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# Whole Triceps transfer to Restore Elbow Flexion after Brachial Plexus Injury

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## Abstract

**Purpose:** The paralysis of the flexor muscles of the elbow is an invalidating sequelae of brachial plexus injuries. The loss of active elbow flexion can be treated with muscle transfers with intact innervation. The purpose of this work is to communicate our experience in solving elbow flexor paralysis by the triceps transfer technique.

**Methods:** A retrospective study was conducted in 10 patients with absent or extremely weak elbow flexion (motor grade 2 or less) and triceps grade greater or equal to MRC 4, who had undergone triceps tendon transfer to restore elbow flexion.

**Results:** The patients' assessments of the outcome showed that seven patients were found to have very good function, two patients had good function, and one patient had mild active flexion of the elbow. The mean loss of passive extension was 6.8°. No intraoperative or postsurgical complications were reported.

**Conclusion:** The complete transfer of the triceps to biceps is a simple and easy technique to perform that allows to obtain good results; only contraindicated in patients who require a powerful active extension but has the disadvantage of leaving in some cases limited flexion contracture of the elbow.

**Keywords:** Elbow Flexorplasty; Brachial Plexus Injuries; Triceps transfer; Triceps-biceps co-contractions

## Introduction

After 12 months of a peripheral nerve injury, muscle atrophy and loss of motor endplate reinnervation potential, implies that the only viable option to restore motor function is the muscle transfer [1-4]. Elbow flexion palsy after traumatic brachial plexus injuries can be restored by muscle tendon transfer, which in the past were used in patients with poliomyelitis. Several surgical techniques used to restore active elbow flexion; among these may be mentioned the Steindler flexorplasty and its modifications [5-7] if the flexor-pronator muscles are intact and available for transfer, transfer of the pectoralis major [8-10], pectoralis minor transfer [11], combined transfer of pectoralis major and minor [12], sternocleidomastoid transfer [13] is currently rarely used due to its poor functional and aesthetic results. The use of latissimus dorsi transfer has also been described with good results [14,15], and satisfactory results have been achieved with triceps transfer, but loss of elbow extension is a major disadvantage [16,17]. When there are not muscles available for transfer in the upper extremity, free functional muscle transfer from other locations in the body replaces denervated skeletal muscle units [18].

## Material & Methods

In 10 patients with paralysis of the elbow flexors secondary to traumatic brachial plexus injury, the whole triceps was transferred to the biceps to restore active flexion of the elbow. The evaluation of muscular strength was carried out according to the Medical Research Council (MRC) scale, and any range of movement at the elbow if present was recorded. The following preoperative conditions are required to perform the triceps transfer: triceps grade greater or equal to MRC 4 and the biceps grade M0 to M2. Active elbow flexion improvement was scored using the criteria established by Alnot and Abols [19] considering muscular power and range of motion:

- Very good: Active elbow flexion against resistance (Grade 4) and range of flexion 120°.

- Good: Active elbow flexion against resistance (Grade 4) and range of flexion below 120°.

- Mild: Active elbow flexion against gravity but not resistance (Grade 3) and range of flexion 80° or more.

- Fail: No active elbow flexion against gravity (Grade 0 to 2).

Assessment of elbow flexion contracture is scored according with the Hospital for Special Surgery (HSS) scoring system [20] for evaluation of the elbow, as follows:

- Less than 15 degrees
- Between 15 and 45 degrees
- Between 45 and 90 degrees
- More than 90 degrees

## Surgical Technique

The surgery was done under general anaesthesia in the supine position and the affected arm placing over the chest to permit access of the relevant portion of the triceps muscle. The first incision was along the center of the back of the arm from the junction of upper and middle third down 6 cm distal to the olecranon process. The insertion of the triceps in the olecranon was sectioned, with proximal dissection of the musculature protecting of the ulnar nerve (Figure 1). A second incision was made at the level of the anterior region of the elbow, with identification of the tendon of the biceps and anterior transposition of the tendon of the triceps was performed, suturing to the tendon of the biceps keeping the elbow between 90° and 110° of flexion (Figure 2). Skin incision was closed in two layers and the limb immobilized in long arm splint. Ten days later the stitches were removed, and the arm was immobilized in long cast for additional 4 weeks. At 6 weeks, the cast was replaced by an arm sling to permit resting elbow flexion of 45° for additional 3 weeks, and elbow flexion against gravity was permitted. At 12 weeks, the arm sling was removed, and elbow flexion strength and elbow flexion range were measured.

**Figure 1:** First incision from the junction of upper and middle third of the arm (posterior side) down to the olecranon process and sectioning the insertion of the triceps in the olecranon.

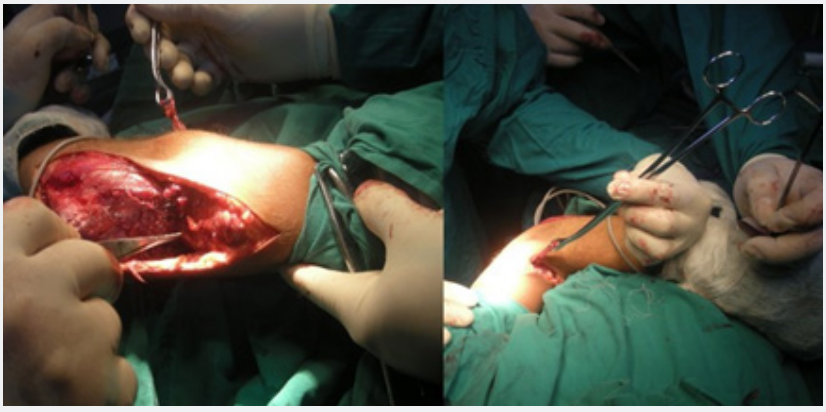

**Figure 2:** Anterior transposition of the triceps to the biceps tendon.



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## Results

All patients were male, and the patients' ages ranged from 16 to 55 years, with a mean of 31.7 years. Four patients were previously treated by surgical exploration with neurolysis, nerve grafting or nerve transposition (Table 1). The patients' assessments of the outcome (clinical follow-up 12.5 months, range from 6 months to 27 months) showed that seven patients were found to have very good function (Figure 3), two patients had good function, and one patient had mild active flexion of the elbow (Table 1) (Figure 3). The mean loss of passive extension was 6.8° (range 0° to 22°). No intraoperative or postsurgical complications were reported.

