Secondary Surgery in Adult Facial Paralysis Reanimation

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Background: The series presented constitutes the entire experience with adult facial paralysis reanimation by a single surgeon over three decades. This report discusses the different reconstructive strategies used in this sample, focusing on the incidence and outcomes of commonly used revisional and ancillary procedures.

Methods: Since 1979, 175 adult cases of facial paralysis underwent facial reanimation surgery performed by the senior author (J.K.T.). The reconstructive strategies varied in accordance with denervation time, cause, and whether the paralysis was complete or partial and unilateral or bilateral. Irrespective of these variables, the number of patients who required secondary surgery totaled 141 of 175 (81 percent). Postrevision videos were available in 122 patients, who constituted the sample evaluated. Four independent observers rated the outcomes of secondary surgery using a five-category scale ranging from poor to excellent.

Results: Interrater reliability testing showed Cronbach's α values above acceptable limits ($\alpha > 0.80$). The effect of diverse revisional and ancillary interventions was measured computing a mean gain percentage score. Secondary surgery yielded a significant upgrade in symmetry and function, with appreciable improvements in all three facial regions (upper face, 28 to 166 percent gain; midface, 33 to 72 percent gain; and lower face, 20 to 127 percent gain).

Conclusions: This comprehensive analysis of the entire series of adult reanimation in the authors' center evidences the beneficial effects of revisional and ancillary interventions to augment function and overall symmetry. Inherent in all methods of dynamic reanimation is the need for secondary adjustments, which should be considered in most cases, as they can transform an adequate result into a gratifying outcome. (*Plast. Reconstr. Surg.* 124: 1916, 2009.)

Facial paralysis patients suffer from a combination of lost functional faculties and impaired facial expressions. Advances in microsurgery over the past 30 years have led to greater expectations and allowed for the realization of a coordinated dynamic panfacial reanimation. Today, the general stance is for dynamic restoration of any partially or wholly deprived mimetic function. However, inherent in dynamic reanimation is the likelihood of secondary revisional adjustments. Bearing this in mind, the reconstructive surgeon ought to plan thoughtfully the rehabilitative strategies for function restoration of all paretic targets. Every stage of the reconstructive process should be ideated so that compatible techniques can be undertaken simultaneously and, at the same time, allowance can be given for the correction of any infirmity that may have resulted from the previous stage. During the first stage, several cross-facial nerve grafts are placed to coordinate animation of all three regions of the face with the contralateral side. In our center, this is often combined with complementary techniques

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such as hypoglossal-to-cervicofacial transfer for depressor management or gold weights, eye springs, or minitendon grafts for eye management. During the second stage, free or regional muscle transfer for smile restoration takes place in conjunction with secondary microcoaptations or direct neurotization of dysfunctional targets. Secondary microcoaptations in stage II refers to the coaptations between selected branches of the affected facial nerve with the cross-facial nerve grafts (usually 9 to 12 months after stage I of the cross-facial nerve graft procedure). Planning in such a manner, neural rehabilitation could be supported with ancillary procedures during the third stage if the results are inadequate. Several investigators have stressed the need for secondary surgery in dynamic reanimation.[1–8]

Particularly in the adult population, several variables, including cause, prognosis, age, and patients' expectations, heavily influence decision-making. Aging worsens the impact of facial paralysis and plays a decisive role in these patients, who are not candidates for standard rejuvenation surgery. In this sense, careful planning remains the *condicio sine qua non* for best possible outcomes. In our center, the likelihood of secondary surgery following the two-standard reconstructive stages is communicated to all patients during the initial consultation.

The senior author (J.K.T) commenced her work at restoring physiologic animation to facial paralysis patients in 1979. This report aims to outline the reconstructive strategies for adult patients in the authors' center, with particular regard to the indications and value of revisional and ancillary procedures. A detailed documentation of all the surgical techniques cited in this series can be found in previous publications.[2,9–19] The Institutional Review Board Committee of the Eastern Virginia Medical School approved the protocol of this retrospective review.

PATIENTS AND METHODS

Data were available for 175 adult patients treated for facial paralysis by the senior author since 1979. All cases without exception had their medical charts studied, and all reconstructive, revisional, and ancillary procedures were analyzed. The mean age of the patients was 36.62 ± 12.9 years (range, 17 to 72 years), with 95 percent of the patients being younger than 60 years. The number of patients within each cause-based category is illustrated in Table 1. The mean time interval after denervation was 121 ± 147 months (range, 1 to 621 months), with 74 percent of the patients (129 of 175) presenting later than 12 months after insult. The sample demographic data are summarized in Table 2. The reconstructive strategies used for specific disabilities and the procedures undertaken at each stage are listed in Table 3.

Table 1. Causes of Adult Facial Paralysis

Cause	No.
Developmental	12
Traumatic	39
Acoustic neuroma	43
Parotid tumor	12
Other tumors/pontine lesion	23
Bell palsy	18
Möbius/Möbius-like	3
Iatrogenic	18
Idiopathic	7
Total	175

Upper Face

Restoration of adequate eye closure and blink are treatment priorities in the facial palsy patient with ocular complaints. Inadequacies of upper and lower lid function must be addressed for an effective near-normal restoration of the eye sphincter.[20] Preoperative evaluation includes a detailed history of eye symptomatology, Bell phenomenon, blink and corneal sensitivity evaluation, and needle electromyography. Earlier reports by the senior author (J.K.T.) have documented decision-making algorithms for eye reanimation at our institution.[13,15,17,18]

No surgical intervention for eye management or upper face aesthetics was needed in 62 of 175 patients (35.4 percent). Conversely, 20 patients (11.4 percent) with atrophied orbicularis oculi, as evidenced by silent electromyography, received a pedicled or free-muscle transfer for orbicularis substitution. Eye impairment prioritized eye reconstruction over smile restoration in four cases

Table 2. Demographic Characteristics

	No.
Side	
Right	89
Left	77
Bilateral	9
Gender	
Female	122
Male	53
Denervation time	
<12 months	30
12–24 months	16
>24 months	129
Grade	
Complete	40
Partial	135

