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Treatment of secondary deformities of birth palsy

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Abstract:Background: There are three primary surgical solutions: neurolysis, neurotization (nerve transfer) and nerve grafting. These may be performed alone or in combination with each other. The choice of which peripheral nerve surgery technique is appropriate is based on which method will maximize and encourage the natural regenerative process of the nerve. We use nerve transfer and grafting, depending on the intra-operative findings and with our surgical experiences. Injuries of C5-C6 do not always warrant surgery if injury to C7 is minor. In patients where C8 and T1 are involved in addition to C5-C7, hand function is also affected, therefore nerve repair for the upper and middle trunks is more likely to be required.Early surgical interventions have been shown to improve the limb functions in this group of patients. Management of secondary deformities in OBPI has typically been through the performance of various operative procedures including tendon transfers, muscle releases, axillary nerve decompression, humeral osteotomy, biceps tendon lengthening, glenohumeral capsulorrhaphy and anterior capsule release

Keywords: secondary deformities, birth palsy.

Introduction

Diagnosis of secondary deformities of the shoulder is important in the assessment of the feasibility of the secondary surgical techniques. For soft tissue secondary reconstructive procedures the absence of severe secondary deformities is considered a prerequisite [1].

Treatment of secondary deformities of birth palsy

1. **Non-surgical interventions**

Non-Surgical interventions are physical and occupational therapies, electrostimulation, neuromotor therapy, BTX-A injections and splinting. Among the most promising of these methods is BTX-A treatment. This has been shown to treat biceps/triceps co-contraction, and shown to improve biceps movement and strength. BTX-A treatment for OBPI has not been effective over long-term[1].

2. Primary surgical solutions

There are three primary surgical solutions: neurolysis, neurotization (nerve transfer) and nerve grafting. These may be performed alone or in combination with each other. The choice of which peripheral nerve surgery technique is appropriate is based on which method will maximize and encourage the natural regenerative process of the nerve. We use nerve transfer and grafting, depending on the intra-operative findings and with our surgical experiences. Injuries of C5-C6 do not always warrant surgery if injury to C7 is minor. In patients where C8 and T1 are involved in addition to C5-C7, hand function is also affected, therefore nerve repair for the upper and middle trunks is more likely to be required [2].

3. Surgical management of secondary deformities

The decision of whether to surgically repair the nerves, however, does typically need to be made in the first 6 months of life. Delay beyond this age in these patients lead to long-term morbidity by causing muscle imbalances and weakness around the shoulder (the deltoid and external shoulder rotators) [3], and bony deformities at the shoulder joint (glenohumeral dysplasia and joint incongruity). These anatomical changes subsequently severely impair the bone growth and development. The major bony deformity that develops is termed as the SHEAR (scapular hypoplasia, elevation, and rotation) deformity, which is caused by the elevation and extrusion of the affected scapula beyond the clavicle. The abnormal anterior rotation of the clavicle together with the protracted scapula causes the acromioclavicular plane to tilt forward and thereby lead to the impingement of the acromion upon the humeral head. Significant secondary deformities that follow include medial rotation contracture (MRC) and elbow flexion.

Early surgical interventions have been shown to improve the limb functions in this group of patients [4]. Management of secondary deformities in OBPI has typically been through the performance of various operative procedures including tendon transfers, muscle releases, axillary nerve decompression, humeral osteotomy, biceps tendon lengthening, glenohumeral capsulorrhaphy and anterior capsule release[5].

<u>Soft tissue operations of secondry deformities of birth palsy:</u>

<u>subscapularis release</u>

subscapularis muscle release is one of the operations that help in treatment of OBPI. Patient is placed in a supine position with a small support under the ipsilateral scapula.A deltopectoral incision was made and the coracoid was exposed. The tip of the coracoid was excised using a subperiosteal exposure. A step-cut lengthening of the subscapularis tendon was made, leaving the laterallybased flap superior. Care was taken to protect the underlying shoulder capsule. A transverse incision was made at the level of the rotator interval, sufficient to allow inspection of the glenohumeral joint to ensure appropriate alignment of the glenohumeral joint using external rotation and abduction. The subscapularis tendon was closed with the arm in the same position of external rotation and abduction. [6]

