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The outcome of soft-tissue release and tendon transfer in shoulders with brachial plexus birth palsy

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A R T I C L E I N F O

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Level of evidence: Level IV; Case Series; Treatment Study

Background: Shoulder involvement in brachial plexus birth palsy is common, and the adduction, internal rotation contracture deformity often requires some form of surgical treatment. There are very few long-term reports on release of contracted muscles and tendon transfers, especially in older children. We are reporting the single-center results of such a surgery with detailed outcome analysis.

Methods: The prospectively collected data from brachial plexus birth palsy cases who had undergone contracture release and tendon transfer were retrospectively studied and examined. The new Mallet and functional scores were compared with the original data forms and then analyzed. The radiographic evidence of glenoid dysplasia and its correlation with age and functional outcome was assessed.

Results: A total of 82 cases with surgery at mean age of 9.5 ± 5.09 years and a follow-up of 8 ± 3.8 (3-20) years entered the study. Of these, 56% of cases had 7 to 20 years of age at surgery. Fifty-four (66%) patients had only shoulder surgery, and 28 (34%) required additional reconstructive surgeries for hand and wrist. Moderate to severe glenohumeral dysplasia was present in 38%. The preoperative Mallet score of 10.6 ± 2.97 improved to 19.3 ± 3.39 ($P < .001$). Eighty-one percent of patients showed improvement in "reaching face" functions, 71% in "above head" functions, and 74% in "midline functions." The cases with lack of improvement in midline function mostly belonged to pan-plexus injuries. Noticeable subjective and objective improvement was also observed in cases with glenohumeral dysplasia in their Mallet and functional scores ($P < .001$). The improvement in function and subjective satisfaction of 92% was observed irrespective of age at surgery.

Conclusion: Soft-tissue release and tendon transfer for brachial plexus birth palsy shoulder can improve function and limb appearance even in older children and young adults and even in the presence of glenohumeral dysplasia.

A traction injury and stretching of the nerves of the brachial plexus during birth produces paralysis and/or paresis in the upper limb. The majority of infants, however, recover from this injury, leaving 25 to 30 percent with long-term deficiencies.[6]

The shoulder contracture in brachial plexus birth palsy (BPBP) is common in adduction and internal rotation.[17] This causes limitation of external rotation, elevation, and abduction of the arm, resulting in inability to reach face and head in a normal pattern, and "trumpet sign."[39] The fixed internal rotation deformity and impaired muscle longitudinal growth and imbalance would produce glenohumeral dysplasia (GHD).[7-10,28,32,36] An early correction of contractures, not only improves appearance of arm and shoulder function but may also prevent dysplasia.[19,41]

The literature often advocates humeral osteotomy, rather than soft-tissue reconstruction, for shoulder problems in older children and in the presence of GHD.[4,11,21,42]

In our center, the patients are often referred later and are older, with varying levels of functional impairment and GHD, at the time of their first visit. They are treated with release of contracted pectoralis major and subscapularis tendons and simultaneous transfer of latissimus dorsi/teres major tendons to posterior humerus and rotator cuff (Modified L'episcopo procedure).[14,26]

The Shiraz University of Medical Sciences Institutional Review Board approved this study.

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The hypothesis for the present study was that lengthening of the subscapularis and pectoralis major tendons and transfer of the latissimus dorsi and teres major tendons to the rotator cuff, even at an older age and in spite of GHD could produce good motion and function, with no need for humeral osteotomy. Good results of this approach in older children have been already published, only in a smaller group, in the literature by Javid and Shahcheraghi.[18]

Material and method

This was a retrospective study. The inclusion criteria were the cases of BPBP treated by the two main authors (GSH and MJ) by a uniform technique of shoulder contracture release and simultaneous transfer of latissimus dorsi/teres major tendons to posterolateral humerus and rotator cuff. Only the cases with more than 3 years of follow-up, and no prior surgery, related to their BPBP, and those who not only could attend for clinical assessment but also had available original Mallet and functional scoring data for comparison were included.

Surgical technique

Through an anterior deltoid-pectoral incision z-lengthening of the pectoralis major, subscapularis tendons as well as conjoined tendon fractional lengthening is performed. The latissimus dorsi and teres major attachments at the medial aspect of humerus were released and mobilized and then moved to a second incision in the posterior humerus, where the tendons were attached to the rotator cuff and periosteum of posterior humerus.[14,18,26] Five weeks of postoperative shoulder spica cast immobilization is then followed by physiotherapy.