Table 3. Patient Distribution by Number of Stages/Procedures

No. of Patients	Stage 1	Stage 2	Stage 3	Stage 4
4	CFNG/IPNG ipsilateral donor	OOM substitution	Free muscle for smile	Revisions/ancillary
10	CFNG/IPNG ipsilateral donor	Free muscle for smile	OOM substitution	Revisions/ancillary
2	CFNG	Secondary microcoaptations (1) with or without mini-temporalis transposition (1)	OOM substitution	
3	CFNG	Split gracilis for eye and smile		
1	CFNG	Split temporalis for eye and smile		
45	CFNG/IPNG ipsilateral motor donor	Free muscle for smile	Revisions/ancillary	
5	CFNG/IPNG ipsilateral motor donor plus revisions/ancillary	Free muscle for smile		
10	CFNG/IPNG ipsilateral motor donor	Free muscle for smile		
4	One-stage free-muscle transfer to ipsilateral stump	Revisions/ancillary		
15	CFNG	Secondary microcoaptations and mini-temporalis transposition	Revisions/ancillary	
6	CFNG	Secondary microcoaptations and mini-temporalis transposition plus revisions/ancillary		
1	CFNG	Masseter transposition for smile		
9	CFNG	Secondary microcoaptations	Revisions/ancillary	
8	CFNG	Secondary microcoaptations plus revisions/ancillary		
6	CFNG	Secondary microcoaptations		
6	Mini-temporalis transposition	Revisions/ancillary		
11	Revisions/ancillary			
9	Secondary repair facial nerve	Revisions/ancillary		
9	Secondary repair facial nerve			
11	First-stage CFNG	Lost to follow-up		

CFNG, cross-facial nerve graft; IPNG, ipsilateral nerve graft; OOM, orbicularis oculi muscle.

(Table 3). Regional transposition of frontalis or temporalis flaps was used in seven and three patients, respectively. Free transfers included three cases of segmental platysma and two cases of extensor digitorum brevis (Fig. 1), one occipitalis and one adductor subunit. A split gracilis transfer was used for eye and smile restoration in three patients, with each segment independently paced by separate cross-facial nerve grafts (Fig. 2). Except for temporalis transfers, all other muscle units were reinnervated by a cross-facial nerve graft carrying motor fibers from the contralateral eye branch for coordinated animation (Table 4).

Sixty-eight of 175 patients (39 percent) with short denervation time or partial rehabilitation after insult showed orbicularis oculi fibrillations on electromyography, which justified an attempt to strengthen its function by direct neurotization (21 patients) or two-stage cross-facial nerve graft (47 cases). Of these 68 patients, 27 achieved satisfactory results without further surgery. Inversely, inadequate results were noticeable in 41 cases, which were corrected with ancillary procedures (gold weight and minitendon, $n = 8$; eye spring and minitendon, $n = 10$; minitendon, $n = 16$; eye spring, $n = 4$; gold weight, $n = 1$; wedge excision, $n = 1$; and lateral canthoplasty, $n = 1$) (Table 4).

Lastly, 25 of 175 patients (14 percent), were treated with static procedures (eye spring, $n = 5$; minitendon, $n = 6$; eye spring and minitendon, $n = 4$; gold weight and minitendon, $n = 2$; gold weight and wedge excision, $n = 1$; wedge excision, $n = 4$; and medial or lateral canthoplasty, $n = 3$) (Fig. 3 and Table 4).

Altogether, patients with inadequate eye protection received at least one intervention and hereafter ranged from two to four, including secondary adjustments. Blepharoplasty ($n = 20$), brow lift ($n = 38$), and webbing correction ($n = 8$) were the three most common aesthetic procedures for upper face symmetry in the adult patients (Table 4).

Midface

When reanimating the midface in adulthood, it is of utmost relevance to select the reconstruc-

Fig. 1. Upper face reconstruction/revisions in case 1. This 40-year-old man presented with right-sided facial paralysis following excision of a parotid pleomorphic adenoma. (*Above*) At the initial consultation, lagophthalmos and ectropion of the lower lid could be seen. He was managed with two cross-facial nerve grafts during the first stage followed by a free gracilis transfer for smile restoration 10 months later. During a later stage, he underwent free extensor digitorum brevis transfer for orbicularis oculi substitution. One year later, he underwent reanchoring of the lower slip of the free-muscle transfer and wedge excision. (*Below*) Functional and aesthetic results 21 months after transfer. The independent observers graded eye closure as poor preoperatively, moderate following orbicularis substitution, and good following secondary surgery.

Fig. 2. Upper face reconstruction/revisions in case 2. This 24-year-old woman presented with right-sided Bell palsy. (*Above*) Photograph obtained at the first office visit. During the first stage, she underwent placement of four cross-facial nerve grafts followed by a split free gracilis transfer for eye and smile during the second stage. The upper segment of the gracilis graft was anchored to the lower eyelid and the lower segment was anchored to the oral commissure. During the revision stage, she underwent insertion of an eye spring to the upper eyelid. (*Below*) Photograph obtained at the 18-month posttransfer follow-up. The averaged score of the panel of observers was moderate preoperatively, good following free-muscle transfer, and excellent following secondary surgery.

Table 4. Reconstructive, Revisional, and Ancillary Procedures to the Upper Face

	No.
Reconstructive options	
Orbicularis oculi substitution	20
Pedicled frontalis transposition	7
Pedicled temporalis transposition	3
Free platysma transfer	3
Free extensor digitorum brevis	2
Free occipitalis	1
Free adductor	1
Free split gracilis	3
Direct neurotization or selective VII–VII transfer	27
Direct neurotization	2
Selective VII–VII transfer	25
Direct neurotization or selective VII–VII transfer and gold weight and minitendon	8
Direct neurotization or selective VII–VII transfer and eye spring	4
Direct neurotization or selective VII–VII transfer and gold weight	1
Direct neurotization or selective VII–VII transfer and eye spring and minitendon	10
Direct neurotization or selective VII–VII transfer and minitendon	16
Direct neurotization or selective VII–VII transfer and wedge excision or lateral canthoplasty	2
Gold weight and minitendon	2
Eye spring and minitendon	4
Eye spring	5
Minitendon	6
Wedge excision	4
Functional revisions	
Revisions to OOM substitution	
Tightening frontalis flap	2
Tightening extensor digitorum brevis flap	2
Tightening split gracilis flap	1
Debulking frontalis flap	1
Debulking platysma flap	1
Eye spring	4
Minitendon	5
Other functional revisions	
Exchange gold weight	2
Remove gold weight	1
Eye spring adjustments	15
Eye spring removal	7
Tightening of minitendon	21
Loosening of minitendon	1
Plication of orbicularis oculi muscle fibers	2
Ancillary procedures	
Lateral canthoplasty	9
Medial canthoplasty	5
Elliptical conjunctiva excision to invert punctum	10
Aesthetic procedures to upper face	
Webbing correction	8
Brow lift (34 open, 3 endoscopic, 1 contour threads)	38
Blepharoplasty	20
Dermal fat to lower lid	4
Selective neurectomy contralateral frontalis	1
Selective myectomy contralateral frontalis	1

VII–VII, contralateral eye branch–to–ipsilateral eye facial nerve branch transfer. OOM, orbicularis oculi muscle.

