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Secondary surgery in paediatric facial paralysis reanimation

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Summary Ninety-two children, the entire series of paediatric facial reanimation by a single surgeon over thirty years, are presented. The objective is to analyse the incidence and value of secondary revisions for functional and aesthetic refinements following the two main stages of reanimation. The reconstructive strategy varied according to the denervation time, the aetiology, and whether the paralysis was uni- or bilateral, complete or partial. Irrespective of these variables, 89% of the patients required secondary surgery. Post-operative videos were available in seventy-two cases. Four independent observers graded patients' videos using a scale from poor to excellent.

The effect of diverse secondary procedures was measured computing a mean-percent-gain score. Statistical differences between treatment groups means were tested by the t-test and one-way ANOVA. Two-thirds of the corrective and ancillary techniques utilized granted significantly higher mean-scores post-secondary surgery. A comparison of pre- and post-operative data found valuable improvements in all three facial zones after secondary surgery. In conclusion, inherent to dynamic procedures is the need for secondary revisions. Secondary surgery builds in the potential of reanimation surgery, effectively augmenting functional faculties and aesthesis.

The advances in facial reanimation over the last 30 years demand a dynamic, panfacial reconstruction. Dynamic reanimation proves superior to any combination of static procedures. Yet, reconstructive efforts that solely focus on mid-face reanimation hinder the overall potential for symmetry and expressivity.[1,2] Admittedly, results are partial at best when specific targets are cared-for while others are neglected (e.g., eye reanimation attenuated by a ptotic brow or smile restoration downgraded by a dysfunctional depressor). Thus, the task ascribed to the

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Table 1 Causes of paediatric facial paralysis

Causes of paediatric facial paralysis	
Developmental	45
Traumatic	8
Iatrogenic	3
Tumor/Pontine Lesion	19
Bell's Palsy	1
Mobius/Mobius Like	16
Total	92

reconstructive surgeon is complex mélange of challenging goals.

Ancillary interventions,[3] secondary procedures,[4,5] complementary techniques[6] or revisional surgery,[7] are different terms for a broad group of procedures aimed at enhancing functional and aesthetic outcomes of reconstructive microsurgery. At our centre the authors observed, as others have,[4,7–10] that irrespective of the reconstructive mode employed, secondary revisions are often needed. For in dynamic reanimation the question is not merely how skillful the surgeon or how severe the pathology, but the degree of response to regenerative procedures. Some investigators have stressed the need for a third-stage of revisions, yet only few have reported their outcomes with corrective interventions.[1,4–13]

Prior to drawing an optimal reconstructive strategy, essential information is gathered through conscientious preoperative testing. Which musculature needs strengthening or substitution? Which target represents a clinical priority (eye vs. oral sphincter)? Which muscle flap is best suited to restore function of the upper- mid- or lower-face? How many CFNG's are required to bring coordinated pacing to all the transferred units? Or else, which motor donor-nerves are available? Which interventions can be undertaken contemporaneously at the first- or second-stages and which require a separate stage? Implicit in this approach is the absolute belief that no single dynamic procedure can restore panfacial reanimation in one-stage reconstruction. All these are questions on which there are numerous viewpoints, and it is hoped that further debate and collaboration will outline guidelines criteria in future.

To this end, the purpose of this series is a comprehensive analysis of the senior author's thirty-year's experience with paediatric reanimation. This report gives an account of the incidence and indications for various secondary procedures. The exact operative details of the techniques listed in this report can be found in previous publications.[1,9,14–27]

Patients and methods

A retrospective search of all paediatric patients operated upon for facial paralysis since 1979 revealed 92 patients. All patients had their medical charts studied, and every reconstructive, revisional or ancillary procedure was analysed. The age range was 14 months to 16 years (8.2 ± 4.6, mean $\pm$ SD), with 37% of the patients being under five. Table 1 lists the diverse etiologies involved. Denervation time ranged from six to 204 months (79.6 ± 53.7, mean $\pm$ SD), with 95% of the cases (88/92) presenting later than 12 months from insult. Demographic characteristics are summarized in Table 2.

Most patients (54.4%) had two-stage physiological smile restoration followed by a later stage of secondary procedures. The different reconstructive strategies and interventions undertaken on every stage are listed in Table 3.

The upper-face

Complete paresis of the orbicularis oculi muscle (OOM) presents as lagophthalmos, ectropion and/or epiphora.[26] By the time of the first consult, most children had already received acute assistance and corrective eye surgery if needed. Nevertheless, all patients had corneal protection and sensitivity evaluated, and all developmental paralysis were referred for amblyopia screening. The senior author (JKT) has previously published the algorithms on which eye reanimation is based.[18,19,21,22]

Twenty-two patients in this series (22/92, 24%) required no intervention for eye support or upper-face aesthesis. Fourteen cases of late paralysis (14/92, 15%) had a silent OOM on needle electromyography (EMG). Thus, the number of OOM substitutions totaled 14, three of which had direct-neurotization previously with inadequate results. OOM substitution consisted of pedicled frontalis transposition in six cases and pedicled temporalis in four. Two patients received a free-contralateral-platysma transfer, and the upper-slip of a free-pectoralis minor was utilized in another two (Table 4). Ocular symptomatology prioritised eye substitution over smile restoration in three cases (Table 3). Frontalis and platysma flaps were re-innervated with a CFNG that yielded coordinated animation with the contralateral eye sphincter. In both segmental-pectoralis transfers, re-innervation of the upper segment was conducted by a separate CFNG dedicated to eye function (Figure 1 a–d).

