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ORIGINAL PAPER

Safe and effective use of free tissue transfer for facial reanimation in complex facial palsy

Stephen E. Morley [1]

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Abstract

Background In irreversible, dense facial paralysis, facial reanimation surgery to recreate the smile is established as the gold standard. Most patients presenting for treatment will have had little or no prior surgical interventions. A significant minority may have undergone prior surgery, making any attempt at facial reanimation complex. These include patients with previous free flap and neck dissection procedures and where multiple prior procedures have been undertaken, including attempts at facial reanimation. Occasionally, a composite tissue reconstruction is required. In these complex cases, it is challenging to determine the best surgical solution for facial reanimation. Microsurgical techniques utilising free tissue transfer may seem to be relatively contraindicated.
Methods A series of 15 cases where free tissue transfer was used successfully for facial reanimation in complex cases is presented. These patients were otherwise deemed to be suitable for facial reanimation and were defined as complex utilising defined criteria. Results were assessed by using the Sunnybrook scoring system where possible and in all cases by measuring symmetry at rest and modiolar excursion when smiling. Standardised pre- and post-operative photos and videos were also used.
Results The average improvement in Sunnybrook score was 39. The average improvement in resting symmetry was 8.5 mm. Thirteen patients developed facial movement corresponding to a good-quality smile with average improvement of modiolus movement of 6 mm. There were no free flap failures.
Conclusions These results demonstrate that even very complex cases of facial paralysis can be effectively and safely treated with free tissue transfer for facial reanimation.
Level of Evidence: Level IV

Keywords Facial palsy · Microsurgery · Complex reconstruction

Introduction

Facial paralysis is a severe condition which leads to an expressionless face with marked asymmetry which is exacerbated when smiling [1, 2]. Afflicted patients often shun company, and the effect on personal life can be devastating. The lack of a smile can be the most significant problem affecting these patients. The surgical restoration of a smile and if possible a smile which expresses emotion spontaneously is the main treatment aim.

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✉ Stephen E. Morley
Stephen.morley@ggc.scot.nhs.uk

[1] Canniesburn Department of Plastic Surgery, Glasgow Royal Infirmary, 84 Castle Street, Glasgow, UK

Common aetiologies of facial palsy include congenital, infective, Bell's palsy and iatrogenic causes including parotid and head and neck surgery and following neurosurgical procedures [3–5]. Where facial paralysis develops following treatment for other conditions then an unfavourable surgical field often results. Examples include oncological surgical treatments with neck dissection and free tissue transfer for reconstruction along with radiotherapy. Subjects with longstanding paralysis may have had multiple prior surgeries either to improve static symmetry or as an attempt at facial reanimation [6]. Patients may present requesting further facial reanimation surgery if these previous treatments have been unsuccessful.

Free tissue transfer is considered to be the gold standard in terms of facial reanimation [7, 8]. The technique involves creating a pocket beneath the skin of the cheek on the affected side and positioning a suitable piece of muscle which is attached around the modiolus distally and in front of the ear and around the temple superiorly. The vascular pedicle is anastomosed to suitable recipient vessel, and the motor nerve of the flap is co-apted either to a previously placed nerve graft or another local nerve source. This technique was described in 1976 [9] and has been refined over the years [10]. In complex cases where other free tissue transfer has been undertaken or attempted or where there is a pre-existing complex surgical field, attempts at free tissue transfer may seem contraindicated. This can be due to previous scarring within the surgical field, radiotherapy-related changes and vessel depletion regarding recipient vessels for microsurgery. Local muscle flaps can also be used for smile reanimation in particular the temporalis myoplasty [11, 12]. In complex cases, in the field of extensive previous surgery, a local approach is often not possible. Where possible, a microsurgical free muscle transfer offers the best results in reanimation surgery in terms of creating a natural and symmetrical smile due to precise positioning of the donor muscle and a choice of suitable nerve supply.