Fig. 3. Upper face reconstruction/revisions in case 3. This 32-year-old woman consulted our center with a history of traumatic left-sided facial paralysis following a motor vehicle accident (*above*). She underwent medial tarsorrhaphy for eye protection by first carers. The midface reconstructive strategy consisted of a two-stage cross-facial nerve graft free gracilis transfer for smile restoration. During the revisional stage, the tarsorrhaphy was released and eye closure was assisted with an eye spring to the upper lid and a minitendon graft to the lower eyelid. (*Below*) Functional and aesthetic results at the 2-month follow-up visit following revisions. The panel of observers awarded her the following scores: moderate before secondary surgery and good after secondary surgery.

tive procedures best suited to the individual. In adult patients, cross-facial nerve graft free-muscle transfer for smile restoration remains the best and most commonly used strategy. Nevertheless, factors such as age, prognosis, and the patient's priorities limit the use of free-muscle transfer in favor of logical alternatives.

In this series, 77 of 175 patients (44 percent) underwent a two-stage cross-facial nerve graft free-muscle transfer for smile restoration. In four patients, the ipsilateral facial nerve stump was deemed suitable for one-stage gracilis transfer to the midface. Regional muscle transpositions were chosen in 30 patients. One patient (0.5 percent) had a two-stage cross-facial nerve graft masseter transfer to the oral commissure, and six patients (3.5 percent) underwent reconstruction with a single-stage segmental temporalis transposition. The larger group of regional transfers included 23 patients who had a significant recovery from the initial insult, achieved satisfactory outcomes from cross-facial nerve grafts, or had a prognosis or personal wishes that contraindicated a free-muscle transfer. These 23 of 175 cases (13 percent) were managed with cross-facial nerve grafts during the first-stage followed by secondary microcoaptations and mini temporalis transposition during the second-stage.

In 24 of 175 patients (14 percent), two-stage cross-facial nerve grafts yielded sufficient rehabilitation, and muscle transfer was deemed unnecessary. Lastly, 18 patients (10 percent) were treated with secondary repair of the injured facial nerve branches, 11 patients (6 percent) required solely ancillary or aesthetic procedures, and 11 cases (6 percent) were lost to follow-up following the first-stage of cross-facial nerve grafts.

Overall, 93 of 175 patients received at least one revisional or ancillary intervention to the midface. A comparison of the three larger subgroups by reconstructive strategy showed that 55 of 77 patients managed with cross-facial nerve graft free-muscle transfer needed secondary surgery (71 percent), 19 of 29 cases treated with cross-facial nerve graft mini-temporalis transfer underwent revisional or complementary procedures (66 percent), and five of 24 cases of two-stage cross-facial nerve grafts had additional procedures (21 percent).

The most common infirmities that may result from a free-muscle transfer are too weak a contraction, too strong a contraction, excessive bulk (Fig. 4), or inversion of the lips at the graft anchoring points. Inadequate direction of pull, lateral fixation of the oral commissure, and skin tethering occur less frequently. As more clinical experience was gained in our center, the senior author observed that providing a second muscle unit, mini-temporalis transfer to the oral commissure, yielded more predictable results than manipulation of the free muscle.[21] In this series, an increase of the muscle tension by free-muscle reanchoring was sought in 19 cases, a mini-temporalis transposition to augment free-muscle function was used in 13 cases,[21] and a combination of both techniques was used in seven cases (Table 5).

To the contrary, excessive pull or lateralization of the oral commissure can be attenuated in mild cases by selective free-muscle myectomies (three patients), or counteracted with a pedicled platysma transposition to the contralateral commissure in more severe instances (seven patients) (Terzis K, Olivares FS, unpublished data) (Table 5). In the cross-facial nerve graft mini-temporalis group, mainly aesthetic procedures were undertaken in the third stage, with the exception of three patients whose inadequate postoperative excursion necessitated a free-muscle transfer in two

Fig. 4. Midface reconstruction/revisions in case 4. This 46-year-old man was referred to our center with right-sided facial paralysis following excision of an intraparotid facial nerve neurofibroma (*left*). He had four cross-facial nerve grafts followed by free gracilis transfer for smile restoration 10 months later. (*Center*) Moderate function and excessive bulk in the right cheek 1 year after muscle transfer. During the revisional stage, he underwent reanchoring of the muscle flap at the zygomatic end, debulking of the free muscle, and cheek and face lift. (*Right*) Functional and aesthetic results 3 years after free-muscle transfer and after revisions to the midface. The averaged score of the panel of observers was fair preoperatively, good following free gracilis transfer, and excellent following secondary surgery at the 3-year follow-up.

Table 5. Reconstructive, Revisional, and Ancillary Procedures to the Midface

Procedures	No.
Main reconstructive strategy	
Two-stage free-muscle transfer for smile	77
CFNG plus free-muscle transfer	74
IPNG ipsilateral motor donor plus free-muscle transfer	3
Alternative reconstructive options	
One-stage free-muscle to ipsilateral VII stump	4
Two-stage VII–VII transfer and mini-temporalis transposition for smile	23
Two-stage VII–VII transfer and masseter transposition for smile	1
Mini-temporalis transposition	6
Two-stage VII–VII transfer (CFNG and secondary microcoaptations)	24
Secondary repair of damaged VII branch(es) with/without ancillary/aesthetic procedures	18
Ancillary/aesthetic procedures exclusively	11
Lost after first stage of CFNG	11
Associated functional revisions	
Reanchor free-muscle transfer	26
Plication of free-muscle transfer	3
Mini-temporalis transposition to augment free-muscle outcomes	20
Tightening of mini-temporalis (used as adjunct to CFNG and secondary microcoaptations)	1
Static fascia sling to support upper lip	2
Static tendon to support upper lip	12
Platysma transposition to counteract excessive pull	7
Selective myectomy of free-muscle contracture	3
Selective myectomy of contralateral levator	2
Botox to contralateral levator	2
Ancillary procedures to the midface	
V-Y advancement of alar base to correct flattening (two patients needed repeated corrections)	14
Cartilage graft to nasal ala	5
Aesthetic procedures to the midface	
Debulk free-muscle transfer (two patients needed repeated debulking)	20
Defat/liposuction cheek	35
Liposuction contralateral cheek	1
Dermal fat graft for contour cheek/nasolabial fold	18
Vascularized superficial temporal fascia for filling contour deficits	3
Vascularized superficial temporal fascia to envelope free muscle	9
Adhesion lysis	11
Face lift (five patients needed repeated face lift over the years)	56
Tip rhinoplasty	5
Scar revision at nasolabial fold	3
Dermal fat graft to upper or lower lip	12
Cheiloplasty/cheilotomy (one patient needed repeated cheiloplasty)	26

CFNG, cross-facial nerve graft; IPNG, ipsilateral nerve graft; VII–VII, contralateral zygomatic branch–to–ipsilateral facial nerve transfer for smile.

cases and tightening of the mini-temporalis flap in one.