In forty-five patients (45/92, 49%) with fibrillations of the OOM on EMG; direct-neurotization (thirty-two cases) or VII-VII transfer (CFNG-secondary microcoaptations, thirteen cases) was intended to strengthen the sphincter. Of these forty-five cases, twenty-five yielded satisfactory

Table 2 Demographic characteristics

Demographic characteristics							
Side		Gender		Denervation Time		Grade	
Right	40	Female	56	<12 Months	4	Complete	18
Left	39	Male	36	12–24 Months	13	Partial	74
Bilateral	13			>24 Months	75		

Table 3 Patients distribution by number of stages/procedures

Patients	Stage 1	Stage 2	Stage 3	Stage 4
46 (50%)	CFNG/IPNG Ips. M. Donor	Free Muscle For Smile	Revisions/Ancillary	
8 (8.7%)	CFNG/IPNG Ips. M. Donor + Revisions/Ancillary	Free Muscle For Smile		
3 (3.3%)	CFNG/IPNG Ips. M. Donor	Free Muscle For Smile		
2 (2.2%)	One-Stage Free Muscle Transfer to Masseter Nerve	Revisions/Ancillary		
9 (9.8%)	CFNG/IPNG Ipsilateral Donor	Free Muscle For Smile	O.O.M Substitution	Revisions/Ancillary
3 (3.3%)	CFNG/IPNG Ipsilateral Donor	O.O.M Substitution	Free Muscle For Smile	Revisions/Ancillary
2 (2.2%)	CFNG	Regional Transfer For Eye And Smile		
2 (2.2%)	CFNG	Secondary Microcoaptations & Mini-Temporalis Transposition	Revisions/Ancillary	
2 (2.2%)	CFNG	Secondary Microcoaptations	Revisions/Ancillary	
6 (6.5%)	CFNG	Secondary Microcoaptations +Revisions/Ancillary		
4 (4.3%)	CFNG	Secondary Microcoaptations		
2 (2.2%)	Revisions/Ancillary			
3 (3.3%)	CFNG	Lost in Follow up.		

* CFNG: First stage of cross facial nerve grafting, IPNG: Interposition nerve graft. Ips. M. Donor:Ipsilateral Motor Donor, OOM: Orbicularis Oculi Muscle. Regional Transfer for eye and smile: free muscle transfer with regionally independent segments for eye and smile restoration, Secondary Microcoaptations: Second stage of cross facial nerve grafting (CFNG −Ipsilateral VII microcoaptations), Mini-Temporalis: Partial Temporalis muscle transposition to the oral commissure.

results without further surgery. Conversely, twenty patients with inadequate outcomes were complemented with ancillary procedures (viz., goldweight {4}, goldweight & minitendon {4}, eyespring & minitendon {2}, minitendon {9}, and wedge excision {1}) (Table 4), (Figure 2 a−c).

Finally, eleven patients (11/92, 12%) were managed with implants and/or static procedures (viz., goldweight & minitendon {2}, minitendon {7}, eyespring & wedge excision {1}, wedge excision {1}) (Table 4). In addition, lateral canthoplasty was needed in eight patients, and medial canthoplasty positioned the lacrimal punctum against the globe in seven cases.[26] Alternatively, an elliptical excision of the conjunctiva inverted the punctum and facilitated drainage in five patients.

Overall, patients presenting with inadequate eye closure required at least one intervention and hereafter the number of surgeries ranged from two to five. The aesthetic procedures most commonly performed in the upper-face were brow-lift {15}, webbing correction {11} and blepharoplasty {7}.

The mid-face

The main strategy for smile restoration (71/92, 77%) consisted of CFNG or nerve-grafting to an ipsilateral motor on the first-stage, followed by a free-muscle-transfer on the second-stage. Two cases of bilateral paralysis received a bilateral free-muscle-transfer to the masseter nerve. Two patients, who exhibited remarkable results following CFNG and Baby-sitter procedure respectively, were complemented with a mini-temporalis transposition to the oral commissure.[24] In a minority of cases (11 patients, 12%), facial reanimation consisted of two-stage VII-VII neurotization (Table 5).

This series comprised 73 cases of free-muscle-transfer for smile (80 muscle-grafts), of which 55 required secondary revisions. Refinements to the two-stage CFNG-free-muscle technique by many investigators have remarkably improved outcomes.[27,28] Nonetheless, the diversity of factors that influence functional recovery after free-muscle-transfer [9] makes too-strong or too-weak results commonplace and ordinary.

In most cases of poor or fair results from a free-muscle-transfer, the senior author provides a second muscle unit during the revisional stage, a mini-temporalis transposition to the oral commissure. This technique has effectively augmented functional and aesthetic results in our centre.[23] In this series, mini-temporalis transposition was utilized in this manner in twenty-three cases. Alternatively, re-anchoring of the muscle-transfer corrected muscle tension and improved function in ten patients (Table 5). Less often, the free-muscle fibres were plicated (six patients) or the muscle-graft repositioned (three cases), aiming for a more efficient excursion. In selective cases (8/92), static techniques such as tendon-graft or fascial-sling, provided means to correcting minor deformities (Table 5) (Figure 3 a−d).

