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Facial reanimation with the mini-temporalis flap

The mini-temporalis turnover flap for midface reanimation: photogrammetric and patient-rated outcomes

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Abstract

Background: Mini-temporalis transposition (MTT) flaps, modified from Gillies' technique, have become less popular than temporalis tendon transfers for midface reanimation. Mini-temporalis transposition involves raising the middle third of the temporalis, transposition over the zygomatic arch and lengthening with deep temporalis fascia which is sutured to the orbicularis oris.

Aim: This retrospective study assessed subjective and objective outcomes following MTTs by a single surgeon from 2009 to 2019.

Methods: Operative and surgical details were recorded. Four blinded consultants rated pre and postoperative videos according to Terzis' scale. Pre and postoperative resting, Mona Lisa and canine smile photographs were analysed using Emotrics, the software which automatically computes differences in inter-landmark distances. Patients also completed the Glasgow Benefit Inventory (GBI) patient-rated outcome measure.

Results: Forty-one patients (mean age 65.8±15.5) underwent MTT, median 3 (0.4 – 57) years post-paralysis and were followed up for median of 2.2 (0.4 – 8.8) years. Higher mean postoperative Terzis score demonstrate symmetric and aesthetic improvements (3±1.3 vs. 2±1) ($p<0.05$). Emotrics analysis showed postoperative improvements in resting and dynamic symmetry of all indices, with the majority statistically significant (p<0.003). The mean GBI was 35.19 with 17 (94.4%) patients reporting improvement whereas one (5.6%) patient reported detriment after surgery. Two (5.4%) patients suffered complications: one haematoma and one infection. Four patients (9.8%) required revisional flap tightening. No patients requested revisional surgery for temporal hollowing or zygomatic fullness.

Conclusions: Mini-temporalis transposition effectively improves both subjective and objective resting and dynamic midface symmetry in a single stage. These results suggest this technique is a good alternative to temporalis tendon transfer techniques.

Introduction

Spontaneous dynamic reanimation of the midface following facial paralysis usually requires a multi-stage reconstruction. The first stage consists of a cross face nerve graft which is used to neurotise a microsurgically transferred muscle in the second stage. Commonly used muscles include gracilis and pectoralis minor. Some authorities believe this to be the gold standard.[1, 2] This approach usually requires a third stage to refine the outcome.[1] Sixty-seven percent of patients in a review of 100 free muscle reanimations required revision.[3] This multistage approach may be inappropriate for patients who are physiologically aged, highly comorbid, have a poor prognosis or cannot accept several operations. Transfer of regional muscles such as temporalis or masseter offers these patients a dynamic reconstructive option, albeit usually producing a nonspontaneous smile.

Masseteric transfer has been largely superseded by temporalis techniques. The temporalis' anatomical position mimics the zygomatic complex more closely than does the masseter. The first temporalis procedures, as reported by Gillies, involved sectioning the middle third of the temporalis origin, transposing it over the zygomatic arch and lengthening it with fascia lata which was sutured to the orbicularis oris.[4] This middle third of temporalis flap is based on the underlying posterior deep temporal neurovascular bundle. Terzis coined the term "mini-temporalis" to distinguish this technique from other techniques that harvested the whole temporalis muscle. McLaughlin's technique of disinserting the temporalis at the coronoid and lengthening the muscle flap with a fascial graft reduced temporal hollowing.[5]

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Modifications of this orthodromic technique now predominate temporalis transfers.[6-15] Labbe's technique of disoriginating and disinserting the temporalis to obviate fascial grafts,[16] and modifications thereof,[17-23] appear to be favoured by many. These techniques, however, demand more extensive dissection and pose a risk to structures deep to the coronoid process.[9]

The mini-temporalis flap, since its description by Gillies, has recently been advocated most vociferously by Terzis. Terzis and Olivares in 2008 published their experiences using this flap to improve outcomes following free muscle transfer.[1] They later presented their outcomes following two-stage reanimations in which they neurotised the mini-temporalis with a cross face nerve graft in attempt to achieve spontaneous smiling,[2] following earlier work.[24] Terzis continued to use the mini-temporalis transposition instead of temporalis insertion transfer techniques due to concerns about external incisions, zygomatic arch osteotomies and the substantial dissections required.[1, 2]

Over the last decade, the senior author has similarly offered mini-temporalis transposition to patients who did not qualify for multistage reanimation (figure 1). This study assessed the subjective and objective outcomes following mini-temporalis transfer to reanimate the midface over the decade from 2009 to 2019.