The majority of muscles used tend to be small, to provide as little additional bulk as possible in the cheek and so as not to overcorrect the amount of movement in the face. Muscles commonly used include the gracilis and pectoralis minor muscles [13, 14]. Larger muscles such as the latissimus dorsi can be useful in cases where a long vascular pedicle is required. Appropriate recipient vessels are required such as the facial or superficial temporal (ST). A motor nerve supply must be connected to the pedicle nerve, either to a branch of the contralateral facial nerve or to a regional motor nerve on the affected side, usually the nerve to masseter (NTM) [15, 16]. If the contralateral facial nerve is selected, then this must be connected via a cross-face nerve graft (CFNG) or by using a muscle with a long pedicle to reach the contralateral side [17, 18]. Smaller muscles have relatively short pedicles making their use in complex cases more challenging although the gracilis muscle in particular has a pattern of vascular branching which makes it well suited for facial reanimation due to the possibility of splitting the muscle for insertion and for dynamic eyelid closure [19, 20].

Where previous oncological surgery or neck dissection has been undertaken, then vessels in the face and neck are commonly depleted. This makes the selection of appropriate donor vessels difficult, and an extensive dissection is required to find suitable vessels. Consideration must also be given to the motor nerve where previous treatments or disease may restrict the options available [19, 21].

Following an extensive literature search including PubMed, no one definition of complex case in the field of facial reanimation was found. The definition devised for use in this paper was defined after analysis of the various factors which led to the case requiring an operative strategy which was complex and unusual including:

1. Previous oncological surgical treatments including neck dissection or previous free flap for head and neck reconstruction. These factors suggest a vessel-depleted recipient and also extensive scarring and a possible restricted number of muscle donor sites.
2. Multiple prior attempts at facial reanimation with free tissue transfer and/or cross-face nerve grafts. A single previous attempt at reanimation with a free tissue transfer was not deemed sufficient to consider a case as complex. Multiple previous free flaps with revisionary procedures would lead to a definition of complexity due to an adverse surgical field and a dearth of donor sites for both muscle and sural nerve harvest.
3. Requirement for a composite tissue reconstruction.

The results of facial reanimation surgery in this group of surgical candidates are presented. Analysis was made of the aetiology of the facial paralysis, previous surgery or other factors which made the surgery complex, the technical details of the surgery undertaken and the results of the surgery.

Patients and methods

Fifteen patients who fulfilled the criteria for complex facial reanimation were identified. The demographics and clinical details are summarised in Tables 1 and 2. The average age at surgery was 44 (range 17–70). The cases included six who had had previous neck dissections; five that had had previous free tissue transfer to the area; two who had received multiple procedures including local flaps which had been unsuccessful; three who required a composite reconstruction; and one patient with longstanding fistulation with a significant soft tissue deficit in the cheek. Facial reanimation was performed using a two-stage technique with nerve grafts and free tissue transfer in four cases and a one-stage technique in 11 cases.

Surgical technique

Prior to a definitive decision concerning the choice of free flap the recipient site was exposed to allow for selection of appropriate donor vessels. Harvest of the relevant free tissue muscle transfer was as described in standard references. For the free gracilis muscle, a strip of tissue approximately 9–11 cm long to correspond to the distance between fixation points and 2–3 cm wide was taken to allow fixation between modiolus and temple region under neutral tension. If a longer vascular pedicle was required, then the next choice of free flap was the latissimus dorsi flap. In this case, a similar size of muscle was taken with micro-dissection of the pedicle to give a sufficient length. It is possible to dissect a sufficient length of pedicle to allow for the thoracodorsal nerve to be connected to the contralateral facial. For fixation around the modiolus the muscles were split distally into three strips for fixation at lower aspect

