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Comparative objective and subjective analysis of temporalis tendon and microneurovascular transfer for facial reanimation

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SUMMARY. The aim of this study was to compare objectively and subjectively the results after temporalis tendon and microneurovascular transfer for reanimation of the paralysed face.

For the objective analysis, measurements of the distances between static and dynamic points in three-dimensional space were performed at rest and during smiling. The patients were assessed subjectively by non-professionals scoring videotapes.

The range of motion of the oral commissure on smiling was 1.7 mm (0.8, mean and SE) after tendon and 5.5 mm (1.6) after microneurovascular transfer ($P < 0.05$) without showing teeth, and 0.6 mm (1.3) vs 3.6 mm (2.4, ns) with showing teeth. Compared with the healthy side, the excursions reached 6% (16) after tendon and 71% (26, $P < 0.05$) after microneurovascular transfer for smiling without, and –4% (14) vs 19% (14, ns) for smiling with showing teeth, respectively. Virtually no difference was found in the measurements at rest as well as in the subjective evaluation. Swelling of the cheek (28%) and tethering of the skin (24%) were shown to be the most disturbing symptoms after microneurovascular transfer.

Better excursion and symmetry of the oral commissure were achieved by microneurovascular reconstruction for voluntary smile. However, the aesthetic outcome after microneurovascular transfer is markedly impaired by chronic complications including swelling of the cheek and tethering of the skin, which were not detected by the three-dimensional measurement technique used. We conclude that the aesthetic appearance should be considered equally important as the range of motion in the reanimated face.

Keywords: facial palsy, surgery, microvascular, muscle, free flap, clinical trials, quantification, observer.

The ultimate goal of a surgical procedure for reanimation of the face is to re-establish voluntary and involuntary motion on the paralysed side. Long-standing palsies require replacement of the irreversibly degenerated mimic musculature. This may be achieved by transfer of a non-paralysed regional muscle, most often the temporalis muscle.[1–4] The introduction of microsurgical techniques has made functional free transplantation of a heterotopic muscle possible whose innervation is provided by a cross-facial nerve graft connected to a buccal branch of the healthy side.[5] The outcome of this approach, despite being more invasive, has been reported to be more satisfactory than tendon transfer.[2,3,6–8] Despite extensive follow-up studies,[4,7,8] the two principal procedures of facial reanimation have not yet undergone direct comparison.

A great variety of methods have been proposed for evaluating the degree of paralysis as well as the outcome of facial reanimation. In general, objective[9–11] and subjective assessments are distinguished, the latter either from the perspective of the investigator[12,13] or the patient.[14] Objective assessment provides quantitative data regarding the re-established motor function in terms of range of motion performed by the tendon transfer or the transplanted muscle.[9–11] However, the success of facial reanimation is determined by the improvement of the facial expression in general, rather than the achieved motion amplitude per se, which seems to make a subjective postoperative analysis more appropriate. To our knowledge, the impact of the extent of re-established motion on the overall aesthetic appearance has not yet been evaluated.

The aim of this study was firstly to compare the outcome of the two main procedures for facial reanimation after long-standing palsy, i.e. temporalis tendon (TT) and microneurovascular (MNV) transfer. To this end, the results were investigated objectively by three-dimensional measurements of range of motion according to the method described by Frey[9] and subjectively by letting non-professionals evaluate changes in facial expression recorded on videotape. The second aim was to test how well the extent of re-established range of motion correlated with the subjective ratings.

Patients, materials and methods

This study was performed according to the local and national ethical guidelines and with the informed consent of the patients.

Seventeen consecutive cases of facial reanimation performed in our unit were investigated. Minimum

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Table 1 Patients' data

Type of transfer	*Temporalis tendon*	*Microneurovascular*
Number	10	7
Age (years)	34–71 (55)	29–45 (36)
Aetiology		
Idiopathic	3	1
Tumour	7	5
Trauma	0	1
Follow-up (months)	26–173 (80)	34–82 (41)
Duration of lesion (years)	2–30 (12)	2–23 (8)
Gender		
Male	2	3
Female	8	4

Values for age, follow-up after main operation or last corrective procedure and preoperative duration of lesion are given as range (mean).

duration of palsy before operation and minimum postoperative follow-up were 2 years. Incomplete lesions were included if no active excursion was preserved, which was the case in five patients in the TT and two patients in the MNV group. Two patients with TT transfer declined to participate. The choice of surgical procedure was decided following full discussion with the patient. However, the application of a MNV procedure was restricted to patients under 50 years of age. Patients' data are listed in Table 1.