Methods

Patients who underwent mini-temporalis transfer for midface reanimation were identified from the senior author's operative logbook after regulatory approval.

Operative sequence

The operative sequence has been well described by Terzis.[1] Briefly, a limited hemi-coronal incision with a pretragal face-lift type extension is made. Skin and temporoparietal fascia are raised as a fasciocutaneous flap. A longitudinal rectangular 2-3 cm wide strip of deep temporal fascia (DTF) overlying the middle third of the temporalis is incised and raised of the muscle in a caudal-cephalad direction. The middle third of the muscle is then raised off the temporal fossa, using a periosteal elevator, with a 2-3 cm pericranium extension at the muscle origin in a cephalad-caudal direction. Subperiosteal elevation ensures the posterior deep

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temporal neurovascular bundle is included in the muscle flap. The base of the flap is at the zygomatic arch.

The strip of deep temporal fascia is then sutured onto the muscle origin/pericranial extension in two rows of 5/0 Prolene® mattress sutures. The free end of the DTF strip is divided into one to three strips depending on the required smile vector. A corresponding number of stab incisions are made at the wet-dry vermillion junction and bluntly dissected to expose orbicularis oris. A tunnel in which the muscle/DTF unit passes is bluntly dissected through the cheek, in a deep subcutaneous plane, connecting the vermilion incisions to the pivot point of the flap. The muscle/DTF unit is transposed over the zygomatic arch and the DTF strips are sutured onto orbicularis oris at preoperatively predetermined points using 3/0 polydioxanone. The temporalis defect is filled by mobilising the zygomatic fat pad and suturing the mobilised anterior and posterior DTF over it. A splint is worn for two weeks to take tension off the temporalis flap.

Data collection

The following data were recorded from medical records: demographics, cause and duration of facial palsy, previous treatments, operative details and complications.

In our unit, consenting patients routinely undergo pre and postoperative videography performing standard facial nerve assessment movements as well as reading from a script. Patients with a complete set of pre and postoperative videos were identified from the hospital's database. Four independent consultant plastic surgeons, blinded to whether the videos were pre or postoperative, rated each video according to Terzis scale. The Terzis scale, published in 1997,[3] is as follows: grade 1 (Poor) - deformity, no contraction, grade 2 (fair) - No symmetry, minimal contraction, grade 3 (moderate) - moderate symmetry and contraction, grade 4 (good) - symmetry, nearly full contraction and grade 5 (excellent) - symmetrical smile with full contraction. Pre and postoperative videos were downloaded onto an encrypted disc and each video was assigned a unique code. The codes were placed into an online random number generator to determine the random order in which videos were played to the raters.

Similarly, consenting patients also undergo pre and postoperative photography performing standard facial nerve assessment movements, including closed lip (Mona Lisa) and upper teeth showing (canine) smiles. Patients with a complete set of pre

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and postoperative resting, Mona Lisa and canine smile photographs were included. Photographs were analysed using Emotrics, software which automatically identifies facial landmarks and computes differences in landmark position in pre and postoperative photographs.[25] Several measurements were computed for each photograph, assessing the differences between the left and right sides: commissure height, upper lip height, smile angle, commissure excursion, dental show and lower lip height. Six photographs were analysed for each patient: pre and postoperative resting, Mona Lisa and canine smile photographs.

