Lower Trapezius Transfer for Patients With Brachial Plexus Injury

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Abstract

Background: Brachial plexus injury is a complex entity that often results in partial recovery. Most studies to date have focused on improving shoulder abduction. However, a recent technique has been outlined—one that transfers the lower trapezius to improve the external rotation of the shoulder. The primary objective of this study was to evaluate the gains in external rotation of the shoulder in patients who have undergone transfer of the lower trapezius; secondarily, we assessed the range of motion in the elbow and shoulder joints, as well as the muscle strength and quality of life. **Methods:** This article presents a prospective cohort study of 10 patients who underwent transfer of the lower trapezius. During the preoperative period and at 6 months after the operation, both active and passive goniometric measurements were assessed, as were muscle strength, Mallet's classification, and patients' responses to the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. **Results:** External rotation exhibited an improvement of 17° in the active range of motion and 14° the passive range, which was not statistically significant. Flexion and active abduction of the shoulder, as well as the responses to the DASH, showed positive results. The Mallet's classification and muscle strength measurement results were not significant. **Conclusions:** The procedure might be an alternative for restoration of shoulder function and glenohumeral stabilization and mainly to improve quality of life. However, additional studies are required to define and refine this surgical technique.

Keywords: brachial plexus, muscle transfers, lower trapezius

Introduction

Mobility is a daily issue in urban centers. The number of traffic accidents, mainly those involving motorcycles and their users, has increased considerably. Accordingly, a proportional increase has been seen in the number of patients with brachial plexus injury.^{24,34}

The brachial plexus is a particularly critical region of the peripheral nervous system in terms of its exposure to trauma. Due to its unique anatomical associations with mobile structures of the neck and shoulder, it may present a variety of clinical patterns based on the topography of the damaged roots.³⁴ Studies have shown that 10% to 20% of injuries in the peripheral nervous system involve the brachial plexus, and 80% to 90% of these occur as a result of traffic accidents.²⁴

Despite countless advancements in neurological surgery, especially those related to the use of nerve transfer surgery, functional recovery is mostly partial, and alternatives for complementary operations do not present a satisfactory gain in the motion of the damaged limb.^{7,8,23}

It is common for patients who have undergone plexus reconstruction to experience an improvement in elbow flexion while simultaneously having a deficit in external rotation of the shoulder. This hinders the excursion of the forearm and hand when flexing the elbow. Options to rehabilitate external rotation, such as nerve transfers, muscle transfers, and contracture releases show variable results depending on the patient's age, time of injury, and mechanism of trauma.^{6,7,15,31-33}

The accessory nerve is, in general, preserved, and in early brachial plexus injuries is an excellent option for nerve transfers with positive results.⁶ However, injuries older than 6 months do not show the same efficient results seen in acute ones.³³

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Figure 1. Position of the patient and references: Yellow line—incision 2 cm below and parallel to the scapular spine, toward the spinous process of T6; black arrows—scapular spine; red arrow—spinous process T6; blue lines—the direction of trapezius fibers between vertebrae spinous processes and scapula; white arrows—medial border of the scapula.

Most studies to date have emphasized the improvement in shoulder abduction, and the upper trapezius has been used with varying results.^{1,14,15,20-23, 27-29} The lower part of the trapezius has been the subject of anatomic and clinical studies with the goal of rehabilitating the external rotation of the shoulder. Some studies have described this transfer, with varying results in terms of the best method to extend the reach of the trapezius to the distal insertional footprint, the location used, and its indications.^{11,13,16}

The primary objective of this study was to assess the gains in external rotation of the shoulder in patients who underwent transfer of the lower trapezius in cases of brachial plexus injury. The secondary objective was to assess the gain in strength and the range of motion and to quantify the improvement in quality of life.

Materials and Methods

The present prospective cohort study evaluated patients who underwent transfer of the lower trapezius to improve external rotation and stabilization of the shoulder based on the technique of Elhassan¹¹ and Bertelli.⁵

A total of 22 patients were observed initially, 14 of whom met the criteria to undergo the procedure; 12 of these patients underwent the surgical procedure between July 2011 and July 2013 at the Orthopedics and Traumatology Institute, but only 10 of these have completed the postoperative protocol and were included here. These were all male, with a mean age of 24 years 4 months at the time of injury. Lower trapezius transfers were performed in all of them with a mean time of lesion of about 1 year 3 months 4 days, and the mechanism of trauma was the same in all cases: motorcycle-vehicle accidents.