Table 1 Details of aetiology

Number	Aetiology	Complicating factor(s)	Age
1	Parotid malignancy	Head and neck tumour resection including temporalis and masseter muscles	44
2	Iatrogenic	Longstanding fistula with osteomyelitis of maxilla with soft tissue loss	52
3	Moebius syndrome	Previous surgery including CFNG and free flap; temporalis myoplasty and masseter transfer	66
4	Congenital	Previous CFNG then 2 previous attempts at free tissue transfer	20
5	Acoustic neuromas bilateral	Previous CFNG and free tissue transfer and multiple static procedures	47
6	Congenital	Previous free muscle transfer with multiple donor vessels used	33
7	Temporal bone malignancy	Previous extended neck dissection with radiotherapy	63
8	Buccal malignancy	Previous excision oral tumour with neck dissection; radiotherapy and chemotherapy	22
9	Iatrogenic	Multiple previous surgeries for hemi-facial macrosomia	22
10	Excision facial tumour	Excision recurrent tumour left cheek with partial maxillectomy requiring composite reconstruction	58
11	Congenital	Previous multiple reanimation surgeries including free flaps and CFNG	59
12	Cranial vascular malformation	Previous 1 stage LD with multiple revisions and static procedures	22
13	Parotid malignancy	Composite reconstruction required	69
14	Acoustic neuromas bilateral	Multiple previous surgeries for bilateral paralysis	48
15	Mandibular malignancy	Previous head and neck tumour excision with neck dissection and radiotherapy	51

of modiolus; upper aspect of modiolus and nasolabial regions. A deep subcutaneous pocket was developed via a pre-auricular incision to accommodate the muscle strip and Ethibond sutures were used for fixation.

Selection of recipient vessels for microsurgery was challenging. Sometimes, it was possible to reuse the facial vessels in the cheek but often vessels further down in the neck had to be utilised. This could necessitate a careful dissection of the carotid and internal jugular vessels (IJV) to allow for optimal vessel preparation. In cases where radiotherapy had been used, this was particularly challenging. The superficial temporal vessels were sometimes available although the vessels tended to be caught up in scar tissue where previous surgeries had been undertaken. The choice of recipient nerve had to be determined early on during surgery. In cases where previous surgery had been undertaken, a two-stage approach with cross-face nerve graft and free muscle transfer was considered inappropriate where a one-stage technique with a muscle transfer attached to the NTM was preferred. This gives a stronger contraction overall which is more suited to an adverse field [22].

Results

In all cases, microsurgical transplantation of a muscle was successfully achieved. There were no free flap losses. The donor motor nerve utilised was the ipsilateral nerve to masseter in nine cases, cross-face nerve graft in three cases, the contralateral facial nerve in two cases and the ipsilateral facial nerve stump in one case. Recipient vessels for microsurgery included the facial vessels in the neck in six cases, the facial vessels in the cheek in three cases, superficial temporal vessels in four cases, the external carotid artery in one case and the maxillary artery with end to side onto the external jugular vein in one case. Follow-up averaged 55 months (range 4 to 108 months). Assessments included the Sunnybrook Facial Grading System, standardised photographs, video assessment and static and dynamic measurements of modiolar position and movement in millimetres [23]. In 13 out of 15 cases, a good-to-excellent result was achieved. Resting asymmetry of the modiolus was diminished by 8.5 mm (range 5–20 mm). A smile assessed as good was established in 15 out of 16 cases with an average increase in modiolar movement of 6.1 cm (range 1–10 mm). Improvement in Sunnybrook Grading System averaged 39 (range 30–51). A subgroup analysis was made to see if there was any significant difference in results between patients having a latissimus dorsi muscle or a gracilis muscle. The average improvement in static position at the modiolus was 10.2 mm with the latissimus dorsi muscle and 6.3 mm with the gracilis muscle (no significant difference found). A similar analysis of movement at the modiolus was made with the average improvement in movement being 6.1 mm with the latissimus dorsi muscle and 5.4 mm with the gracilis muscle (no significant difference found). An assessment of teeth exposure before and after surgery was also made using the technique described by Chuang [24]. The average improvement using this scale was 1.5. There was no significant difference between any of the subgroups using this analysis.