Surgical techniques

TT transfer

Temporalis tendon transfer was performed according to the method first described by McLaughlin et al.[1] The insertion of the temporalis tendon was exposed by a face-lift incision and longitudinal splitting of the masseter muscle. The apex of the coronoid process was detached by osteotomy and provided with a drill hole of 6 mm diameter. A 25×2.5 cm strip of fascia lata was pulled through the osseous ring and secured by non-absorbable sutures. The two slips of the fascial graft were routed subcutaneously to the midline of the upper and lower lip where they were anchored in previously inserted conchal grafts under tension that resulted in overcorrection. Excessive preauricular skin was resected in a conventional face-lift fashion.

Rehabilitation exercises were started within the first week immediately after settlement of the immediate postoperative inflammation. No external splinting was applied.

MNV transfer

A conventional cross-facial nerve graft was performed 6–9 months before microvascular transfer of the muscle.[6–8] The distal end of a sural graft of 25 cm length was united to a branch of the buccal nerve on the healthy side which was dissected through an incision along the anterior margin of the masseter muscle and identified by nerve stimulation. Using additional incisions in the upper lip and the nasolabial fold, the nerve graft was gently pulled to the paralysed cheek in the deep subcutaneous plane. The proximal end of the graft was marked with a metallic clip and placed anterior to the tragus.

The MNV muscle transplantation was performed after clinical verification of nerve growth in the end of the graft by Tinel's sign. Latissimus dorsi and gracilis muscles were chosen as donors in three cases each, and the pectoralis minor in one case. The paralysed cheek was undermined subcutaneously from an extended face-lift incision and the sural graft identified. The vessels of the muscle flap were anastomosed to the facial artery and vein and the motor nerve connected to the sural graft using microsurgical techniques. The muscle flap was then trimmed to the requested dimensions (approximately $13 \times 5 \times 1.5$ cm) and its distal end split longitudinally. The proximal end of the muscle was sutured to the periosteum of the zygomatic arch in the area of insertion of the major zygomatic muscle. The two distal slips were routed subcutaneously to the midline of the upper and lower lip where they were attached to the orbicularis oris muscle by additional skin incisions and under slight overcorrection. Skin closure was achieved after resection of excessive skin.

If required, the correction of lagophthalmus was performed in combination with, before, or after, the operations for facial reanimation. The techniques applied were static fascial suspension, tarsorrhaphy, and cartilage and gold implantation. The different methods were equally distributed in both groups. The outcomes of these ancillary procedures were not assessed in this study.

Methods of examination

Objective

The objective analysis was performed according to the protocol established by Frey.[9] Distances between static and dynamic points were measured in three-dimensional space with a caliper which is connected to a digital display (Frey's faciometer, S&T Marketing AG, Neuhausen am Rheinfall, Switzerland). For investigation of the mouth region, tragus (T) and central nose (CN) were defined as static, and philtrum (Ph), oral commissure (C), and midlateral upper (MU) and lower lip (ML) as dynamic points. Measurements were taken at rest, showing teeth, and during smiling with and without showing teeth. All measurements were done by the same investigator (OL). Excursions were calculated by subtracting the values obtained in motion from the ones at rest. In addition, the excursions of the reconstructed side were divided by the ones of the healthy side in order to obtain a measure of symmetry.

Subjective

Black-and-white videotapes were recorded from a frontal view. The patients were requested to perform the same motions as for the objective measurements and additionally some more complex movements including chewing, whistling and reading. At the end of the recording (which lasted about 3 min), the patients were involved in a conversation with the investigator in which involuntary emotional expressions including mental concentration, smile and laughter were provoked. The sequence of patients was distributed randomly.