After obtaining the university ethics committee and also research commission approval, the patients were called back for reassessment. An informed consent for examination and data collection was obtained from each patient and/or parents.

The patients underwent upper limb physical examination and also were assessed with Mallet score. An independent examiner – a licensed physiotherapist (Z) – interviewed, examined, and guided the patients in filling the evaluation forms. The questionnaires filled by the patients were Modified American Shoulder and Elbow Surgeons and Shoulder Pain and Disability Index standardized assessment forms[33,34] consisting of 16 different questions where the best score would be 48 points[18] (Supplementary Appendix S1). All those 16 functions were analyzed separately, but because they were too large for reporting, the similar functions were put together and summarized into 4 groups – each group consisting of 4 sets of functions (Supplementary Appendix S2). They, therefore, consisted of reaching the face and mouth, overhead activities, reaching back, and finally the midline body activities such as buttoning shirt or pants in front of the body.

The same questionnaires, having been originally filled by the patients, prior to surgery, were given to them to compare with their most recent shoulder status and function.

The surgical results were also analyzed in the context of those patients who had only shoulder disability, vs. those who also had wrist, hand, or forearm weakness from partially recovered total BPBP. The findings were also analyzed and compared in 3 different age categories, that is, surgery performed below 7, between 7 and 15, and over 15 years of age.

Every patient had anteroposterior and axillary radiographs of both shoulders, and the dysplastic features of the affected side were compared with the normal side. The radiographic findings were analyzed for dysplasia by the irregularity of glenoid fossa, loss of inferior scapular neck, humeral head, and acromion/coracoid dysplasia. They were categorized in accordance with descriptions by Wirth et al and Theodorou et al into mild, moderate, and severe dysplasia (Table I).[1,37,45]

The subjective satisfaction and reasons for dissatisfaction were documented.

The data were analyzed using IBM SPSS, version 19 (IBM, Armonk, NY, USA). Normality was evaluated using a Kolmogorov test. Independent and paired sample T test and one-way analysis of variance were applied, as appropriate, for comparing continuous data. Chi square data were used for evaluating categorical variables.

Results

The number of BPBP cases with more than 3 years of postoperative follow-up was 92, but only 82 patients could attend the final visits for physical examination and filling the questionnaires (6 cases could not be reached and 4 had missing or incomplete preoperative questionnaires). The report is on 82 patients, 36 (44%) men and 46 (56%) women – 48 (58%) right and 34 (42%) left – with a mean age at surgery of 9.5 ± 5.09 years (range 3-31 years). The age at surgery was equal or less than seven years in 36 patients, between 7 and 15 years in 38, and 16 to 3 years in the remaining 8 cases (44%, 46%, and 10%, respectively).

The follow-up duration ranged from 3 to 20 years with an average of 8 years (SD: 3.8). The age at the final follow-up ranged between 9 and 35, with mean $SD = 20.6 \pm 7.18$. Fifty-four (66%) patients had only shoulder involvement and shoulder surgery, while 28 (34%) had also hand or wrist involvement and required secondary reconstructive surgeries such as tendon transfers or fusion for wrist or thumb.

The mean preoperative Mallet score of 10.6 ± 2.97 improved to 19.3 ± 3.39 ($P < .001$). The mean functional score of 12.5 (SD: 11.12) changed to 32.9 (SD: 11.39) ($P < .001$).

The patients with additional hand or wrist involvement, in comparison with the ones with pure C5, C6 roots affection, had lower Mallet scores and functional scores both before and after surgery. This score change, however, was not statistically significant (Table II).

Shoulder forward flexion, abduction, external rotation, and also elbow flexion contracture showed statistically significant improvement post-surgery (Table III). The change in Mallet and functional scores showed similar improvement in all the 3 age categories (Table IV).

In terms of function – which was stated by the patients after looking and comparing their original questionnaires with the final forms – improvement was observed in all the 4 categories of function. The lowest improvement was observed in toilet management (seen in 54% of patients) and highest improvement in combing hair and drinking out of a cup (observed in 84%). Eighty-one percent of patients showed improvement in "reaching face" functions, 71% in "above head functions," and 74% in "midline functions" (Fig. 1). The scores for the aforementioned four items for hand-involved cases were lower than pure C5-C6 group, although only items in "midline function" and "reaching back" were statistically meaningful ($P = .0003$ and .008, respectively). The unimproved cases in shirt-buttoning were mostly observed in panplexus cases.