Debulking of the cheek and muscle graft, face lift (Fig. 4), and correction of lip deformities were the most frequent aesthetic revisions to the midface. Nasolabial fold irregularities (with adequate function) can be improved by dermal fat grafting (Fig. 5). Likewise, dermal fat grafts efficiently corrected inversion of the upper or lower lip at the free-muscle fixation points (Fig. 6). A superficial temporal fascia flap proved advantageous in enhancing free-muscle gliding underneath the skin envelope, and harmonized contour deficits in the paretic cheek.[22] Nineteen V-Y advancement flaps were undertaken to improve alar base positioning, and five cartilage grafts were harvested to assist inspiration and restore alar contour (Table 5).

Lower Face

In this series, 90 of 175 patients (51.4 percent) had adequate function of the depressor mechanism. Unlike them, 36 of 175 patients (20.6 percent) evidenced a complete paresis of the lower-lip depressor, and function was substituted with a pedicled platysma flap in 19 cases and an anterior digastric flap in 17 (Fig. 7).

Thirty-five of 175 patients (20 percent) had ineffective excursion, with electrical activity on needle electromyography. In these cases, direct neurotization (12 patients) or facial to facial nerve transfer (23 patients) was carried out to augment function. These neural techniques yielded adequate outcomes in 30 patients. Five cases of direct neurotization resulted in less satisfactory results and were complemented with contralateral myectomy in three cases and ipsilateral depressor plication in two (Table 6).

Nine of 175 patients (5 percent) had hypoglossal-to-cervicofacial transfer during the first stage, along with placement of cross-facial nerve grafts (Fig. 8). Lastly, five patients (3 percent) were managed exclusively with selective myectomy of the contralateral depressor. In patients with dysfunctional depressors, the minimum number of interventions was one and the maximum was two. Neck lift and neck defatting, along with implants or dermal fat graft to the chin, were the most commonly performed aesthetic interventions in the lower face.

There were 31 miscellaneous aesthetic revisions (19 scar revisions in the face, nine scar revisions on the legs, and three otoplasties).

Data Analysis

Of the 175 patients in this series, 141 (81 percent) required secondary surgery (at least one supporting revisional or ancillary intervention).

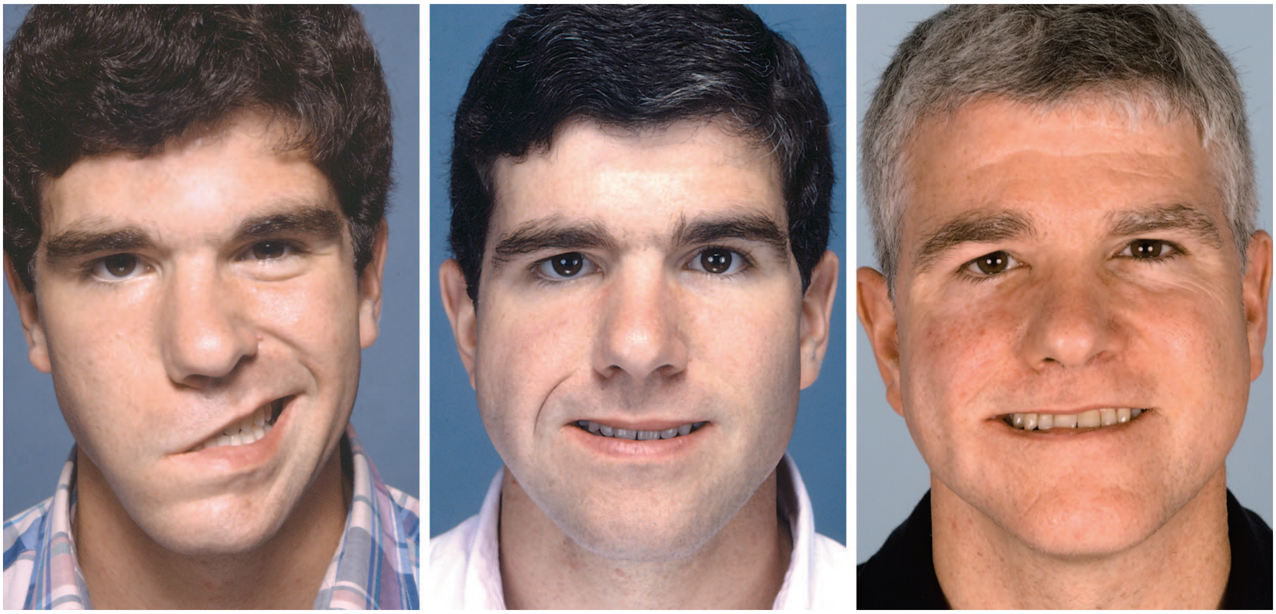

Fig. 5. Midface reconstruction/revisions in case 5. This 25-year-old man presented with a diagnosis of right-sided developmental facial paralysis. (*Left*) Preoperative visit. He underwent two-stage cross-facial nerve grafts times three followed by free gracilis transfer to the midface. Free-muscle fixation and postoperative adhesions resulted in an unsightly deep crease at the nasolabial fold. (*Center*) One year later, this abnormality was efficiently corrected with a dermal fat graft. The oral commissure was supported with a static tendon graft in the same setting. (*Right*) Functional and aesthetic results at the long-term follow-up visit, 8 years after free-muscle transfer and following revisions. The panelists rated his smile as poor preoperatively, good after free-muscle transfer, and excellent after secondary surgery.

Fig. 6. Midface reconstruction/revisions in case 6. This 18-year-old male patient was referred to our center with traumatic left-sided facial paralysis (*left*). Midface reanimation consisted of placement of three cross-facial nerve grafts during the first-stage and free gracilis transfer 8 months later. (*Center*) There was adequate function 1 year after muscle transfer but appreciable bulk in the left cheek and inversion of the corner of the upper lip. During the revisional stage, he underwent defatting of the cheek, face lift, and dermal fat graft to the upper lip. (*Right*) Appearance at the 6-month follow-up visit after secondary surgery. The independent observers rated this patient as poor preoperatively, good after free-muscle transfer, and excellent following secondary surgery.