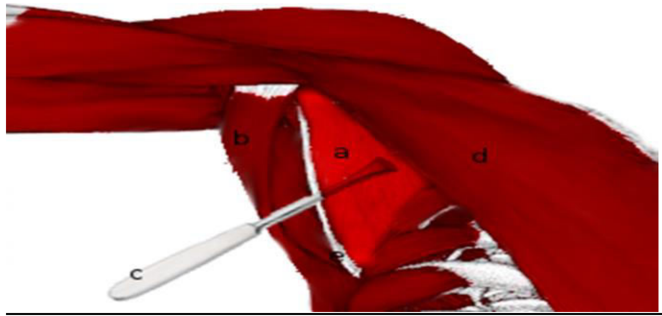

Fig 1: Extraperiosteal elevation of the subscapularis off the anterior aspect of the scapula. a Subscapularis, b latissimus dorsi, c periosteal elevator, d pectoralis major, e scapula

Teres major tendon transfer

A single posterior incision was used, and the insertion of the latissimus dorsi and teres major were identified and released, then transferred posteriorly to the long head of the tripceps muscle on to the rotator cuff, as superiorly as possible. This converted the latissimus dorsi and teres major tendons into external rotators of the shoulder.[6]

UPPER TRAPEZIUS TRANSFER

The trapezius is the most common tendon transfer performed for adult patients with brachial plexus injury, including those who undergo spinal accessory nerve transfer as part of their brachial plexus reconstruction.[7,8] In these patients, the remnant of the upper trapezius retaining function hypertrophies and may be transferred. Its use was described by Hoffa in 1891, followed by Lewis in 1910 and Lange in1911.[8] Tendon prolongation with fascia lata led to poor results attributed to stretching and scarring .[9] Bateman described the transfer of the muscle with its acromial insertion into the proximal humerus in 1955, later modified by Saha (1967), whose name is now associated with the surgery.[7]

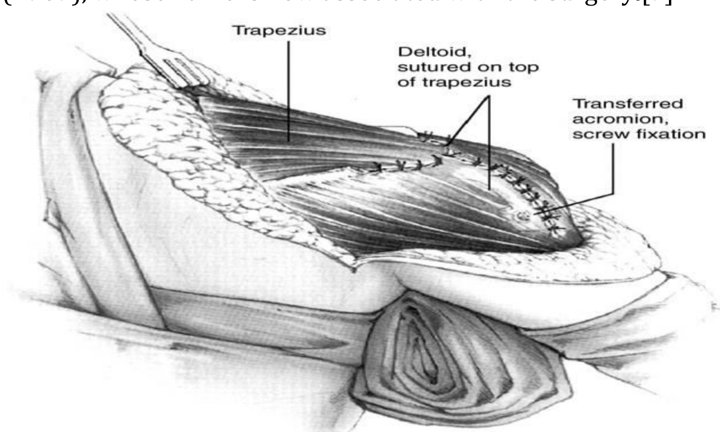

Fig 2: Drawing showing the original Saha technique Trapezius transfer in brachial plexus palsy

Latissmus Dorsi TRANSFER

Direct LD tendon transfer, with or without teres major transfer, is commonly used in obstetrical brachial plexus injury to restore abduction and external rotation. [10] Its use in the adult has not been reported. Most pediatric patients not only have latissimus function,rare in the generally more severe adult traumatic injuries, but also have additional deltoid and subscapularis function that may be critically important. Gerber considered their paralysis to be contraindications to LD transfer.[11] In patients without deltoid and subscapularis, its transfer to the greater tuberosity may magnify inferior subluxation and function to adduct and extend the shoulder. When performed to reconstruct massive irreparable rotator cuff tear, however, it functions appropriately as a humeral head depressor and external rotator in the presence of normal subscapularis and deltoid.

PECTORALIS MUSCLE TRANSFER

Hou and Tai reported on 7 patients who underwenttransfer of either the upper portion of the pectoralis alone (4 patients) or combined with the upper trapezius transfer (3 patients) for deltoid paralysis.[12] They defined the functional anatomy of the pectoralis major muscle as having 3 parts: clavicular (originating from the clavicle), sternocostal (originating from the first to sixth sternocostal regions), and abdominal (originating from the junction of the lower sternocostal and rectus abdominis fascia). These muscular parts converge laterally and insert on the greater tuberosity of the humerus as anterior and posterior tendons. The tendinous portions of the clavicular and upper sternocostal parts make the anterior tendon. These parts are supplied by the thoracoacromial artery and innervated by the lateral pectoral nerve, whereas the lower part is supplied by either the thoracoacromial artery or the internal thoracic branch of the axillary artery and innervated by the medial pectoral nerve.

