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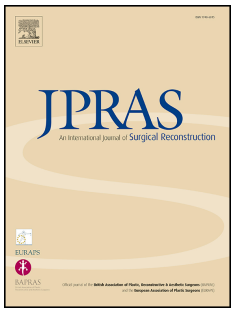

A technique for facial reanimation: The partial temporalis muscle-tendon transfer with a fascia lata sling

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Title Page

A technique for facial reanimation: The partial temporalis muscle-tendon transfer with a fascia lata sling

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Prior presentation

Part of this work has previously been presented at the BAPRAS Winter Meeting 2012, at the Royal College of Surgeons of England, London, United Kingdom in December 2012 and at the 3rd International Conference of the Kenya Society of PRAS, Nairobi, Kenya in August 2013.

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with travel costs during this project. Aside from this, none of the authors have any financial interests, conflicts of interest, commercial interests nor financial disclosures to declare.

List of all products, devices, drugs, etc., used

Facial Assessment by Computer Evaluation (FACE) software (available at URL: http://www.sircharlesbell.org/facial_nerve_programs.html)

Microsoft Excel Software (Version 2007; Microsoft Corp, Redmond, WA)

Prolene (Polypropylene suture material, Ethicon, UK)

Vicryl (Polyglactin suture material, Ethicon, UK)

R (Version 3.2.2).

Authorship

Mr Thomas E. Pidgeon performed the literature review, collected the clinical and photographic data, analysed the results and co-wrote the concluding remarks. Mr Radovan Boca designed the study and suggested the use of FACE, reviewed the manuscript and co-wrote the concluding remarks. Mr Fazel Fatah conceived the technique, wrote the section on surgical technique, provided the photographs and reviewed the manuscript. All approved the final submitted version.

Summary

Background: This report describes the results of a surgical procedure for facial reanimation. This one-stage technique involves the orthodromic transfer of only a superficial segment of the temporalis tendon. This is extended with fascia lata to achieve elevation of the oral commissure along the desired vector in the paralysed hemi-face.

Methods: A retrospective case note review was performed. Patient photographs were objectively evaluated with Facial Assessment by Computer Evaluation (FACE) software.

Results: Thirty-nine patients underwent the procedure from 2001-2011. Median age at operation was 57.0 years (interquartile range 38.2-66.3 years) and median duration of follow-up was for 0.9 years (IQR 0.5-1.8 years). All patients achieved early improvements in appearance and function after surgery. Three patients underwent further, minor procedures for aesthetic and functional adjustments around the oral commissure. Complications occurred in three patients; comprising two minor facial haematomas and one thigh wound infection. Surgery did not disturb natural temporalis muscle function.
FACE analysis demonstrated that no significant movement of the oral commissure took place during attempted smiling in the paralysed hemi-face before surgery. However, symmetry was achieved when the healthy and paralysed hemi-faces were compared post-operatively, both in repose and during controlled smiling.

Conclusions: This modified, single stage technique for facial reanimation improves commissure mobilisation and has been objectively shown to restore symmetry of the commissure to the reanimated hemi-face.

Keywords: Facial reanimation, temporalis, transfer, paralysis, plastic surgery.

INTRODUCTION

Longstanding facial paralysis remains a complex management challenge. No single technique currently allows the complete restoration of an immediate, spontaneous smile, normal speech, oral sphincter competence, and satisfactory appearance in repose. Regional muscle transfer using orthodromic transfer of the temporalis tendon can be used to achieve dynamic reanimation of the oral commissure. The procedure offers dependable, early and controllable reanimation of the smile.

However, an invariable vector of movement relative to the Frankfort [1] and occlusal planes [2] is created with the temporalis tendon transfer. This is worsened when the tendon is attached to only a single point around the mouth and when the temporalis is stretched, overcorrecting the paralysis [3]. In the past, little effort has been made to augment the direction of pull of the temporalis to create a symmetrical smile. Additionally, several studies have outlined the anatomical structures at risk during mobilisation of the temporalis tendon from the coronoid [2,4,5], and these techniques can disrupt the natural function of the temporalis.

