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ORIGINAL

Outcome of trapezius transfer to improve shoulder abduction in children with birth brachial plexus palsy

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Background: Addition of a trapezius to deltoid transfer has been recommended by various authors in overcoming the deficit in shoulder abduction while correcting the deficit in external rotation of the shoulder in patients with birth brachial plexus palsy (BBPP). Literature analyzing the effect of trapezius transfer in patients with paralyzed deltoid stands limited. The purpose of our study is to report the outcome of trapezius transfer for improvement in shoulder abduction in patients with BBPP with weak deltoid function (motor power $<$ grade 3) and to analyze the various preoperative factors that could potentially influence the outcome of the surgery.

Methods: 25 patients with a mean age of 11 years with limited shoulder abduction and deltoid power $<$ grade 3, underwent trapezius transfer between 2013 and 2023. Pre-operative assessments included age, range of shoulder abduction, extent of involvement, Mallet score, and power of elbow flexion. Post-operative range of shoulder abduction and Mallet score were noted. These patients were followed up for a minimum of 1 year (range, 12–60 months).

Results: Average shoulder abduction improved from 48° to 100° (range: 40°−147°). The mean improvement in shoulder abduction noted was 52 $\pm$ 12 degrees (p-value, $<$0.05). No statistically significant correlation was found between the improvement in shoulder abduction and the extent of neurological involvement, power of elbow flexion, and previous nerve surgery. However, a weak-to-moderate negative correlation was noted between the age at surgery and the improvement in shoulder abduction (Pearson's r = −0.4138). A moderate positive correlation between the outcome of trapezius transfer and the pre-operative abduction was also noted (Pearson coefficient of 0.5175).

Conclusion: Trapezius transfer is an effective method to improve shoulder abduction in patients with deltoid power less than grade 3. Younger children with better preoperative abduction tend to get superior results of trapezius transfer.

Keywords: trapezius, birth brachial plexus palsy, adduction contracture, tendon transfer, soft tissue release
Level of evidence: III

Introduction

Adduction and internal rotation contracture of the shoulder is the commonest secondary problem in patients with birth brachial plexus palsy (BBPP) (1, 2). The deformities are a result of complex interactions between the muscle imbalance because of asymmetric recovery and co-contractions resulting from cross innervation and growth in this group of patients. Infants who fail to develop antigravity elbow flexion within 4–6 weeks of age are likely to develop these deformities (3). Multiple surgical procedures have been described to correct these deformities, the majority of them directed towards the correction of internal rotation contracture and additionally correcting the shoulder adduction component with muscle transfers (4–7). Soft tissue release procedures around the shoulder have been valuable in patients who have antigravity shoulder abduction, deltoid power of ≥ M3 (Medical Research Council grading), and strong co-contractions between the shoulder abductors and adductors (8). A trapezius-to-deltoid transfer to augment shoulder abduction was recommended by Gilbert when the pre-operative shoulder abduction is less than 90° (9). Chen et al. (10), followed by Abdelaziz et al. (11), recommended adding trapezius transfer with latissimus dorsi and teres major transfer to infraspinatus transfer when the shoulder abduction is less than 90° and deltoid power is less than M3. Sabapathy et al. reported good results with soft tissue release operations irrespective of the range of shoulder abduction provided the deltoid has grade 3 or more power with obvious contraction of a deltoid and there is clinical evidence of abductor-adductor co-contraction (12). However, in cases with deltoid weaker than grade 3, we prefer to augment it with a trapezius transfer while performing surgery to improve shoulder abduction. This article presents the outcome of trapezius transfer to improve shoulder abduction in this select group of patients with BBPP with an analysis of the preoperative factors that could potentially influence the outcomes.