Fig. 7. Lower face reconstruction in case 7. This 22-year-old woman presented with a diagnosis of traumatic facial paralysis following a motor vehicle accident. (*Above*) She had inadequate lower lip depression on initial consultation. Smile restoration followed the standard two-stage cross-facial nerve grafts times three followed by free gracilis transfer. During the revisional stage, a pedicled digastric muscle was transposed to the lower lip for depressor substitution. (*Below*) The patient demonstrated effective lower lip excursion on long-term follow-up. The panel of observers graded her depressor function as moderate preoperatively and excellent 5 years after digastric transfer.

Table 6. Reconstructive, Revisional, and Ancillary Procedures to the Lower Face

	No.
Reconstructive options	
Depressor labii inferioris substitution	36
Platysma transposition	19
Digastric transposition	17
Direct neurotization or selective VII–VII transfer	35
Direct neurotization	7
Direct neurotization and selective contralateral myectomy	3
Direct neurotization and ipsilateral depressor plication	2
Selective VII–VII transfer	23
Hypoglossal-to-cervicofacial transfer	9
Selective myectomy contralateral depressor	5
Associated functional revisions	
Tightening of platysma flap	2
Loosening of digastric flap	1
Ancillary procedures	
Botox to contralateral depressor	1
Aesthetic procedures to the lower face	
Dermal fat graft to chin (soft-tissue flattening)	17
Implant to chin	2
Botox to skin dimples on chin	1
Defat neck	23
Neck lift	22
Myectomies contralateral platysma bands	3
Platysma strip to enhance neck contour	2

VII–VII, contralateral marginal mandibular branch–to–ipsilateral facial nerve transfer.

Postoperative videos were available in 122 of 144 patients with additional surgery, 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: before secondary surgery and after secondary surgery (Table 7). In cases with more than one stage of revisions, the videos obtained preoperatively and after the last set of revisions were evaluated. Panelists were blinded to patients' characteristics and interventions undertaken. Cronbach's α was computed for internal consistency of the evaluating tool (preoperatively, $\alpha = 0.97$; postoperatively, $\alpha = 0.93$).

Using as the evaluating instrument a five-category scale ranging from poor to excellent results in a skewed distribution that obliges use of nonparametric analysis. However, nonparametric analysis is less sensitive in small-sized groups and thus the more powerful t test was computed following normal standardizing of the data set by conversion of x values to z values by the transformation [$z = (x - \text{mean})/\text{SD}$].[23–25] After transformation of the data into a near-normal distribution, the Shapiro-Wilk test was computed on paired data from all treatment groups sized $n = 17$ or larger, and no evidence of nonnormality was found. To measure the effect of additional surgery on functional and aesthetic outcomes, postoperative gains were computed using a percentage gain score (mean and SD). One-way analysis of variance was computed for comparison of three or more groups managed with different corrective techniques. Unpaired t test and one-way analysis of variance compared two or more groups, respectively. Statistical analysis was performed using GraphPad InStat version 3.00 (GraphPad Software, Inc., San Diego, Calif.) and SPSS version 14.0 (SPSS, Inc., Chicago Ill.).

Fig. 8. Lower face reconstruction in case 8. This 44-year-old woman consulted our center with right-sided facial paralysis following complete resection of cholesteatoma. (*Above*) Preoperative visit. During the first-stage of reconstruction, along with the placement of three cross-facial nerve grafts, the hypoglossal nerve was coapted in an end-to-side manner to the right cervicofacial branch. During the second stage, she underwent secondary microcoaptations, face lift, and dermal fat graft to the chin. The hypoglossal-to-cervicofacial transfer satisfactorily corrected her depressor dysfunction and no further interventions were needed. (*Below*) Functional and aesthetic results on the lower face at the 1-year follow-up visit. The panel of observers graded her depressor function as moderate before secondary surgery and excellent following secondary surgery.

Table 7. 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

RESULTS

Upper Face

Of 122 patients in the study group, 98 received at least one procedure for eye management or upper face aesthesis. These 98 cases were grouped according to the secondary interventions undertaken (Table 8). For each corrective mode, a mean percentage gain was calculated comparing preprocedure and postprocedure scores. To variable degrees, ocular symptomatology improved in all patients. Irrespective of the muscle flap used (one-way analysis of variance, $p = 0.4732$), orbicularis substitution adequately restored eye closure and corneal protection in most of the patients, with a significant increase in postoperative averaged scores (Table 8). Physiologic sphincter substitution required secondary revisions at a later stage. Five muscle flaps were tightened and two needed debulking (Table 4). Middling results from orbicularis substitution were upgraded with an eye spring in four patients, and in five cases, the lower eyelid was tightened with a minitendon graft (Table 4).

Fifteen of 19 eye springs (79 percent) required adjustments, and seven (37 percent) were removed at a later stage. Of the 11 gold weights implanted, two were exchanged to a lighter load and one was removed. Used exclusively or in combination with other techniques, minitendon graft was the most common procedure in eye management.[18] Of 46 mini-tendon transfers in this series, 21 needed tightening (46 percent) and one needed loosening. All but one of the treatment-based groups attained significantly higher averaged scores after secondary surgery (Table 8). Of 98 cases with eye interventions, the panel of observers graded 35 percent as good results and 56 percent as excellent results.

Table 8. Mean Percentage Gain Scores before Versus after Secondary Surgery with Different Revisional and Ancillary Procedures to the Upper Face*

Procedures for Eye	No. of Patients	Percentage Gain Score before and after Revision	p (Normalized Data, Dependent t Test)
Pedicled frontalis transposition	7	69 ± 63	0.001†
Pedicled temporalis transposition	3	37 ± 5	0.0198†
Free platysma transfer	3	166 ± 115	0.0198†
Free extensor digitorum brevis transfer	2	117 ± 25	0.0304†
Free regional gracilis transfer	3	90 ± 42	0.0168†
Direct neurotization or VII–VII transfer	16	28 ± 19	0.0002†
Direct neurotization or VII–VII transfer and eye spring and minitendon	10	52 ± 44	0.0012†
Direct neurotization or VII–VII transfer and gold weight and minitendon	8	54 ± 29	0.0006†
Direct neurotization or VII–VII transfer and eye spring	4	70 ± 46	0.0007†
Direct neurotization or VII–VII transfer and minitendon	16	31 ± 29	<0.0001†
Eye spring and minitendon	4	87 ± 76	0.0054†
Gold weight and minitendon	2	66 ± 47	0.126
Eye spring	4	34 ± 10	0.0022†
Minitendon	4	31 ± 16	0.0313†