This report describes a technique to reanimate the smile that attempts to address these shortfalls. The *partial* temporalis muscle-tendon transfer (pTTT) with a fascia lata sling was performed by the lead author from 2001-2011 in 39 patients. This study reports the long-term outcomes using this technique, including an objective evaluation of commissure excursion distance and smile symmetry.

PATIENTS AND METHODS

The study was registered with and approved by the centre's Clinical Effectiveness Department as a non-experimental, retrospective service evaluation of an existing practice. The work complied with relevant aspects of the Declaration of Helsinki. Each patient was offered the range of surgical reanimation options. All patients in this cohort chose to undergo the pTTT after providing full, informed consent. A case note review was performed.

Facial Assessment by Computer Evaluation (FACE) Software demonstrates strong inter- and intra-observer agreement [6] and was employed by a single author (TEP) to objectively measure commissure location (the primary outcome) from patient photographs as described in the work of others [7,8]. Analysis of the normal and affected sides of the face, in repose and whilst smiling, pre-operatively and post-operatively was performed. FACE yields four main measurements; lateral (horizontal) displacement of the oral commissure (from the middle of the lower vermillion border), vertical displacement, the hypotenuse (total) displacement, and the angle of elevation of the commissure from the vertical plane. To ensure the accuracy of the FACE measurements, photographs were excluded from analysis if the irises were not visible (distance is calibrated to the diameter of the iris), if the head was rotated, or if both eyes were not directed at the camera.

Preoperative preparation

Preoperatively, the vector of the smile on the normal side and the effect of the smile on the shape of the upper lip is determined. The patient is asked to smile while the affected side is kept in a balanced position by counteracting the pull from the normal side using two fingers to stabilise the naso-labial line of the affected side. This manoeuvre helps to determine the points where the strips of the fascia lata are attached to produce a symmetrical smile and shape to the lips.

Surgical technique

(Please see the video, Supplemental Digital Content 1, which demonstrates the technique in full).

A strip of fascia lata measuring 12 cm X 2.5 cm is harvested from the thigh on the same side as the facial palsy using a 10 cm long, longitudinal incision. A flipped L-shaped incision is made starting 3cm above the zygoma, in the temple and down to the pre-auricular area (Figure 1). In women the incision can follow a post-tragal line. A 2cm incision is made in the nasolabial line just above the oral commissure and another 1cm incision is

made just below the oral commissure in the natural crease to mimic the muscle pull on the normal side. An upper lip pocket is dissected down to the lip margin and two-thirds towards the philtrum. The lower lip pocket extends along the lip margin for the width of the incision close to the midline, where a 1cm long incision is made along the lip margin to facilitate the plication of the fascial strip medially.

Subcutaneous dissection of the skin of the temple and the cheek is carried out above the superficial temporal fascia (STF) and superficial musculo-aponeurotic system (SMAS) until the anterior margins of the parotid gland. From this point, two separate tunnels are dissected, one wider, about two centimetres, in the direction of the upper lip incision and another, narrower, in the direction of the lower lip crease incision. These tunnels are dissected bluntly with scissors and deep to the cheek fat to produce a natural round cheek contour during smiling, as opposed to a flattening of the cheek when the fascia strip is in a subcutaneous plane. Both tunnels must surface just under the skin margins of the incisions. The angle of the two separate tunnels in relation the horizontal varies in individual patients to mimic the muscle pull and the smile on the normal side.

While avoiding the superficial temporal vessels and to expose the temporalis muscle tendon, first a distally based 2.5cm X 4 cm rectangular flap of the STF is raised down to the upper border of the zygomatic arch. The lateral incisions are extended over the bone to facilitate the osteotomy of the arch. Secondly, a similar flap of the deep temporal fascia is raised on a superior base. Thirdly, the zygomatic arch is cut with a saw after two fine holes are drilled either side of each osteotomy line for repair of the arch later on. The osteotomies are carried out through the narrow part of the arch. The cut section of the bone, still attached to the soft tissues, is gently forced out to expose the tendon. A superiorly based U-shaped incision, maximum 2cm wide and 2.5cm long is made through the temporalis tendon. This small flap of tendon and the underlying attached section of muscle, is lifted from below and teased away from the main muscle bulk with gentle blunt dissection for the length of the raised tendon, thus retaining both the innervation and blood supply from the original main muscle bulk. No bleeding is encountered from this blunt dissection. This allows exteriorization over the zygomatic arch. This represents a “new” muscle unit piggybacked on the temporalis muscle. The flap can be raised from the anterior, middle or the posterior part of the wider temporalis tendon depending on the vector of pull required for the re-animated smile. The zygomatic arch is repaired with two 3/0 absorbable Vicryl sutures using the drill holes. The STF flap is folded over the repaired arch to fill the gap from raising the muscle flap and to form a gliding surface.

