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Functioning free muscle transfer for the restoration of elbow flexion in brachial plexus injury patients

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ABSTRACT

Background: Restoration of elbow function in traumatic brachial plexus injury patients remains the priority in the reconstruction of the involved extremity. In cases of complete nerve root injuries and in delayed cases, the only option for elbow reconstruction is the functional free muscle transfer. The purpose of this paper was to present the clinical outcomes and complications of functioning free muscle transfers using the gracilis muscle for the restoration of elbow flexion in brachial plexus injury patients in a tertiary institution from January 1, 2005 to January 31, 2014.

Patient and methods: A retrospective review of all patients who had functioning free muscle transfers for elbow flexion was done with a minimum of 12 months follow-up. Outcome measures were elbow flexion in terms of range of motion in degrees, muscle strength of the transferred muscle, VAS (visual analogue scale) for pain, postoperative DASH scores and complications of the procedure.

Results: There were 39 males and three females. The average age at the time of surgery was 28.6 (SD, 8.5) years. The average delay to surgery was 16 months (range, 3–120 months). The flap success rate for viability was achieved in 38 of 42 patients. The average follow-up for the 38 patients was 30 months (range, 12–103 months, SD 19 months). Success rate of at least M3/5 muscle strength was achieved in 37 of 42 patients with an average range of elbow flexion of 107° (SD, 20.4°). The average post-operative VAS for pain was 3.6 (SD, 3.0). The average post-operative DASH score was 43.09 (SD, 14.9). There were a total of 10 minor complications and five major complications.

Conclusion: Functioning free muscle transfer using the gracilis muscle was a reliable procedure in the restoration of elbow flexion in patients with incomplete brachial plexus injury treated beyond 6 months from the time of injury and in patients with complete injuries.

Introduction

Restoration of elbow function remains the priority in the reconstruction of the involved extremity in patients with traumatic brachial plexus injuries. Reconstructive options for elbow flexion depends on several factors. These include the time from injury to treatment, the severity of the injury, and the available donor nerves or muscles for reconstruction. The options for reconstruction include nerve repair or grafting, nerve transfers, and local or free muscle transfers. Patients who are seen early are often treated with nerve reconstructive procedures. In cases where no donor nerve is available for nerve grafting or nerve transfer, and in cases that are seen late, (>12 months), muscle transfers whether free or pedicled are often used. Functioning free muscle transfers can also be used in cases of failed nerve grafting or nerve transfer procedures [1,2].

The most frequently used free muscle transfer is the gracilis muscle [1–7], however, other muscles such as the rectus femoris [7] and latissimus dorsi muscles [8,9] were also reported with good results.

In patients with complete avulsion injuries of the C5-T1 nerve roots, there are no donor nerves available for nerve grafting and extraplexal nerves are often used for the restoration of elbow flexion, sensation and shoulder stability. Success rates as determined by the usefullness of the transferred muscle to regain muscle strength of at least MRC (Modified Medical Research Council) grade of 3/5 elbow flexion range from 46 to 80% [6–12]. Complication rates however are not uncommon. Adams et al. [5] reported a failure rate of 15.4%. Failures were defined as the

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non-functioning muscle transfers or those that failed acutely. The most common complication in their study was the fracture of the clavice (5.4%; 7 of 130 patients) [5].

Some authors preferred the latissimus dorsi muscle for the restoration of elbow flexion [8]. Vekris et al. [8] preferred the pedicled latissimus dorsi transfer for elbow flexion due to its early return to function and larger size. Terzis and Kostopoulos [13] also found that the free latissimus dorsi was significantly stronger compared to gracilis transfer for elbow flexion (mean grade of 3.33 (standard deviation (SD), 0.6) versus gracilis at a mean of 2.25, SD, 0.6; $p = 0.045$) when the intercostal nerves were used. On the other hand, in a review of free muscle transfers for elbow flexion, Fisher et al. [14] reported that the latissimus dorsi and rectus femoris muscles don't have the excursion and pedicle characteristics unique to the gracilis muscle which makes the gracilis an ideal muscle for the restoration of elbow flexion. This is because the gracilis is a strap muscle and that the muscle fibers are arranged parallel to its line of pull which run the full length of the muscle. If the maximum contraction of a muscle was estimated to be approximately 40% of its fully stretched physiologic length [15], then a 30 cm gracilis muscle can shorten by at least 12 cm. In addition to this, the outer diameter of the artery of the gracilis is 1.6–1.8 mm, whereas the vein outer diameter is 1.5–2.5 mm, both of which are 6–8 cm in length from the profunda femoris vessels [16]. This makes it suitable for anastomosis to the thoraco-acromial artery and cephalic vein. The latissimus dorsi and rectus femoris muscles are bulky, and the latissimus dorsi lacks the distal tendinous portion for good repair to the biceps tendon stump. The rectus femoris muscle, on the other hand, has been associated with weakness of knee extension after harvest [16].

The purpose of this study was to present the clinical outcomes and complications of using functioning free muscle transfer for the restoration of elbow flexion in patients with traumatic brachial plexus injury done in a tertiary hospital.