VII–VII, contralateral eye facial nerve branch–to–ipsilateral facial nerve transfer.
*Sample evaluated: 122 patients, of whom 98 had at least one procedure for eye function or upper face symmetry. In this table, 86 of these 98 patients are accounted for. The remaining 12 patients had free occipitalis ($n = 1$), direct neurotization and gold weight ($n = 1$), direct neurotization and wedge excision ($n = 1$), direct neurotization and lateral canthoplasty ($n = 1$), exclusively lateral canthoplasty ($n = 2$), exclusively medial canthoplasty ($n = 1$), wedge excision ($n = 4$), or gold weight and wedge excision ($n = 1$).
†Statistically significant.

Midface

In the study group, 86 patients received at least one additional revisional or ancillary intervention for function or symmetry improvements. In the midface, it proved difficult to group patients by the additional procedure used because most of the patients had a combination of techniques. Table 9 lists the most common procedures used in the midface, but a salutary effect must be assumed on computation of postoperative gains.

Mini-temporalis transposition for augmenting moderate results of a free-muscle transfer[21] yielded greater postprocedural gain than reanchoring or plication of the free-muscle transfer (Table 9). Platysma transposition to the contralateral commissure to counteract excessive pull from the transferred muscle fared better than selective myectomies and with less risks associated (superior averaged percentage gain and significantly higher postintervention mean scores) (Table 9). Cheek and free-muscle debulking, cheiloplasty, and static tendon/fascia slings were often needed, and all yielded significant improvements to the overall symmetry of the midface. Of 86 patients

Table 9. Mean Percentage Gain Scores before Versus after Secondary Surgery with Different Revisional and Ancillary Procedures to the Midface*

Procedures for Smile	No. of Patients	Percentage Gain Score before and after Revision	p (Normalized Data, Dependent t Test)
Reanchor free-muscle transfer	17	53 ± 43	0.0001†
Mini-temporalis transposition to augment free-muscle outcomes	13	72 ± 83	0.0001†
Plication free-muscle transfer	3	33 ± 27	0.1125
Static tendon or fascia sling to support upper lip/commissure	14	40 ± 39	<0.0001†
Platysma transposition to oral sphincter to counteract excessive pull	7	41 ± 16	<0.0001†
Selective free-muscle transfer myectomy to counteract excessive pull	3	33 ± 18	0.0528
Debulk free-muscle transfer	20	55 ± 63	<0.0001†
Cheiloplasty/cheilotomy	25	51.7 ± 68	<0.0001†

*Sample evaluated: 122 patients, of whom 86 had at least one procedure for smile function or midface symmetry. In the midface, a combination of several revisional interventions was the norm; thus, an interaction effect must be acknowledged.
†Statistically significant.

with revisions to the midface, 35 percent were graded as having good results and 42 percent were rated as having excellent results.

Lower Face

Seventy-two patients in the study group received at least one intervention for depressor restoration. Patients were readily grouped according to the reconstructive technique (Table 10). Digastric transposition was undertaken in patients in whom the platysma muscle was not usable. No significance was found when comparing postrevision scores between both groups (unpaired *t* test, $p = 0.0579$), yet greater mean percentage gain was noted with digastric transfer (Table 10). At a later stage, two platysma flaps needed tightening and one digastric case needed loosening. Three platysma and two digastric transfers resulted in moderate results and were complemented with contralateral myectomy.

In cases of a dysfunctional depressor, neural rehabilitative techniques such as direct neurotization, contralateral buccal branch–to–ipsilateral facial nerve transfer, or hypoglossal-to-cervicofacial transfer yielded a significant functional enhancement (with postoperative mean percentage gain ranging from 40 to 74 percent) (Table 10). Of 72 patients with revisions of the lower face, 34 percent were categorized as good results and 31 percent were categorized as excellent outcomes.

DISCUSSION

As a rule, dynamic muscle substitution of any deprived function (that of the eye, oral sphincter, or the depressor mechanism), paced by the contralateral seventh nerve, fares better than any neural or static reconstruction. Superiority of outcomes is achieved at the expense of a greater likelihood of revisions. Secondary surgery is equally needed in both adult and pediatric populations, yet aging is associated with a greater chance of additional procedures in the long term. Some ancillary or revisional techniques are best suited to adult patients. For instance, compliance with eye springs is better in adults than in children. However, age can be a limiting factor for certain techniques, and a shorter rehabilitation might be a priority over best possible outcomes in a significant number of adults.[26] Old age renders the patient incapable of cortical plasticity and therefore less complex reconstructive strategies make coherent sense in this group.[27,28]

In all three facial regions, a variable postintervention mean percentage gain was seen among different technique-based categories. Nevertheless, comparison of postintervention mean scores by different techniques used for correcting one specific deformity yielded no significance. However, the latter analysis may not be representative of the true difference among treatment modes, because preintervention scores varied greatly (as illustrated by the large standard deviation percentages). This is particularly true when patients suffering from partial and complete paralysis are evaluated together in a case series study. Partial paralysis patients are likely to start from a higher score than total paralysis cases. They are also likely to undergo fewer procedures and often need a less complex reconstruction. Therefore, the authors find the comparison of preintervention and postintervention mean scores— rather than the measure of averaged percentage gain—more informative of the actual effect of secondary surgery.

Table 10. Mean Percentage Gain Scores before Versus after Secondary Surgery with Different Revisional and Ancillary Procedures to the Lower Face*

Procedures for Depressor	No. of Patients	Percentage Gain Score before and after Revision	*p* (Normalized Data, Dependent *t* Test)
Pedicled digastric transposition	17	127 ± 95	<0.0001†
Pedicled platysma transposition	17	80 ± 59	<0.0001†
Direct neurotization or VII–VII transfer	21	74 ± 56	<0.0001†
Direct neurotization or VII–VII transfer and contralateral myectomy	3	134 ± 72	0.0568
Direct neurotization or VII–VII transfer and plication ipsilateral depressor	2	40 ± 29	0.1109
End-to-side transfer of hypoglossal to facial cervicofacial branch	8	65 ± 28	0.0002†
Contralateral myectomy	4	85 ± 17	0.019†

VII–VII, contralateral marginal mandibular branch–to–ipsilateral facial nerve transfer.
*Sample evaluated: 122 patients, of whom 72 had at least one procedure for depressor restoration. All 72 patients are accounted for in this table.
†Statistically significant.