Table 4 Reconstructive, revisional and ancillary procedures to the upper-face

Target: the upper face			
Reconstructive options		Functional revisions	
1. Orbicularis Oculi Substitution	14	Revisions to O.O.M substitution	
Pedicled Frontalis Transposition	6		
Pedicled Temporalis Transposition	4	1. Tightening frontalis flap	4
Free Platysma Transfer	2	2. Debulk frontalis flap	1
Free Split Pectoralis	2	3. Goldweight	1
		4. Minitendon	3
2. Direct Neurotization or Selective VII-VII Transfer	25		
Direct Neurotization	15	Other functional revisions	
Selective VII To VII Transfer	10		
		1. Exchange Goldweight	2
3. Direct Neurotization or Selective VII-VII Transfer & Goldweight & Minitendon	4	2. Removal Goldweight	3
		3. Eyespring Adjustments	2
		4. Eyespring Removal	2
		5. Tightening Of Minitendon (2 Patients Needed Re-Do Tightening)	6
4. Direct Neurotization or Selective VII-VII Transfer & Goldweight	4	6. Tightening Of Orbicularis Oculi Muscle	1
5. Direct Neurotization or Selective VII-VII Transfer & Eyespring & Minitendon	2		
6. Direct Neurotization or Selective VII-VII Transfer & Minitendon	9	Ancillary procedures	
		1. Lateral Canthoplasty	8
6. Direct Neurotization or Selective VII-VII Transfer & Wedge Excision	1	2. Medial Canthoplasty	3
		3. Eliptical Conjunctiva Excision to Invert Punctum	5
7. Goldweight & Minitendon	2		
8. Eyespring & Wedge Excision	1	Aesthetic revisions to upper face	
9. Minitendon	7	1.Webbing Correction	11
		2.Brow Lift (12 Open/2 Endoscopic/1 Contour Threads)	15
10. Wedge Excision	1	3. Blepharoplasty	7
* No Interventions For Eye Or Forehead	22		

To the contrary, excessive free-muscle contraction may overcome the contralateral musculature and fix the oral commissure to a lateral position. In this series, disproportionate force from the free-muscle was observed in six patients with variable degrees of asymmetry. Four patients were managed with selective myectomies and two cases counteracted with a platysma transposition to the contralateral commisure.

Transfer of a free-muscle to the paretic cheek has a definitive effect on the overall contour of the mid-face. In a minority of cases, it may compensate for soft-tissue atrophy or traumatic/oncologic-related deficits. However, all too often excessive volume requires debulking of the muscle-graft or defatting of the cheek (Figure 4 a—c). Inversion of the upper lip at the anchoring sites makes cheiloplasty the third commoner aesthetic revision. In our centre, a superficial-temporal fascial flap has efficiently treated contour deficits and provided a highly vascularized free-muscle envelope in cases of skin tethering and impaired function [25] (Table 5).

Lastly, paresis of the nasalis muscle may result in alar collapse on inspiration. In addition, provision of a free-muscle-transfer to the paretic hemiface triggers new muscular forces that can pull and flatten the alar base. In this series, eighteen ear-cartilages were grafted to the nasal ala to assist inspiration and restore natural contour, while nineteen V-Y advancement flaps were used for proper positioning of the alar base.

The lower-face

Thirty-seven patients (37/92, 40%) had an effective depressor mechanism. Conversely, twenty-four patients deprived of lower lip depressor (26%), had its function substituted by an ipsilateral pedicled platysma {5}, anterior digastric {16} or anterior sternocleidomastoid flap {3}. Platysma transposition was the senior author's first choice when available, and the anterior digastric the preferred alternative. Figure 5 a-c and Figure 6 a and b.

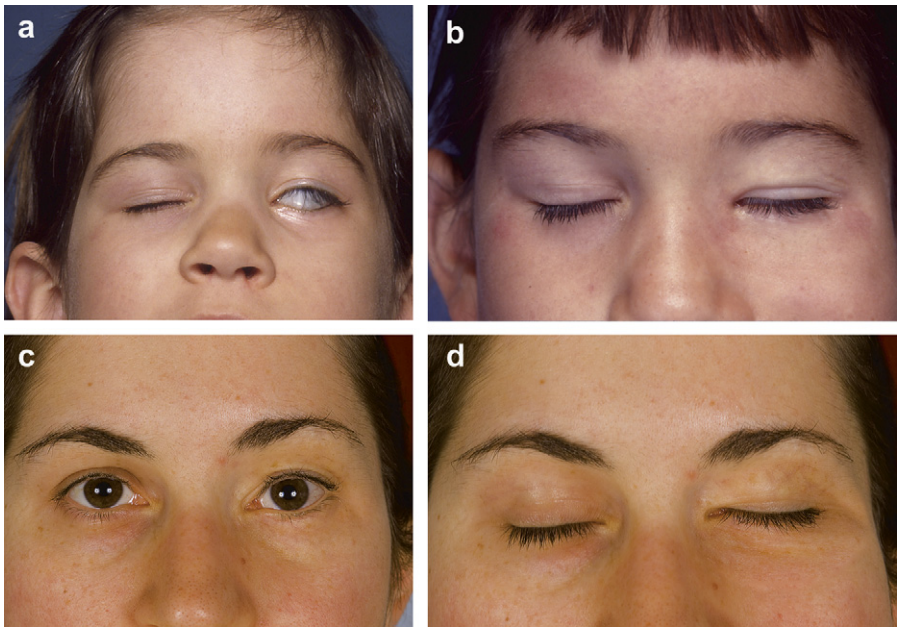

Figure 1 a-d. Upper-Face Reconstruction/Revisions- Exemplary Case 1. This three year old girl presented with left developmental facial paralysis. Figure 1.a corresponds to her initial presentation. Note lagophthalmos upon eye closure. She was managed with three CFNG followed a year later by free- pectoralis minor transfer (one slip for eye closure and three slips for smile restoration). Figure 1.b shows the functional result at one year post free-muscle-transfer. In the revision stage she underwent webbing correction and upper eyelid blepharoplasty. Figure 1.c and 1.d demonstrate functional and aesthetic results in long term follow-up, nineteen years later. The independent observers graded eye closure as Moderate- preoperatively, Good- a year after free-muscle substitution, and Excellent- following revisions. Note that both functional and aesthetic outcomes endure over lengthy periods and grow in harmony with the expanding facial skeleton.

