Addressing Residual Shoulder Deformities in Birth Brachial Plexus Palsy: Mod Quad Release Revisited

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Abstract

Birth brachial plexus palsy is not an uncommon condition. Despite spontaneous recovery in most cases, some residual deformities do exist in the upper limb. Out of these deformities, a decreased range of movement in the shoulder (abduction and external rotation) is common.

To improve shoulder abduction and external rotation, the procedure described are Mod Quad procedure which includes the release of pectoralis major and minor muscles, transfer of latissimus dorsi and teres major to teres minor muscle, and axillary nerve neurolysis which is based on the principle of releasing the contracted muscles and augmenting the paralytic muscles. Although it is a simple technique, gives early results, and is easy to reproduce, but less details are available in the literature.

The present article aims to revisit the Mod Quad procedure, doing a comprehensive review of its pros and cons, technical considerations, and outcome analysis.

Keywords

- Mod Quad release
- Mod Quad procedure
- birth brachial plexus palsy
- obstetric brachial plexus injury (OBPI)

Introduction

Birth brachial plexus palsy (BBPP) is a relatively common birth injury, affecting approximately 0.15 to 3 in every 1,000 births.[1] It occurs when the brachial plexus is damaged during delivery as may happen when the baby's neck or shoulders are stretched, compressed, or wedged in the birth canal. In the context of childbirth, risk factors such as macrosomia, protracted labor, gestational diabetes, maternal obesity, and breech presentation are associated with an increased likelihood of brachial plexus injury, resulting in upper extremity muscle weakness or paralysis.

However, the recovery rate in BBPP varies up to 95%[2] and often results in residual shoulder deformities (along with elbow and hand) with a deficit in shoulder abduction and external rotation.

The three major factors, cross-reinnervations, muscle imbalance caused by paralyzed muscles and recovered muscles and growth, are responsible for shoulder deformities as described by Chuang et al.[3]

Most of these injuries are Sunderland's grade first- and second-degree injuries which recover spontaneously or postganglionic injuries with incomplete rupture or rupture with a small gap where regeneration of axons may occur. However, a preganglionic injury may also occur which can be either partial or global and with or without Horner syndrome. During the recovery phase, due to full or incomplete recovery of a few muscles and no recovery of another group of muscles, there is muscle imbalance. Also, cross-reinnervation of regenerating axons causes cocontractions of two opposite groups of muscles. As the child grows, it causes contracture and shortening of adductor and internal rotator muscles which further decreases the range of motion and requires release.[3,4]

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The Mod Quad procedure includes the release of pectoralis major and minor muscles, transfer of latissimus dorsi and teres major to teres minor muscle along with decompression of axillary nerve or neurolysis. This results in significant improvement in shoulder abduction and external rotation and thus improves the overall Mallet score. This may or may not be combined with subscapularis muscle release.

Despite the simplicity of the technique resulting in significant improvement in the range of motion with the early result and good satisfaction of the parents and surgeons, fewer details are available in the literature. The article aims to describe a comprehensive review of the Mod Quad release procedure with technical details and outcomes.

Natural History and Residual Shoulder Deformities

While many (up to 95%) infants recover fully from BBPP, a significant number continue to experience residual secondary shoulder deformities and functional impairment such as the inability to abduct and externally rotate the shoulder with limitations to reaching the mouth and neck with the hand. This limitation in movement can significantly impact a child's ability to perform daily activities and participate in various physical tasks.

Several anatomical changes may occur in the shoulder joint, including scapular winging, flattening of the humeral head, glenoid deformity, and potential posterior dislocation of the glenohumeral joint. These changes can have significant implications for medical treatment and management.

In terms of long-term follow-up, those with BBPP must pursue continuous monitoring and treatment as each individual's recovery trajectory can greatly vary. Monitoring of shoulder deformities should involve regular physical examinations to ascertain the child's functional capacity and posture. Imaging studies such as magnetic resonance imaging or ultrasonography and electrophysiological (electromyography and nerve conduction studies) studies may also be employed to assess nerve reinnervation and musculoskeletal changes over time. A multidisciplinary team, involving child physicians, surgeons, physical therapists, and occupational therapists, among others, plays a crucial role in this long-term care. The aim of the team is not only to promote recovery of function but also to address psychosocial aspects considering the potential impact of the deformities and functional limitations on the child's self-esteem and social involvement. To avoid long-term functional impairments and increase the quality of life of those affected, it is essential to address any shoulder deformities caused by BBPP.