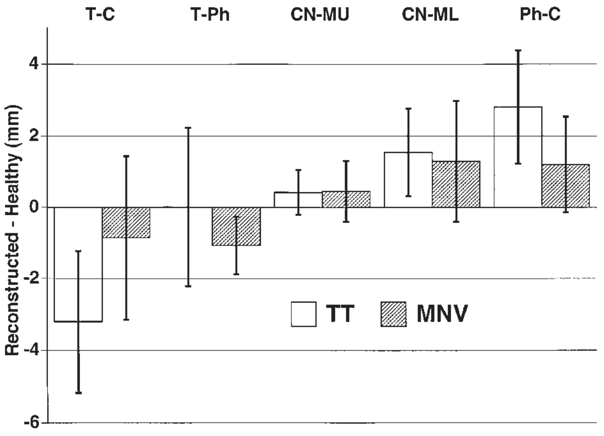

Figure 1—Symmetry at rest after temporalis tendon (TT) and microneurovascular (MNV) transfer. The values are calculated as (distance on reconstructed side) – (distance on healthy side) and given as mean and standard error in mm. The distances were measured between T = tragus, C = oral commissure, Ph = philtrum, CN = central nose, MU = midlateral upper lip and ML = midlateral lower lip.

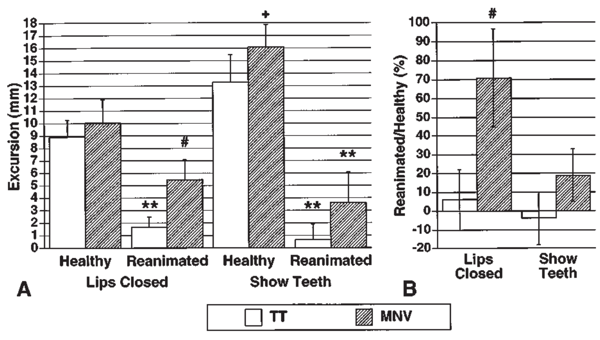

Figure 2—Range of motion after temporalis tendon (TT) and microneurovascular (MNV) transfer for smile with and without showing teeth. (A) Absolute excursion on healthy and reanimated side, measured between tragus and oral commissure and calculated as (distance at rest) – (distance on smiling). Values are given as mean and standard error in mm. (B) Relative excursion as compared to the healthy side, given in percent (mean and standard error).** $P < 0.01$ vs healthy side, #$P < 0.05$ vs TT, +$P < 0.05$ vs lips closed.

The videotapes were shown to 30 medical students at a preclinical level who rated each sequence on a scale from 1 to 5 (1 worst, 5 best). Data were calculated as the sum of scores per patient, theoretically ranging between 30 and 150.

In addition, each observer was requested to indicate the most disturbing feature in each patient. Data were quantified as quotations per observer and patient.

Statistics

The InStat© 2.03 program was utilised for statistical analysis. Unless indicated differently, values were given as mean and standard error of the mean (SE). The unpaired Student's *t*-test was used for comparison between groups and the paired Student's *t*-test for comparison within the groups, except for cases with significantly differing standard deviations in which the alternate Welch *t*-test was applied. $P < 0.05$ was set as statistically significant. The correlation between age of patients and excursions was analysed with the Pearson test.

Results

One severe haematoma occurred in the MNV group which required urgent revision due to compression of the trachea. No infections or wound healing problems were observed. The MNV transplantations healed without any microsurgical complications.

Five patients in the TT and four patients in the MNV group underwent secondary corrective procedures. The operations included tightening or refixation of the transfer (three patients), reconstruction of the nasolabial fold (three) and correction of the lips (two) in the TT, debulking (three) and/or refixation (two) of the transferred muscle, release of skin retractions (two) and reconstruction of the nasolabial fold (one) in the MNV group.

At rest, no significant difference of symmetry was found between the two groups for all measurements in the mouth region (Fig. 1).