Patients were telephoned and asked to complete the Glasgow Benefit Inventory (GBI) scale. This validated questionnaire assesses the benefit or detriment a patient receives from a particular surgical procedure.[26]

Statistical analysis

Shapiro-Wilk’s test was performed to assess for normality of data distribution. Normally distributed data were reported as means (standard deviation) whereas skewed data were reported as medians (range). Interrater agreement of Terzis scores was assessed using Kendall's W coefficient of concordance. The significance of the difference between pre and postoperative median Terzis scale scores was tested using the nonparametric 2-group Wilcoxon signed rank test. Significance for the measurements above was set at $p<0.05$. The significance of the difference in Emotrics measurements pre and postoperatively was also tested using the Wilcoxon signed rank test. The significance of these measurements was set at $p<0.003$ following a Bonferroni alpha correction.

Results

Patient demographics and operative details are summarised in table 1. Forty-one patients, with a mean age of 65.8 (±15.5), underwent mini-temporalis transposition to reanimate the midface between 2009-2019. Twenty-four (58.5%) were males and the remaining 17 (41.5%) were female. The median duration of palsy was 3 (0.4 – 57) years at the time of surgery. Six patients (14.6%) had undergone previous midface reanimation procedures. Sixteen patients (42.1%) had partial facial paralysis.

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The median operative time was 202.5 (81 – 460) minutes. This value includes ancillary procedures which were performed for a majority of the patients (78%). The median length of stay was 3 (1 – 8) days. Patients were followed up for a median of 2.2 (0.4 – 8.8) years. Only two (5.4%) patients suffered complications: one haematoma requiring evacuation and one infection treated with antibiotics. The four patients (9.8%) requiring revisional surgery all had tightening of the temporalis. No patients suffered temporal hollowing requiring surgery. All patients had some degree of zygomatic fullness, but none requested debulking and were warned of this risk preoperatively.

There were 18 (43.90%) patients with a complete set of pre and postoperative videos eligible for the rater analysis. The Kendall W for interrater agreement of preoperative and postoperative Terzis scale scores were 0.7 and 0.75 respectively. The overall Kendall W was 0.75. The mean postoperative Terzis scale score was statistically significantly higher than the preoperative score (3 ± 1.3 vs. 2 ± 1) ($p<0.05$). This equates to an average relative gain of 74% and an average median gain of 1.1 points. Fourteen (77.8%) patients had improved Terzis scale scores, three (16.7%) had the same score and one (5.6%) patient had a worse score.

There were 27 (65.85%) patients with a complete set of pre and postoperative photographs eligible for Emotrics analysis. There was an improvement in resting midface symmetry following mini-temporalis transposition (table 2). The differences in commissure height, smile angle and upper lip height between the normal and affected sides all improved significantly after surgery ($p<0.003$). Symmetry of lower lip height improved postoperatively, but this did not reach statistical significance ($p>0.003$).

There was an improvement in midface symmetry whilst smiling with lips closed following mini-temporalis transposition (table 3). The differences in commissure height, smile angle and upper lip height between the normal and affected sides all improved significantly ($p<0.003$). There was a smaller difference in commissure excursion and lower lip height postoperatively, but this did not reach statistical significance ($p>0.003$).

There was an improvement in midface symmetry whilst smiling with teeth showing (canine smile) following mini-temporalis transposition (table 4). The differences in

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commissure excursion, commissure height and upper lip height between the normal and affected sides all improved significantly ($p<0.003$). There was a smaller difference in dental show deviation, smile angle and lower lip height postoperatively, but this did not reach statistical significance ($p>0.003$).

Eighteen patients (44%) completed the Glasgow Benefit Inventory scale. The mean GBI was 35.19. Seventeen (94.4%) patients reported improvement after surgery whereas one (5.6%) patient reported detriment.

Twenty-five patients (60.98%) had at least two of the following data sets: complete set of photographs, complete set of videos and GBI score. Table 6 shows a summary of data sets per patient.

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Discussion

The results currently presented show that the mini-temporalis transposition effectively improves both resting and dynamic symmetry of the midface, as judged by independent surgeons, validated symmetry assessment software and patients themselves (figure 2, supplementary videos). Morbidity from the procedure is minimal. Aesthetic defects such as temporal hollowing can be remedied primarily[27, 28] and were not significant in this series. Few patients required revisional surgery.

