Journal of Plastic, Reconstructive & Aesthetic Surgery (2010) 63, 1142–1149

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

# Microvascular free functioning gracilis transfer with nerve transfer to establish elbow flexion☆

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Received 6 February 2009; accepted 11 May 2009

**KEYWORDS**
Elbow flexion;
Gracilis;
Microsurgery;
Microvascular;
Free tissue transfer

**Summary** The loss of elbow flexion is an uncommon, but devastating consequence of injury to the upper limb and a complex problem to manage. This paper describes our experience with free functioning gracilis muscle transfer (FFGMT) to the upper limb for elbow flexion.

33 patients were followed up after FFGMT for elbow flexion. 26 patients were male, and 20 were children. Indications for FFGMT included obstetric brachial palsy ($n = 13$) and adult brachial plexus injury ($n = 12$), arthrogryposis ($n = 4$), sarcoma, polio and radial dysplasia. Seventy percent ($n = 23$) of patients had a successful outcome. Power comparable to the other side (M5) was recorded in two patients, 19 patients scored M4, and three scored M3. FFGMT in the OBP group alone ($n = 13$) was the most successful; all had a pre-operative score of M2 or less and post-operatively 12 (92%) achieved a score of M4 or greater. A greater increase in Medical Research Council (MRC) grade for elbow flexion was achieved when intercostal nerves (ICN) were transferred to innervate the gracilis flap (mean gain three points, SD1.3), than ulnar fascicles (mean gain 1.75 points, SD2.3), $P = 0.05$.

With a multidisciplinary team approach involving experienced surgeons, theatre staff and therapists, a significant, reproducible and measurable improvement in elbow flexion can be achieved by FFGMT.


Elbow flexion is an important function to restore.[1–4] Microvascular free functioning muscle transfer (FFMT) is a treatment option either when muscles are absent or when time from nerve injury means that irreversible changes of denervation preclude direct repair.[1,4,5] This paper describes the senior author's experience with free functioning gracilis muscle transfer (FFGMT) to the upper limb for elbow flexion.

☆ Presentations: BAPRAS – London – December 2006, IFSSH & IFSHT – Sydney – March 2007, 1st Sino-European meeting on brachial plexus microreconstructive surgery – Venice, Italy – April 2008.

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doi:10.1016/j.bjps.2009.05.021

## Methods and materials

Ethical Committee approval was obtained to review retrospectively case notes and assess prospectively all cases of FFGMT undertaken within the St James' University Hospital Plastic Surgery Unit over a 14-year period from 1991 through to 2005. To make the sample group as homogenous as possible the FFGMTs for elbow flexion were selected, and this group further examined by indications and technique.

### *Data collection*

The patients were identified from a prospectively-collected database of all free tissue transfers carried out in the Leeds Plastic Surgery Unit since 1985. Pre-operative details, including the diagnosis, pre-existing elbow function, previous surgeries and comorbidities, were obtained from the case notes. Intra-operative information was taken from the database and case notes, including survival, or otherwise, of the transfer. Patients were then assessed in the outpatient department, seeking the patient's opinions on the surgery, the subsequent function and any donor/recipient site problems. A physical examination was included to assess the function of the transfer and range of elbow flexion, using the Medical Research Council (MRC) grading system (Figure 1).[6] Success was defined as a gain in MRC grade of one or more to grade M3 or greater.

Microsoft Access and Excel™ databases were used to organise the data, and a hospital-affiliated statistician advised on analysis.

### *Anaesthesia and per-operative care*

All cases involve a dedicated microsurgical team. Under general anaesthesia augmented by regional anaesthesia, with invasive monitoring, surgery is carried out in a warmed theatre (27 °C). The target for central–peripheral temperature difference ($\triangle$T) is $<$1 °C during the procedure and the subsequent high dependency unit care.

**Operative method**

A senior surgeon operates with assistance and does not use a double team approach. With the patient supine, the recipient arm is explored and adequate vessels and nerves are prepared. After complete preparation of the recipient bed and vessels, the gracilis is harvested, and to this end the lower limb is draped so that it may be moved independently as required.

| MRC Grade | |
|---|---|
| 5 | Normal power |
| 4 | Active movement against gravity and resistance |
| 3 | Active movement against gravity alone |
| 2 | Active movement, with gravity eliminated |
| 1 | Flicker or trace of contraction |
| 0 | No contraction |

**Figure 1** MRC grading system used in assessing elbow function.[6]

*Donor nerve* The selection of the nerve for transfer is important and will have been decided pre-operatively and confirmed during preparation of the recipient bed. Experience in planning is required to determine the likely level of neurosynthesis and so set the level at which the vascular repair is made. Donor nerves are either intercostal nerves (ideally three nerves; III–V), motor fascicles of the ulnar or median nerves, or rarely the spinal accessory or thoracodorsal nerve. The selection of donor nerve is based on the aetiology of the presenting condition.

*Gracilis harvest* With the hip abducted and the knee flexed, the gracilis muscle is harvested through an incision 2–4 cm posterior to a line joining the palpable anterior limit of the adductor origin with the medial tibial tubercle. A short incision centred on the junction between the upper and middle thirds of the muscle is sufficient, and experience will show that the muscle can be safely raised without time consuming endoscopy through a very short incision. Three steps are used to confirm the identity of the gracilis muscle when using a short incision: firstly it is the only muscle in this location to change length with knee flexion and extension; secondly the pedicle is consistently at the junction of middle and proximal third; and thirdly the branch of the obturator nerve joins the vascular pedicle at a characteristic oblique angle lying upon the adductor (Figure 2). The muscle is usually harvested without skin paddle for monitoring, although that option exists. It remains attached both distally and proximally until the neurovascular pedicle is dissected completely. A nerve pedicle of up to 10 cm in length can be harvested. Once the muscle is isolated on the neurovascular structures its insertion is divided, after first tensing the distal tendon, by percutaneous tenotomy. The origin may then be divided under direct vision taking care to maintain the fibrous tissue of attachment. Finally the vascular pedicle is carefully divided conserving as much length as possible. This requires powerful retraction aided by hip abduction.

We believe that warm ischaemia time should ideally be kept to less than 1 h, and so the insetting of the muscle must be planned and prepared before the pedicle is divided. Muscle force is proportional to cross-sectional area, but work capacity is related to the volume of muscle units in line with the vector of pull, and so we do not wrap the muscle around the clavicle or use other methods of proximal attachment that sacrifice volume. In most cases we make use of the tendinous origin of the muscle to fix it either with bone anchors or direct per-cartilaginous sutures (in the child) to the coracoid process.

The distal insertion is equally important. Where a healthy biceps tendon exists, the gracilis muscle is woven into it with the elbow flexed at 45° and under considerable tension (Figure 3). Our commonest mistake in early years