Five of 20 cases of orbicularis oculi substitution needed tightening, and four were complemented with an eye spring. This is a cautionary tale of the importance of overcorrection in dynamic reconstruction. Other investigators have emphasized this.[29,30] The potential drawback of synkinesis in territorial muscle transfer is well documented.[31,32] Careful identification of facial nerve branches using intraoperative microstimulation techniques helps prevent this occurrence. Of three patients in this series with segmental gracilis transfer for upper and midface reanimation, no synkinetic movements were apparent in any of the cases at 1-, 2-, and 5-year follow-up, respectively.

In the midface, when presented with moderate results from the free-muscle transfer, the efficacy of reanchoring and tightening the muscle graft to augment function has been overstated.[6] In our center, adding a second muscle unit, the mini-temporalis, has yielded effective, reliable, and reproducible results.[21] Secondary surgery is safely undertaken, provided that detailed information from previous stages is available. The importance of keeping detailed operative records (notes, drawings, pictures, and videorecordings), which document the position of the cross-facial nerve grafts and vessel anastomosis, cannot be overemphasized.

It is hoped that this study will stimulate multicenter collaboration so that evidence-based algorithms on corrective strategies can be produced in the future. Toward this effort, Figures 9 through 11 represent experience-based methodology at our institution.

CONCLUSIONS

Revisional and ancillary techniques efficiently compensate for common infirmities of dynamic reanimation, and allow for a panfacial restoration of function and symmetry. This conclusion is corroborated by the reproducible functional and aesthetic improvements observed in the study sample.

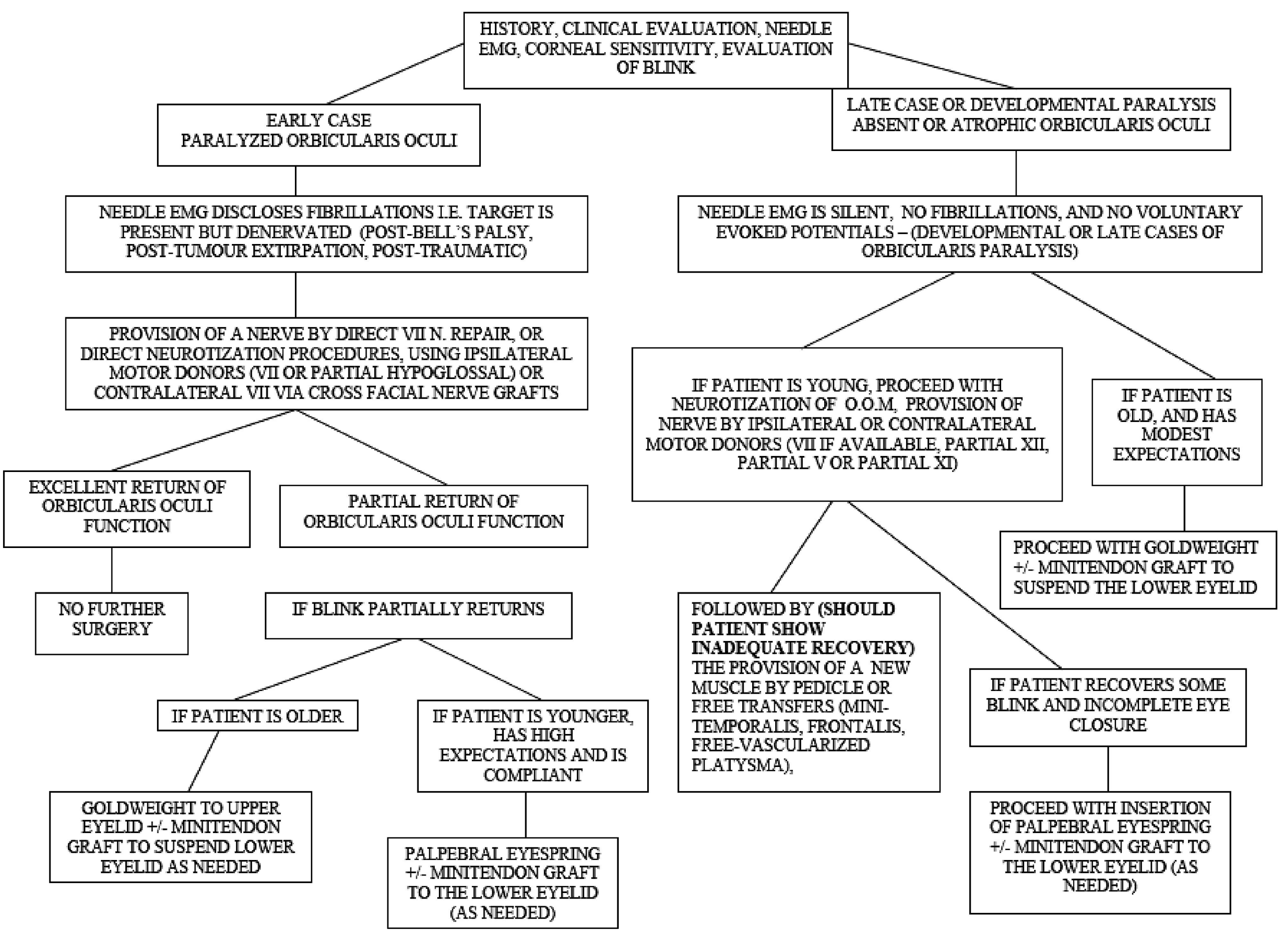

Fig. 9. Management algorithm for upper face revisional and ancillary interventions.