Table 2 Details of surgery

Number	Free tissue	Donor nerve	Recipient vessels	Improvement static (mm)	Improvement movement (mm)	Improvement Sunneybrook score
1	Free latissimus dorsi	Contralateral facial neve	Sup thyroid	8	3	42
2	Free gracilis	NTM	FV in cheek	7	9	33
3	Free gracilis	NTM	FV in cheek	10	9	30
4	Free gracillis	NTM	STV	8.5	6	47
5	Free latissimus dorsi	NTM	Facial in neck	20	10	47
6	Free latissimus dorsi	CFNG	Facial in neck	10	6	33
7	Free latissimus dorsi	NTM	Facial in neck	10	7	30
8	Free gracilis	CFNG	STV	5	5	N/A bilateral
9	Free gracilis	NTM	Facial in neck	8.5	6	37
10	Free latissimus dorsi	Ipsilateral facial	FV in cheek	10	10	42
11	Free gracilis	NTM	ECA e to S/RTM vein	5	3	30
12	Free gracillis	CFNG	STV	6	5	42
13	Free latissimus dorsi	NTM	Facial in neck	8.5	6	37
14	Free gracilis	NTM	FV in cheek	5	5	51
15	Free latissimus dorsi	Contralateral facial	Maxillary artery/IJV	5	1	N/A

Clinical examples

Case 1 is an example of a female patient who had developed an iatrogenic facial paralysis due to the removal of an infected malar implant, which had been placed for cosmetic reasons. The case was complicated by a long-standing fistula over the zygoma caused by an area of osteomyelitis. The patient presented with an 18-month history of facial weakness along with a significant soft tissue defect over the zygoma. Several factors contributed to the complexity of the case including the fistula and soft tissue defect. Surgery was undertaken using a one-stage free gracilis flap motored onto the nerve to masseter. The muscle was used both for facial reanimation and to obliterate the cheek fistula and encourage healing of the osteomyelitis of the cheek. The arterial anastomosis was extremely challenging due to the friable nature of the facial vessels caused by irritation from the fistulation. Further refinements utilising fat grafting have been made. The patient now has satisfactory facial movements with a healed fistula and improved facial contour (Figs. 1, 2, 3 and 4).

Case 2 illustrates a patient who had undergone radical parotidectomy for adenocarcinoma with resection of the facial nerve, cheek skin, masseter muscle and temporalis muscle. The patient was left with a dense facial paralysis, had received a free tissue transfer for soft tissue reconstruction, had received post-operative radio- and chemotherapy and had had a comprehensive neck dissection. The case presented multiple challenges as no local option for muscle transfer was available and the nerve to masseter was also unavailable to power a free tissue transfer. Previous neck dissection and radiotherapy meant there existed a vessel-depleted neck and adverse scarring. Facial reanimation in this case was achieved by raising a microdissected free latissimus dorsi flap with a pedicle sufficiently long to reach the contralateral side of the face for coaptation to a buccal branch of the contralateral nerve. As per the technique described, the muscle was raised as a small segment on a very long pedicle. The end result showed good resting symmetry and a smile which is triggered emotionally (Figs. 5, 6, 7 and 8).

Case 3 illustrates a male patient with a unilateral facial paralysis which developed following treatment for a cranial vascular malformation. A previous attempt at facial

Fig. 1 Case 1 is female patient who had developed an iatrogenic facial paralysis due to the removal of an infected malar implant

Fig. 2 Case 1 shown smiling pre-operatively

reanimation had been attempted 9 years before with a one-stage latissimus dorsi as a one-stage procedure motored to a branch of the contralateral facial nerve. The case was complex due to the previous major procedure including microsurgery where the facial vessels had been utilised fairly low in the neck. A branch of the contralateral facial nerve had also been sacrificed. A free gracilis muscle transfer was performed using the superficial temporal vessels and the nerve to masseter as a motor. The patient has developed a satisfactory smile result with improved excursion at the modiolus which is emotionally triggered (Figs. 9, 10, 11 and 12).