The fascia lata strip is partially split distally to travel down the two separate cheek tunnels. The strips are fixed to the predetermined points in the lips and the oral commissure making sure that neither is slack when

the main strip is pulled. The positions of the fixation points are adjusted as necessary to achieve a symmetrical smile.

The right level of tension in the fascia lata is vital to ensuring the best quality in reanimation. The exteriorized portion of the tendon is pulled down with two stay sutures to its original level before the dissection. Next, the fascia lata is pulled up towards the tendon until the lips and the commissure just start to initiate a smile and begin to delineate the naso-labial crease. The fascia is held over the tendon and both structures are marked with a blue line one centimetre above the cut edge of the tendon. This represents the line of fixation of the two structures together to form the active sling.

The tendon-fascia repair begins with three-five 4/0 Prolene core sutures. The tendon stays in front of the fascia lata. A middle suture is inserted first along the marked lines entering the outer surface of the fascia, through the tendon and back, from the tendon through the fascia and tied on the fascial surface. The other sutures are inserted along the same line and any excess of the fascia beyond the cut edge of the tendon is trimmed. The free edges of the tendon and the fascia are then folded down to bury the knots. These are sutured together to the main fascial strip with a continuous 5/0 Prolene suture. This starts from one end of the marked line and finishes at the other in a U-shape taking care not to pick up the underlying tissues. The deep temporal fascia flap is repaired with absorbable sutures, followed by skin closure. Normally, tissue glue is used and drains are not required. Patients are kept in hospital overnight and are advised to eat soft food for ten days. Figures 2 and 3 show pre-operative and post-operative photographs.

The mechanism by which the muscle produces a smile is explained to the patient in detail both pre- and post-operatively, in order to aid cerebral adaptation and to promote controlled smiling. Post-operative oedema is allowed to resolve. Then the patient is encouraged to stand in front of a mirror and to produce a smile based on the function of the temporalis muscle on the affected side whilst smiling naturally on the contralateral side. Patients are advised to practice smiling exercises three times a day for fifteen minutes. They are given the task of producing the most ‘controlled’ symmetrical smile they can using the partial temporalis muscle.

Statistical analysis

Statistical analysis was performed using the software R (Version 3.2.2). Shapiro-Wilk testing for normal distribution (significance level $P<0.05$) was performed on FACE measures and on demographic data. Wilcoxon Signed Rank testing was used to compare the difference of medians of paired observations that were

not normally distributed. Significance level was adjusted with Bonferroni correction for multiple comparisons and set at $P<0.003$. Comparison was made between FACE measurements from photographs.

RESULTS

39 patients underwent the procedure from 2001-2011. Shapiro-Wilk testing showed that demographic parameters were not normally distributed. Data were therefore presented as median values with an inter-quartile range. Sixteen patients were male and 23 female. Aetiology of facial paralysis was varied (Table 1). Median age at onset of facial palsy was 43.6 years (IQR 15.7-60.1 years). The right hemi-face was affected in 16 and the left in 23 patients. Median age at presentation to the unit was at 56.0 years (IQR 37.8-65.7 years) with a median duration of paralysis of 8.1 years (IQR 3.3-19.2 years).

Presenting symptoms are shown in Table 2. Thirty-eight of 39 patients had a complete facial palsy, the final patient had smile asymmetry from weak zygomaticus major and minor muscles, and is depicted in the third panel of Figure 2 and 3. At presentation, only 11 patients had had no previous surgery to correct or mediate their facial palsy. Of those that had had previous surgery, gold weight insertion was the most common procedure that had been performed in 12 patients. Many had undergone previously unsuccessful attempts at reanimation. Six had had facial nerve grafts, four had undergone hypoglossal nerve transfers and one patient had had a free gracillis muscle transfer.