Patients and methods

Between 2013 and 2023, 33 patients of BBPP underwent transfer of the upper trapezius to the deltoid for improving shoulder abduction. The indication for the surgery is limited shoulder abduction with deltoid power of ≤ M2. Out of 33, 25 patients were available for assessment at a minimum of 1 year follow-up (range: 1–5 years) and they form part of this study. There were 16 females and nine males with right-side involvement in 15 patients and left-side in 10 patients. These patients were grouped according to the neurological/root involvement as per Narakas (13). For the purpose of analysis, patients with only upper plexus involvement (Narakas I) were categorized as Group 1, whereas those with more extensive involvement (Narakas II-IV) were categorized as Group 2. There were 14 patients in Group 1 and 11 patients in Group 2. The mean age at surgery was 11 years and ranged from 3 years to 21 years. Five of these 25 patients had undergone previous nerve surgery, namely, neurolysis of the brachial plexus in two, neurolysis and spinal accessory nerve to suprascapular nerve transfer in two, and one patient had neurotization of the upper trunk with the C5 root with nerve grafts.

All the 25 patients were preoperatively assessed for range of global shoulder abduction (humero-thoracic angle), deltoid power, grade of elbow flexion, and modified Mallet scale (14). Nineteen of these 25 patients underwent concomitant release of the shoulder adductors because their preoperative assessment revealed substantial co-contractions of the adductors while the children attempted shoulder abduction and contracture of adductors (**Table 1**). One patient had soft tissue release at an earlier date with insufficient recovery of shoulder abduction. In the remaining five patients, the adductors were not released as there was no clinical evidence of their contracture or co-contraction with the shoulder abductors.

Surgical technique

All the patients were operated on under general anesthesia in the lateral position. Release of the adductors as per the preoperative assessment as detailed above was done first. For the upper trapezius to deltoid transfer, a lazy S-shaped or triradiate incision was made across the shoulder, extending from the medial border of the spine of the scapula across the acromion to the deltoid region of the arm. The upper trapezius was exposed all along its insertion into the clavicle, acromion, and spine of the scapula. It is mandatory to identify the plane between the trapezius and supraspinatus for the former muscle to be well mobilized to advance distally. In patients less than 12 years of age, the acromial insertion of the trapezius was raised along with the periosteum, and the muscle was mobilized proximally, teasing off the other insertions (**Figures 1A–D**). In older patients, osteotomy of the acromion was carried out along with the trapezius insertion. The deltoid was divided from its proximal insertion and reflected distally to expose the sub-capital region of the humerus. The well-mobilized trapezius was pulled distally and sutured to the periosteum of the proximal humerus just beyond the humeral head with non-absorbable sutures in younger children, and in the older children, the acromion was fixed to the humerus with a cancellous screw, both with the shoulder abducted to 90°. The proximally divided deltoid muscle was then pulled up maximally and sutured proximally over the trapezius as suggested by O'Ruhmann et al. to improve its leverage action (15). The upper limb was immobilized in a customized splint with 90° shoulder abduction and 90° elbow flexion for 2 months, following which active assisted shoulder abduction exercises were started and the splint was gradually discarded as per the child's comfort (**Figure 2**).

Statistical analysis

Pre-operative and post-operative shoulder abduction, age at surgery, extent of neurological involvement, and pre-operative power of elbow flexion were the variables assessed for their influence on the outcome of the trapezius transfer. A paired t-test was used to compare the pre-operative and post-operative assessment of shoulder abduction. Pearson correlation and the Mann-Whitney test were used to

TABLE 1 | Patient demographic details and their improvement in shoulder abduction.