Fig. 3 Case 1 shown with a healed fistula

Fig. 4 Case 1 shown with improved facial contour and smile post-operatively

Discussion

Surgical treatment for reanimation in facial paralysis can produce excellent results in terms of creating symmetry of the face when smiling or at rest. The best results are achieved when treating children and young adults where there have been no prior surgical interventions. This study shows that even in patients where an adverse surgical field indicates a poorer outlook that microsurgical techniques for smile restoration should be considered. In this

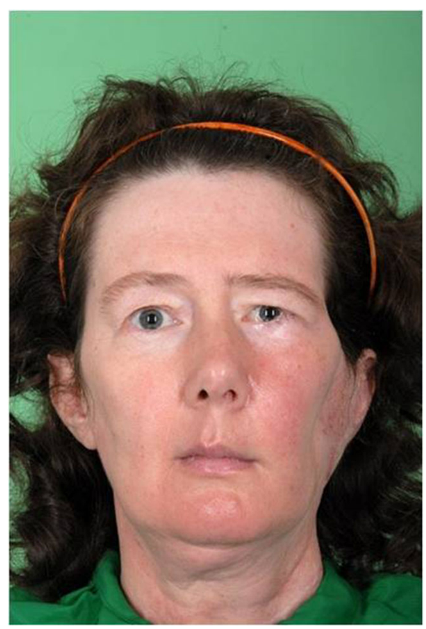

Fig. 5 Case 2 is a patient who had undergone radical parotidectomy for adenocarcinoma with resection of the facial nerve, cheek skin, masseter muscle, and temporalis muscle

Fig. 6 Case 2 with a dense facial paralysis smiling

Fig. 8 Case 2 is shown with good resting symmetry and a smile which is triggered emotionally post-operatively

cohort, the patients had an average age of 44 with other adverse factors. Despite this, all cases were completed successfully and the majority of patients developed a socially acceptable smile. The results obtained are not comparable with what would be expected in a cohort of cases with no previous surgery however.

In many cases, a one-stage reconstruction was utilised using the nerve to masseter as a nerve supply. In complex cases and where a single stage reconstruction is important, the extra power and reliability of this nerve transfer have some advantages over a two-stage technique. There are many technical nuances to bear in mind when complex facial reanimation is contemplated. Recipient vessels for microsurgery may be difficult to access. This might mean utilising other vessels such as the superficial temporal vessels. In this series, the facial vessels were utilised even though a previous free tissue transfer had been performed using these vessels. To achieve the necessary dissection, a good exposure of the facial vessels must be made but often enough length is obtained in this manner.

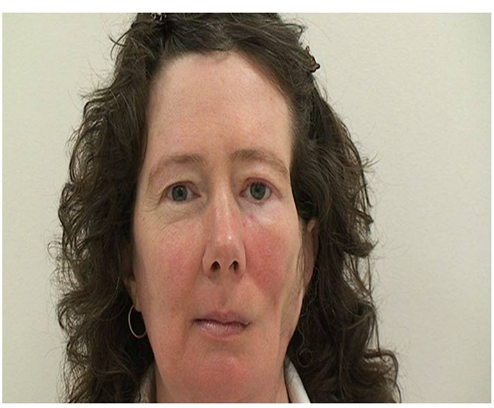

Fig. 7 For case 2, muscle was raised as a small segment on a very long pedicle

Where a neck dissection has been undertaken previously, then the facial vessels will have been transacted at a varying point distal to the external carotid artery. In these cases, it is advisable to select a muscle flap with a long pedicle length such as the latissimus dorsi flap. This will obviate the need for a vein graft and minimise the risk of microsurgical failure.

When patients present with facial paralysis with significant complicating factors, the decision to attempt facial reanimation needs to be carefully weighed against the risks of surgery.