Median age at operation was 57.0 years (IQR 38.2-66.3 years). 29 patients had additional procedures performed at the same time as the pTTT. These procedures were patient specific and therefore varied; 12 patients required a brow lift and six had gold eyelid weights inserted. Median operating time was 180 minutes (IQR 155-195 minutes).

All 39 patients were followed up. Median duration of follow-up after surgery was for 0.9 years (IQR 0.5-1.8 years). over a median of four outpatient appointments (IQR 3-5 appointments). All patients experienced an improvement in their symptoms post-operatively. Two patients did not feel the excursion was adequate, and they underwent either a Puckett lip correction or a static lip lift to successfully correct this. Two patients reported some persistent drooling, but this was again later corrected with upper lip lipomodelling in one and the other did not require further surgery. There were three complications; two facial haematomas that required drainage and one thigh wound infection from the fascia lata harvest that was successfully treated with antibiotics.

Photographs were available for FACE analysis for 17 of the 39 patients. Results of FACE measures and statistical analyses are shown in Figures 4 and 5. Shapiro-Wilk testing showed that FACE measures were not normally distributed ($P<0.05$) and data were thus compared using Wilcoxon Signed Rank testing. Pre-operatively, FACE revealed a significant difference in all measured parameters relating to commissure position

between the normal and paralysed hemi-face, both whilst in repose and during attempted smiling. No significant difference in commissure position existed between repose and attempted smiling in the paralysed hemi-face before surgery; the hemi-face was immobile. Post-operatively, across all measured parameters, there existed no significant difference between the normal and affected hemi-faces. Symmetry had been restored to the face both in repose and during controlled smiling.

DISCUSSION

In longstanding facial nerve paralysis, where the existing facial muscles have undergone endplate fibrosis and atrophy, transfer of innervated muscle is required to restore active movement [9].

This can be achieved with distant, microvascular, free muscle transfers innervated by a donor nerve [9,10]. Re-innervation by a facial nerve source should allow the recovery of spontaneous movement [9,11]. However, a need to wait for axonal regeneration will prevent immediate reanimation [10], which may take 2-6 months to develop [12,13]. Two stage procedures may be necessary and failure of the procedure [11] or of the flap itself [10] is possible. Free muscle transfers require microsurgery, with a prolonged operation time and hospital stay [12]. A contour defect may be present over the flap [12], and final movement results can be unpredictable until re-innervation is complete [12].

Of the regional transfers of locally innervated muscle to the oral commissure, the temporalis transfer remains most popular [9,10]. Orthodromic transfer offers early reanimation [14] (as the muscle remains innervated) that the patient can control, in a reliable, single stage procedure, that does not require microsurgery. Temporalis surgery avoids further interference with the injured or recovering facial nerve [15,16]. Temporalis transfer has therefore been performed as a temporary reanimation measure where facial nerve recovery is foreseen but is prolonged [15]. However, the smile is not immediately spontaneous, and must be “learnt”. The smile can be further reinforced by physiotherapy [1] and may become spontaneous in time [3,17–20]. Further disadvantages are an undesirable vector of movement [1,2] for the reanimated smile, which will be exacerbated by overcorrection [3]. Further drawbacks are the potential for injury to the anatomic structures at risk during access to the coronoid [2,4,5], post-operative temporal hollowing and a potential need for revisional tenolysis (especially in paediatric patients) [12].

Orthodromic temporalis transfer has been compared to other reanimation operations with mixed results [11,17,21,22]. The largest comparative series of facial reanimation techniques to date included just four orthodromic temporalis transfers [11]. Free muscle transfer created greater lateral movement than temporalis transfer, and a spontaneous smile, but symmetry was not objectively evaluated [11]. Excursion is reported to be greater with free muscle transfer when compared to temporalis transfer, however swelling and skin tethering can reportedly impair the final aesthetic result [21]. Only one systematic review compares temporalis transfer with free muscle transfer [23]. This found weak evidence showing that less lateral excursion is achieved with the temporalis transfer and inconclusive evidence regarding spontaneity, but that the procedure was less invasive and achieved earlier results than with free muscle transfer [23].

