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Pectoralis minor muscle transfer for unilateral facial palsy reanimation: An experience of 35 years and 637 cases☆

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Summary *Background:* Free functional muscle transfers are often the treatment of choice for facial reanimation. We describe our experience with 637 cases over a 35-year period.
Methods: Data was collected prospectively on all case undergoing functional muscle transfer for unilateral facial paralysis. Results were judged by the operating surgeon and an Independent panel of four observers.
Results: 354 patients had an excellent result as judged by the surgeon. An independent panel rated patients to have a significant change pre- and post-operatively comparing their Hay's scores ($p < 0.001$, t-test). 27.2% of patients required revisional procedures. 13.3% of patients developed late onset tightness of the transferred muscle.
Conclusions: Facial reanimation with functional muscle transfers is a complex procedure and provides a significant improvement for the patient to display humour and emotion.

Introduction

It is curious in the many centuries of medical endeavour that it is only in the last few decades that we have been able to offer reanimation to the paralysed face. A mother will notice an emotional change in her adult child but commonly miss an anatomical change. The facial nerve alone mediates emotional response. No other nerve emulates it without extensive retraining or being less than seven years of age. Zielonko in 1874 wrote in his St Thomas's Hospital Reports about the possibility of muscle grafting.[1] Sir Charles Alfred Balance introduced crossed facial nerve grafts as early as 1895.[2] However it was Noel Thompson in the 1970s who invited the plastic surgical world to reconsider muscle transfer.[3] Although his early

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concepts proved largely unsuccessful the development of microvascular surgery completely changed the success rate. Harii in 1976 transferred the whole length of gracilis and revascularised it successfully.[4] Initially Peer and Thompson had considered that the whole length of muscle fibres was required and it was at this stage that we looked for a smaller muscle. Subsequently it was realised that only the motor end plate zone of the muscle was necessary. It was the search for a smaller muscle that did not require much reduction which stimulated DHH to employ the pectoralis minor muscle for facial reanimation.[5] Reinnervation of the muscle similarly passed through various stages but was found to be most effectively achieved by a crossed facial nerve graft extending the buccal branch of the contralateral facial nerve carried out six months prior to muscle transfer. We describe our experience and follow-up of 637 cases.

Patients and methods

Between 1981 and 2008 neurovascular-free muscle transfer was performed in 637 cases (390 DHH and 247 AOG) using a standard two-stage technique. A group of 76 patients operated upon by the senior author (DHH) were not available for independent long-term evaluation, a reflection of his international practice with a percentage of patients from abroad. These patients were excluded from the study, leaving us with a cohort of 561 patients with adequate follow-up. The pectoralis minor muscle was used in the majority of cases (528). Alternatively the latissimus dorsi (28 cases) or the gracilis (3 cases) or EDB (2 cases) were used in a standard two-stage approach.

During the first stage a single sural nerve is harvested through stepladder incisions from an appropriate leg. Since 2000 one of the authors (AOG) has used a standard vascular endoscopic harvesting set and the nerve graft was removed endoscopically assisted through an initial incision directly over the nerve at the level of the lateral malleolus. A single stab incision was utilised between the two heads of the gastrocnemius muscles to complete the harvest. The animated side of the face was approached through an extended parotidectomy incision. A suitable buccal branch of the facial nerve (VIIth) can normally be identified 1 cm below the parotid duct. A nerve stimulator is used to confirm the appropriate motor activity. The sural nerve is reversed and passed through a tunnel made with a specially designed trochar through the paralysed side of the face and fixed pre-auricular. The nerve graft is sutured to the buccal branch with 10-0 SNT under the operating microscope. The time between the first and second stage ranged from 6–36 months (mean 9 months). Axonal regeneration is monitored across the facial nerve graft by following the Tinel sign.