Glenoid dysplasia was absent or mild in 51 (62%) of cases and moderate or severe in 31 (38%) cases. The prevalence of moderate and severe glenoid dysplasia were 31%, 47%, and 25%, respectively, for the ages of up to seven years, between seven and fifteen years,

Table I
Radiographic classification of glenoid dysplasia.

Severity of dysplasia	Radiographic findings[24,25]
Mild	Shallow, slightly irregular glenoid fossa with portion of the inferior scapular neck and glenoid rim present
Moderate	More irregular and elongated glenoid fossa with loss of the inferior scapular neck and glenoid rim
Severe	Extensive hypoplasia of the inferior glenoid and scapular neck; humeral head dysplasia and varus angulation; abnormalities of the acromion, coracoid, and distal clavicle

Table II
Distribution of Mallet and functional scores in the pure C5, C6 vs. additional hand involvement.

	Hand (SD)	C5-C6 (SD)	*P* value
Mallet score			
Before	9.5 (3.67)	11.1 (2.43)	**.026**
After	17.4 (2.85)	20.3 (3.26)	**<.001**
Change	7.9 (3.47)	9.2 (2.95)	.083
Functional score			
Before	9.7 (7.4)	14.04 (12.51)	.069
After	25.0 (12.11)	32.3 (8.36)	**<.001**
Change	15.4 (10.44)	23.7 (12.37)	**.008**

Significant *P* values are indicated in bold.

Table III
The comparison of preoperative and postoperative shoulder and elbow motions in the 82 patients.

	Mean	SD	*P* value
Forward flexion			
Before	71.5	30.25	<.001
After	122.1	40.07	
Abduction			
Before	59.8	32.94	<.001
After	116.7	42.72	
External rotation			
Before	−31.5	17.66	<.001
After	35.4	11.45	
Elbow flexion contracture			
Before	19.1	15.32	<.001
After	11.7	14.47	

and greater than fifteen years. The radiographs of severe glenoid fossa dysplasia suggested or mimicked a shoulder subluxation, but there was no clinical evidence of head moving in or out of its place (partly or fully) in the provocative testing before or at surgery. Furthermore, no posterior shoulder dislocation was recognized in the preoperative axillary radiographs or in the intraoperative assessments at any age group.

The postsurgery Mallet scores were not different between those with and without glenoid dysplasia either ($P = .806$ and .216, respectively) (Fig. 2). The improvement in function, as stated by the patients or parents comparing their preoperative forms, in groups with absent or mild GHD was similar to those with moderate and severe glenoid dysplasia (Fig. 3).

On directly asking patients or parents if they were satisfied with the surgery and if they would have accepted the surgery, had they known the results then, 76 (93%) patients were satisfied and would have again consented to that surgery. The common complaints in the unsatisfied cases were appearance of the arm and functional limitations. No association was observed between satisfaction rate and age or what level nerve root was involved ($P = .268$ and .654, respectively).

Discussion

This manuscript is the report on a large number of brachial plexus birth palsy cases with a long-term follow-up of shoulder release and tendon transfer from a single center. The majority of the cases were children older than 7 years of age. The higher percentage of older cases in this series was from late referrals owing to being from smaller towns or villages with poor access to specialty hospitals, in addition to poor economic status. The low accessibility, as well as high cost of computed tomography (CT) or magnetic resonance imaging (MRI) studies resulted into the use of only plane radiographs.

The treatment of residual shoulder contracture and deformity in BPBP is surgical. Tendon transfer has shown between 67 to 75 degrees improvement in abduction of shoulder and 67 to 85 degrees in external rotation in the literature as well as the present report.[16,18,29,43] This can be better achieved by open release of contractures, rather than arthroscopic release, as abduction improvement has been reported in 67% in open and 28% in arthroscopic release.[8,24,27] Although one could see that the cases with very low preoperative total shoulder motion arc do not obtain full arc after surgery, but they achieve enough functional and arm – appearance improvement that 93% of cases are satisfied with the contracture release and tendon transfer surgery.

We showed a significant improvement in shoulder motion and also functional scores, even in the older children: The disability to reach the mouth by spoon or drinking out of a glass and similar functions as seen in 89% of patients, improved remarkably in more than 80% of the cases after surgery (Fig. 4).