Few studies objectively report their results by quantifying movement achieved at the oral commissure or comment on post-operative facial symmetry. Reanimation should create an *appropriate* amount of movement in the correct direction. Both insufficient and excessive reanimation of the commissure compared to the healthy side of the face can produce unsightly asymmetry. Previous reports support the use of the entire temporalis tendon based on its 45^{o} vector of pull relative to the occlusal plane [1,2]. This may result in an excessive angle of commissure elevation. The mean angle of commissure elevation in the healthy hemi-face during smiling in this cohort was found to be 122^{o} from the vertical (range 113-130^{o}). The symmetrical results achieved with the pTTT may not be generalisable to a population with excursion angles outside of this range.

FACE demonstrated that the pTTT mobilised the oral commissure with the precision to remove any significant difference in commissure excursion distance and angle, between the healthy and reanimated hemi-faces both in repose and during controlled smiling. Symmetry had been restored to the face. This precise vector of pull is achieved with careful pre-operative planning to identify and mimic the direction of the muscle pull on the normal side, by employing two, separate, patient-individualised tunnels to the lips to create a matching vector on the affected side, and by varying the site of the muscle-tendon flap to compliment this approach. Compared to those cases of free muscle transfer where the patient develops an unpredictable 'mass', asymmetric or distorting movement, the use of local temporalis "facial" musculature allows a more predictable, discriminating level of movement control.

The literature suggests that the temporalis transfer (and therefore the pTTT) is suited for patients with longstanding paralysis [5,15,21], desiring early post-operative movement with a reliable, single stage procedure, and where free muscle transfer is unsuitable or not desired [11]. Temporalis transfer is appropriate for patients where uncertain levels of smile spontaneity are acceptable. The technique has a relatively short operative time and is suitable if ancillary procedures are desired at the same time [12] (also demonstrated in this cohort). Temporalis transfer can provide temporary reanimation if facial nerve recovery is foreseen in patients that desire a smile during the recovery period [15]. A requirement for large excursion distances or more reliable spontaneity may be better addressed by free muscle transfer [23].

The pTTT has additional benefits; including the creation of a symmetrical commissure displacement and angle both during controlled smiling and in repose. There is only a limited insult to the temporalis, that retains its original function. The technique was also used as a salvage operation in those patients who had undergone other failed reanimation attempts.

A need to section the zygomatic arch may be seen by some as a drawback of the pTTT. Zygotomy is necessary as part of the pTTT in order to access specific segments of the temporalis muscle-tendon unit deep to the zygoma. This is in turn necessary to achieve adequate excursion from the muscle flap to produce a smile and sufficient lateral movement. We have not found any reports describing access to this segment of the temporalis tendon without osteotomy. In contrast to other techniques, this method preserves the natural function of temporalis. Stripping of the muscle from the temporal bone and sectioning of the coronoid are avoided. The zygotomy is easily repaired with sutures and no complications relating to the osteotomy were encountered. The need for a fascia lata donor site is acknowledged.

CONCLUSIONS

The partial temporalis muscle-tendon transfer is a safe and effective procedure for reanimation of the paralysed smile. The technique provides a high degree of control over both the distance and direction of pull on the reanimated commissure. It has been objectively shown that is has the capability to restore symmetry to the paralysed face in a diverse array of patients in a single procedure.

CONFLICTS OF INTEREST

None of the authors have any financial interests, conflicts of interest, commercial interests nor financial disclosures to declare.

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FIGURE LEGENDS

Figure 1: Pre-operative marking: Dotted lines show the incisions. The arrow on the cheek indicates the desired direction of pull from the muscle.

Figure 2: Pre-operative images of patients with hemi-facial paralysis prior to undergoing corrective surgery

Figure 3: Post-operative images of patients at follow-up having undergone partial temporalis tendon transfer. Notice the effect of the dissection of the pockets deep to the cheek fat on the round contour of the cheek when the patients smile.