At the second stage the patient is draped in the supine position and an extended parotidectomy is used to approach the paralysed side of the face. Care is taken to raise the skin flap thicker than in a standard rhytidectomy to minimise adhesions between the muscle graft and the skin flap. The facial vessels are located as they crossed the mandible and dissected into the face. The artery proceeds to the angle of the mouth, the vein in a vertical direction. If one of these elements is not present the transverse facial vessels are sought. The pectoralis minor is approached via an incision in the anterior axillary fold. The lateral edge of the muscle is identified and followed to the coracoid process where it is divided. The tendinous insertion is retracted towards its origin and the vascular and neural pedicle identified. The muscle is then transferred to the face where the hilar structures are placed superficially. The tendinous insertion is split into three and fixed to the alar base of the nose, the upper lip and the lower lip. The origin of the muscle is placed well anteriorly on the malar bone to emulate the zygomaticus muscle and then spread out and fixed to the parotid fascia and the lower fibres to the sterno-mastoid in the neck. The crossed-facial nerve graft which has been previously elevated is then repaired to the nerves supplying the pectoralis minor and the facial artery and vein are anastomosed to the hilar vessels. The diameter of these structures is remarkably similar. Revascularisation of the muscle is clearly evident and is monitored post-operatively with an impedence device placed deep to the muscle. In circumstances where there are problems with the facial vessels and longer hilar structures are required in the muscle a heavily thinned segmental latissimus dorsi is used and blood vessel anastomosis carried out in the neck. This decision can normally be made pre-operatively.

The etiology of our patients was shown in Figure 1. The age of the patients ranged between 4 and 64 years (mean 25.4 years). The gender distribution was relatively even with 245:316 male to female. The surgical time for the second stage varied from 2 to 11.5 h (mean 4.6). Patients were followed up for a minimum of 6 months to 360 months (mean 23.8 months). Sixty-one patients experienced early post-operative complications. Haematomas were the most common complication (34), followed by 11 cases with superficial skin infections, 9 cases of parotid fistulas and 7 cases of flap failure.

Evaluation

All patients were followed up by the operating surgeon and graded according to a clinical scale described by the senior author (DHH) (Table 1).[5,6] An independent panel of four observers was also used to evaluate the 561 patients available for long-term follow-up utilising still photographs and videos. They were asked to grade the patients according to the Hay's score[7] first used for psychiatric evaluation of rhinoplasty patients but popularised by Poole and co-workers in craniofacial deformities.[8] All statistical analysis done with Origin version 6 (OriginLab).

Results

The outcomes of patients can be seen as rated by the operating surgeon in Table 2.

The Hay's score shows a significant improvement comparing pre- and post-operative Hays scores ($p < 0.001$, t-test) by the independent panel. There was no statistical difference between the ratings of the individual panellists' scores ($p = 0.252$, t-test). Figures 2–5 shows some pre- and post-operative results – all rated as +++ by the operating surgeon.

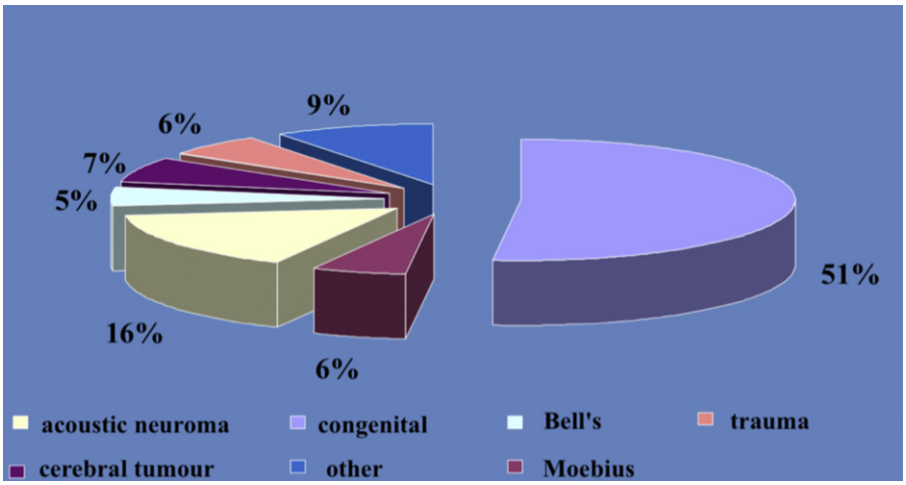

Figure 1 Etiology.

The younger group of patients appears to do better. If we compare the group of patients above and below the mean age the younger group did better (Above and below 24.9 years). This was statistically significant ($p < 0.001$, t-test)

One hundred and fifty-three patients (27.2%) had revisional procedures (see Table 3). Late onset tightness of the muscle in the static position was seen in 71 patients (13.3%). Patient reported experience and outcomes on part of our group of patients have already been published and were not available for the entire group.

