteria

Table 3 summarizes patient demographics and surgical details for the three types of shoulder procedures. The Fairbank operation was performed on younger patients, all aged 2–10 years, with more males (31) than females

(17), predominantly on the right side (37 patients). All Fairbank surgeries were completed in under 60 minutes. In contrast, derotation osteotomy was performed on an older group (10 patients aged 11–18), with a slight male predominance (8 males, 4 females), mostly on the right side (10 patients), and all surgeries lasted 60–120 minutes. Trapezius transfer was also performed in older patients, mainly in the 11–18 age group (6 patients), with a relatively even gender distribution and mostly right-sided surgeries. These procedures typically took 60–120 minutes. Overall, the Fairbank operation was quicker and performed on younger patients, while the other two procedures took longer and were performed on older children.

**Evaluation of Surgical Outcome**

Table 4 presents the outcomes of the three different surgical procedures based on the modified Mallet score. Preoperatively, all patients in the Fairbank operation, derotation osteotomy, and trapezius transfer groups had

Grade 2 obstetrical brachial plexus palsy (indicating poor shoulder function). Postoperatively, the Fairbank operation group showed significant improvement, with 87.5% of patients achieving Grade 3 (moderate function) and only 12.5% remaining in Grade 2. In contrast, the derotation osteotomy group had a more varied outcome, with 66.7% reaching Grade 4 (good function), 25% achieving Grade 3, and 8.3% remaining in Grade 2. The trapezius transfer group showed no improvement, with all patients remaining at Grade 2 postoperatively. These findings suggest that the Fairbank operation and derotation osteotomy are more effective at improving shoulder function compared to trapezius transfer.

**Complications**

No vascular or neurological complications occurred intraoperatively or postoperatively; blood transfusions were not required; and no infections were encountered in any case.

**Table 3:** Distribution of patients according to type of surgery.

Type of surgery	Age of patients		Sex		Side		The average duration of surgery	
	2–10	11–18	male	female	right	left	<60min	60–120 min
Fairbank	48	0	31	17	37	11	48	0
Derotation osteotomy	2	10	8	4	10	2	0	12
Trapezius transfer	2	6	3	5	6	2	0	8

**Table 4:** Evaluation of surgical outcome.

Group (Surgery type) (No.)	Modified Mallet score preoperatively	Modified Mallet score postoperatively		
	Grade 2 (for all patients) No. (%)	Grade 2 No. (%)	Grade 3 No. (%)	Grade 4 No. (%)
Fairbank operation (48)	48 (100%)	6 (12.5%)	42 (87.5%)	0 (00%)
Derotation osteotomy (12)	12 (100%)	1 (8.3%)	3 (25%)	8 (66.7%)
Trapezius transfer (8)	8 (100%)	8 (100%)	0 (00%)	0 (00%)

## DISCUSSION

In this study, males were affected more than females, and the right side was more frequently involved than the left. This finding contrasts with a study by Julia et al., where the distribution of patients between the two genders was nearly equal, with 51 males (51.51%) and 48 females (48.48%). In their study, the right side was affected slightly more often (48 patients or 48.48%) than the left side (46 cases or 46.46%). Five patients (5.05%) presented with bilateral obstetrical brachial plexus palsy.<sup>13</sup>

In the present study, three patients (4.4%) had mothers with diabetes. Van der Looven et al. propose that obstetrical brachial plexus palsy in diabetic mothers could be attributed to macrosomia and shoulder dystocia.<sup>14</sup> However, Okby and Sheiner's study indicated that macrosomia was a significant risk factor for neonatal brachial plexus palsy, while maternal characteristics such as diabetes were not.<sup>15</sup>

Vertex intrauterine presentation accounted for obstetrical brachial plexus palsy in 66 patients (97.1%), while breech presentation accounted for two (2.9%) cases, which is approximately similar to the study conducted by Johari et al., where vertex presentation accounted for 94%–97% and breech presentation for 1%–2% of cases.<sup>16</sup>

Forty-two (87%) out of 48 patients who underwent subscapularis release experienced satisfactory improvement in shoulder motion or extremity function, with external rotation improving to approximately Grade 3 on the modified Mallet score (external rotation from 0 to 20 degrees). Six patients (12.5%) showed no improvement in external rotation and remained at Grade 2. Restoration of the arm's functional position was associated with increased use and function of the arm, with a surgery duration of about 30 minutes.

This surgical outcome is comparable to the study by Elkady et al., in which subscapularis muscle release combined with latissimus dorsi and teres major transfer resulted in significant functional and clinical improvements. The mean global Mallet score increased from 7.1±1.0 SD (range 6–9) to 13.2±0.8 SD (range 11–15) postoperatively. They reported 29 excellent cases, five good cases, and none with poor scores, compared to 30 poor cases, four good cases, and none with excellent scores preoperatively.<sup>17</sup>

The 12 patients who underwent derotation osteotomy in this study showed good improvement in shoulder motion, with three cases (25%) achieving Grade 3 (0 to

20-degree external rotation) and eight cases (66.7%) achieving Grade 4 (more than 20-degree external rotation). One case (8.3%) showed no improvement. In contrast with this study's results, Burair et al. reported excellent gains in external rotation of the shoulder, with the mean shoulder external rotation measuring 45 degrees (ranging from 30 to 60 degrees). All 40 patients included in their study had their Grade change from 2 to 4.<sup>18</sup> The excellent gain in external shoulder rotation occurs because the osteotomy positions the arm in a functional position although it does not create active external rotation.

The trapezius tendon transfer cases in this study showed less favorable results, with all patients exhibiting no improvement. Similarly, Rühmann et al. did not report progress in postoperative external rotation in the shoulder.<sup>19</sup> In contrast, Garcon et al. observed that all the five patients who did trapezius tendon transfer, exhibited improvements in external rotation in the shoulder and the Mallet score; however, this change was not statistically significant. Their data also suggest that performing such surgery at a younger age (before 8 years old) may yield greater benefits in rotator muscle strength.<sup>20</sup>

## CONCLUSIONS

In conclusion, subscapularis release surgery is suitable for early and flexible obstetrical brachial plexus palsy, yielding satisfactory results, while derotation osteotomy is appropriate for fixed obstetrical brachial plexus palsy in toddlers and older children, demonstrating good results. Trapezius tendon transfer alone has no beneficial effect in terms of functional improvement.

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