LOWER TRAPEZIUS TRANSFER

Elhassan et al. reported the transfer of middle and lowertrapezius to restore shoulder external rotation.[13] The patient had a brachial plexus injury with complete paralysis of the deltoid, infraspinatus, and teres minor. The trapezius was prolonged by an Achilles' tendon allograft positioned at the infraspinatus tendon insertion. The patient gained 70° of external rotation and was satisfied with the outcome of surgery.

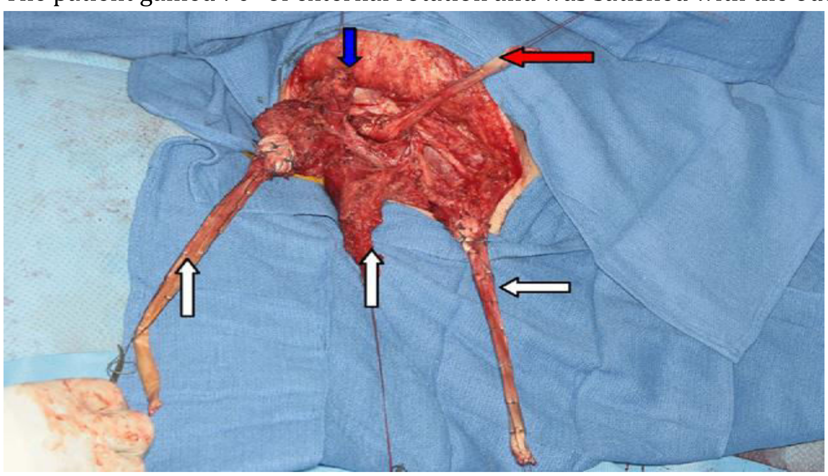

Fig 3 :Showing an example of multiple tendon harvesting for multiple tendon transfers, to restore the shoulder force couple in addition to the deltoid function (white arrows point to the upper trapezius on the left, middle trapeziusin the middle, and lower trapezius on the right of the picture; blue arrow points to the levator scapulae; and red arrow points to the serratus anterior.

Posterior glenohumeral capsulorrhaphy

Posterior glenohumeral capsulorrhaphy tightens the posterior capsule surrounding the humeral head and repositions it anteriorly. This procedure does not address the SHEAR deformity and its central influence in the pathophysiology of the medial rotation contracture. Posterior capsulorrhaphy, on its own, is often not sufficient to address the glenohumeral subluxation, as is predictable when taking the SHEAR into consideration. Successful restoration of position and function in failed humeral osteotomy patients has followed from surgically addressing the SHEAR deformity. It may be inferred that the SHEAR correction, the Triangle Tilt surgery is a more specific operation because it addresses the root cause of the medial rotation [5] .

Modified Quad

The modified Quad is a modification of the Quad Procedure, which is a soft tissue release operation performed in patients with partially recovered brachial plexus injuries to improve shoulder abduction and flexion function. The Quad couples neurolysis and decompression of the axillary nerve with an untethering release of soft tissue contractures that limit abduction power [13]. The modified Quad is a modification of the combination of muscles released and their inset positions to improve upon a previously described operation by Narakas [14].

More specifically, it is based on the following four steps:

(1) Latissimus dorsi muscle release and transfer for external rotation and abduction.

(2) Teres major muscle release and transfer for scapular stabilization.

(3) Subscapularis release without transfer.

(4) Axillary nerve decompression and neurolysis.

Other nerve decompressions or muscle/tendon transfers (such as pectoralis muscle releases) might be performed at the same time, depending on the individual child. In the modified Quad procedure, the latissimus dorsi, teres major, subscapularis, and pectoralis muscle contractures are released. As performed by Narakas, the latissimus dorsi and teres major muscles are sutured to a low position in the teres minor muscle . The deltoid can now act more effectively, due to the enhanced stabilization of the rotator cuff, while not tethering shoulder abduction and flexion ability [15].