Comparison to other mini-temporalis series

The majority of patients in this series underwent mini-temporalis transposition as a sole reanimative procedure, innervated by its native posterior deep temporal nerve. There have been other series in which mini-temporalis transposition has been used a sole reanimative procedure.[17, 29-33] A direct comparison with these studies is not possible due to the heterogeneity of outcome assessment methods. However, table 5 shows that the majority of patients in these series had outcomes rated as “good” or “moderate.” The postoperative mean Terzis scale achieved in this series corresponds to a “moderate” result according to this scale. However, comparative conclusions cannot be confidently made until the results of mini-temporalis transposition are compared to either free muscle transfer or temporalis insertion transfer techniques.

A few mini-temporalis studies calculated commissure excursion. Holtmann *et al* used FACEgram to assess their outcomes in 20 patients undergoing mini-temporalis transposition.[31] They found statistically significant improvements in postoperative resting oral commissure symmetry, as in the present study, but oral commissure excursion was not statistically improved, whereas it improved in the present study. Another study comparing mini-temporalis and free gracilis transfer found that both groups had improvements in excursion and symmetry in repose and when smiling, as in the present study .[34] None of these differences reached statistical significance, although this study had a small sample size (10 gracilis, 12 mini-temporalis).

Comparison to series assessing temporalis insertion transfer techniques

More studies have addressed outcomes following temporalis insertion transfer techniques than have the mini-temporalis transposition.[6, 8-15, 17-22] Similarly, outcome

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measurement methods have been varied, limiting direct comparisons. Although several studies have compared insertion transfer techniques to free tissue transfer,[11, 12, 15, 17, 19] no comparison to mini-temporalis transpositions have been published.

The excursion of the affected side following temporalis insertion transfer techniques has ranged from 1.6mm to 10mm[8, 13, 15, 20, 22] although most ranged from 5mm to 10mm. However, a systematic review of comparisons between lengthening temporalis myoplasty and gracilis, found contradictory results with respect to commissure displacement following lengthening temporalis myoplasty.[19] Many temporalis insertion transfer series also report improvements in dynamic symmetry[8, 9, 14, 15, 19, 21, 22] with many patients reporting high satisfaction with this procedure, as they are with the mini-temporalis.[8, 13, 21] The literature is unclear whether one procedure produces better results than the other.

Patient-rated outcomes

A common limitation to temporalis series assessing both origin and insertion techniques has been the failure to assess patient rated outcomes.[1, 2, 9, 10, 12, 14, 15, 17, 20, 22, 29, 33] Some have used simple Likert-scale satisfaction scales[13, 21] which the authors felt did not fully assess the complexity of the interventions. Others have used the validated Facial Clinimetric Evaluation (FaCE) Scale. [8, 34] However, this patient-rated assessment of global facial function was deemed inappropriate for an analysis of only midface function. One other study used the GBI as a patient rated outcome measure, as was used in this study.[31] This study by Holtmann *et al*[31] found a smaller GBI than found in the present study (27.1 vs. 35). The GBI scale ranges from -100 (maximum detriment), through zero (neutral) to 100 (maximum benefit). All, but one, patients reported deriving a benefit from mini-temporalis transpositions in the present series. Others have found that patients undergoing mini-temporalis transfers have quality of life gains similar to those undergoing free gracilis reconstructions.[34] There is no published comparative quantification of the quality of life differences in patients undergoing the two types of temporalis transfers.

Complications

Complications and revision rates in this series were also low but several series had relatively more complications[8, 9, 14, 15, 22] or revisions[14, 20] than the present mini-temporalis series. Complications in this series were low (4.9%) and easily

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remediated. Complications have similarly been low in other mini-temporalis series[1, 2, 30, 31, 34] although one early series had a complication rate of 21%[33]. Some series did not report their complications.[29, 31] Similarly, temporalis insertion transfers also generally have low complication rates[8, 9, 13, 22] although one reported a rate 43%.[15]

With regards to temporal hollowing, no patients in this series requested remediation. The senior author's technique of primary zygomatic fat pad and TPF transposition, and advancement and suture of the anterior and posterior DTF follows published techniques and has been successful.[1, 2, 27, 28, 35] Van Veen *et al* also did not find hollowing to be a concern in their mini-temporalis series.[34] This potential remediable complication should therefore not be a barrier to offering mini-temporalis transposition. Interestingly, temporal hollowing can also occur following lengthening myoplasty[20] but techniques to avoid this have been published.[18]