The excursions of the oral commissure towards the tragus during smiling with and without showing teeth are shown in Figure 2. On the healthy side, the excursions were more prominent during smiling with rather than without showing teeth for both groups ($P < 0.05$ for MNV). On the reanimated side the excursions were higher after MNV than after TT transfer during both types of smiling ($P < 0.05$ on smiling with closed lips). However, excursions on the reanimated side were lower than on the healthy side ($P < 0.01$ except ns for MNV on smiling with closed lips). Better symmetry was found on smiling with closed lips and after MNV transfer ($P < 0.05$ vs TT on smiling with closed lips).

Neither of the two reconstructive techniques was able to avoid a shift of the philtrum to the healthy side during smiling. The extent of the shift, expressed by the difference of the distances between T and Ph, was similar in both groups. 2.1 mm (2.6) were measured after TT vs 2.1 mm (1.2) after MNV during smiling without and 2.6 mm (2.3) vs 3.7 mm (1.7) during smiling with showing teeth.

The restricted indications for a MNV procedure resulted in an unequal distribution of age in the two groups. However, absolute and relative excursions for smile were randomly distributed in each group. The correlation coefficient r ranged between –0.23 and 0.15 after TT and between –0.26 and 0.28 after MNV transfer, respectively (all ns).

According to the subjective evaluation, general impression as well as appearance at rest, while showing teeth and smiling with showing teeth were slightly better after TT, whereas a higher score was obtained for MNV on smiling with closed lips (Fig. 3). However, the differences did not reach statistical significance. Virtually no difference was seen for the complex movements including whistling, chewing and reading.

Poor cosmesis in the eye region was cited as most disturbing after TT in 44%, but in only 18% after MNV transfer. In the TT group, other features

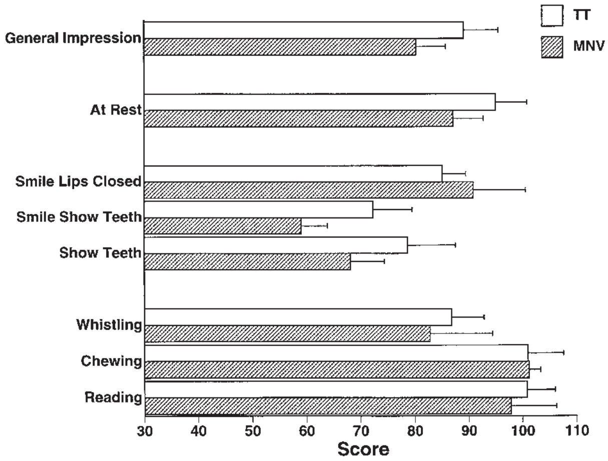

Figure 3—Scores obtained by subjective analysis. The values are given as mean and standard error per patient and group and divided into four sections: general impression, at rest, voluntary motion (smile with and without showing teeth, showing teeth) and complex motion (whistling, chewing, reading). TT = temporalis tendon transfer, MNV = microneurovascular transfer. No significant differences were found between the groups.

including unnatural oral commissure (19%) and unnatural smile (10%) were less frequently criticised, whereas in the MNV patients, swelling of the cheek (28%) and tethering of the skin (24%, Figs 4, 5) appeared to be more disturbing than the eye region.

Discussion

The principal findings of the present study were the markedly improved excursion and symmetry of the oral commissure on smiling after MNV compared with TT transfer, whereas virtually no difference was found in the subjective analysis.

Frey's faciometer, the instrument utilised for objective evaluation, has been developed in order to introduce a data basis for quantitative measurements which can be acquired in a clinical set-up. This requires a system which is easy to handle and provides reproducible results.[9] The latter has been tested by letting two observers perform measurements on the same individual on two different days.[9] This yielded ranges of errors that were markedly lower than the standard errors obtained by a single observer in the present study, which emphasises the reliability of our objective findings.