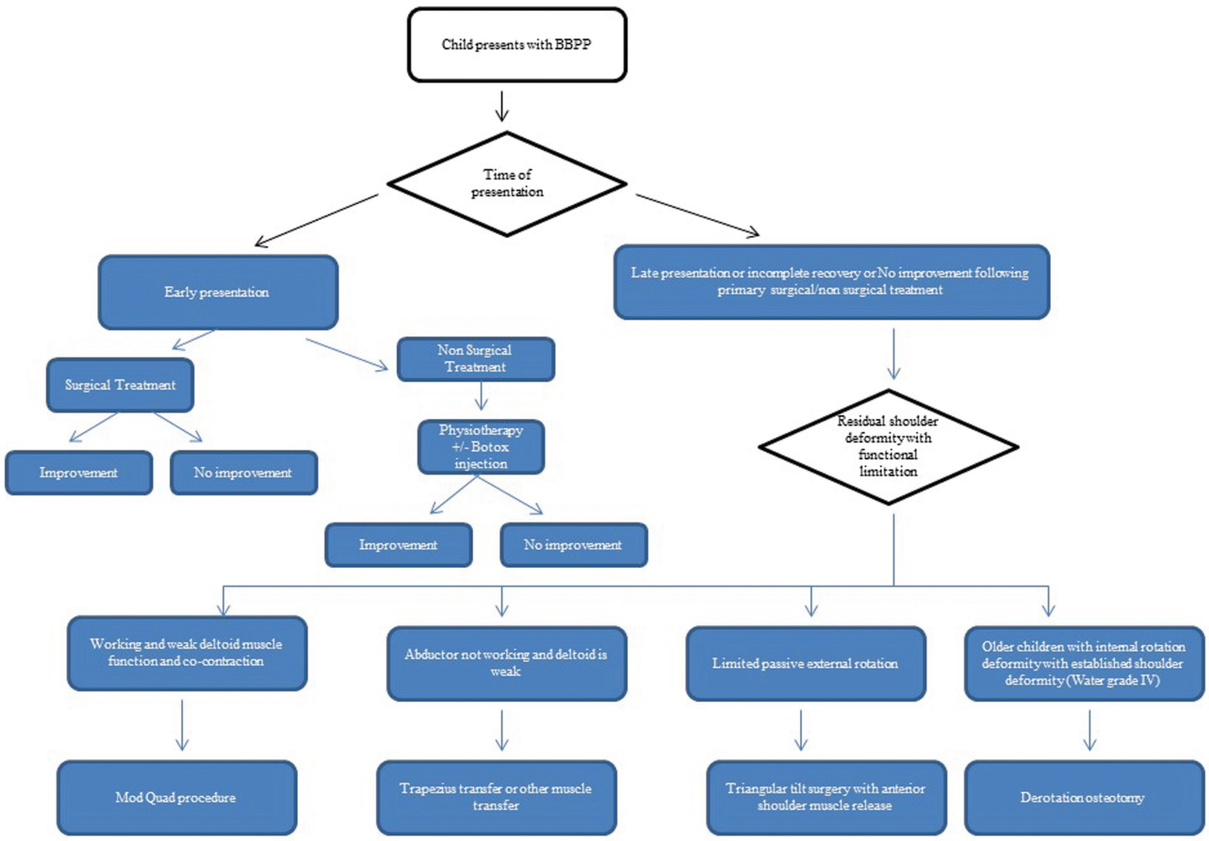

Fig. 1 An algorithm for addressing the shoulder deformities in birth brachial plexus injury (BBPI).

Evaluation

It is mandatory to evaluate the child to assess the presence of working and paralyzed or weak muscles around the shoulder. The child is asked to hold an object by abducting their affected arm and one can feel the deltoid contraction around the shoulder.