Zygomatic fullness is another common sequalae of mini-temporalis transposition. Others have performed manoeuvres to reduce this such as segmental zygomectomy to reduce prominence or passing the muscle flap deep to the arch.[1, 2] All patients in this series had temporalis transposition superficial to the zygomatic arch without fullness-reducing procedures. All patients had some degree of fullness, but none requested debulking. Van Veen et al also did not find zygomatic fullness to be a patient concern in their mini-temporalis patients.[34] These findings may be because the temporalis is usually a thin muscle, with a mean ultrasonic thickness of about 2 - 6 mm.[36, 37] This aesthetic defect will be more visible in patients with thicker muscles and more prominent zygomatic arches. In comparison, debulking procedures are common following free muscle transfer.

Four patients required revisional tightening of the temporalis muscle (9.8%). Rates of revisional tightening in other mini-temporalis series range from 3.2%-16.7%[2, 34] This compares well to free pectoralis minor and gracilis transfers which have required up to 27% and 71.9% revision rates in some series.[1, 38] Revisional rates following lengthening temporalis myoplasty has reached 64% in some series[15] although the majority have lower rates. Another potential benefit of the technique described is the avoidance of nasolabial scars, which can rarely lead to salivary fistulas.[13]

Limitations

This retrospective cohort analysis suffers the same limitations as any retrospective study. The lack of a control group means the presented results cannot be compared to alternative options such as temporalis insertion transfer techniques or free tissue transfers. There was also an issue of missing data i.e. complete pre and postoperative photograph and video datasets. Conversely, this study provides one of the more comprehensive objective and subjective analyses of mini-temporalis transpositions. Ongoing work from this group includes comparisons of our mini-temporalis outcomes to our free gracilis outcomes. Similarly, detailed comparisons of mini-temporalis and temporalis insertion transfer techniques would further inform this debate.

Conclusions

The mini-temporalis transposition effectively improves both resting and dynamic symmetry of the midface, as judged by independent surgeons and patients themselves. The majority of patients derive benefit from this low morbidity procedure, which rarely requires further revisions. The presented results show that mini-temporalis transposition is an effective and safe single stage option for midface reanimation. This procedure can be used not just to upgrade the results of prior microvascular free muscle transfer, but also as an option to temporalis insertion transfer techniques.