In twenty-five patients (27%) with electrical activity on EMG but inadequate lower-lip excursion, function was augmented by means of direct-neurotization {14}, VII-VII transfer {4}, end-to-side hypoglossal to cervicofacial branch {6} or end-to-end mini-hypoglossal to cervicofacial transfer {1} (Table 6) (Figure 7 a and b). Two of the fourteen cases of direct-neurotization yielded inadequate outcomes and were complemented with contralateral myectomy in one case and plication of the ipsilateral depressor in another. Six patients (6.5%) were managed exclusively with contralateral myectomy.

Therefore, patients with dysfunctional lower lip excursion required a minimum of one and a maximum of two procedures for depressor management. Aesthetic interventions to the chin and neck helped the overall aesthesis and symmetry of the lower-face (Table 6). Table 7 lists other aesthetic procedures often needed in this group of patients.

Data analysis

Of the 92 patients in this series, 82 cases necessitated secondary surgery (at least one supporting revisional/ancillary intervention). Postoperative videos were available in 72 of the 82 patients with additional surgery (72/92,

Figure 2 a-c. Upper-Face Reconstruction/Revisions. Exemplary Case 3. This eight year old girl presented with right developmental paralysis. Figure 2.a relates to the first office visit. The reconstructive management consisted of a two-stage CFNG (x 3) and free gracilis transfer for smile restoration. On the revision stage, the upper CFNG was utilized for direct neurotization of the orbicularis oculi in conjunction with minitendon transfer for suspension of the right lower eyelid. Figure 2.b and 2.c correspond to a follow-up visit four years post-revisions. The averaged-score of the panel of observers was Moderate- preoperatively and Excellent- following revisions.

Table 5 Reconstructive, revisional and ancillary procedures to the mid-face

Target: the middle face			
Main reconstructive strategy		Functional revisions associated	
Two- Stage Free Muscle Transfer For Smile	71	1. Reanchor Free Muscle Transfer	13
CFNG + Free Muscle Transfer	63	Reanchor Laterally at Zygoma	6
IPNG Ipsilat. Motor Donor + Free Muscle T.	8	Reanchor Medially at Modiolus	4
		Reanchor at Both Ends	3
		2. Plication Of Free Muscle Transfer	6
		3. Mini-Temporalis Transposition To Augment Free Muscle Transfer For Smile	23
		4. Static Fascia Sling To Support Upper Lip	2
		5. Static Tendon To Support Upper Lip	6
		6. Platysma Transposition To Counteract Excessive Pull	2
		7. Selective Myectomy of Free Muscle Contracture	4
		8. Selective Myectomy of Contralateral Levator	2
		9. Botox Contralateral Levator	2
		Ancillary procedures to the midface	
		1. V-Y Advancement of Alar-base to Correct Flattening (2 Patients Needed Re-Do Corrections)	19
Alternative reconstructive options		2. Cartilage Graft to Nasal Ala	18
1. One-Stage Free Muscle to Masseter Nerve	2	Aesthetic revisions to mid-face	
		1. Debulk Free Muscle Transfer (3 Patients Needed Re-Do Debulk)	25
2. Two Stage VII- VII Transfer & Minitemporalis Transposition For Smile	2	2. Defat/Liposuction Cheek	31
		3. Liposuction Contralateral Cheek	1
		4. Dermal Fat Graft For Contour Cheek	7
3. Two Stage VII-VII Transfer	11	5. Vasc. Sup. Temporal Fascia For Filling Contour Def	4
		6. Vasc. Sup. Temporal Fascia to Envelope Free-muscle	3
		7. Vasc. Calf Fascia For Filling Contour Deficit of Cheek	1
		8. Face Lift	10
		9. Tip-Rhynoplasty	3
		10. Scar revision at Nasolabial Fold.	3
		11. Dermal Fat Graft To Upper Lip	7
		12. Cheiloplasty/Cheilotomy (2 Patients Needed Re-Do Cheiloplasty)	18
* Only Revisions Or Lost After First Stage	6		

88%), which constituted the study group evaluated. A panel of four independent observers used the Terzis' Functional and Aesthetic Grading System to grade patients' videos at two time-periods: pre- and post-secondary surgery (Table 8). In cases with more than one stage of revisions, the preoperative and the last-set of revisions videos were evaluated. The observers were blinded to patient's characteristics and interventions undertaken. Cronbach's alphas for internal consistency of the evaluating tool were computed at .91 and .96.

Using as the evaluating instrument, a five-category scale from poor to excellent, results in a skewed distribution that obliges to non-parametric analysis. Yet, in small groups, non-parametric analysis is less sensitive, thus the more powerful t-test was computed following normal-standardizing of the data by conversion of x values to z values by the transformation [$z = (x - \text{mean})/\text{standard deviation}$)] . Following transformation of the dataset, results of the Shapiro-Wilk test upheld the assumption of normality. To measure the effect of secondary surgery, postoperative gains were computed using a percent-gain-score (mean and standard deviation). Unpaired t-test and one-way ANOVA was computed for comparison of two or more groups managed with different techniques respectively. Statistical analysis was performed using SPSS v.14.0. (SPSS Inc., Chicago IL).