Discussion

The mechanism of smile in the normal face is perfectly designed for the task. The zygomatic muscle elevates the upper lip, the lower lip depressors pull the lip downwards and the buccinator which is deeply placed in the cheek pulls the mouth backwards and thins the lip as it does so. Exposure of the teeth is then achieved.

Surgeons can only try and emulate this by placing a triangular muscle into the face. The upper part of the triangle pulls the upper lip upwards, the lower part downwards and the central part backwards. The problem with the central part of this muscle however is that unlike the buccinator it can attach to the skin and in thin people particularly produce some crenations in the cheek. Delayed reinnervation of the muscle flap can produce some tightening in the muscle in the static position. The latter is confirmed when one considers the effects of a late-recovered Bell's.[9] These factors make it difficult to guarantee perfect symmetry at the outset of facial palsy reconstruction.

However very good results can be achieved and at least most of the patient are pleased with the result. In our experience the better results are achieved in the first two decades of life but the fitness and youthfulness of the patient can produce a response seen in the young particularly in respect of speed of reinnervation of the muscle. Fast axonal growth clearly reduces the period in which the muscle graft is denervated and its likelihood of tightness in the static position. We would usually expect reinnervation of the muscle to occur at six months. Children can reinnervate at four months and late reinnervations can occur as late as eighteen months. We have had good results in patients aged sixty and older but in general we prefer to operate before the age of fifty-five. In the older age groups the static position is much more their concern and therefore we would move to fascial slings to support the face.

Evaluating the outcome of this procedure has been a topic of numerous papers. Fixed points can be placed on the face and the excursion measured accurately.[10] These methods however can be cumbersome in an outpatient facility and do not necessarily correlate with the overall aesthetic picture. Manktelow et al.[11] advocate the use of a handheld ruler and magnetic resonance imaging has been suggested.[12] The surgeon's evaluation is often considered biased and the use of an independent non-medical panel looking at photographs and videos as proposed by Terzis is now widely accepted as perhaps the best means available.[13,14] The limitations of filming in a studio is acknowledged and in our opinion a video made by the parents with the patient on holiday laughing and smiling in response to humour is much more convincing than the rather contrived

Table 1 Results: Surgeon's score method.

Score	Interpretation
Nil	No improvement
+	Improvement but poor movement or static position
++	Good movement of the muscle graft but not exposing the teeth completely and symmetrically
+++	Good static position, smile exposing the teeth symmetrically, response to emotion

Table 2 Outcomes of surgery as rated by the surgeon.

Score	Number of patients
Nil	17
+	31
++	159
+++	354

Figure 2 (a) Patient pre-surgery smiling. (b) Patient post-surgery smiling with lips closed. (c) Patient post-surgery smiling with lips open.

smile achieved in a medical environment. It was of interest that during the independent evaluation by a clinical psychologist sixty of our patients concurred with the surgeon's evaluation.[15]

Numerous muscles have been advocated for functional muscle transfers. Our preference is the pectoralis minor because of its size in respect that it does not need much reduction, its fan-like shape and good tendinous insertions that are ideal to facilitate a perioral insertion. The muscle was primarily employed because its function is relatively unimportant and its removal causes no collateral damage.[16] The scar does not seem to cause concern to the patient. In order to enhance the microsurgical repair the muscle is inserted with a pedicle superficially. In consequence if the muscle is to be thinned at a later stage it can be raised with the skin and the posterior part of the muscle reduced. The hilar structures of the pectoralis minor muscle are relatively short[17] and therefore the facial vessels need to be dissected well into the face so that the vessels can be easily transferred to the superficial part of the muscle for easy anastomosis. Absolute vascular diameter is not as important as their being of comparable diameter. In this case the facial vessels are very similar to that of the muscle. Should the facial artery and vein be unsuitable then we would transfer to a heavily reduced latissimus dorsi muscle as it is of a triangular shape.[18] The pectoralis minor is split into three and the tendinous insertion is made into the alar base, upper lip and lower lip. The upper fibres of the

Figure 3 (a) Patient pre-surgery smiling. (b) Patient post-surgery smiling with lips closed. (c) Patient post-surgery smiling with lips open.

