"Dynamic reconstruction of facial paralysis in craniofacial macrosomia"

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Short running head: Facial paralysis reconstruction in craniofacial microsomia

ABSTRACT

Background:

Craniofacial microsomia (CFM) is associated with maxillomandibular hypoplasia, microtia, soft tissue deficiency, and variable severity of cranial nerve dysfunction, most commonly of the facial nerve. This study evaluated the incidence of patients with CFM and facial paralysis and their outcomes following free functioning muscle transfer for dynamic smile reconstruction.

Methods:

A single center, retrospective cross-sectional study was performed from 1985-2018 to identify pediatric patients with CFM and severe facial nerve dysfunction who underwent dynamic smile reconstruction with free functioning muscle transfer (1985-2018). Pre- and post-operative facial symmetry and oral commissure excursion during maximal smile were measured using photogrammetric facial analysis software.

Results:

This study included 186 patients with CFM; 41 patients (22%, 21 males; 20 females) had documented facial nerve dysfunction, affecting all branches (51%) or the mandibular branch only (24%). Patients with severe facial paralysis (n = 8) underwent midfacial (smile) reconstruction with a free functioning muscle transfer neurotized either with a cross face nerve graft (n = 7) or with the ipsilateral motor nerve to masseter (n =1). All patients achieved volitional muscle contraction with improvement in symmetry and oral commissure excursion (median 8 mm, IQR 3-10 mm). The timing of orthognathic surgery and facial paralysis reconstruction was an important consideration in optimizing patient outcomes.

Conclusions:

Our institution's incidence of facial nerve dysfunction in children with CFM is 22%. Free functioning muscle transfer is a reliable option for smile reconstruction in children with CFM. To optimize outcomes, a novel treatment

algorithm is proposed for CFM patients likely to require both orthognathic surgery and facial paralysis reconstruction.

INTRODUCTION

Craniofacial microsomia (CFM) is the second most common craniofacial anomaly with an estimated incidence of 1 in 5,600 live births.[1] First described in 1861, CFM is characterized by dysgenesis of the first and second branchial arches resulting in ipsilateral hypoplasia of the facial skeleton (mandible, maxilla, zygoma, and/or temporal bone), auricle, facial musculature, and subcutaneous tissues, with bilateral features in 5-30% of cases.[2-6] In addition to the classic soft tissue and skeletal findings of CFM, cranial nerve anomalies may be present, most commonly of the facial nerve. Facial nerve dysfunction has been reported in 10-45% of cases, with involvement ranging from single branch paresis (most commonly of the marginal mandibular branch) to complete hemifacial paralysis.[7, 8]

The management of patients with CFM has focused most commonly on addressing the maxillomandibular hypoplasia, auricular deformity, and soft tissue deficiency with multiple stages of orthognathic surgery, auricular reconstruction, and free tissue transfer or autologous fat grafting.[9-12] Despite the occurrence of facial nerve dysfunction, published reports regarding the management and outcomes of CFM patients with facial paralysis are limited. Other than reports of direct muscular neurotization with a cross face nerve graft (CFNG) from the contralateral intact facial nerve, to our knowledge, there is only one published series of dynamic smile reconstruction in this population and no quantitative outcomes were reported.[13-15]

The objective of this study was to evaluate the incidence of facial nerve involvement in patients with CFM and to report the experience of a single pediatric institution's surgical outcomes of free functioning muscle transfer for smile reconstruction in patients with CFM and facial paralysis. The primary outcome measure was commissure excursion of maximal voluntary smile using a computer-based facial analysis software. Secondary objectives were to describe the incidence of facial nerve dysfunction in CFM and to evaluate the timing of facial paralysis reconstruction.

METHODS

A retrospective cross-sectional study was conducted at the Hospital for Sick Children (Toronto, Canada) of patients with a diagnosis of craniofacial microsomia or Goldenhar syndrome under 20 years of age treated between

1985-2018 in the Division of Plastic and Reconstructive Surgery. All patients with CFM and unilateral or bilateral facial nerve dysfunction who underwent dynamic smile reconstruction with free functioning muscle transfer were included in the study. All smile reconstruction procedures were performed by one or both of the two senior authors (R.M.Z, G.H.B). Exclusion criteria included patients with isolated microtia, concurrent diagnoses of other craniofacial syndromes, and children who underwent static facial procedures only.

Using the Hospital for Sick Children's Craniofacial Microsomia Database, children with CFM and facial nerve dysfunction were identified to determine the incidence of facial nerve involvement. The Hospital for Sick Children's Facial Paralysis Database (1985-2019) was concomitantly reviewed and cross-referenced to identify patients with CFM and severe facial paralysis who underwent dynamic reconstruction of facial paralysis with free functioning muscle transfer.