S. no.	Age/sex	Type (Narakas)	Side	Pre-op shoulder abduction	Pre-op Mallet score	Pre-op external rotation	Pre-op elbow flexion (MRC)	Post-op shoulder abduction	Post-op Mallet score	Follow-up (months)
1	7/F	C5,6,7	Left	0	13	0	3	118°	18	12
2	5/M	C5-T1	Right	60°	17	30°	3	90°	17	60
3	9/M	C5-T1	Right	34°	12	20°	3	116°	16	24
4	20/F	C5,6	Left	43°	14	40°	5	90°	16	12
5	7/F	C5,6	Left	85°	8	0	3	135°	11	12
6	4/F	C5-8	Right	72°	12	0	4	144°	14	60
7	16/F	C5-T1	Left	38°	14	0	3	95°	13	36
8	10/M	C5,6,7	Right	61°	11	0	4	136°	13	36
9	9/F	C5,6	Left	40°	12	20°	3	40°	14	36
10	11/F	C5-T1	Right	38°	5	0	4	90°	14	12
11	10/F	C5,6,7	Left	90°	13	20°	3	110°	15	36
12	15/F	C5,6	Right	64°	15	50°	5	130°	18	24
13	6/F	C5-T1	Right	31°	10	0	2	147°	14	24
14	21/F	C5-T1	Right	18°	14	20°	4	51°	15	12
15	8/M	C5,6	Right	68°	15	20°	3	110°	15	24
16	13/F	C5,6	Left	30°	16	90°	3	50°	15	12
17	3/M	C5,6	Right	38°	11	0	4	120°	13	12
18	4/F	C5,6	Left	64°	14	20°	4	125°	16	12
19	9/M	C5,6	Right	54°	15	60°	4	120°	16	12
20	11/F	C5,6	Left	60°	11	0	4	130°	15	12
21	19/M	C5,6,7	Right	70°	12	0	4	95°	16	36
22	17/F	C5,6	Right	30°	12	0	4	70°	12	36
23	12/F	C5,6	Left	60°	14	20°	5	95°	19	36
24	10/M	C5,6	Right	20°	14	0	4	40°	15	24
25	19/M	C5,6	Right	30°	12	0	4	55°	12	12

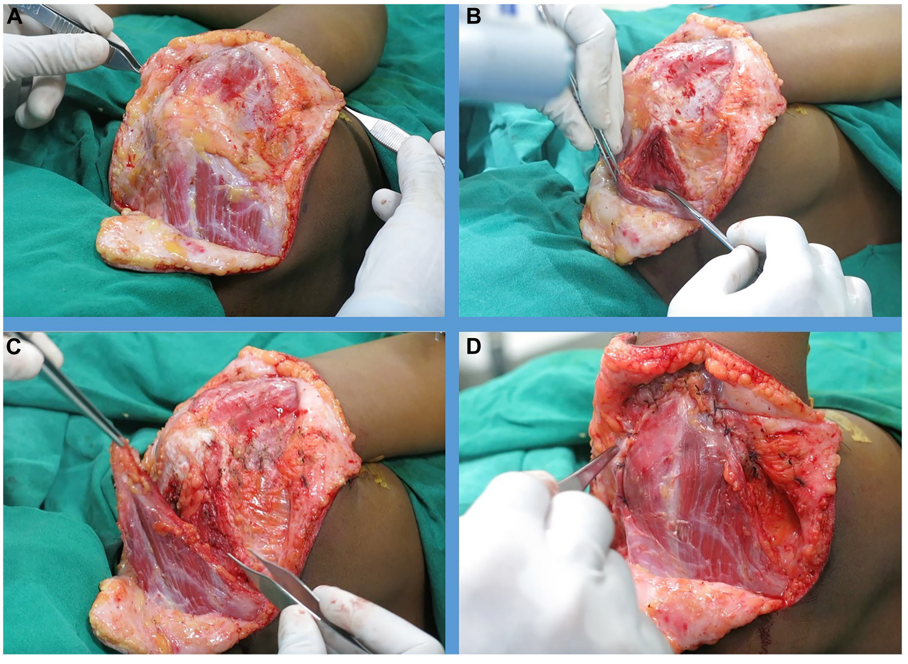

FIGURE 1 | The surgical procedure involves exposure of the trapezius and deltoid **(A)**, dissecting off the trapezius from all its insertion and identifying the plane between the trapezius and supraspinatus **(B)**, completely mobilizing the trapezius **(C)** and suturing it to the deltoid after mobilizing the origin of the latter in a 'double-breasting' fashion **(D)**.

FIGURE 2 | 90–90° Abduction splint used for post-operative immobilization.

analyze the effect of variable pre-operative factors on the improvement in shoulder abduction.