Results

The upper-face

Of 72 patients in the study group, 58 received at least one intervention for eye management. These 58 patients were grouped according to the surgical intervention/s undertaken. For each mode of reconstruction, a mean-percentage-gain was calculated comparing pre- and post-secondary surgery scores. Table 9.

Ocular symptomatology improved in all patients to variable degrees. Orbicularis substitution efficiently restored eye closure and corneal protection irrespective of

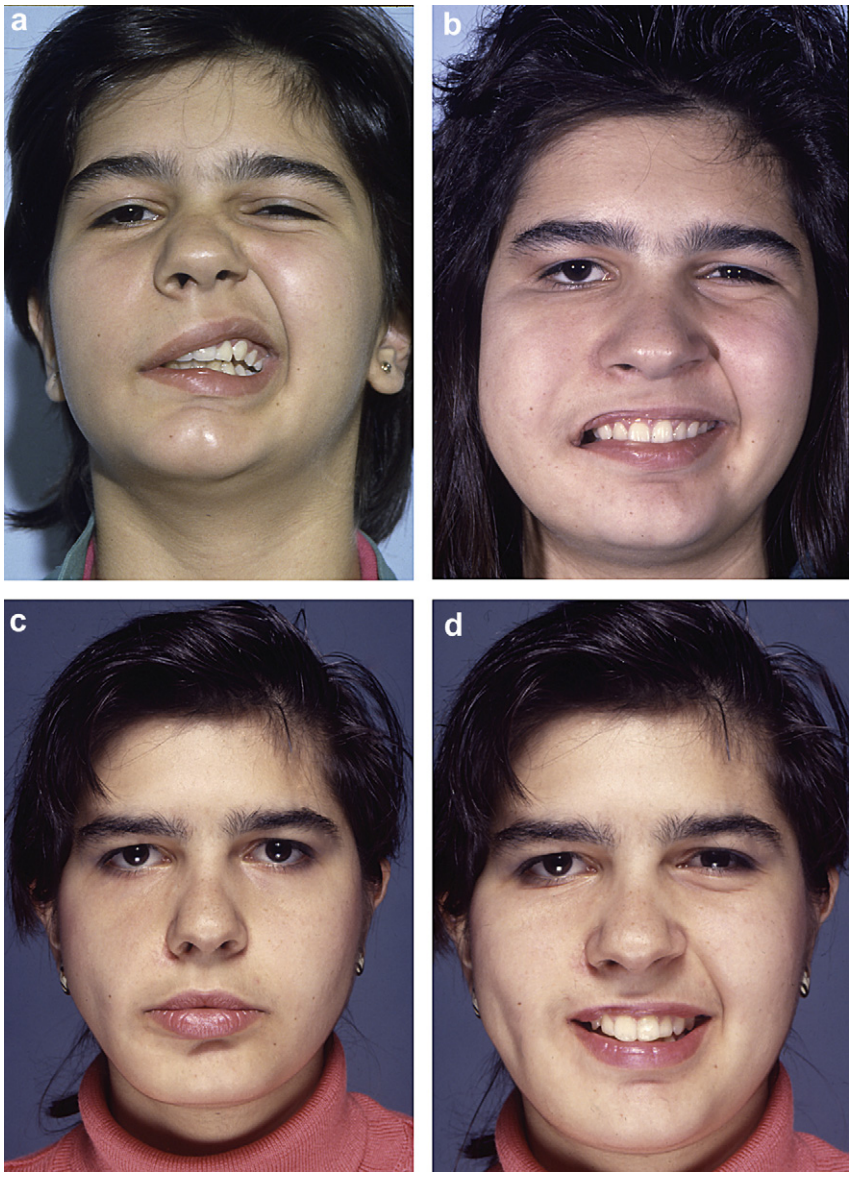

Figure 3 a-d. Mid-Face Reconstruction/Revisions. Exemplary Case 1.This 12 year old girl consulted our centre with a history of right developmental facial paralysis (Figure 3a). She underwent placement of three CFNG followed by free pectoralis minor transfer for smile restoration a year later. The excursion of the upper lip and commissure was markedly improved twelve months after free-muscle-transfer. However, there remained a degree of asymmetry between the oral commissures, and inadequate facial contour with excessive bulk on the right cheek (Figure 3b). The following procedures were undertaken on the revisional stage: static tendon support of the right commissure, debulk and re-anchoring of the free-muscle graft, defatting of the cheek and dermal-fat graft to the right upper lip. Figure 3.c and 3.d show the functional and aesthetic results at the one year follow-up visit after revisions. The panel of raters awarded her the following scores: Fair- preoperatively, Good- post free-muscle-transfer, and Excellent- following revisions.

the muscle flap utilized (one-way ANOVA, $p = .2876$). However, frontalis transfers were bound to a greater number of additional revisions. Four flaps were tightened, one needed debulking and one was supported with a goldweight (Table 4). Of the two cases of segmental-pectoralis transfer, one patient exhibited a minor degree of oral-to-eye synkinesis in spite of the upper-slip being empowered by an independent CFNG.[29]