The inclusion criteria consisted of patients who had had a brachial plexus injury at any level for more than a year while also showing a passive range of motion (PROM), a minimum of 90° of elbow flexion, 15° of external passive

shoulder rotation, biceps strength of M4 or greater, and free mobility at the scapulohumeral joints.

The exclusion criteria were patients subjected to procedures using the accessory nerve for nerve reconstruction and patients who were noncooperative or had difficulty understanding the protocol for rehabilitation.

This study was authorized by the Ethics Committee of the Institute of Orthopedics and Traumatology, protocol number 1025.

The surgical technique was performed under general anesthesia with the patient in the lateral decubitus position, with the injured side facing up and the forearm resting over an auxiliary table while maintaining shoulder abduction (Figure 1).

The incision was made along a parallel line 2 cm below the scapular spine, starting at the posterior deltoid and proceeding toward the spinous process of T6 (Figure 1). After incision of the skin and subcutis, the interval between the middle and lower trapezius was identified according to its direction and muscle fiber contractions through the administration of electrical intramuscular stimulation. The accessory nerve was identified through blunt dissection along the fibers of the lower trapezius, 2 cm below the medial border of the scapula and along the spinal line (Figure 2).

After elevating the muscle from its upper portion in line with and below the scapular spine until its distal limit and preserving the muscular insertion next to spinous processes, the lateral paramedian dissection was performed using the deltoid fascia to elevate and extend the muscle to achieve the proper length to be transferred. The dissection limits were as follows: above the lower border of the scapular spine and laterally at the posterior border of the deltoid (Figure 3).

After these steps, the infraspinatus muscle tendon was sutured to the lower extended part of the trapezius using the Pulvertaft weave technique, with shoulder abduction at 90° and at maximum external rotation (Figure 4).

Figure 2. Topography of the accessory nerve in the yellow square—2 cm below the medial border of the scapula and situated between the fibers of the lower trapezius.

Figure 3. Elevation of the muscle for transfer: drawing showing the lower trapezius; arrow—deltoid fascia used to extend the reach of the transferred muscle.

Figure 4. Muscle isolation: white arrow—infraspinatus muscle; yellow arrows—lower trapezius.

After thorough hemostasis, closure was performed using an occlusive dressing. After the procedure, a previously

constructed orthosis was placed with shoulder abduction at 90° and at maximum external rotation with a reduction in

Figure 5. Orthosis during the postoperative period, at 2 weeks of follow-up, and a progressive reduction in abduction and external rotation.

Table 1. Postoperative Rehabilitation Protocol.

Immediate postoperative period	Orthosis: shoulder abduction at 90° + passive external rotation at maximum + orientation.
Week 1	Reduction in shoulder abduction to 75°, with external rotation at maximum; start of workout routine in supine position.
Week 2	Removal of stitches; start of scar tissue massage; orthosis adjusted to 60° of abduction and maintenance of external rotation. Active range of motion (ROM) in decubitus against light resistance. Start of elbow, wrist, and finger ROM.
Week 3	Start of workout routine against gravity while standing. Orthosis adjusted to 45° of shoulder abduction; maintenance of external rotation.
Week 4	Orthosis adjusted to 30°; external rotation maintained.
Week 5	Patient could return to daily activities with shoulder abduction at 30°. The fixed orthosis that preserved external rotation was removed.
Week 6	Orthosis use was intermittent; active and passive workout routine continued, and the limb could be used normally for daily activities. Resistance exercises were introduced.

the range of abduction and progressive external rotation during the postoperative period (Figure 5).

The progressive adjustment in abduction and external rotation of the shoulder was performed on a weekly basis for 6 weeks following the surgical procedure. This process allowed the healing and prevented the excessive stretching of the tendon. The introduction of an exercise routine to increase strength and joint mobility was performed according to a protocol established by the Department of Occupational Therapy,¹⁴ as shown in Table 1.

The following goniometric measurements were obtained during follow-up and in the preoperative and postoperative periods: flexion, extension, abduction, internal and external shoulder rotation, and elbow flexion and extension.

In addition to these parameters, measurements of manual muscle strength were assessed according to Lovett and Sunderland's standardization,²⁰ Mallet's classification,²² and Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.^{2,17} A single evaluator performed these evaluations during the preoperative period and in the sixth month following the procedure.

Statistical Analysis

Descriptive statistical analysis was performed on qualitative variables (function tests) and quantitative variables (active and passive motion in shoulder and elbow). Data were cataloged and analyzed with Microsoft Excel using

Figure 6. Range of motion via goniometry in the preoperative and postoperative periods; the mean/average gain is indicated in degrees in the vertical axis and statistical significance indicated as the *P* value.

the Mann-Whitney *U* test and the *t* test for quantitative variables and the chi-square test and Fisher exact test for qualitative variables. A *P* value of <.05 indicated statistical significance.