Data were collected on patient demographics, details of facial nerve dysfunction, surgical interventions including skeletal and soft tissue reconstruction, and outcomes data. Facial nerve dysfunction was classified using the OMENS Classification for craniofacial microsomia: orbital distortion, mandibular hypoplasia, ear anomaly, nerve involvement, and soft tissue deficiency.[5] Outcomes data included post-operative complications, clinical measurements of commissure excursion, and pre- and post-operative 2D frontal face photographs of repose and maximal smile. All photographs were obtained by a medical photographer with standardized head position, lighting, and neutral background with informed written consent. Lower face symmetry and oral commissure excursion during maximal voluntary smile effort were quantified using the Massachusetts Eye and Ear Infirmary (MEEI) FACE-Gram facial analysis software by comparing pre- and post-operative photographs. The MEEI FACE-Gram is a user-friendly, freely available, commonly used, and clinically validated computer software program that provides quantitative objective analysis of facial features from a single high-resolution frontal view of the patient's face.[16-22] Facial features are scaled in reference to the iris diameter (corneal white-to-white diameter), which is conserved at 11.71 ± 0.42 mm in humans from ages 5-80 years.[23] Following manual annotation of specific surface anatomical landmarks, MEEI FACE-Gram calculates the scaled distances between facial landmarks of interest. By comparing pre- and post-operative photographs in repose and maximal smile, dynamic measurements for philtral deviation, vertical lip asymmetry, and commissure excursion were calculated. Manual annotations and automatic calculations

were performed three times and the average value was used for each measurement of interest. The MEEI FACE-Gram measurements for oral commissure position pre- and post-facial paralysis reconstruction is illustrated in Supplemental Digital Content.

Institutional Research Ethics Board approval was obtained for a retrospective study of medical records and photographs. Results are reported in accordance with the STROBE checklist.[24] Descriptive statistics were used to summarize patient demographics, facial nerve characteristics, and OMENS classification. Non-parametric, paired statistical analyses were performed using two-tailed Wilcoxon-Rank Sum test with an alpha of 0.05 considered the threshold for statistical significance. Fisher's Exact test was used to compare the pre- and post-operative proportions of patients who had lower face asymmetry of the philtrum, upper lip, lower lip, and commissure. Asymmetry was defined as a greater than 3 mm difference in measurements of the ipsilateral and contralateral sides of the lower face, as the observed threshold of perception of facial asymmetry has been determined to be 3 mm.[25]

RESULTS

Of 211 patients in the Craniofacial Microsomia Database, 186 met the inclusion criteria and were reviewed for documentation of facial nerve involvement. Facial nerve deficits were reported in 41 patients (21 males; 20 females) for an incidence of 22%. Most patients had involvement of all facial nerve branches (21/41, 51%); in most of these patients (14/21, 67%), although all branches were involved, there was incomplete paralysis of the affected branches with some residual weak, faintly visible muscle contraction but no meaningful movement. In 7 of these patients (7/21, 33%), there was complete paralysis of all facial nerve branches with no visible muscle contraction or meaningful movement. The most commonly affected single branch of the facial nerve was the marginal mandibular branch (n = 10) (Table 1).

Eight patients (2 males; 6 females) with CFM and severe facial nerve dysfunction underwent dynamic smile reconstruction. Six of these eight patients had N3 nerve dysfunction as per the OMENS classification (all branches affected); of these six patients, four had complete paralysis of all the affected branches and two had incomplete paralysis with some residual faint muscle contraction of the affected branches but no meaningful movement (Table 2). Seven patients (median age 9 years, range 4 to 18 years) underwent two-stage facial paralysis reconstruction

with a cross face nerve graft (CFNG) from the contralateral functioning facial nerve, followed by gracilis free functioning muscle transfer 6-12 months later. One patient (17 year old female), who was referred to us after a failed previous CFNG performed at an outside center, underwent a single stage masseteric nerve transfer to a free functioning gracilis muscle. No patients required preoperative CT angiography for facial vessel visualization and intraoperatively there were no complications related to vessel anatomy or caliber. The overall timing of gracilis free functioning muscle transfer in relation to other procedures in this patient series is shown in Table 2.

There were no post-operative complications following smile reconstruction surgery. In two patients, post-operative photos were not available for MEEI FACE-Gram analysis and values from manual clinical measurements for commissure excursion as described by Manktelow et al. were used for analysis.[26] After a minimum of one year following surgery, 7 of 8 patients returned for follow up and demonstrated volitional muscle contraction with improvement in oral commissure excursion (median 8 mm, IQR [3 mm, 10 mm]) (Table 3, Figure 1). Seven patients had preoperative measurements and six patients had postoperative measurements for lower face symmetry. Although the proportion of patients with asymmetry of greater than 3 mm of the philtrum, upper lip, lower lip, and commissure decreased following surgery, this did not meet the predetermined statistical threshold of significance of 0.05 (Figure 2).

The overall timing of gracilis free functioning muscle transfer in relation to other procedures is shown in Table 2. Three cases are presented below highlighting the use of motor nerve to masseter neurotization of a gracilis free functioning muscle transfer, as well as the considerations involved in timing of facial paralysis reconstruction relative to orthognathic surgery.