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Figure legends

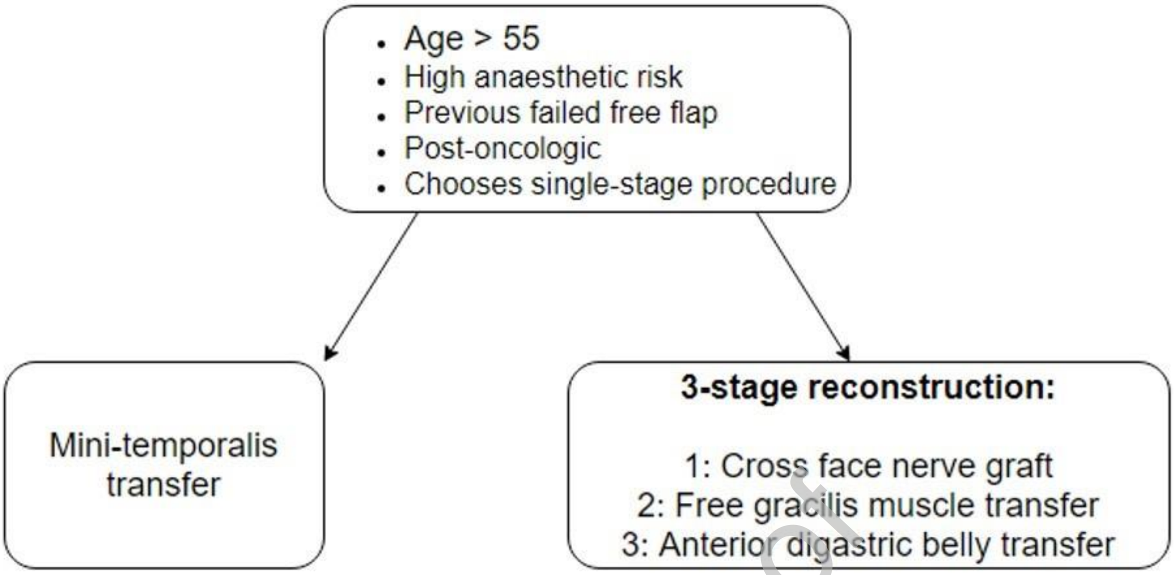

Figure 1: Local algorithm for midface reanimation

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Figure 2: Illustrative case presentations (A-D) 74-year old with left sided paralysis secondary to parotid surgery and (E-H) 94-year old with left complete paralysis and medical history of previous stroke and atrial fibrillation. (A/E) Preoperative repose, (B/F) postoperative repose, showing improvements in static symmetry, (C and D) pre and postoperative canine smile photographs showing improvements in commissure height, commissure excursion and teeth show symmetry, (G and H) pre and postoperative Mona Lisa smile showing improvements in commissure excursion symmetry and nasolabial fold definition. Both patients underwent tarsorrhaphy.

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Table 1: Demographic and Intraoperative data

Patient	Age (years)	Sex	Cause	Comorbidities	Side	Duration	Type	Previous surgery	Surgery
1	38	M	Parotid carcinoma	Nil	L	10 years	Complete	Free gracilis + gold weight	Repositioning free gracilis, minitemporalis muscle transfer, temporoparietal fascia flap and left browlift
2	89	M	Base of skull osteomyelitis	CVA, Scoliosis, PAF, SCC	L	18 months	Complete	Brow lift	Tightening of lower eyelid and minitemporalis muscle transfer
3	34	M	Medulloblastoma	Nil	L	3 years	Complete	Gold weight	Left minitemporalis muscle transfer and tarsal strip advancement
4	76	F	Parotid adenoma	Hypothyroidism, HTN	L	36 years	Partial	Mid face lift, lower lid resuspension (tarsal strip), fascia lata sling	Left mini Temporalis Muscle Transfer, repositioning lower eyelid and left open browlift
5	71	M	Parotid carcinoma	HTN	L	Unknown	Partial	lower lid resuspension, SOOF, tarsorrhaphy	Left minitemporalis muscle transfer
6	72	M	Bell's Palsy	Smoker, Schizophrenia	R	19 years	Complete	Nil	Browlift, tarsal strip and right minitemporalis muscle
7	62	M	Acoustic neuroma	Epilepsy, IHD	R	7 years	Partial	Gold weights, upper lid blepharoplasty	Tightening of right lower eyelid, right minitemporalis muscle transfer and right face lift
8	53	F	Congenital	Asthma, GORD, high BMI, Osteoporosis	R	53 years	Partial	transcanthal SOOF lift + canthopexy	Right canthopexy and right minitemporalis muscle transfer
9	69	F	Ramsey-Hunt	Meniere's disease	R	9 months	Complete	Nil	Right minitemporalis muscle transfer and repositioning of lower eyelid
10	75	M	SCC	AF, HTN	L	Unknown	Unknown	Unknown	Left pinnectomy, parotidectomy, neck dissection and left minitemporalis muscle transfer
11	55	M	BCC	Asthma	L	10 years	Unknown	Nil	Wide excision BCC left cheek, pinnectomy, free ALT flap and left minitemporalis muscle transfer
12	66	M	SCC	AAA, prostate cancer	L	2 years	Complete	Previous ALT flap	Flap debulking and left minitemporalis muscle transfer
13	94	M	Ear infection	Hypothyroidism, HTN, AF, CVA	L	7 months	Complete	Nil	Left minitemporalis muscle transfer, left direct browlift and tarsal strip advancement
14	53	F	Bell's palsy	Nil	R	2 years	Partial	Botox and biofeedback	Right minitemporalis muscle transfer, temporoparietal fascia cover, bilateral brow lifts and right upper blepharoplasties
15	51	F	Schwannoma	HTN, CKD	R	3 years	Complete	Tarsorrhaphy, CFNG, free gracilis	Left minitemporalis muscle transfer
16	40	F	Parotid adenoma	Depression, hypothyroidism	R	40 years	Partial	SOOF lift, fat injections, tarsorrhaphy	Right minitemporalis muscle transfer and titanium chain to right upper eyelid
17	67	M	Congenital	OA, ankylosing spondylitis	L	2 years	Unknown	Nil	Debridement necrotic tissue left temporal area and left minitemporalis muscle transfer
18	74	F	SCC	CLL	R	5 months	Partial	Nil	Wide excision SCC at right zygomatic area and right minitemporalis muscle transfer
19	93	F	SCC	HTN	R	8 months	Partial	Nil	Wide excision SCC, upper eyelid, right minitemporalis muscle transfer and FTSG
20	74	F	Schwannoma	Unknown	L	2 years	Complete	Left lower lid tightening	Left minitemporalis muscle transfer and left brow lift