Weighted against other reconstructive modes, patients managed solely with direct-neurotization or VII-VII transfer attained lesser gains, yet significant improvements. Altogether, correction of lagophthalmos with goldweight outnumbered the cases of eyespring insertion. Ten goldweight implants were used in total; two of which were exchanged for a different load, two removed and one replaced with an eyespring. Of four children who received an eyespring, two

Figure 4 a-c. Mid-Face Reconstruction/Revisions. Exemplary Case 3. This 7 year old girl was referred to our centre with left developmental facial paralysis (Figure 4a). Mid-face reanimation consisted of CFNG (x3) and free pectoralis minor transfer. Figure 4b shows improved function but asymmetrical facial contour a year post free-muscle-transfer. She underwent debulking of the muscle graft and free-cartilage-graft correction of the left ala on a final revisional stage. The degree of debulking proved insufficient, hence the patient necessitated a second debulk of the muscle graft and defatting of the cheek. Figure 4.c demonstrate the long term results, fourteen years after reconstruction. The averaged-observers score was Fair- preoperatively, Moderate- post free-pectoralis minor and Excellent- long-term post-revisions.

Figure 5 a-c. Lower-Face Reconstruction/Revisions. Exemplary Case 2. This eleven year old boy presented with a diagnosis of left developmental facial paralysis. Figure 5a relates to the preoperative visit and depicts absent depression of the left lower lip. On the first two stages of reconstruction, his mid-face was reanimated with the CFNG-free-pectoralis minor strategy. On the third stage of revisions, the paretic depressor was substituted with a pedicled platysma flap. Short- (two years) and long-term follow-up (17 years) from revisions are shown in Figure 5b and c respectively. The averaged-observers score for lower lip depression and symmetry was Poor- preoperatively and Excellent- following ipsilateral platysma transfer.

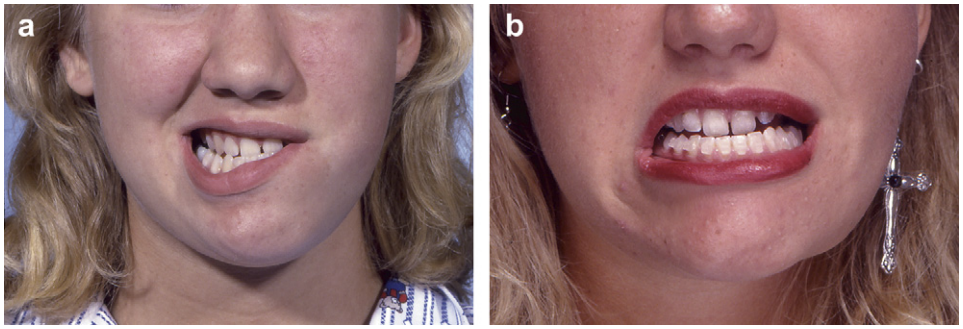

Figure 6 a-b. Lower-Face Reconstruction/Revisions. Exemplary Case 5. This eleven year old girl was referred to our centre with left facial palsy following the excision of a parotid haemangioma. Mid-face reanimation took place on the first two stages (CFNG-free-pectoralis minor). On the third stage of revisions the inadequate depressor function was augmented using a digastric transfer to the lower lip. At the one year follow-up visit, the degree of depression obtained was judged moderate, and hence the digastric flap was tightened further. Preoperative function (Figure 6.a) and final functional and aesthetic results ten years after digastric transfer are depicted on Figure 6.b. The independent observers rated this patient as Fair- preoperatively and Excellent- post digastric muscle transposition.

Table 6 Reconstructive, revisional and ancillary procedures to the lower-face

Target: the lower face			
Reconstructive options		Functional revisions associated	
1. Depressor Labii Inferioris Substitution	24	1. Tightening Of Digastric Transfer	2
Digastric Transfer	16		
Platysma Transfer	5		
Anterior Sternocleidomastoid Transfer	3		
		Ancillary procedures	
2. Direct Neurotization Or Selective VII-VII Transfer	15	1. Botox Contralateral Depressor	1
Direct Neurotization	11		
Selective VII-VII Transfer	4		
3. Direct Neurotization & Ipsilat Depressor Plication	1	Aesthetic revisions to lower-face	
		1. Dermal Fat Graft To Chin (soft-tissue flattening)	4
4. Direct Neurotization & Selective Contralat Myectomy	2	2. Implant To Chin	3
		3. Botox to Skin Dimples on Chin	3
5. Cervicofacial VII to Ipsilateral Hypoglossal Transfer	7	4. Defat Neck	6
6.Selective Myectomy Contralateral Depressor	6		
* No Interventions For Depressor Or Lower-Face	37		

Figure 7 a-b. Lower-Face Reconstruction. Exemplary Case 7. This thirteen year old girl consulted our centre with left facial paralysis following complete resection of an astrocytoma. On the first stage of reconstruction along with the placement of three CNFG's, the cervico-facial branch of the facial nerve was coapted in an end-to-side manner to the hypoglossal nerve. Free-gracilis transfer for smile restoration was undertaken on the second stage. The hypoglossal to cervicofacial transfer satisfactorily corrected her depressor dysfunction and no further interventions were needed for this target. Figure 7a and b demonstrate her preoperative status and functional results two years after hypoglossal-cervicofacial transfer. The panel of observers graded her depressor function as Good- preoperatively and Excellent- post intervention.

needed additional adjustments and two were removed. Minitendon tightening was necessary in six patients (with further tightening being needed in two cases).

Of the 58 patients with eye interventions, 50% were graded as good results and 44% were rated as excellent results by the evaluating panel.