Figure 4: Box and whisker plots (with jittered layers) to demonstrate median values and range for the location of the oral commissure (distance) from analysed photographs obtained with FACE software. Significant differences were observed ($P<0.003$) in the commissure position (lateral, vertical, total displacement and angle of elevation) between the normal and affected hemi-faces pre-operatively, both in repose and during attempted smiling. No significant difference in commissure position (lateral, vertical, total displacement and angle of elevation) existed between repose and attempted smiling in the affected hemi-face pre-operatively. There was no significant difference in commissure position (lateral, vertical, total displacement and angle of elevation) between the normal and affected hemi-faces post-operatively, both in repose, and during controlled smiling. Wilcoxon estimates, upper and lower bounds and P values not shown. Affected (the paralysed/ reanimated hemi-face), normal (the unaffected, healthy hemi-face).

Figure 5: Box and whisker plots (with jittered layers) to demonstrate median values and range for the location of the oral commissure (angle of excursion) from analysed photographs obtained with FACE software. Significant differences were observed ($P<0.003$) in the commissure position (lateral, vertical, total displacement and angle of elevation) between the normal and affected hemi-faces pre-operatively, both in repose and during attempted smiling. No significant difference in commissure position (lateral, vertical, total displacement and angle of elevation) existed between repose and attempted smiling in the affected hemi-face pre-operatively. There was no significant difference in commissure position (lateral, vertical, total displacement and angle of elevation) between the normal and affected hemi-faces post-operatively, both in repose, and during controlled

smiling. Wilcoxon estimates, upper and lower bounds and P values not shown. Affected (the paralysed/ reanimated hemi-face), normal (the unaffected, healthy hemi-face).

TABLES

Table 1: Aetiology of facial paralysis

Table 2: Prevalence of facial paralysis symptoms at presentation

SUPPLEMENTARY DATA

Video, Supplemental Digital Content 1

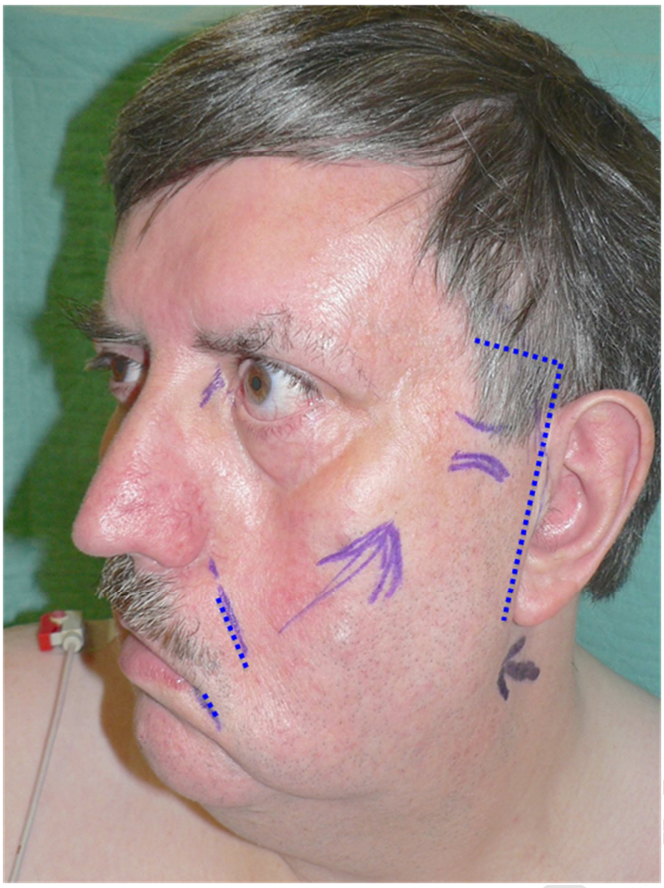
Intra-operative surgical technique for the partial temporalis tendon transfer with a fascia lata sling