Results

All means are expressed with 95% confidence intervals [Mean ± 95% CI]. At a minimum follow-up of 1 year (average: 24.96 months; range: 12–60 months), average shoulder abduction improved from 48° (SD 9.07) to 100° (SD 13.61) (range: 40°–147°). The mean improvement in shoulder abduction noted was 52° (SD 12.11). There was a statistically significant difference between the pre-operative and post-operative shoulder abduction as noted with a paired t-test (p-value $<$ 0.05). Moderate positive correlation was observed between them, with a Pearson coefficient of 0.5175. The average improvement of shoulder abduction in group 1 (Narakas I) patients was 45° (SD 12.13) and in group 2 (Narakas II-IV), it was 62° (SD 20.34). There was no statistically significant difference between the groups as noted with the Mann-Whitney test (p-value, 0.238). In order to assess the effect of age at surgery on the improvement in shoulder abduction, the patients were grouped into those $\leq$10 years (n = 14) and $>$10 (n = 11). Improvement in shoulder abduction of the former group was 60° (SD 20.25), while the latter group showed improvement of 43° (SD 11.44) with no statistically significant difference between the groups. However, weak to moderate negative correlation was found between age at surgery and improvement in shoulder abduction (Pearson's r = −0.4138). In comparison, patients with power of elbow flexion of grade 3 (n = 8), with a gain of abduction of 39° (SD 22.54), and those with grade 4 and above (n = 17), with a gain in abduction of 51° (SD 11.39), did not show any statistically significant gain in shoulder abduction (Mann-Whitney test, p-value 0.2713).

The average score on the Mallet scale improved from 13 to 15 following the procedure. 20 patients showed improvement in the grade of shoulder abduction in the Mallet scale, and those who remained in the same grade of Mallet score as pre-op showed an improved range of shoulder abduction of 32°.

Average improvement in patients who had undergone previous nerve surgery for shoulder was 65° (SD 42.01), whereas improvement in shoulder abduction in patients who have not undergone any previous nerve surgery was 49° (SD 10.25) (Table 2).

Discussion

The limited shoulder abduction seen in patients with BBPP, can be either due to the co-contracting adductors in the presence of partly recovered shoulder abductors or due to the severe paralysis of shoulder abductors, where the deltoid is either weak or lacks palpable contraction. Augmentation of the deltoid by trapezius transfer must be considered. Transfers primarily intended to improve shoulder external rotation (latissimus dorsi and/or teres major transfer to the rotator cuff) could result in some improvement of shoulder abduction by the "force couple" effect, where the transfer to the rotator cuff enhances its stabilizing property and allows the deltoid to act more efficiently (16). However, with the deltoid paralyzed, this effect may not result in improvement of shoulder abduction. Chen et al. reported their study of 34 patients with BBPP, where 25 patients underwent transfer of latissimus dorsi and teres major to infraspinatus, and nine patients had an additional trapezius transfer (10). 13 out of 25 in the former group and eight out of the nine in the latter group showed improvement in shoulder abduction, while external rotation was found improved in all these patients. This study concluded that trapezius transfer should always be

TABLE 2 | Effect of various pre-operative factors on the improvement in shoulder abduction.

Pre-operative factors		Mean improvement in shoulder abduction (°)
Extent of neurological involvement	Narakas type I	61.8 ± 20.3
	Narakas type II-IV	44.6 ± 12.1
Elbow flexion power	MRC = 3	38.9 ± 22.5
	MRC >/= 4	51.3 ± 11.4
Age at surgery	</=10	59.6 ± 20.2
	>10	42.8 ± 11.4
Previous nerve surgery for shoulder	Yes	65.2 ± 42
	No	49 ± 10.2

FIGURE 3 | Pre and post-operative shoulder abduction in a 4 years child with C5, C6 palsy at 3 years follow-up.

added when pre-operative shoulder abduction is ≤90°. Aydin noted that the gain in abduction is independent of the pre-operative shoulder abduction, and functional shoulder abduction could be achieved in all patients before the development of severe glenohumeral deformities irrespective of the deltoid power (17). He recommended against concomitant trapezius transfer and advised to preserving it for later if needed.