Results

Assessment of Range of Motion

All patients were observed during 2 distinct periods—preoperatively and at 6 months after the operation—and the passive and active range of motion of the shoulders and elbows were measured through goniometry. The data collected and the average gains in joint motion are shown in Figure 6. Statistical analysis using the Mann-Whitney *U* test and *t* test showed that the changes in active shoulder flexion and its active abduction were statistically significant, *P* = .046 and *P* = .026, respectively.

Analysis of the remaining range of active and passive motion of the shoulder and elbow did not reveal significant differences.

Evaluation of the DASH Questionnaire

Improvement in quality of life assessed via the DASH questionnaire revealed an initial average score of 46.57, which decreased to 26.74 within 6 months of surgery, resulting in a statistically significant difference (*P* = .008).

Outcomes of Mallet's Classification

Mallet's classification was used to measure the improvement in the assessed parameter and showed a 1-point gain between the preoperative and postoperative periods in Abduction (6 patients), External Rotation (4 patients), Hand to Head (1 patient), Hand to Back (2 patients), and Hand to Mouth (5 patients). It is important to emphasize that the surgical procedure did not appear to set a limit to passive and active internal rotation sufficiently to decrease Mallet scores. Values were analyzed using Fisher exact test, which did not reveal statistically significant changes.

Assessment of Muscle Strength

The gain of muscle strength in the shoulder and elbow joints was measured using Lovett and Sunderland's standardization,²⁰ which showed no statistically significant changes in the sixth month.

Discussion

Limited information and consensus are available to guide surgeons through the difficult task of late reconstruction of the shoulder after brachial plexus injury. Most complaints refer to the loss of external rotation of the shoulder and pain related to glenohumeral joint subluxation.^{10,30} Restoring external rotation, mainly active rotation, allows for

positioning of the hand in front of the body, which improves forearm and arm excursion in elbow flexion.^{3,4,21}

A foundational understanding of biomechanics is required to perform the proposed transfer, including knowledge of vector forces, muscle tension, and excursion in the shoulder girdle. Such knowledge will facilitate the most compatible transfer in the muscles to be replaced. Herzberg et al performed a cadaveric study by dissecting 13 muscles in the glenohumeral region to analyze the relative excursion and tension of muscles. They found that the transfer of the latissimus dorsi associated with the teres major could lead to an improvement in external rotation, while the transfer of the upper trapezius could allow for better shoulder abduction.¹⁶

L'Episcopo in 1930 described the use of teres major and latissimus dorsi to restore shoulder external rotation in obstetric brachial plexus paralysis (OBPP).¹⁹ This procedure is well established in OBPP patients, while Beauchamp et al tried to perform L'Episcopo procedure in 11 adult plexopathy patients and achieved a mean of 28° of external rotation.³ Terzis and Kostopoulos in 2010 showed that the rerouting of the latissimus tendon around the humerus yields much better results in children rather than in adults. In their series, the adult patients who underwent this surgery achieved $22.33^\circ \pm 20.31^\circ$ of shoulder external rotation.³³ Similar results could be observed in another study from Terzis and Barmptsioti with preoperative mean shoulder abduction and external rotation of $9.07^\circ \pm 18.08^\circ$ and $11.70^\circ \pm 25.30^\circ$, respectively, and postoperative shoulder abduction of $39.64^\circ \pm 37.14^\circ$ and external rotation of $26.70^\circ \pm 29.72^\circ$.³¹

The main indication for transferring the lower trapezius is the complete loss of external rotation of the shoulder, with the following requirements: similar tension in the transferred and original muscle, compatible excursion, minimum strength of M4, and integrity of the spinal accessory nerve.¹³

Currently, there are few comparative studies of the surgical incision points used to perform the transfer of the lower trapezius, including single and double incisions as well as the inclined, longitudinal and parallel directions. In this study, a single incision was performed along an imaginary line 2 cm parallel and below the scapular spine, starting at the posterior deltoid and proceeding toward the spinous process at T6.^{5,11}

The goniometry results indicated a relevant improvement in external rotation among patients, with an average gain of 17° in the active range of motion and 14° in the PROM. The same was found for active and passive abduction, with gains of 13° and 14°, respectively. Although statistical analysis showed that only the parameters of active shoulder abduction and flexion were significantly altered, the improvement in other parameters may contribute to better performance in daily activities among patients, resulting in an improvement in life quality as measured by the DASH questionnaire.