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21	36	F	Bell’s palsy	Anaemia, Asthma, HTN	R	30 years	Partial	Sural nerve graft, 2x failed LD, pec minor, tarsorrhaphy	Right minitemporalis muscle transfer, right brow lift and titanium weight to upper eyelid
22	57	M	Bell’s palsy	Epilepsy, haemorrhoids	L	45 years	Partial	Mid face re-suspension, CFNG free gracilis, gold weight, lower lid tarsal strip advancement	Left minitemporalis muscle transfer
23	66	F	Acoustic neuroma	Nil	L	4 years	Complete	Left tarsorrhaphy, SOOF lift	Left minitemporalis muscle transfer
24	87	M	SCC	SCC	R	1 year	Complete	Nil	Right minitemporalis muscle transfer
25	51	M	Schwannoma	HTN, T2DM	L	5 years	Partial	Nil	Left minitemporalis muscle transfer
26	63	F	Bell's palsy	TMJ disfunction	L	13 years	Partial	Nil	Left minitemporalis muscle transfer
27	83	M	Fracture facial bone	PEG fed, prostate cancer	L	11 months	Complete	Left tarsorrhaphy	Left minitemporalis muscle transfer
28	84	M	Parotid adenoma	HTN, OA	R	57 years	Complete	Nil	Right minitemporalis muscle transfer and tightening of lower eyelid
29	69	F	Cholesteatoma and mastoiditis	Nil	L	18 months	Complete	Nil	Left minitemporalis muscle transfer, titanium weight insertion and brow lift
30	45	F	Bell's Palsy	CVA, wheelchair bound, HTN	L	20 years	Partial	Lower lid tarsal strip suspension, Botox	Left minitemporalis muscle transfer and left brow lift
31	64	F	Vestibular schwannoma	Asthma	R	2 years	Partial	Nil	Right minitemporalis muscle transfer CFNG for lower lip
32	57	M	Acoustic neuroma	HTN, Epilepsy, Brain aneurism	L	3 years	Complete	Free Gracillis flap and palmaris longus	Left minitemporalis muscle transfer and CFNG for lower lip
33	78	M	Bell’s palsy	SCC, TB	L	20 years	Complete	Nil	Left minitemporalis muscle transfer
34	74	M	Parotid adenoma	Asthma, RA, BPH	L	8 months	Partial	Nil	Left minitemporalis muscle transfer, left direct browlift and tarsal strip advancement
35	67	M	Bell’s Palsy	Nil	R	25 years	Complete	Multiple face lifts and gold weights	Right minitemporalis muscle transfer, tarsal strip advancement right lower eyelid and direct browlift
36	90	M	Necrotising Otitis Externa	OA, COPD	L	7 months	Complete	Nil	Left minitemporalis muscle transfer, left brow lift and left lower lid tarsal strip advancement
37	64	M	Bell’s Palsy	COPD, Depression, Smoker	L	9 years	Complete	Nil	Left minitemporalis muscle transfer and titanium weight to left upper eyelid
38	70	M	Salivary Duct Carcinoma	BPH	L	13 months	Complete	Nil	Lower eyelid repositioning, left parotidectomy and neck dissection and left minitemporalis muscle transfer
39	48	F	Acoustic Neuroma	OA, HTN	R	9 years	Partial	Nil	Right minitemporalis muscle transfer and CFNG for lower lip
40	62	F	Congenital	Nil	L	25 years	Complete	Left tarsorrhaphy	Left minitemporalis muscle transfer and fat transfer to right nasolabial fold
41	75	M	CVA	OA	L	1 year	Complete	Nil	Left minitemporalis muscle transfer and left titanium plate insertion