The Mallet score improvement in all and functional improvement in the majority of cases, even adolescents and in the presence of GHD, was significant. The interesting finding was that the ones with remaining difficulty for midline body functions such as buttoning-up shirts or functions such as toileting were mostly those who had residual hand, wrist, or forearm weakness and much less in pure C5 and C6 injury levels. There were specific function improvements, on postoperative “front of the body” and “back-reaching” activities in those who had good hand function, albeit the surgery had increased external rotation in the expense of losing some internal rotation power.

The decision on soft-tissue surgery vs. osteotomy in surgical treatment BPBP has been historically based on the GHD that is seen more commonly in older children with more severe contractures. The use of rotational osteotomy of humerus for moderate to severe GHD and older children, as suggested by several authors,[3,4,11,21,35,42,44] was defied by Javid et al[18] by showing the good results of tendon transfer in shoulders of older children. The osteotomy does not improve glenohumeral motion or arc of shoulder motion and only provides a more functional position of the hand in space.[3-5,20,35,42] Waters and Bae[42] and also Abzug et al[2] report on rotational osteotomy of the humerus in children of a mean age of 10 years. They showed Mallet score improvement from around 13 to around 18 and still a decline in midline activities such as buttoning and toileting.

Our results of Mallet score improvement to 19.3 $\pm$ 3.39 from 10.6 $\pm$ 2.97 and statistically significant functional improvement (increasing from 12.5 $\pm$ 11.12 to 32.9 $\pm$ 11.39), with soft-tissue reconstructive procedure is impressive. The older children and adolescents, who had also moderate to severe GHD, still showed improvement in the appearance of arm during motion and several different functions (Fig. 1, Table II). This refutes the view that such cases should only be treated by humeral osteotomy.[42]

Table IV
Severity of nerve involvement in different age groups and correlation with the Mallet and functional scores.

	No	Mallet change	Functional score change	Hand	C5-C6	F/U year
<7 yr	36	8.4	21.3	13	23	8.7
7-15 yr	38	8.9	20.3	11	27	7.8
>15 yr	8	9.5	17.0	4	4	6.1
Total				28	54	

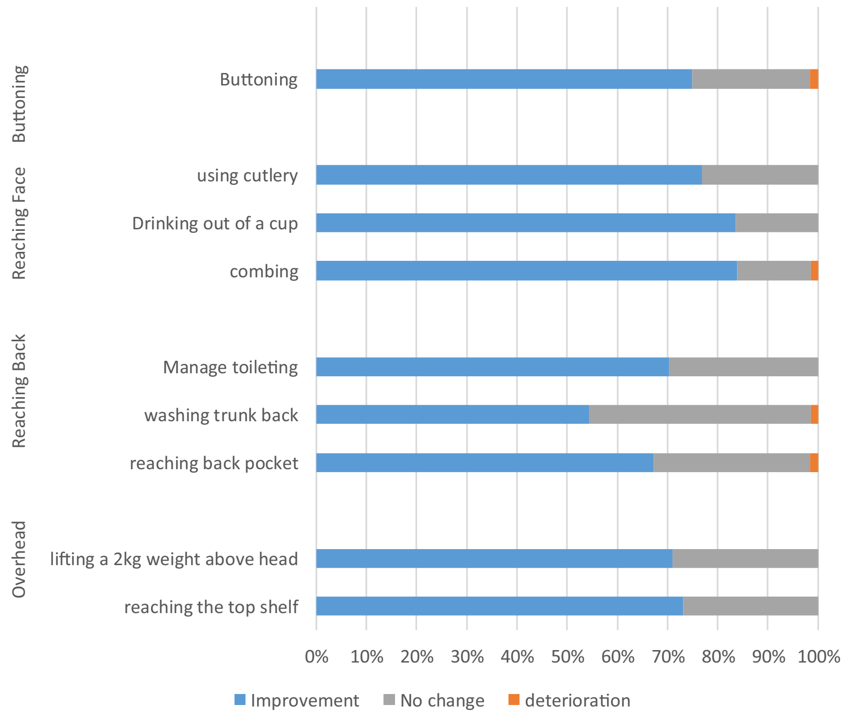

Figure 1 The prevalence of improvement in different functions.