Patient and methods

A retrospective review of all patients who had functioning free muscle transfers for the restoration of elbow flexion in patients with traumatic brachial plexus injuries with at least 12 months follow-up was done from 2005 to 2014. The outcome measures were elbow flexion in terms of range of motion in degrees, muscle strength using the modified British Medial Research Council staging (BMRC), VAS (Visual Analog Scale) for pain, post-operative complications and postoperative DASH scores.

Inclusion criteria were traumatic brachial plexus injuries where a functioning free muscle was used for elbow flexion with at least 12 months follow-up. Excluded were patients who had a combination of nerve reconstruction or local muscle transfer with free muscle transfer procedures for the restoration of elbow flexion and brachial plexus injuries with concomitant spinal cord injuries. Patients with bilateral plexus injuries were also excluded because bilateral injuries, by nature of the injury, tend to have a poorer prognosis regardless of reconstructive procedure compared to unilateral injuries and thus, the two cannot be evaluated together. The ethics review board of the institution approved the research.

Surgical technique

Standard harvest for the gracilis muscle was done using the technique described by Addosooki et al. [17] for traumatic brachial plexus injuries. The contralateral gracilis was used in all cases of single muscle transfer for the restoration of elbow flexion. This was ideal because of the following reasons: The course of the vascular pedicle of the gracilis runs from the profunda femoris laterally and enters the medial-deep aspect of the muscle. This orientation of the vascular pedicle makes it ideal for anastomosis to the thoraco-acromial vessels and cephalic vein on the medial side of the contralateral shoulder when used as an elbow flexor. The nerve to the gracilis also enters the gracilis just proximal to the vascular pedicle and is long enough for primary repair to the spinal accessory nerve, which was the donor nerve of choice in this series (Fig. 1). The contralateral thigh is abducted with the hips slightly flexed and externally rotated. The most palpable tendon in the proximal thigh is the tendon of the adductor longus. The gracilis muscle is medial to the adductor longus. A line is drawn slightly inferior to this tendon going to the medial femoral condyle. An elliptical skin island flap is drawn approximately 9 cm × 5 cm over the proximal third of thigh, along this line, with the anterior 1/3 of the skin covering the adductor longus and the posterior 1/3 covering the gracilis muscle. The skin island flap is used as an additional coverage for loose closure and as a monitoring device post-operatively (Fig. 2). The blood supply of the skin island of the proximal part of the gracilis muscle comes mainly from the transversely oriented perforators from the main gracilis perforating arteries, which pass anterior to the gracils muscle along the intermuscular septum between the gracilis and adductor longus [18].

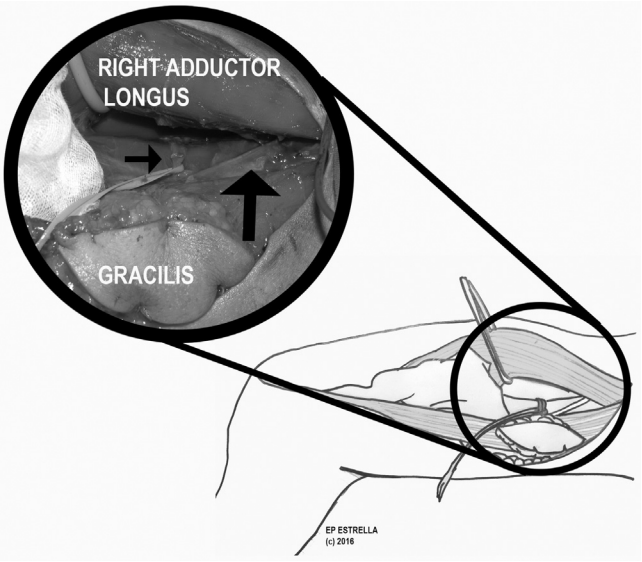

Fig. 1. The orientation of the vascular pedicle (small arrow) and nerve (big arrow) from medial to lateral is appropriate for anastomosis to the thoraco-acromial vessels and repair to the spinal accessory nerve on the contralateral shoulder when used as an elbow flexor. The nerve to the gracilis is just proximal to the vascular pedicle at an angle of 45°. It is enough for primary repair to the spinal accessory nerve.

Two teams did the surgery simultaneously: One team explores the brachial plexus, isolates the donor vessels, isolates the spinal accessory nerve and prepares the proximal and distal attachments of the transferred gracilis. The other team harvests the gracilis muscle. After exploration, the cephalic is usually identified first and then traced proximally until the thoraco-acromial artery and veins are identified as well. In this technique, the gracilis muscle was sutured proximally to the lateral third of the clavicle and distally to the biceps tendon (Fig. 3). The spinal accessory nerve was used as the donor nerve in all cases except for one case where the 3rd-5th intercostal nerve was used because of trapezius paralaysis.

A single-staged, double muscle transfer technique was also used. In this technique, [19] we used the gracilis-adductor longus muscle as donor muscles to restore elbow flexion (adductor

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