Simultaneously, while abducting the arm, one can palpate the cocontraction of adductor muscles at the anterior and posterior axillary fold, and that guides the procedure to be chosen to improve the shoulder's range of motion. Once muscles are evaluated, it is also important to see joint conditions and whether the shoulder joint is congruent or not. For that a simple X-ray or if in doubt computed tomography arthrogram can depict a better picture of joint abnormalities.

The range of movement around the shoulder is further evaluated by Gilbert's scoring system[5] and the overall functioning of the limb by Mallet score.[6] The corresponding author follows the guidelines described by many authors[3,4] and here we summarize an algorithm for the readers based on those principles (►**Fig. 1**).

Management

The various options to address shoulder deformities or to improve the range of motion are the Mod Quad procedure, triangular tilt surgery, trapezius muscle transfer, and derotational osteotomy. These are all viable surgical interventions for the management. Each of these procedures possesses unique advantages and potential limitations. The selection of an appropriate surgical intervention is contingent upon the specific requirements and clinical condition of the patient.

Mod Quad Release

When there is limited abduction due to muscle imbalance between abductors and adductors, or cocontractions, contracted adductors can be released and transferred to the lateral humerus or infraspinatus or teres minor that will help in external rotation. The technique is usually indicated in those children (over 2–3 years of age) where conservative, nonsurgical management including physiotherapy and/or Botox injection has failed to get the desired result or even with a history of prior nerve surgery with inadequate outcome.

Surgical Technique

The surgery is usually performed under general anesthesia. The anterior axillary fold is marked which is formed by the underlying pectoralis major muscle (►**Fig. 2**). Simultaneously, posterior axillary fold formed by latissimus dorsi and teres major is also marked and the same incision can be extended posteriorly over the scapula (►**Fig. 3**). Few surgeons also prefer to make single incisions for anterior as well as posterior release. Adrenaline with saline is infiltrated along the incision line and the pectoralis major muscle is exposed

Fig. 2 Marking for anterior incision.

and dissected (►**Fig. 4**). It is divided at its musculo-tendinous insertion by electrocautery and checked for a complete passive range of abduction (►**Fig. 5**). If there is still tightness, pectoralis minor can also be released.

Posteriorly, latissimus dorsi and teres major are dissected (►**Fig. 6**) and released at their conjoint tendinous insertion. The conjoint tendon is formed by these two muscles; latissimus dorsi (more tendinous and superficial) and teres major (more muscular and deeper) (►**Fig. 6**). Once released, the tendons will slide back. The tendons of latissimus dorsi and teres major are weaved through teres minor by a few sutures of prolene (►**Fig. 7**). In the quadrangular space, one can see the axillary nerve which is decompressed by releasing the overlying tight fascia and thus the nerve is neurolysed externally (►**Figs. 8** and **9**).

The skin flaps are sutured in layers. The arm is immobilized in a plaster of Paris slab in 110 degrees of abduction which is converted into a detachable splint in the next dressing. After 10 to 14 days, both active and passive range of abduction and external rotation exercises are started. ►**Figs. 10** (case-1) and **12** (case 2) show a preoperative picture of limited shoulder abduction and external rotation. ►**Fig. 11** (case-1) and ►**Figs. 13**–**14** (case-2) show the postoperative result of improved abduction of more than 100 degrees and improved hand-to-head reach.

Discussion

Limited shoulder abduction and external rotation are common sequelae after spontaneous recovery from BBPP. Due to

Fig. 3 Marking for posterior incision.

Fig. 5 Release of pectoralis major muscle.

Fig. 4 Dissection of pectoralis major muscle.

the established contracture of soft tissue and underlying muscles and after the failure of conservative surgery or late presentation, it becomes essential to do a secondary surgical procedure to improve the shoulder's range of movements to perform overhead activities.

The different approaches described are Mod Quad release, triangular tilt surgery, trapezius transfer, or derotational osteotomy. These techniques are based on principles of navigating the effect of cocontracted synergistic and antagonistic groups of muscles, augmenting the paralyzed or paretic muscle, and correcting established deformities.