**Figure 3:** Patient who underwent a previous nerve repair without active elbow flexion with residual paralytic hand. After the triceps transfer was performed, the following result was achieved: very good elbow flexion, and lag of extension 6°.

**Table 1:** List of patients, showing age, sex, length of follow-up, results, loss of passive extension and complications.

| Case | Age/Sex | Previous Surgery | Length of Follow-up (months) | Results | Loss of passive extension | Complications |
|---|---|---|---|---|---|---|
| 1 | 31/ male | | 18 | VG | 3° | no |
| 2 | 42/ male | nl, ng, nt | 10 | VG | 7° | no |
| 3 | 28/ male | | 6 | G | 13° | no |
| 4 | 32/ male | nl, ng | 8 | VG | 0° | no |
| 5 | 38/ male | | 27 | G | 5° | no |
| 6 | 26/ male | | 14 | VG | 2° | no |
| 7 | 31/ male | nl, ng | 12 | VG | 11° | no |
| 8 | 18/ male | | 9 | VG | 6° | no |
| 9 | 55/ male | | 7 | M | 22° | no |
| 10 | 16/ male | nl, ng | 14 | VG | 4° | no |

nl: neurolysis; ng: nerve grafting; nt: neurotization; VG: Very Good; B: Good; M: Mild; F: Fail

## Discussion

The management of traumatic injuries to the brachial plexus in the initial phase consists of microsurgical repair of the nerve structures involved to restore the function of paralyzed muscle groups. When direct surgical repair of the brachial plexus does not provide satisfactory results or in chronic cases, reconstructive procedures should be considered, and restoration of active elbow flexion should be the priority. After incomplete spontaneous recovery or failed surgical repair of peripheral nerve injuries for more than 12 months, muscle atrophy and loss of motor endplate reinnervation potential leave muscle transfer the only viable option [1-4].

The transfer recommended depends upon the extent of plexus injury, strength of the muscle groups remaining available, patient goals, and surgeon preference. If active elbow flexion is weak, Steindler flexorplasty provides good functional results and the pronation contracture that commonly develops is well tolerated. Pectoralis transfer in women is avoided because due the marked cosmetic deformity of the anterior chest wall, but it would be an option for a patient with a stiff (or fused) shoulder.


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The latissimus and pectoralis major are often partially denervated in upper trunk brachial plexus injuries and should be tested prior to transfer because any muscle with weak baseline strength should not be transferred.

Anterior transfer of the triceps initially, it contradicts one of the basic principles of muscle transfer using an antagonist, but it has been shown to work and is indicated in the loss of elbow flexion without the existence of another powerful motor available, especially when there are biceps-triceps co-contractions [16,17]. Complete transfer of the triceps causes loss of elbow extension which is important if the patient has a range of active shoulder abduction, since in cases of patients who use crutches or wheelchairs and those who need elbow extension, this technique is contraindicated. The transfer unique from the long head of the triceps to the anterior aspect of the ulna is described to achieve active flexion without losing extension of elbow [21-23]. Restoration of elbow flexion by transfer of one head of triceps to biceps (the medial portion of the conjoined triceps or the long head of triceps) permits return elbow flexion retaining active elbow extension [24].

The anatomy of the medial head of the triceps has been described, highlighting the neurovascular independence of the rest triceps. Innervation of the long head of the triceps is an issue great discussion. There are studies that show that motor branches for the innervation of the latter emerge from the axillary nerve [25], while other anatomical studies assure which are branches of the radial nerve that originate proximally; in other cases, it emerges as a trunk independent of the radial nerve and the axillary nerve, arising directly from the posterior trunk [26]. When there are not muscles available for transfer in the upper extremity, free functional muscle transfer from other locations in the body replaces denervated skeletal muscle units [18]. The results obtained in the present study by means of the complete transfer of the triceps to restore elbow flexion are like those previously reported by other authors (10 operated patients: seven patients had very good function, two patients had good function, and one patient had mild active flexion of the elbow) [15,16, 27].

A comparison with the preoperative passive elbow extension status shows that an increased limitation in consequence of the operation. In nine patients the flexion contracture was less than 15 degrees, and in one patient between 15 and 45 degrees (mean 6.8°, range 0° to 22°). A limitation of the passive elbow extension does not provide a pessimistic result [28]. The full potential of the elbow's range of motion is not required for most daily activities. A study of 15 activities of daily living established that most functions can be performed using an arc of 100 degrees of flexion between 30 and 130 degrees [29]. The functional impact of loss of the flexion arc is also not equally distributed between flexion and extension. Flexion is more value than extension in a ratio of about 2:1 [30].

## Conclusion

The complete transfer of the triceps to biceps is a simple and easy technique to perform that allows to obtain good results; only contraindicated in patients who require a powerful active extension but has the disadvantage of leaving in some cases limited flexion contracture of the elbow.

## Declarations

### Disclosure of potential conflicts of interest and funding

The author declares that there is no conflict of interest related to the subject of this paper. No external source of funding was used for this study.

### Statement of Human and Animal Rights

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 2000 and 2008.

### Informed Consent

Informed consent was obtained from all individual participants included in the study.

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