Frey's documentation system includes a variety of distances between static and dynamic points, whereas our investigation was focussed on the distance between the tragus and oral commissure. The reason to do so was because the vector of motion which the oral commissure describes during normal smiling approximately points to the tragus.[11] The other dynamic points, on the other hand, move in directions which do not correspond to the ones assessed by Frey's documentation system, or they present a higher inter-individual variability. Accordingly, the line between the oral commissure and tragus reflects the principal direction of traction of TT and MNV transfer. Therefore, we chose the excursion of the oral commissure towards the tragus as a measure of the functional result of the transfer which showed markedly better results after the MNV procedure. The values we obtained were comparable to the ones reported in a two-dimensional analysis assessing the excursions of the mouth corner after facial reanimation with functional free flaps.[11]

Because the antagonist (healthy side) was innervated simultaneously, motion amplitude of the transfer depended on the balance between the muscle strengths of both transfer and healthy mimic musculature. At rest, relatively good symmetry was obtained for all distances in both groups. However, a shift of the philtrum to the healthy side was observed on smiling which was similar in both groups, but more pronounced on smiling with rather than without showing teeth. These observations indicate that force development was similar in both types of transfer. Furthermore, our observations are in accordance with the ones by Frey, who suggested that due to a higher degree of innervation, a stronger pull is produced on smiling with rather than without showing teeth in a healthy face.[9] The force developed on smiling with showing teeth cannot be compensated by the transfer, whereas maximal symmetry and therefore optimal facial expression may be achieved on smiling without showing teeth.

Our principal findings may be questioned because of the older population in the TT group following the suggested restriction of MNV transfer to patients under 50 years of age.[2,3,6] However, the age-related distribution of our results suggests that lower age would not be responsible for superior objective results obtained in the MNV group. This is in accordance with the data reported by Terzis and Noah in a large series of 100 MNV transfers.[8]

A variety of features, which can only be assessed subjectively, have to be taken into consideration when evaluating facial expression. For the subjective analysis, we chose medical students of a preclinical level that we considered as non-professionals representing a normal population capable of rating their observations.

It has generally been suggested that MNV transfers provide good synchronicity of involuntary and emotional movement, which markedly contributes to the aesthetic result after facial reanimation.[2,3] In addition, our objective analysis revealed more symmetrical excursions of the mouth corner during voluntary smiling after MNV. Therefore, we speculated that better subjective results would be obtained in the MNV group. However, this was not confirmed in our study, where similar ratings were obtained in both groups for both voluntary and involuntary motions. We assume that factors other than symmetry and synchronicity may disturb the improved aesthetic result expected after MNV transfer.

According to our questionnaire, swelling of the cheek (28%) and tethering of the skin (24%) were most disturbing after MNV transfer. In O'Brien et al's follow-up of 47 patients having received MNV transfer, bulging of the cheek was judged as excellent in 0%, good in 60%, fair in 38% and poor in 2%.[7] These

Figure 4—Postoperative result after microneurovascular transfer (A) at rest and (B) on smiling with closed lips. Note the unnatural appearance of the reanimated cheek, caused by bulging and unphysiologic configuration of the nasolabial fold due to tethering of the skin.

results were obtained after secondary debulking in 15% of the cases compared to 26% in Terzis and Noah's[8] and 43% in our study. Tethering of the skin was reported as a major complication which required operative correction in 60% in O'Brien et al's[7] and 21% in our patients, respectively. However, the comparison with the two large series of O'Brien et al and Terzis and Noah may indicate that our aesthetic results might improve with increasing experience in terms of initial trimming of the muscle and avoiding tethering of the skin. Furthermore, a more natural smile may be achieved by inserting the transferred muscle in a fan-like manner which should result in a more multidirectional traction. The pectoralis minor muscle has been suggested to be the most suitable for fulfilling this purpose.[6,15,16] However, the results of our study emphasise the relevance of aesthetically disturbing aspects related to MNV transfer which are barely detected by quantitative assessment.

In summary, our objective analysis revealed a better range of motion and better symmetry of the oral commissure after MNV than after TT transfer for smiling, whereas similar results were achieved at rest. The minimal excursions obtained after TT transfer indicate that similar objective and subjective results may be achieved by a static procedure. However, the expected superior result in general aesthetic appearance after MNV procedure was not confirmed in our subjective evaluation. This may be explained by disturbing complications including tethering of the skin and swelling of the cheek which were not detected by the three-dimensional measurement technique used, and whose avoidance deserves more attention in order to make the advantages of the MNV transfer more afferent.

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