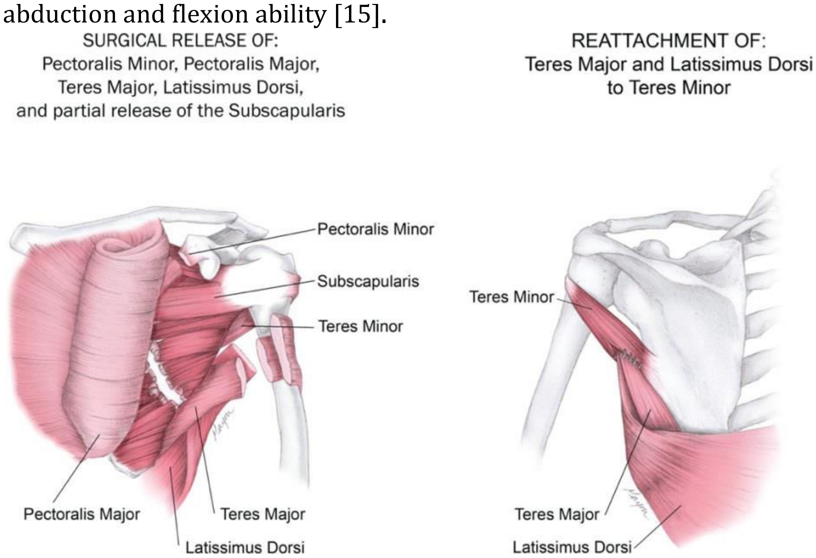

Fig 4: The Mod Quad Procedure

The Mod Quad Procedure improves shoulder abduction and flexion. Left, release of major internal rotator muscles: subscapularis (not shown), teres major, latissimus dorsi, pectoralis major and minor. Right, teres major and latissimus dorsi are transferred to the teres minor, increasing external rotation, abduction and scapular stability. Neurolysis and decompression of the axillary nerve furtherincrease range of motion [16].

Bony operations:

Rotation/Derotational Humeral Osteotomy

Rotation osteotomy of the humerus has been described by several authors to treat [17] the internal rotation contracture of the shoulder in OBPI. Eng *et al* reported that later surgical treatment with rotational osteotomy of the humerus seems to improve cosmesis [18] but not function. Recently, Al-Qattan has also shown that this procedure mainly improves the cosmetic appearance of children with total brachial plexus birth palsy. In [19] addition, Al-Qattan *et al* also found surprisingly, a significant decrease in shoulder abduction on long-term follow-up of his OBPI patients (the mean shoulder abduction was 135°, 146° and 109° measured pre-, early post- and late postoperatively, respectively). This technique has been used as a preferred procedure in older OBPI [20] children, and shown to improve shoulder function, yet was not demonstrated as effective procedure comparatively [14]. Waters *et al* showed improvement of 5.0 to 5.6 in total Mallet score after humeral osteotomy [20].

Ilizarov bone lengthening

In severe OBPI patients, who is left with severe bony rotational and shortening deformities that are functionally limiting, the use of Ilizarov bone distraction technique is appropriate. This technique is used for rotation and lengthening of the humerus as well as the forearm. Functional gains are significant as the hand is placed into a more useful position [21].

The triangle tilt surgery

Definition and nomenclature

The triangle tilt is a bony surgical procedure that detaches the distal acromioclavicular triangle ("ACT", with its sides defined by the clavicular shaft and the acromion process and its base by an imaginary line connecting their medial ends)- humeral head complex from the abnormally positioned scapula; subsequent reversal of the anterior tilt of the ACT then would allow a natural rotation of the humeral head back into a more neutral position within the glenoid fossa. This procedure differs from more conventional approaches (tendon transfers, axillary nerve decompressions, and external rotation osteotomy of the humerus) in that it addresses and corrects the scapular hypoplasia, elevation and external rotation (SHEAR) deformity associated with typical OBPI cases [22].

Indications

The triangle tilt procedure has been previously shown as an effective treatment option for children and can be used for adolescents without modification. The procedure can theoretically be applied to patients between the ages of 8 months and 16 years. Triangle tilt is ideally suited for patients who have developed a medial rotation contracture and scapular elevation; if these abnormalities are observed, the surgery is effective in the presence of mild, moderate and severe neurological defects, including complete glenohumeral dislocations and as salvage for failed previous reconstructive surgeries[4].

Timing

It's recommended that the triangle tilt surgery be performed before the age of 2 years for optimal improvements in outcomes of clinical functioning. This surgery can be performed as early as nine months, and up until late adolescence (16-17 years). Optimal clinical outcomes are achieved if this surgical procedure is performed before the age of 2 years, but improvements in functioning are observed if the surgery is performed after this age as well [22]

Diagnosis

Diagnostic tools used to identify which lesions are permanent in OBPI include computed tomography (CT), magnetic resonance imaging (MRI), myelogram, and electromyography (EMG) as well as nerve conduction velocity (NCV) studies. Distinguishing preganglionic (avulsion) from postganglionic (rupture) lesions is critical, and can be difficult at initial presentation based on clinical examination alone in these infants. Our experience with MRI for pre-operative assessment of the spinal roots has been unfavorable. EMG testing is the procedure of choice for preoperative evaluation of nerve-muscle integrity [14].