To have a clearer recommendation regarding the need for adding a trapezius transfer, Abdelaziz performed a randomized controlled study in patients with less than 90° of shoulder abduction preoperatively. In 17 patients, they performed only a teres major transfer to the rotator cuff, while in another 18 patients, they added a trapezius transfer to the teres major to rotator cuff transfer (the augmented transfer). They observed that the trapezius transfer seemed to be needed only in patients who have a deltoid power of <M3 and the range of shoulder abduction was not an indicator to decide its indication (11). In our experience also, the range of shoulder abduction is not an indicator to choose a trapezius transfer. All the cases in our present series underwent trapezius transfer because their deltoid power was less than grade 3.

Shoulder abduction improvement observed in our study of 52.6° (range: 0°–118°) is statistically significant (p-value < 0.05) and comparable to the other similar studies in the literature (**Figure 3**). The results of trapezius transfer seem to be better in children than what has been observed in adults with brachial plexus palsy, probably because of the partial recovery of the supportive muscles in children with BBPP, which aids the transfer (18, 19).

While analyzing our data for the preoperative factors that could influence the outcome of trapezius transfer, we analyzed age at the time of surgery, previous nerve surgery, extent of involvement, elbow flexor muscle grade, and preoperative shoulder abduction. As the shoulder abduction component of the Mallet scale comprises groups with a wider range (no movement, abduction <30°, 30°–90°, and >90°), we did not consider this scale for statistical analysis. However, to mention, 20 of the 25 patients have shown improvement in their Mallet grade of shoulder abduction, and in five patients, though the Mallet grade for the shoulder abduction component remained that same, their mean shoulder abduction improved from 39° to 71°.

FIGURE 4 | Pre and post-operative shoulder abduction in a 21 years patient with C5-T1 palsy at 1-year follow-up.

When categorizing our patients by their age at the time of trapezius transfer, the mean gain in shoulder abduction was best in patients who were less than 5 years (61°) as opposed to the least improvement of 38° in the age group of >15 years (**Figure 4**). Curiously, the improvement in abduction gradually declines as age increases (**Figure 5**). However, there was no statistically significant correlation found between the age at surgery and improvement in shoulder abduction.

Aydin et al. observed that significant improvement in shoulder abduction could be achieved with tendon transfers irrespective of the previous nerve surgery (20). In our patients also, previous nerve surgery did not seem to affect the outcome of trapezius transfer.

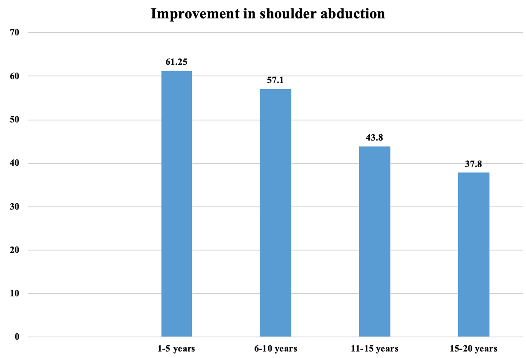

FIGURE 5 | Improvement in shoulder abduction declining with the age at surgery.

FIGURE 6 | Improvement noted in a child, a case of breech delivery, where co-contractions are totally absent.

The improvement in shoulder abduction was not substantially different among patients with Narakas grade I or more severe brachial plexus involvement. The average improvement of shoulder abduction in group 1 (Narakas I) patients is 45° (SD 12.13), and in group 2 (Narakas II-IV), it is 62° (SD 20.34) (p-value, 0.238). This could be expected because the trapezius is uninvolved in all the cases and produced a similar effect. Also, the preoperative elbow flexor muscle power did not seem to affect the outcome of the trapezius transfer (p-value 0.2713).