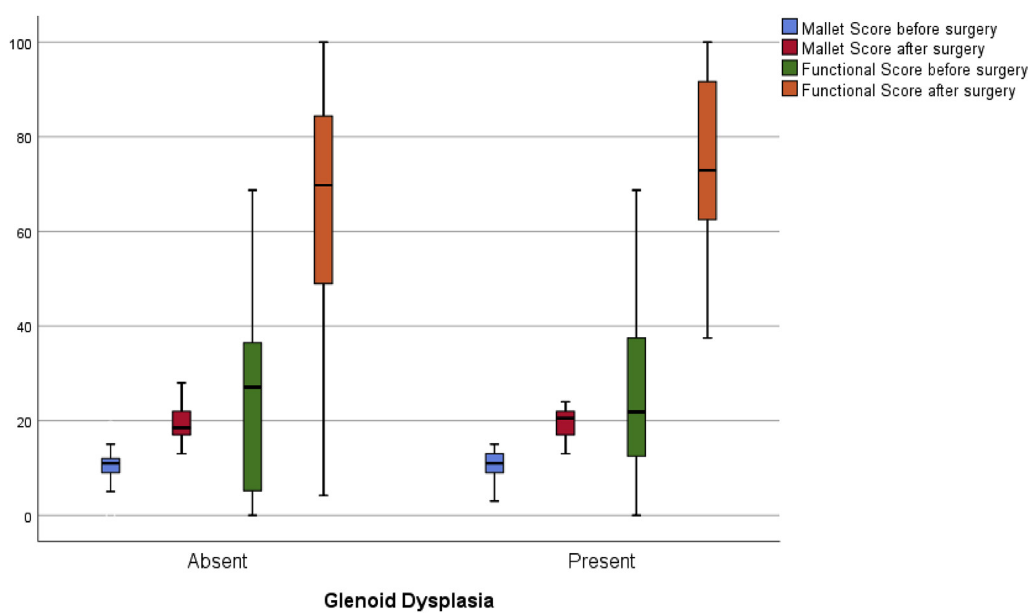

Figure 2 Distribution of Mallet score and functional score in those with and without moderate and severe glenoid dysplasia.

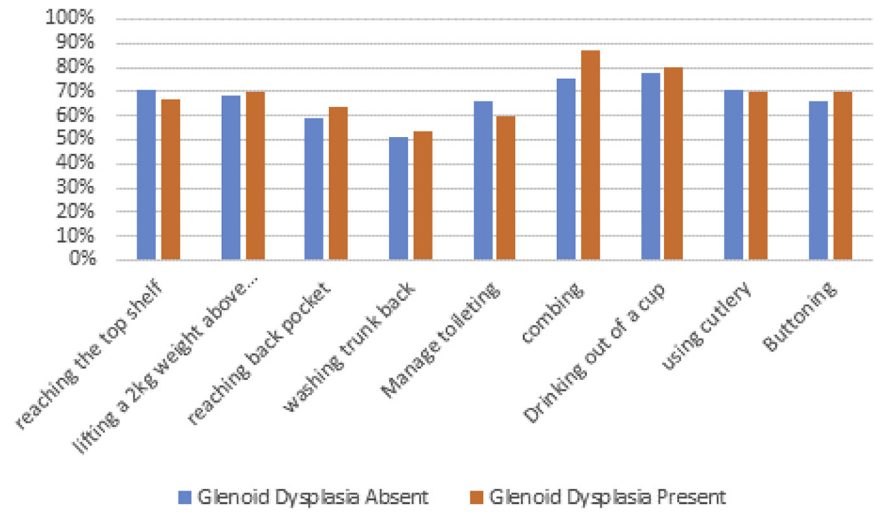

Figure 3 The comparison of functional improvement in different functions in groups with no or mild vs. moderate and severe glenoid dysplasia.