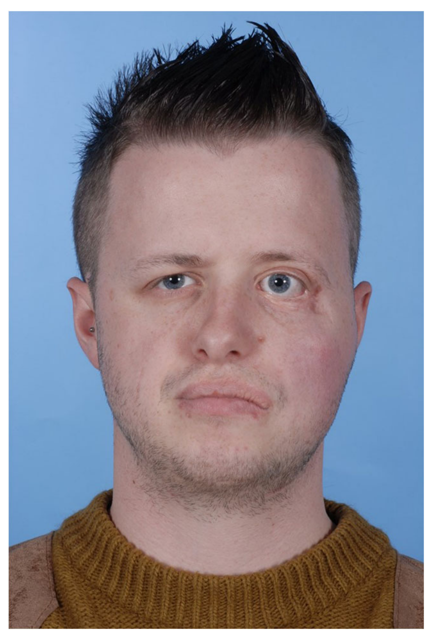

Fig. 9 Case 3 is a male patient with a unilateral facial paralysis which developed following treatment for a cranial vascular malformation

Fig. 10 Case 3 has complexities due to a previous major procedures that include microsurgery

Fig. 12 Case 3 has developed a satisfactory smile result with improved excursion at the modiolus

Surgeons undertaking this work must have expert knowledge of the various vascular and neural pedicles that may need to be accessed. Reanimation surgery should be offered to suitable cases that are medically fit. Preoperative planning is crucial, and selection of the appropriate free flap is essential. Functional results with the free gracilis or similar small muscle are generally superior to using larger muscles. Where a long pedicle is required, for instance, following neck dissection, then it is safer to plan to use a carefully dissected latissimus dorsi muscle. Sometimes, a decision regarding the donor muscle cannot be made until the appropriate blood vessels in the neck have been explored.

Fig. 11 On case 3, a free gracilis muscle transfer was performed

This study demonstrates the safety and efficacy of free tissue transfer for facial reanimation in complex cases. Careful attention must be paid to the choice of free flap to balance the desire for a small muscle flap to allow for fine movement and not to create too much bulk against the possible requirements for a long vascular pedicle or need for a long segment of nerve to reach the contralateral side of the face if required. Over recent years, facial reanimation has also seen a trend towards early intervention with nerve transfers and nerve grafts to try and reinnervate the facial musculature before wasting of the muscle can occur [25–27]. The cases described above were not suitable as in these cases the paralysis was generally long standing. In such cases, microsurgical muscle transfer seems to be the best way to recreate a smile. Where early intervention is feasible, however, nerve transfers and grafts alone should be considered.

Patients with facial paralysis may have seen a number of practitioners and received numerous procedures for facial reanimation. Many patients will still be left with an unsatisfactory result and will seek further reanimation procedures even if they are no longer in their youth. This series shows that patients with facial paralysis with various complicating factors can achieve good results with microsurgical free tissue transfer for facial reanimation. Although anecdotally the best results in facial reanimation are thought to occur in children, this series shows good results across a wide age range. Before undertaking such procedures, the surgeon must give careful consideration to the most appropriate muscle for transfer. This decision must take into account the likely recipient vessels available and also which donor nerve can be used. The nerve used to motor a free flap in complex cases can be a difficult decision. For an optimal spontaneous smile, it is generally held that utilising a branch of the facial nerve is the best solution. In this series, it was possible to find the cut stump of the facial nerve for co-aptation to a free flap on one occasion, but most frequently, the nerve to masseter was utilised. The results of this cohort would not as good as would be expected using free muscle transfer in a series of primary cases. With good surgical planning, however, and sufficient microsurgical experience excellent, results can be achieved even in these most challenging cases.

Compliance with ethical standards

Funding No funding was received for this project.

Conflict of interest Stephen E. Morley declares that he has no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This is a retrospective study. For this type of study, formal consent is not required.

Informed consent All images of patients to be published were obtained with a level of informed consent including the use for publication.

Patient consent Patient provided written consent before their inclusion in this study.

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