The mid-face

Of 72 patients in the study group, 60 received at least one revisional/ancillary intervention for smile enhancement or symmetry improvements. In the mid-face, patients' classification based upon corrective revision/s proved impractical, for the majority of cases received a combination of procedures. Table 10 lists the most common procedures utilized in the mid-face, but an interaction effect must be assumed on computing postoperative gains. The commonest two infirmities following free-muscle-transfer are excessive bulk and inversion/alterations to the lip's shape. Debulking of the muscle-graft with defatting of the cheek, and cheiloplasty or

Table 7 Miscellaneous aesthetic procedures

Miscellaneous	
Aesthetic revisions	
1. Scar Revisions To Face	30
2. Scar Revisions To Legs	10
3. Otoplasty	5

Table 8 Terzis' functional and aesthetic grading system for eye, smile and depressor

	Description	Score
Eye grade		
Excellent	No scleral show.	V
Good	More than one-half decrease in scleral show.	IV
Moderate	One-half decrease in scleral show	III
Fair	Less than one-half decrease in scleral show	II
Poor	No change in scleral show	I
Smile grade		
Excellent	Symmetrical Smile with teeth showing, Full Contraction	V
Good	Symmetry, nearly Full Contraction	IV
Moderate	Moderate Symmetry, Moderate Contraction, Mass Movement	III
Fair	No Symmetry, Bulk, Minimal Contraction	II
Poor	Deformity, No Contraction	I
Depressor grade		
Excellent	Normal symmetric movement of the lower lip	V
Good	Almost complete excursion of lower lip, depression and full denture	IV
Moderate	Observable movement but inadequate excursion, no symmetry	III
Fair	Trace contraction but no movement	II
Poor	Total paralysis, no contraction	I

dermal-fat-grafts to the upper lip respectively, are effective and reproducible methods of correcting these abnormalities.

In our centre, patients with poor or fair outcomes of a free-muscle-transfer fared better by adding a mini-temporalis than by manipulation of the muscle-graft. The counter to excessive muscle contractions is similarly, the transposition of an extra muscle unit. A pedicled platysma to the contralateral commissure compensated excessive forces of the free-muscle without the risks associated with selective myectomies.

Of 60 patients with secondary interventions to the mid-face, the independent observers graded 73% as good or excellent results (45% good/28% excellent).

The lower-face

Forty-eight patients on the study group received at least one intervention for depressor restoration. Patients were readily classified in seven groups according to the reconstructive strategy (Table 11). Physiologic restoration of the

Table 9 Mean gain percent (Pre- vs. Post-Secondary Surgery Mean-Scores)with different revisional and ancillary procedures to the upper-face

Target: the upper face				
Procedures for eye	Group size	% Gain score Pre/post-revision		Normalised data Dependent T -test
		Mean	ST. DEV	
Pedicled Frontalis Transposition	$n = 6$	46%	13%	* $p = .0005$
Pedicled Temporalis Transposition	$n = 4$	116%	169%	* $p = .0488$
Free Platysma Transfer	$n = 2$	50%	24%	$p = .2050$
Free Regional Pectoralis Transfer	$n = 2$	117%	46%	$p = .0837$
Direct Neurotization or VII-VII Transfer	$n = 15$	24%	18%	* $p < .0001$
Direct Neurotization or VII-VII Transfer and Goldweight	$n = 4$	55%	64%	$p = .2068$
Direct Neurotization or VII-VII Transfer and Goldweight and Minitendon	$n = 4$	46%	28%	* $p = .0348$
Direct Neurotization or VII-VII Transfer and Eyespring and Minitendon	$n = 2$	27%	9%	$p = .2052$
Direct Neurotization or VII-VII Transfer and Minitendon	$n = 9$	34%	32%	* $p = .0037$
Goldweight and Minitendon	$n = 2$	80%	28%	$p = .0903$
Minitendon	$n = 5$	25%	14%	* $p = .0104$

Sample evaluated: 72 patients of which 58 had at least one procedure for eye function or symmetry. Fifty-five patients accounted for on Table 9. Remaining three patients had: Direct Neurotization & Wedge Excision (1), Eyespring & Wedge Excision (1), Wedge Excision (1).* Statistical significance.

Table 10 Mean Gain Percent (Pre- vs. Post-Secondary Surgery Mean-Scores) with Different Revisional and Ancillary Procedures to the Mid-Face

Target: the middle face				
Procedures for smile	Group size	% Gain score Pre/post-revision		Normalised data Dependent T -Test
		Mean	ST. DEV	
Reanchor Free Muscle Transfer	$n = 10$	42%	41%	* $p = .0001$
Minitemporalis Transposition to Augment Free Muscle Outcomes	$n = 21$	49%	29%	* $p < .0001$
Plication Free Muscle Transfer	$n = 3$	22%	18%	$p = .1093$
Static Tendon or Fascia Sling to Support Upper Lip/Commissure	$n = 3$	32%	21%	$p = .0709$
Platysma Transposition to Oral Sphincter to Counteract Excessive Pull	$n = 2$	42%	2%	$p = .3230$
Selective Free Muscle Transfer Myectomy to Counteract Excessive Pull	$n = 2$	35%	11%	$p = .2048$
Debulk Free Muscle Transfer	$n = 25$	49%	60%	*$p < .0001$
Cheiloplasty/Cheilotomy	$n = 18$	48%	27%	* $p < .0001$

Sample evaluated: 72 patients of which 60 had at least one procedure for smile function or mid-face symmetry. In the mid-face, a combination of several revisional interventions was the norm, hence a possible interaction effect must be acknowledged.* Statistical significance.

depressor by muscle substitution yielded remarkable improvements, seen with all three muscle-flaps utilized. Digastric or sternocleidomastoid transpositions were performed in cases of non-functional platysma muscle. One-way ANOVA showed no significant difference by muscle type ($p = .0902$). Concerning additional revisions, two digastric flaps needed tightening, and one platysma transfer was complemented with a contralateral myectomy at a later stage.