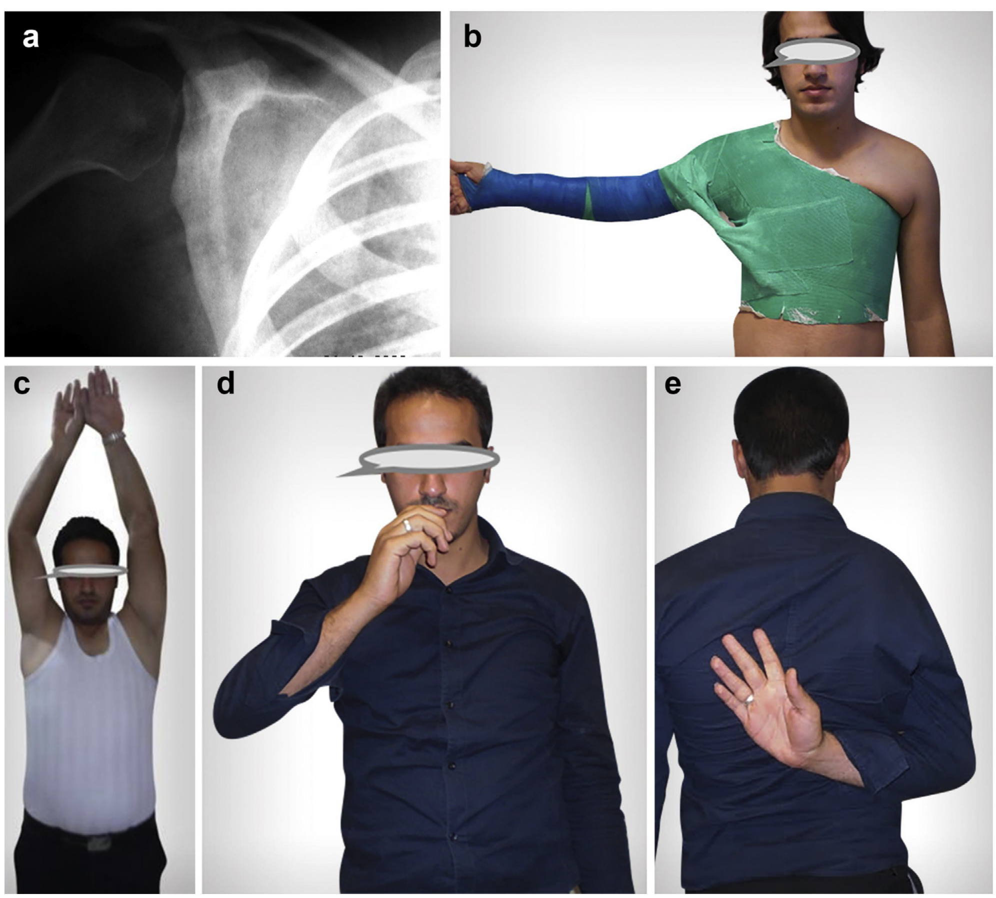

Figure 4 A 23-year-old man with Mallet score of 7, surgery at age 19 years. (**a**) Severe gleno-humeral dysplasia. (**b**) Postoperative casting with elbow in extension. (**c-e**) Abduction, flexion, internal rotation, mouth – reaching 4 years after surgery.

The accurate measurement of glenoid and humeral head version, even by various imaging technics (MRI, CT, arthrography, and radiography), in BPBP is very difficult.[12,13,22,23,31] It has been also shown that the function and appearance of the arm in performing various functions do not correlate with dysplasia.[13,15,32,43] Generally, there are conflicting results in the literature when one tries to correlate the result of surgery with the severity of GHD.[13,25,29,30] There is also insufficient evidence to indicate that any surgery – osteotomy or release and tendon transfer with or without open reduction – would reverse the already established GHD.[25] Waters et al[41,43] using MRI images, in 14 children who received posterior reefing of capsule simultaneous with the release and tendon transfer, suggested 83% dysplasia improvement in measuring coverage of humeral head by the glenoid with a chosen slice of the MRI. These results are hard to verify in short follow-ups, in imaging of very young children, and while contracture of the shoulder makes child's position difficult in the imaging gantry. The scapular orientation may all give false measurement of the imaging studies. How to choose a specific CT or MRI imaging slice to label the shoulder as subluxated or dislocated is not very clear.[40] Therefore, the notion of “improving dysplasia” with surgery remains difficult to prove.[32,38] It has also been suggested that earlier surgery may improve or reverse the dysplasia, but the factors influencing the development of GHD remain unclear and so does the prediction of postsurgical improvement of dysplasia.[2,16,24,25,41,42] Although the dysplasia is more commonly seen in children with more significant shoulder joint contracture, it is not a uniform finding.

Conclusion

The present article, in its long-term follow-up of contracture release and tendon transfer, without any intentional arthrotomy showed improvement of function and Mallet scores irrespective of dysplasia – even with moderate or severe GHD in the older-age group – was successful. We could not comment on whether GHD would change after surgery because good-quality original radiographs were not available for all the cases in our long-term follow-up. However, we showed in a long-term study that even with GHD, acceptable function and motion improvement is obtainable with the suggested soft-tissue reconstruction surgery.

The limitations of this article are that it is retrospective study, lacking preoperative or postoperative CT or MRI imaging studies, and inability to comment on any possible postoperative radiographic improvement and changes in GHD with this long-term study.

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Supplementary data

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