We noted a moderate positive correlation between the outcome of trapezius transfer and the pre-operative abduction (Pearson coefficient of 0.5175), indicating that the patient with better preoperative abduction is likely to get a better outcome. However, a notable exception was a 3-year-old child with no preoperative shoulder abduction at all who improved to 118° after trapezius transfer, the best in our series (**Figure 6**). Apart from dedicated physiotherapy by the parents and the thin build of the child, we believe that total lack of co-contracting adductors allowed better abduction function. This child was a case of breech delivery-related brachial plexus palsy, which is known to have avulsion of the upper roots, resulting in no co-contractions of the adductors with abductors (21).

A decrease in the shoulder abduction as the child grows is another reported concern in these patients (22). The factors implicated include the dehiscence of the humeral attachment of the trapezius, development of adhesions at the acromion with prolonged immobilization, growth, weight gain, and lack of proper rehabilitation. Recent literature also points at abnormal stunted growth of the involved muscles themselves (23). Our follow-up duration is lesser to have a detailed assessment of this phenomenon; however, in two patients who had a 5-year follow-up, we did observe a marginal decrease in shoulder abduction (**Figure 7**). Being aware of this fact, we have been very vigilant in guiding parents to prevent the loss of abduction gained by continuing abduction-stretching exercises. Long-term follow-up of the remaining patients is required to assess whether the loss in abduction is inevitable. Though it cannot be proved

FIGURE 7 | With growth of the child, there is a loss of the gained shoulder abduction.

objectively, we observed that the participation of the parents in the post-operative rehabilitation does play a significant role in the outcome. Also, though we did not have the body mass index for all our patients, we observed that the best results were seen in thin-built children, and the children who reduced abduction over a period of time were the ones who had put on excessive weight during adolescence. Parents must be counseled regarding these issues to obtain a satisfactory outcome.

The Outcome of this study suggests that trapezius transfer is effective in improving shoulder abduction in children with BBPP with paralyzed deltoids. Such patients need to be identified preoperatively to provide them the best possibility for improvement of shoulder abduction. The more popular conventional adductor release and transfers to augment the rotator cuff are insufficient to improve shoulder abduction in this group of patients. Hence, adding a trapezius transfer is strongly recommended in patients with deltoid power of M2 or less. Though improvement in shoulder abduction was seen in all the patients in this series, the best results were seen in patients younger than 5 years.

Ethical approval

Our study was approved by the institutional review board-EC Ref. No: 2022-09-01.

Author contributions

VV: Data curation, Formal analysis, Investigation, Writing – original draft, Examination of patients, Literature review. PB: Conceptualization, Investigation, Writing – review & editing. HV: Writing – review & editing. SRS: Writing – review & editing.

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Informed consent declaration