The Sever-L'Episcopo tendon transfer procedure (described in 1934) was used to treat obstetric brachial plexus palsy. The procedure involves transferring the latissimus dorsi and teres major muscles from their insertion on the anteromedial aspect to the lateral aspect of the humerus by passing posteriorly to the shaft of the humerus.[7]

Nath and Paizi popularized the technique of Mod Quad release. They published results of 98 patients with soft tissue contractures and shoulder deformity concluding that surgical treatment, including transfer of latissimus dorsi and teres major muscles, release of subscapularis, pectoralis major and minor muscles, and axillary nerve decompression and neurolysis, significantly improved active abduction in young patients with muscle imbalance due to obstetric brachial plexus palsy. The mean active abduction range was 45degrees (20–90 degrees) before and 162 degrees (100–180 degrees) after the Mod Quad release surgery.[8]

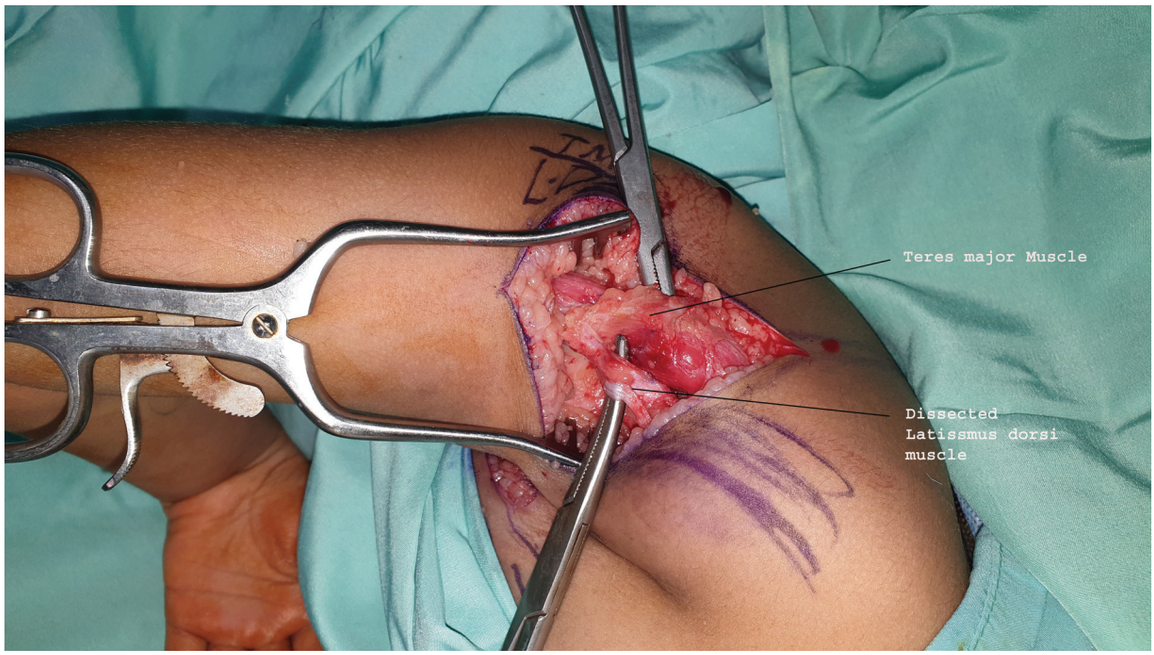

Fig. 6 Dissection of latissimus dorsi (LD) and teres major muscle.