Patients who underwent hypoglossal to cervicofacial transfer, direct-neurotization or VII—VII transfer for depressor enhancement, were granted significantly higher postoperative averaged-scores. End-to-side hypoglossal to cervicofacial transfer yielded superior results to those observed with direct-neurotization or VII-VII transfer (Figure 7a and b). The simpler (but not always reliable) contralateral myectomy might be indicated in selected patients.

Of 48 patients with reconstruction of the depressor function, 40% were rated 'Good' and 38% were rated 'Excellent'.

Discussion

It is widely held that a microneurovascular-muscle-transfer empowered by the contralateral facial nerve holds the greatest potential for an effective and coordinated smile. Yet, one cannot single out with the same certitude the revisional procedure/s best suited to compensate a misshapen result. There are few reports on revisional surgery, and at times confusing accounts are

Table 11 Mean Gain Percent (Pre- vs. Post-Secondary Surgery Mean-Scores) with Different Revisional and Ancillary Procedures To The Lower-Face

Target: the lower face				
Procedures for depressor	Group size	% Gain score Pre/post-revision		Normalised data Dependent T -TEST
		Mean	ST. DEV	
Pedicled Digastric Transposition	$n = 14$	121%	50%	*$p < .0001$
Pedicled Platysma Transposition	$n = 5$	87%	22%	*$p = .0003$
Pedicled Anterior Belly of Sternocleidomastoid Transposition	$n = 3$	101%	30%	*$p = .0199$
Direct Neurotization or VII-VII Transfer	$n = 13$	58%	39%	*$p < .0001$
Direct Neurotization or VII-VII Transfer and Contralateral Myectomy	$n = 2$	70%	14%	$p = .0903$
End-to-side Hypoglossal to Facial Cervicofacial Branch Transfer	$n = 3$	81%	48%	* $p = .0416$
Contralateral Myectomy	$n = 6$	97%	33%	* $p = .0001$

Sample evaluated: 72 patients, of which 48 had at least one procedure for depressor restoration. Forty-six patients accounted for on Table 11. Remaining two patients had: Direct Neurotization & Plication of Ipsilateral Depressor (1), End to End partial-XII-VII Transfer (1).* Statistical significance.

available. Scarce material and lack of consensus on eye and depressor reanimation complicates decision-making when managing these targets. The goal is physiological coordinated reanimation of all three main centres (eye-smile-depressor). To-date no single dynamic technique accomplishes this goal, thus the reconstructive surgeon must of necessity recourse to complementary procedures.

Kumar et.al. stated that despite the overall satisfaction with facial reanimation, 88% of patients managed with one-stage and 77% of patients managed with two-staged reconstruction were conscious of persistent asymmetries.[5] In 1997, Terzis and Noah reported a 67%,[9] while recently Takushima stated a 39.1% (exclusively to the mid-face).[7] More interestingly, Frey et.al indicated an 80% occurrence of revisions, and specified 95% in adults and 30% in children.[4] Indeed, paediatric patients have a tendency for superior outcomes and higher potential for cortical reorganisation, hence the lesser incidence of revisions in children. On the other hand, parents are mainly preoccupied with faculty restoration and ancillary aesthetic procedures are often disregarded in this age group. It does us great discredit to neglect, for example, a webbing correction in a Mobius child; if one considers that what is central to children is to feel as normal and beautiful beings.

Secondary procedures should be undertaken once the free-muscle has reached final functional recovery (12-18 months from transfer).[4] Insomuch as parents recognise that, despite the likelihood of revisions, optimal outcomes are accomplished by physiological reanimation, the number of procedures is often of little consequence.

In the upper-face, many recommend the use of lid-loading implants or eyespring for correcting lagophthalmos.[30–34] On the contrary, others find the bulging and complications rate unacceptable, and support the routine use of temporalis transposition.[4,5] In the authors' judgement, confident of the regenerative and reintegration abilities of the paediatric patients, a positive stance towards physiologic eye reanimation is justified.

In the mid-face, the senior author first documented in 1997, the use of mini-temporalis transposition to augment free-muscle outcomes.[9] In patients with excessive pull from the transferred muscle, Kumar et.al recommends using a strip of fascia to elongate the muscle,[5] whilst Frey et. al suggest a reduction of the muscle volume.[4] In our centre, in addition to loosening the free-muscle tension, provision of a counter force by a contralateral-platysma transposition has efficiently addressed these difficult cases.

In the lower-face, as any other zone, the large standard deviation observed with some of the techniques evaluated, cautions of the importance of identifying the appropriate patient for the procedure.[1] With hindsight, careful patients' selection remains the key matter to satisfactory outcomes.

Secondary surgery in facial paralysis is of great value in improving outcomes and enhancing overall symmetry. Given the complexity of facial reanimation, a reconstructive approach based on one- or two-staged dynamic reconstruction followed by revisional/ancillary procedures, is necessary for panfacial reanimation and will become more prevalent in facial paralysis centres.

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