Steps

The procedure involves tilting of the acromioclavicular plane (in which the ACT lies) to a neutral and functional position through osteotomies of the clavicle, acromion process and scapula, thereby allowing for the repositioning of the humeral head into the glenoid fossa, in a more anatomic situation. 18 for a preoperative plane, versus a neutral anatomic plane. More specifically, the triangle tilt surgery consists of:

(1) osteotomy of the clavicle at the junction of the middle and distal thirds
(2) osteotomy of the acromion process at its junction with the spine of the scapula
(3) ostectomy of the superomedial angle of the scapula to reduce scapular winging
(4) splinting of the extremity in adduction, external rotation, and forearm supination

Additional minor elements of the procedure include bone grafting of the acromion process and clavicular osteotomy sites and semi-rigid fixation of the clavicular osteotomy segments to prevent nonunion [16]. for illustrations of the procedure and the bone realignment following triangle tilt surgery.

Surgical technique

The procedure began with an incision along the medial edge of the superomedial border of the scapula. Soft tissue was dissected from the scapula and the prominent superomedial angle of the scapula was excised with a bone cutter to create a rounded surface. An incision was made over the spine of the scapula and soft tissue dissection exposed the scapular spine, which was cut with an electric saw. The scapula and the acromion process derotated after osteotomy, indicating preoperative twisting and internal rotation caused by the elevated scapula. The bone removed during osteotomy was morselized and placed in the bone defect between the scapular spine and the acromion process. An incision was made over the distal third of the clavicle and the soft tissue was dissected to expose the clavicle. Osteotomy of the clavicle was performed with an electric saw and the distal and proximal clavicle segments were fastened together in semirigid fixation with titanium screws and absorbable suture. The clavicle segments were noted to "twist" relative to each other after the osteotomy, indicating torsion in the clavicle due to scapular elevation. An incision was then made above the posterior glenohumeral joint and careful dissection through the deltoid muscle exposed the posterior glenohumeral capsule. Laxity in the capsule was removed with a circumferential suture in a purse-string fashion. Wounds were closed in multiple layers and the patient was splinted in adduction and supination, with the humerus externally rotated and in a neutral position. The patient was splinted for 6 weeks and then splinted only at night for additional 3 months. Physical therapy was prescribed for 6 months [4].

Fig 5: photograph showing the splint for immobilisation of the shoulder after triangle tilt surgery [14].