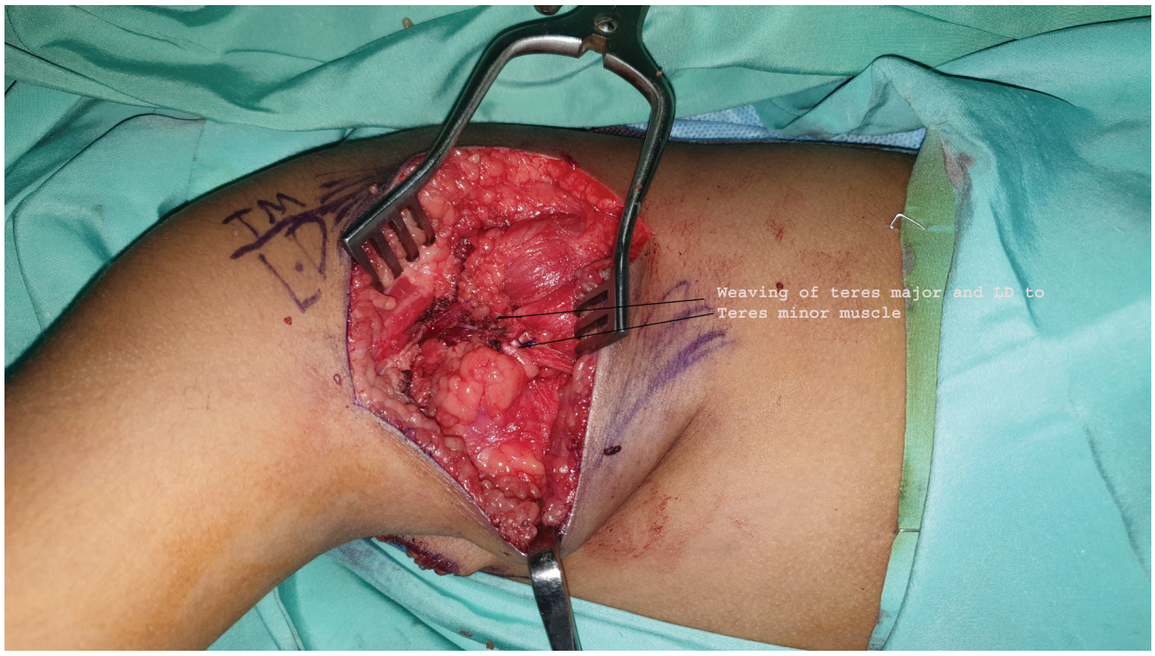

Fig. 7 Transfer of latissimus dorsi (LD) and teres major muscle to teres minor muscle.

Chuang et al described the technique of muscle transposition to minimize the effect of cross-innervation. They released the antagonistic muscles (pectoralis major and teres major muscles) and augmented the paretic muscles (transferring the teres major to the infraspinatus muscle) along with reinserting both ends of the pectoralis major laterally. This seems to be logical which improved the shoulder abduction to 151 degrees (an average gain of 104% or 77 degrees and that of external rotation was 72 degrees with an average gain of 200% or 48 degrees).[3]

Nath and Somasundaram also found that the Modified Quad surgical procedure is as effective in preteen and teen patients with BBPP. At a mean follow-up of 1.5 years for all their patients ($n = 16$), the mean active abduction was improved to 132 degrees (range: 40–180 degrees, $p < 0.0003$). The overall Mallet score was also increased to 19.7 (range: 13–25,

Fig. 8 Axillary nerve decompression.

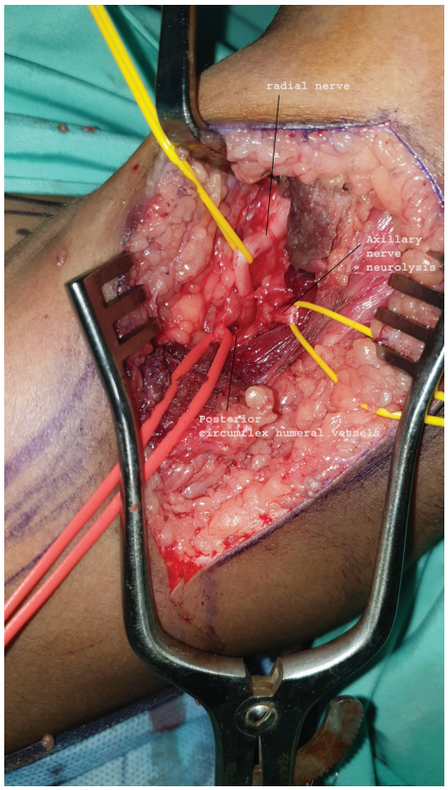

Fig. 9 Axillary nerve neurolysis.

Fig. 10 Preoperative pic showing limited shoulder abduction < 30 degrees (right upper limb birth brachial plexus injury [BBPI] with residual shoulder deformity).

$p < 0.0001$).[9] Several authors support the concept of the release of contracted muscles and some form of tendon transfer to improve abduction and external rotation; however, the new insertion of latissimus dorsi and teres major may vary according to the surgeon's choice[3,10–14] (►**Table 1**).