Written informed consent was obtained from all subjects before the study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Waters PM. Management of shoulder deformities in brachial plexus birth injuries. *J Pediatr Orthop*. (2010) 30:S53–6. doi: 10.1097/BPO.0b013e3181c1893d
2. Yuceturk A. Palliative surgery: tendon transfer to the shoulder in children. In: Gilbert A editor. *Brachial Plexus Injuries*. Martin Dunitz (2001). p. 239–47.
3. Waters PM. Update on management of pediatric brachial plexus palsy. *J Pediatr Orthop B*. (2005) 14(4):233–44. doi: 10.1097/01202412-200507000-00001
4. Gilbert A, Romana C, Ayatti R. Tendon transfers for shoulder paralysis in children. *Hand Clin*. (1988) 4(4):633–42.
5. 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(3):686–94. doi: 10.1097/00006534-199803000-00015
6. Waters PM, Peljovich AE. Shoulder reconstruction in patients with chronic brachial plexus birth palsy. A case control study. *Clin Orthop Relat Res*. (1999) 364:144–52. doi: 10.1097/00003086-199907000-00019
7. Terzis JK, Kokkalis ZT. Outcomes of secondary shoulder reconstruction in obstetrical brachial plexus palsy. *Plast Reconstr Surg*. (2008) 122(6):1812–22. doi: 10.1097/PRS.0b013e31818cc1fc
8. Nath RK, Paizi M. Improvement in abduction of the shoulder after reconstructive soft-tissue procedures in obstetric brachial plexus palsy. *J Bone Joint Surg Br*. (2007) 89(5):620–6. doi: 10.1302/0301-620X.89B5.18403
9. Gilbert A. Obstetric brachial plexus palsy. In: Tubiana R editor. *The Hand*. Philadelphia: WB Saunders (1993). p. 576–601.
10. Chen L, Gu YD, Hu SN. 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(4):275–80. doi: 10.1055/s-2002-30183
11. Abdelaziz TH, Samir S, Magdy W. Restoring shoulder abduction in children with Erb's palsy: when to add trapezius transfer to a teres major transfer. *J Bone Joint Surg Br*. (2012) 94(11):1579–82. doi: 10.1302/0301-620X.94B11.29092
12. Sabapathy SR, Bhardwaj P, Venkatramani H. Value of Soft tissue release procedure around the shoulder to improve shoulder abduction in birth brachial plexus palsy and analysis of the factors affecting outcome. *J Hand Surg Asian Pac Vol*. (2017) 22(2):174–83. doi: 10.1142/S0218810417500216
13. Narakas AO. Obstetric brachial plexus injuries. In: Lamb DW editor. *The Paralysed Hand*. Edinburgh: Churchill Livingstone (1987). p. 116–35.
14. Russo SA, Kozin SH, Zlotolow DA, Thomas KF, Hulbert RL, Mattson JM, et al. Scapulothoracic and glenohumeral contributions to motion in children with brachial plexus birth palsy. *J Shoulder Elbow Surg*. (2014) 23(3):327–38. doi: 10.1016/j.jse.2013.06.023
15. Rühmann O, Schmolke S, Bohnsack M, Carls J, Wirth CJ. Trapezius transfer in brachial plexus palsy. Correlation of the outcome with muscle power and operative technique. *J Bone Joint Surg Br*. (2005) 87(2):184–90. doi: 10.1302/0301-620x.87b2.14906
16. Phipps GJ, Hoffer MM. Latissimus dorsi and teres major transfer to rotator cuff for Erb's palsy. *J Shoulder Elbow Surg*. (1995) 4(2):124–9. doi: 10.1016/s1058-2746(05)80066-7
17. Aydin A, Ozkan T, Onel D. Does preoperative abduction value affect functional outcome of combined muscle transfer and release procedures in obstetrical palsy patients with shoulder involvement? *BMC Musculoskelet Disord*. (2004) 5:25. doi: 10.1186/1471-2474-5-25

18. Pruitt DL, Hulsey RE, Fink B, Manske PR. Shoulder arthrodesis in pediatric patients. *J Pediatr Orthop*. (1992) 12(5): 640–5.
19. Monreal R, Paredes L, Diaz H, Leon P. Trapezius transfer to treat flail shoulder after brachial plexus palsy. *J Brachial Plex Peripher Nerve Inj*. (2007) 2:2. doi: 10.1186/1749-7221-2-2
20. Aydın A, Biçer A, Özkan T, Mersa B, Özkan S, Yıldırım ZH. Does primary brachial plexus surgery alter palliative tendon transfer surgery outcomes in children with obstetric paralysis? *BMC Musculoskelet Disord*. (2011) 12:74. doi: 10.1186/1471-2474-12-74
21. Al-Qattan MM. Obstetric brachial plexus palsy associated with breech delivery. *Ann Plast Surg*. (2003) 51(3):257–65. doi: 10.1097/01.SAP.0000063750.16982.E4
22. Raimondi PL, Muse A, Saporiti E. Palliative surgery: shoulder paralysis. In: Gilbert A editor. *Brachial plexus injuries*. London: Martin Dunitz Ltd (2001). p. 225–38.
23. Cheng W, Cornwall R, Crouch DL, Li Z, Saul KR. Contributions of muscle imbalance and impaired growth to postural and osseous shoulder deformity following brachial plexus birth palsy: a computational simulation analysis. *J Hand Surg Am*. (2015) 40(6):1170–6. doi: 10.1016/j.jhsa.2015.02.025