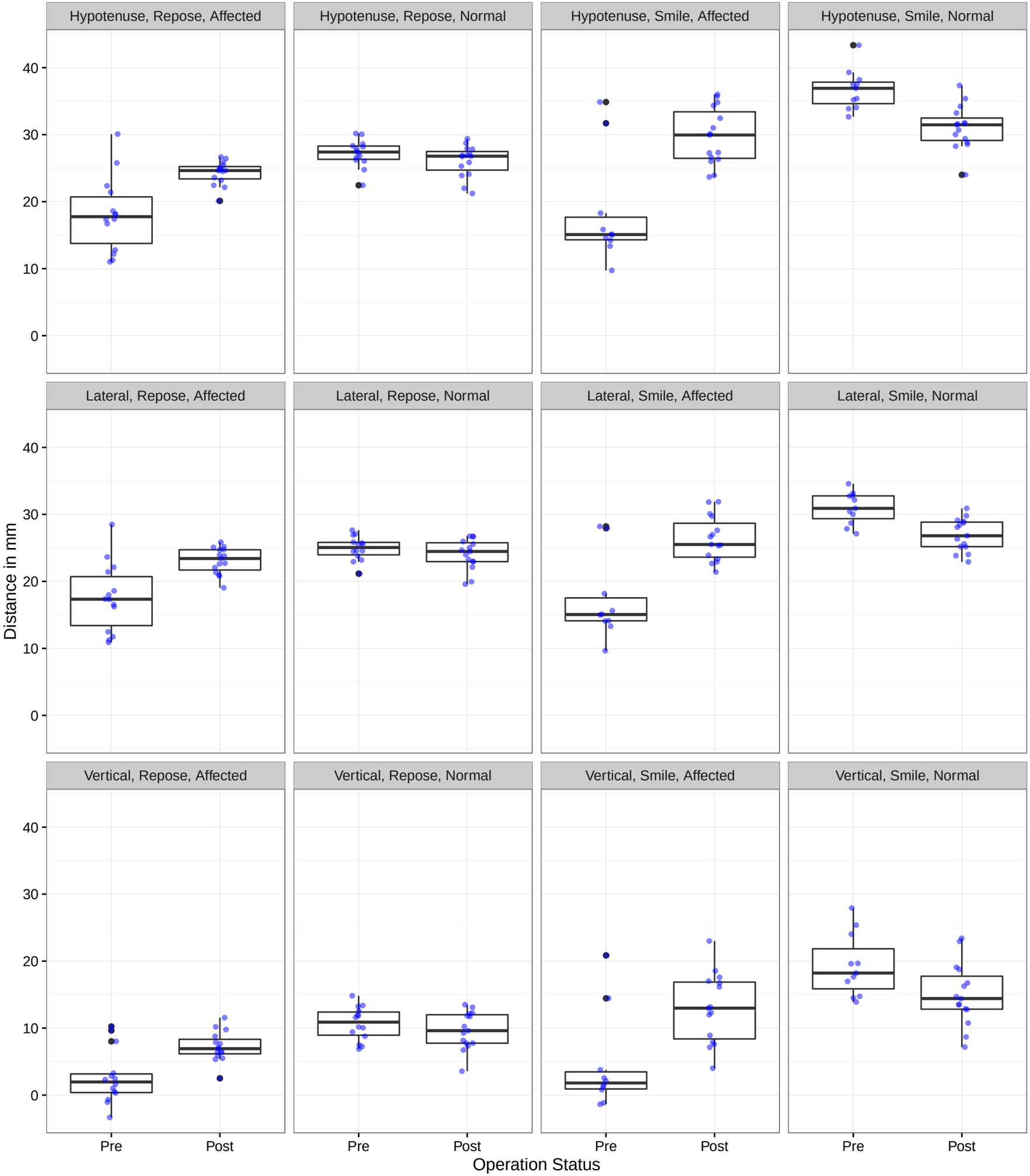
Table 1: Aetiology of facial paralysis

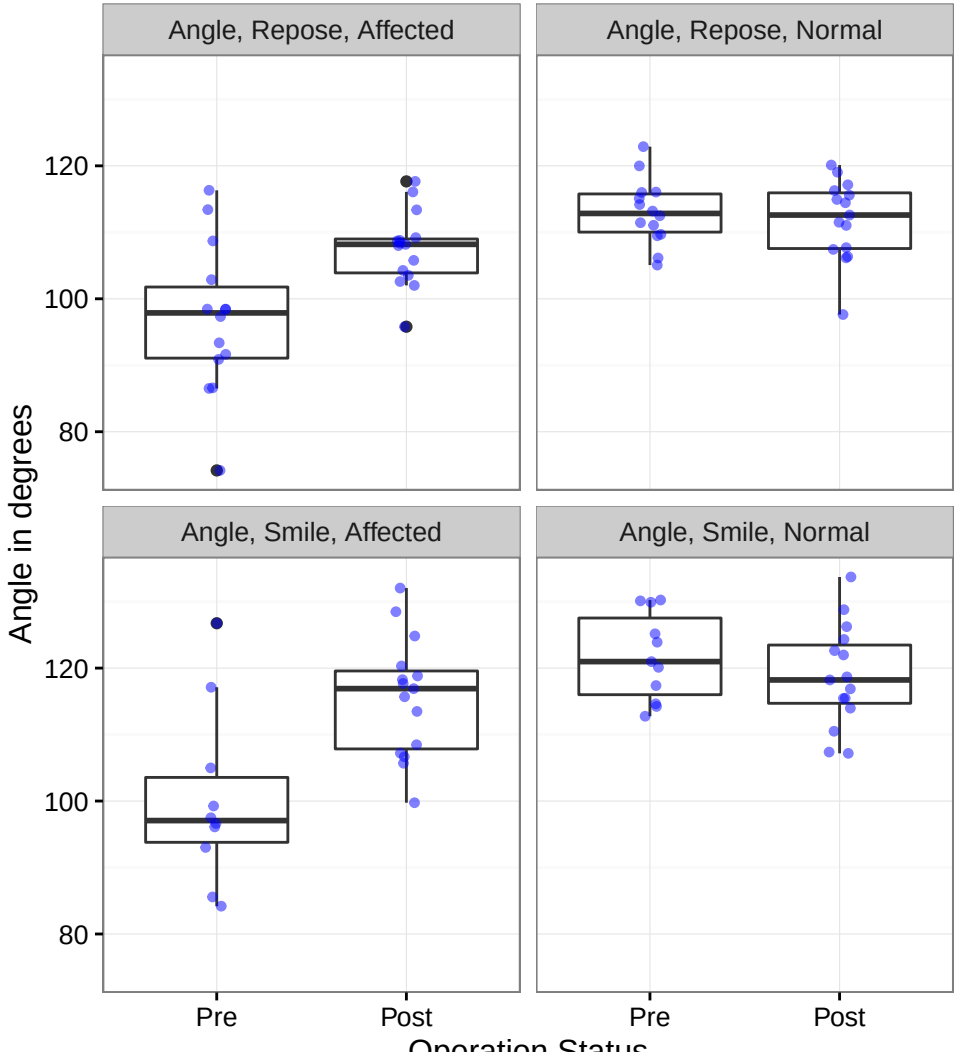
Aetiology	Number of patients
Surgical resection/ iatrogenia	12
Intracranial tumour	11
Idiopathic	5
Congenital	5
Trauma	3
Other	3

Table 2: Prevalence of facial paralysis symptoms at presentation

Symptoms	Number of patients affected
Dissatisfaction with appearance	38
Poor food handling	27
Difficulty drinking	26
Speech impairment	25
Drooling	10
Eye exposure	10
Nasal airway obstruction	8
Cheek biting	3
Synkinesis	2




Hypotenuse, Repose, Affected
Hypotenuse, Repose, Normal
Hypotenuse, Smile, Affected
Hypotenuse, Smile, Normal
Lateral, Repose, Affected
Lateral, Repose, Normal
Lateral, Smile, Affected
Lateral, Smile, Normal
Vertical, Repose, Affected
Vertical, Repose, Normal
Vertical, Smile, Affected
Vertical, Smile, Normal
Distance in mm
0
10
20
30
40
Pre
Post
Operation Status


Angle, Repose, Affected
Angle, Repose, Normal
Angle, Smile, Affected
Angle, Smile, Normal
Angle in degrees
120
100
80
Pre
Post
Operation Status