Nath et al further noticed that the Modified Quad procedure improves the conduction of the median nerve from 8.04 to 9.26 ($p < 0.022$) postoperatively along with improvement

Fig. 11 (Case-1) Postoperative picture showing improved shoulder abduction up to more than 140 degrees (right upper limb) (case-2).

Fig. 12 (Case-2) Preoperative picture showing limited shoulder abduction and external rotation (right upper limb birth brachial plexus injury [BBPI] with residual shoulder deformity).

Fig. 13 (Case-2) Postoperative picture showing improved shoulder abduction of more than 120 degree.

Fig. 14 Postoperative picture showing improvement in hand-to-head reach (case-2).

Table 1 Comparison of different techniques with outcomes used to correct shoulder deformities in BBPI (birth brachial plexus palsy)

Serial number	Authors	Number of cases	Procedure described	Average follow-up	Improved range of movement of the shoulder	Improvement of external rotation	Improved Mallet score
1	Chomiak et al (2014)[10]	15	LD and TM transfer to the lateral side of humerus + lengthening of pectoralis major and subscapularis muscle	1–22 y	Average 108.33 (SD 34.27)	31.1 (SD 7.82)	Total score 17 (SD 1.73) Average3.31 ± SD 0.20 Gain 5.11 (SD 1.83)
2	Phipps and Hoffer (1995)[11]	56	LD and TM transfer to rotator cuff	5 y	120 degrees	31 degrees	Not available
3	Odeh and Odeh (2015)[12]	19	Elongation of pectoralis major and subscapularis + LD and TM transfer to the lateral aspect of the humerus, anterior capsulotomy	3 y,3 mo	137 degrees (*p*-value 0.005)	65 degrees (*p*-value 0.005)	Total 21.3
4	Ozben et al (2011)[13]	26	Pectoralis major lengthening with transfer of LD and TM to rotator cuff No subscapularis release	43 mo	115 degrees (*p*-value < 0.005)	35 degrees (*p*-value 0.005)	Mean abduction 3.7 ± 0.5 Mean external rotation 3.5 ± 0.8 Hand to head 3.4 ± 0.7 Hand to mouth 3.0 ± 0.7 Internal rotation 2.8 ± 0.7 (not significant)
5	van der Holst et al (2016)[14]	115	ICR and MMT (internal contracture release with LD and TM transfer to humeral head)	6 y (SD 32 y)	T0 (preop)–T5 (10 y follow-up) (change score) = 50.1	T0 (preop)–T5 (10 y follow-up) (change score) = 38.6	T0 (preop)–T5 (10 y follow-up) (change score) = 2.02

Abbreviations: ICR, internal contracture release; LD, latissimus dorsi; MMT, muscle tendon transfer; SD, standard deviation; TM, teres major.

in shoulder abduction from preop of 30 degrees ± 23.3 to 142 degrees ± 33.7 ($p < 0.0001$).[15]

Ozben et al concluded that subscapularis release is not always required to overcome internal rotation contracture.[13] Also, the main disadvantage or complication of this technique is reduced power of shoulder adduction (decreases by one-third of that unaffected side).[3] Thus, we do not include subscapularis release

Nath and Somasundaram studied 17 patients treated with Mod Quad (and triangular tilt) and had a long-term follow-up of these patients (more than 10 years) preserving their improved functions for a longer time.[16] They also found an improvement in total functional Mallet score after 3 years (mean, 18.8 ± 2.1; p-value < 0.01) from a preoperative score of 14.5 ± 1.2. This improvement was maintained for a prolonged period and significantly improved in a few patients

Conclusion

In conclusion, BPBP can result in residual shoulder deformities even after spontaneous recovery or inadequate outcomes after primary nerve surgery. These deformities result in a decreased range of motion of the shoulder's abduction and external rotation.

Mod Quad procedure is a simple surgery focused on releasing the contracted adductors and tendon transfer for an external rotation along with axillary nerve decompression and neurolysis that gives early good results. This procedure significantly improves the active and passive range of motion of the shoulder joint and thus improves the overall Mallet score.

Disclosures

- None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.
- The manuscript, figures, tables, and data have not been published previously and are not under consideration for publication elsewhere.

Declaration of Informed Consent

Informed consent has been duly signed by the patient's parents for publication in a research journal.

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Conflict of Interest

None declared.

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