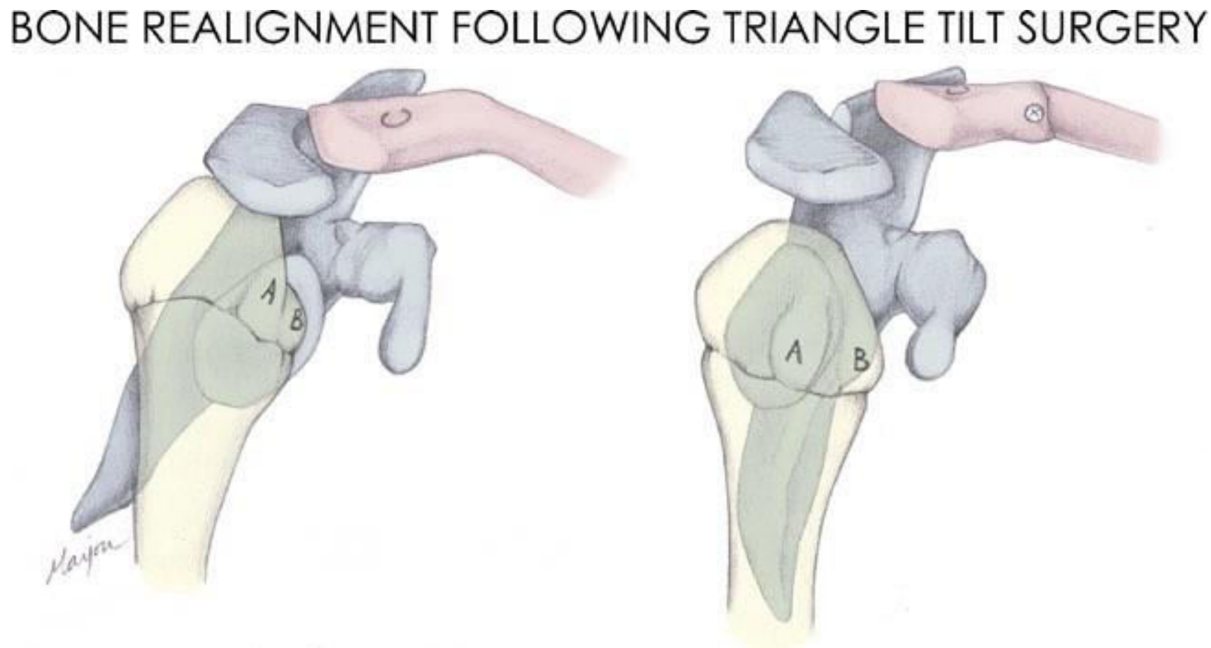

Fig 6: Artist's rendering of acromioclavicular interface before (left) surgery [23].

Postoperative care and physiotherapy

On table perform splint in adduction, external rotation, and forearm supination. The splint is called Sarobrace and should be worn day and night without removal for 3 to 6 weeks. *This will be pending on severity of shear deformity.* Saro position goal is elbow crease forward with thumb up. The axillary area should be clear from the pastic of the splint. Splint should be sitting above hip joint unless child is female with breast development [22].

Fig 7: position of SARO brace.

Elbow Passive range of motion begins at postoperative day 2 to prevent elbow stiffness and biceps spasms. Saro brace is removed at post-op week 3 to 6 at home or therapy clinic. Heat modalities are recommended in

the form of hot pack or hot bath. Loss of ROM at shoulder is expected at this time. So, no Saro brace at night until functional active range of motion at the shoulder is regained [22].
Therapy resumes at post-op weeks 3-6 to 8 (when saro brace is no longer used). Early therapy goals at this time is to Increase AROM to shoulder flexion/abduction and elbow flexion [14].

At weeks 8 to 12 continue with progressive AROM activities. Constraint-induced therapy is recommended with attention paid to maintaining alignment. All compensatory movements to be discouraged such as hiking the hip, rotating or bending body backward. Serial casting at the elbow might be started if elbow flexion contracture present [14].
At weeks 12+ assess alignment of the scapula on the rib cage and alignment, mobility and strength of the gleno-humeral joint. Treatment focus initially on strengthening of the scapular stabilizers to promote scapulo-humeral rhythm [14].
Therapy protocol after triangle tilt surgery generally begins with a frequency of twice weekly but should be modified on a case by case basis. Therapy is recommended for at least 6 months following TT surgery [22].

Advantages

- Triangle tilt surgery is effective in the treatment of older pediatric patients because it directly addresses the bony deformations that occur during childhood.
- Allow for better remodelling of the shoulder joint by repositioning of the glenohumeral joint to maximize alignment. This doesn't only improve function and growth but has been shown to encourage joint remodeling [4].

Disadvantages

Triangle Tilt surgery doesn't improve abduction if done alone and should be preceded by Mod Quad surgery in cases with weak abduction or complete OBPI [23].

Complications

Nonunion of the clavicular osteotomy occurred in minority of patients early in the series and was treated by wire fixation. This complication led to the introduction of semi-rigid fixation of the clavicular fragments by titanium pins (Smith & Nephew Donjoy, Carlsbad, California) connected by an absorbable suture. The titanium pins were subcutaneous and tied together with absorbable sutures [14].

Outcomes

The triangle tilt procedure alone or combined with the modified Quad procedure (if patients have limited shoulder abduction) serves as an effective approach in the management of patients with secondary deformity from initial brachial plexus injury, which can give patients excellent to outstanding long-term improvements both functionally and anatomically [13].
The patients displayed a significant improvement in the mean Mallet score from 11.88 points preoperatively to 15.17 points postoperation. Improvements were noticed in all the functional Mallet parameters including external rotation hands to mouth, hands to neck, hands to spine, and forearm supination. The position of the arm at rest also improved following surgery [24].
In addition to functional improvements, anatomical improvements were also noticed following surgery. Posterior subluxation measured using the PHHA value, improved from 14% preoperatively to 25% postoperatively There was also significant improvement in glenoid retroversion from -32° preoperatively to -23° postoperation. The scapulae were less elevated after the surgery, thereby decreasing the SHEAR deformity. Taken together, this study demonstrates that the triangle tilt surgery enhanced shoulder function and anatomy in OBPI patients with or without prior failed surgeries [13]

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