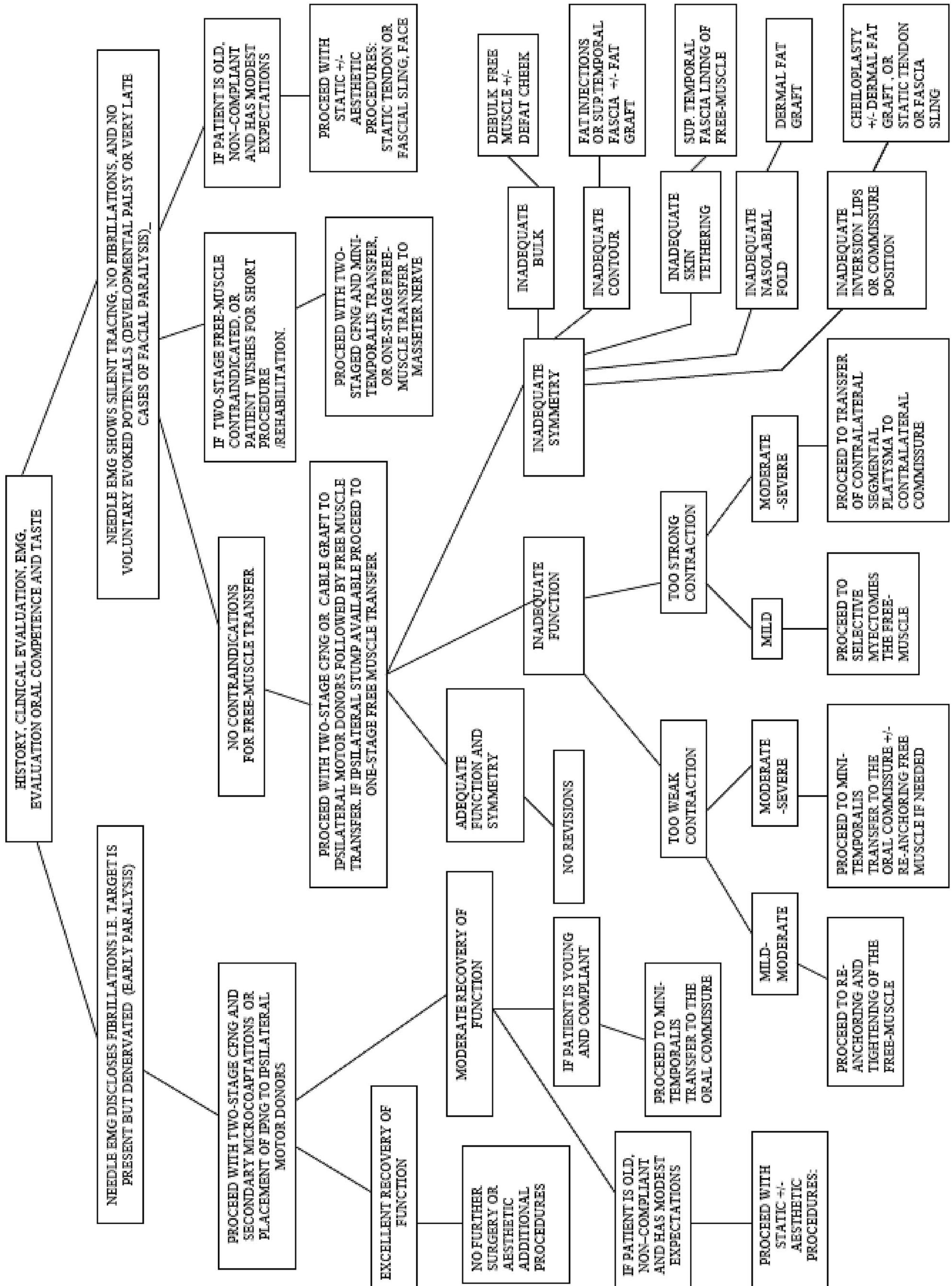

Fig. 10. Management algorithm for midface revisional and ancillary interventions.

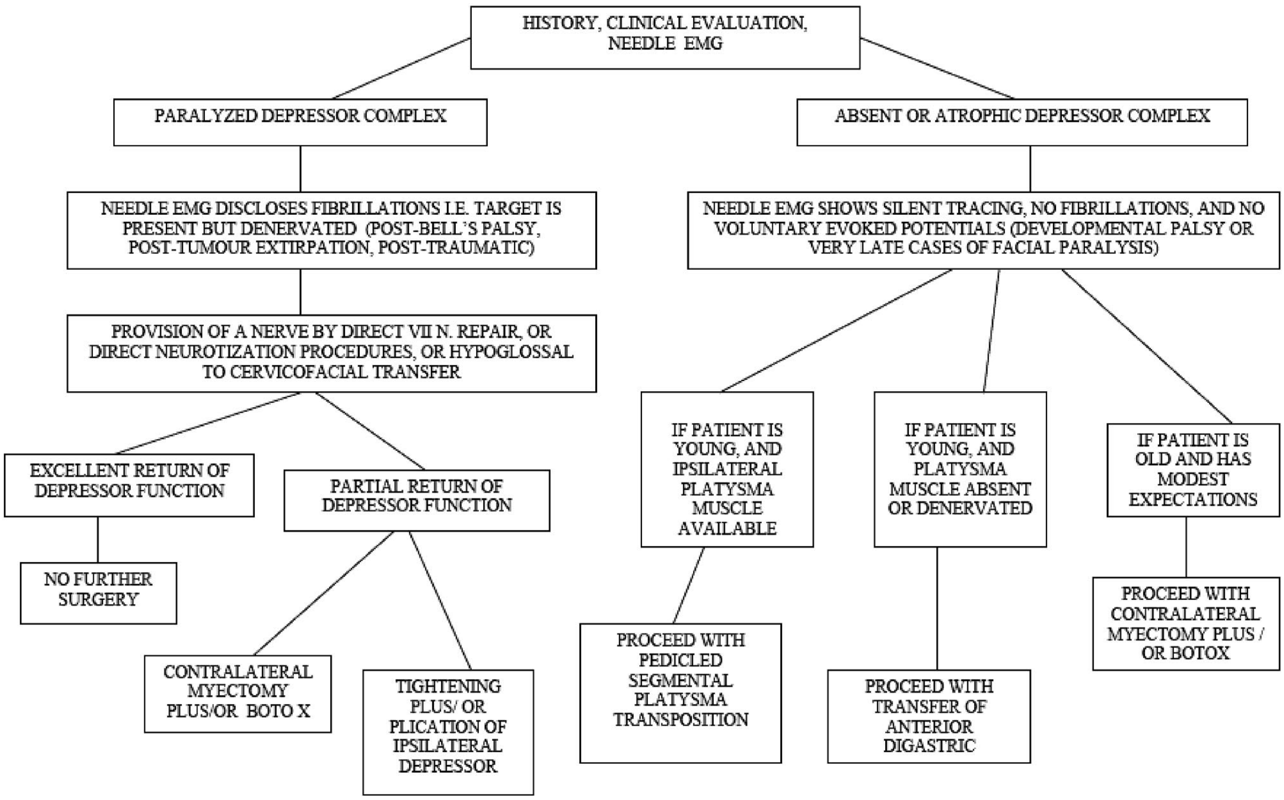

Fig. 11. Management algorithm for lower face revisional and ancillary interventions.

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