In their study on lower trapezius transfers associated with other muscle transfers to produce better shoulder function among 40 patients with brachial plexus injury, Elhassan et al¹² reported an improvement of 95° in the average external rotation; however, they did not specify this range of motion as active or passive, and bias was present regarding the association of transfers from different muscle groups.

Bertelli and Guizoni, in 2011, demonstrated positive results with the accessory nerve to suprascapular transfer in patients with 3 to 10 months of trauma. Their technique ensured adequate return of shoulder function, especially when combined with a triceps motor branch transfer to the axillary nerve, with an average abduction and external rotation gain of 105° in their partial plexus injuries group.⁶ Unfortunately, their article did not present results in late presentations, which was the aim of this article.

Terzis and Kostas in 2006 observed that in the early group of patients with a denervation time of less than 6 months, the functional results were significantly better for the accessory to suprascapular nerve transfer than those in the late group with a denervation time greater than 12 months.³²

The pertaining literature presents an enormous quantity of papers dealing with the unopposed contraction of the shoulder internal rotators and adductors, as a result of the weakening of the external rotators and abductors in children with brachial plexus birth palsy.^{9,18,25,26} Latissimus dorsi and/or teres major tendon transfers combined with open musculotendinous lengthening and internal rotator's releases can improve shoulder function in children, but the achieved results reported in adults across related studies are not similar.³² The authors did not find studies on internal rotators muscle release as an isolated procedure to improve external rotators in adults.

Additional external rotation could be achieved through the shoulder contracture release at the time of surgery; this could allow for better joint mobility and perhaps increase the excursion of the shoulder joint seen in the postoperative period. This could justify why the authors did not obtain significant increases in shoulder external rotation despite the inclusion criteria of 15° of external passive shoulder rotation.

In terms of grafting of tendons to expand the lower trapezius and suture techniques for the transferred muscle near the infraspinatus tendon, some thought may be given to a comparison between the present study and Elhassan's review.¹¹ This study used muscle extension via the deltoid fascia, while in Elhassan's study, grafting was the preferred choice. Regarding the suturing of the lower trapezius and infraspinatus tendon, we used Pulvertaft weaving, which differed from Elhassan's direct 2-layer suture in the remaining portion of the infraspinatus muscle, adjacent to its insertional footprint in the proximal humerus. These differences may have contributed to an apparently better outcome in Elhassan's study for external rotation.¹¹

Current studies do not present comparative research on the best method to reinsert the transferred muscle adjacent to the infraspinatus footprint in the greater tubercle of the humerus. Some reports have discussed different techniques, including transosseous insertions, the use of anchors, and varying techniques of tendon sutures, such as the method used in this study.^{5,12}

Significantly positive goniometry results demonstrated that despite the uncertain prognosis of late whole brachial plexus injury, it is possible to achieve better shoulder stability and an improvement in active flexion and abduction of the shoulder with the proposed transfer.

The improvement in such parameters may have partially contributed to the stabilization of the glenohumeral joint, which may also have assisted the clinical and functional augmentation of the shoulder flexion by improving the arm positioning in space allowing a better motion without hindering the excursion of the forearm and hand when flexing the elbow. The active abduction shows statistical relevance after the lower trapezius transfer, maybe due to the new balance between the external and internal shoulder rotator forces. The aforementioned changes may have contributed to the DASH questionnaire improvement ($P = .008$), which was also comparable with previous studies.¹³

No complications have been observed, though in Elhasan's¹¹ review article, 2 cases of rupture and 2 cases of infection occurred in the surgical zones.

The results of Mallet's classification and the measurement of muscle strength did not show statistically significant differences. A comparison between previous and present studies was not possible due to the lack of studies using these 2 measurements of the proposed transfer.

Some limitations to the present study are the small number of patients, the short postoperative follow-up observation, the absence of internal rotators contracture release at surgical procedure, no measurement of pain during the preoperative and postoperative periods, and the lack of a control group and medical imaging. New studies with a greater number of treated patients and longer follow-ups are needed to better compare the effectiveness of the techniques described. It is also important to widen the knowledge base regarding the transfer of the lower trapezius to improve shoulder function in cases of brachial plexus injury.

Conclusion

The procedure might be an alternative for restoration of shoulder function and glenohumeral stabilization and mainly to improve quality of life. However, additional studies with a greater number of patients and long-term assessments of the results are required to define and refine this surgical technique.

Ethical Approval

This study was authorized by the Ethics Committee of the Institute, under protocol 1025.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all patients before being included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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