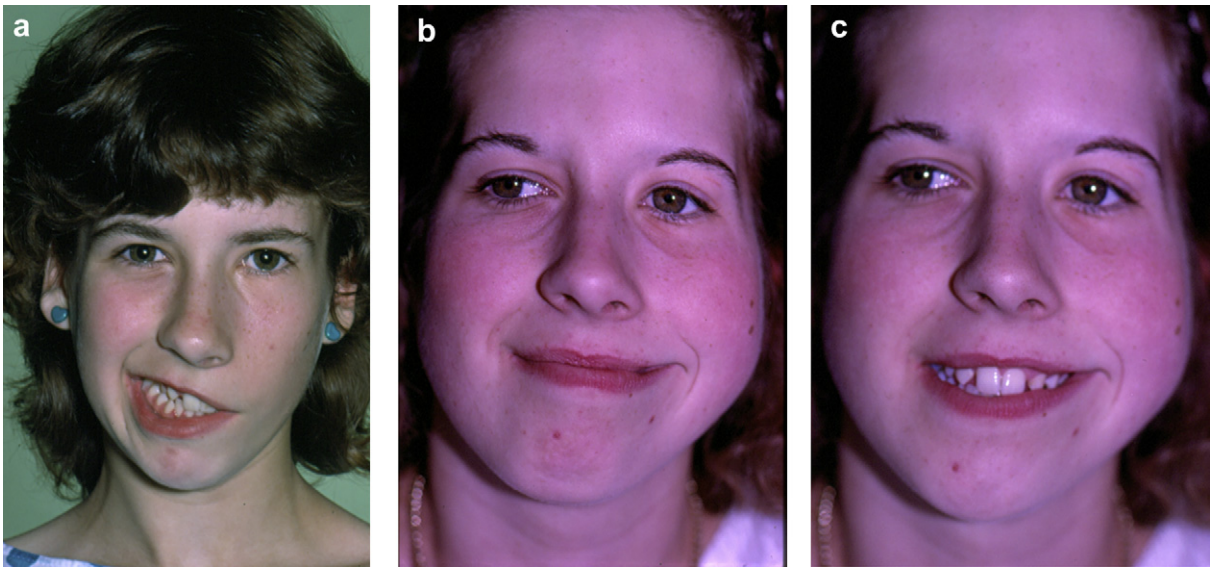

Figure 4 (a) Patient pre-surgery smiling. (b) Patient post-surgery smiling with lips closed. (c) Patient post-surgery smiling with lips open.

muscle are arranged well forward on the zygoma to emulate the zygomaticus muscle and provide elevation to the upper lip. Rarely it has been necessary to refix this to the upper lip employing a Palmaris longus tendon graft. The crossed facial nerve has to be preserved. Haemostasis is clearly important in these procedures to avoid a post-operative haematoma which needs immediate evacuation and similarly infections should they occur ten days post-operatively properly washed out and drained.

Revisional procedures are common in facial reanimation procedures.[19] It leads to Frey's description of a three-stage procedure[20] and was required in 27.2% of cases in our series. Post-operative tightness in the static position is an inherent problem of a functional muscle transfers.[20–22] It relates to delay in reinnervation of the muscle graft. Should this develop it may pull the lip to the reanimated side and the philtral ridges. A V—Y advancement can be used to close the angle of the mouth but compromise may be required to not over-elongate the distance between the angle of the mouth and the nasolabial fold. Deepening of the nasolabial fold and groove can be corrected by shaving the epidermis from the fold and advancing it medially beneath the scar. If the lip mucosa becomes thin then it can be augmented with a lipodermal graft.

Further minor improvements can be achieved with fillers or Botox into the contralateral lower lip depressors.

Facial reanimation surgery is a rewarding procedure which in a small proportion may require some fine-tuning.

Figure 5 (a) Patient pre-surgery smiling. (b) Patient post-surgery smiling with lips closed. (c) Patient post-surgery smiling with lips open.

Table 3 Revisional procedures.

Procedure	Number of patients
Debulking of the muscle	59
Closure of the angle of the mouth	43
Fascial sling to augment upper lip insertion	12
Adjustment of nasolabial fold	7
Scar revisions	23
Lipodermal grafts	9

To be able to display humour and emotional response in a face is to enable a person to return to a good if not excellent quality of life. It is in our opinion probably not for the occasional surgeon.

Conflict of interest

No financial disclosures or products are applicable.

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