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Abbreviations: BCC, basal cell carcinoma; SCC, squamous cell carcinoma; CVA, cerebrovascular accident; OA, osteoarthritis; HTN, hypertension; BPH, benign prostatic hypertrophy; COPD, chronic obstructive pulmonary disease; RA, rheumatoid arthritis; TB, tuberculosis; t2DM, type 2 diabetes mellitus; CLL, chronic lymphocytic leukaemia; CKD, chronic kidney disease; AF, atrial fibrillation; IHD, ischaemic heart disease; GORD, gastroesophageal reflux disease; SOOF, suborbicularis oris fat; CFNG, crossface nerve graft; LD, lattisimus dorsi; FTSG, full thickness skin graft; ALT, anterolateral thigh;

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Table 2: Summary of measurements from pre and postoperative repose photographs

Measurement	Preoperative (mm)	Postoperative (mm)	P-value
Commissure height deviation	8.0 ± 6.3	3.9 ± 3.3	p<0.001
Smile angle deviation	14.0 ± 11.4	7.3 ± 5.3	p<0.003
Upper lip height deviation	7.0 ± 4.4	3.7 ± 2.7	p<0.001
Lower lip height deviation	2.3 ± 2.3	1.6 ± 1.5	p=0.118

Table 3: Summary of measurements from pre and postoperative Mona Lisa smile photographs

Measurement	Preoperative (mm)	Postoperative (mm)	P-value
Commissure excursion deviation	10.1 ± 7.4	5.6 ± 4.3	p=0.008
Commissure height deviation	11.3 ± 6.5	6.0 ± 5.1	p<0.001
Smile angle deviation	19.4 ± 10.3	10.4 ± 8.1	p=0.001
Upper lip height deviation	8.4 ± 4.8	4.5 ± 3.5	p<0.001
Lower lip height deviation	3.3 ± 2.5	2.1 ± 1.8	p=0.031

Table 4: Summary of measurements from pre and postoperative canine smile photographs

Measurement	Preoperative (mm)	Postoperative (mm)	P-value
Commissure excursion deviation	16.4 ± 9.2	8.0 ± 7.0	p<.001
Commissure height deviation	13.1 ± 8.3	7.8 ± 6.4	p=.002

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Smile angle deviation	15.2 ± 11.4	10.1 ± 7.8	p=.118
Upper lip height deviation	12.4 ± 7.5	6.5 ± 4.7	p=.003
Dental show deviation	7.7 ± 4.8	6.4 ± 4.6	p=.124
Lower lip height deviation	3.8 ± 2.5	3.4 ± 2.5	p=.486

Table 5: Summary of published mini-temporalis results

		Rating of result				
Paper	Number of transfers	Excellent N (%)	Good N (%)	Moderate N (%)	Fair N (%)	Poor N (%)
May 1984[32]	13	10	2	NR	1	
May and Drucker 1993[33]	219	71 (37)	83 (43)	NR	31 (16)	7 (4)
Hu et al 2005[29]	38	13 (34)	20 (53)	NR	3 (8)	2 (5)
Terzis and Olivares 2008[1]	35	3 (9)	17 (49)	14 (40)	0	0
Terzis and Olivares 2009[2]	31	3 (9.8)	16 (51.6)	9 (31)	3 (9.8)	0
Gousheh et al 2011[17]	73	0	22 (30)	43 (59)	NR	8 (11)
Chen et al 2015[30]	15	(33.3)	(26.7)	(33.3)	NR	NR

NR, not reported

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