Patient 4

A 17 year old female with left craniofacial microsomia and previous autogenous ear reconstruction was referred for facial paralysis after a failed attempt at CFNG at an outside institution. Preoperatively, the oral commissure excursion was 5 mm. She underwent a single stage gracilis free functioning muscle transfer with neurotization by the ipsilateral motor nerve to masseter. She subsequently returned to her outside institution.

Although she successfully achieved commissure excursion, quantitative measurements were not available and she was subsequently lost to follow up.

Patient 5

A 17 year old female with right craniofacial microsomia who previously underwent cleft lip repair, cleft palate repair, and autogenous ear reconstruction presented at age 13 years with incomplete right facial paralysis. She had good eye closure but no forehead elevation and lateral commissure deviation of 4 mm with no upward excursion, compared to commissure excursion of 20 mm on her unaffected left side. She underwent staged facial paralysis reconstruction at age 18 years with a CFNG followed by gracilis free functioning muscle transfer. At two year follow up, she had excellent symmetry at rest and had spontaneous commissure excursion with smiling. At age 24 years, she sought dentofacial reconstruction for Class III malocclusion, maxillary retrusion, and right maxillary deviation. She was referred to the craniofacial team who felt she would benefit from a LeFort I maxillary advancement osteotomy. Significant discussion was undertaken between the original facial reanimation surgeon and the craniofacial surgeon regarding the risk of this procedure to cause iatrogenic injury to the tunnelled CFNG in the upper gingivobuccal sulcus as well as the anchored gracilis muscle transplant. As maintaining her smile was of great importance to the patient, and in light of the concerns of temporary or permanent downgrading of function of her smile reconstruction, the craniofacial team felt she was not a good candidate for LeFort I maxillary osteotomy. The orthodontic and orthognathic plans were adjusted to avoid maxillary disruption. She subsequently underwent compensatory mandibular setback with bilateral sagittal split osteotomy and reduction genioplasty with excellent improvement in her concave facial contour. Five years after facial paralysis reconstruction, she had excellent spontaneous commissure excursion of 7 mm but did have a subtle delay in animation and mild synkinetic gracilis contraction with contralateral eye blink.

Patient 7

A 14 year old female with right craniofacial microsomia with incomplete right facial paralysis had been followed longitudinally. With animation, she had no nasolabial crease and -2 mm of commissure excursion,

compared to commissure excursion of 19 mm on her normal left side. She had right lateral cross bite and right mandibular angle recession, but eye closure, oral competence, and speech were all normal and she was not interested in surgery. At age 16 years, she expressed interest in smile reconstruction but this was delayed as the craniofacial team felt she would benefit from maxillary advancement and right vertical ramus lengthening prior to placement of a CFNG to avoid the risk of injury. She underwent pre-orthognathic treatment with orthodontics to improve her dental alignment and subsequently decided not to opt for any skeletal surgery. At age 17 years, she underwent staged facial paralysis reconstruction with a CFNG and gracilis free functioning muscle transfer (Figure 3), followed by three sessions of autologous fat grafting to increase her soft tissue bulk. At 2 year follow up, she had 6 mm of spontaneous commissure excursion (Figure 3). Botulinum toxin was offered for her depressor imbalance but she declined.

DISCUSSION

Facial nerve dysfunction is relatively common in craniofacial microsomia (CFM). Reported incidences range from 10% to 45%, with several large series noting an incidence of 22-24%, which is consistent with our institution's incidence of 22% over the last 30 years.[5, 7, 8, 27-29] Although the marginal mandibular branch is the most common single branch affected, involvement of all facial nerve branches was present in 51%; among these patients, 33% had complete hemifacial paralysis. Consequent impairments in emotional expression, corneal protection, nasal airway patency, oral competence, and vocal articulation may have significant functional implications on quality of life.[30, 31]

Our findings support the safe and reliable use of free functioning muscle transfer (FFMT) to restore smile function in children with CFM and severe facial paralysis. All patients in our case series who returned for follow up had improved facial symmetry during smile with respect to philtrum, upper lip, and lower lip, as well as a median increase of 8 mm for commissure excursion.

Treatment algorithms for CFM have traditionally focused on addressing the ipsilateral mandibular hypoplasia and soft tissue anomalies with dental-skeletal realignment, auricular reconstruction, and soft tissue augmentation.[32-36] Publications discussing the role and timing of dynamic facial paralysis reconstruction in CFM

patients are very limited.[7, 8] Early reports in the 1990s suggested early postnatal intervention using direct muscle neurotization with a CFNG from the contralateral intact facial nerve.[13, 14, 37, 38] This strategy must be considered with discretion, given the possibility of developmental dysgenesis of the ipsilateral facial musculature, overlooking the possibility for spontaneous recovery, and the late presentation of these patients.[39-41] The largest retrospective case series of CFM was a multi-institutional collaboration reporting on the surgical interventions in 565 patients.[3] In this case series of eight patients, only two patients underwent surgical treatment for facial nerve dysfunction: one patient underwent a CFNG at age 15, and the other received gold weights for static correction of lagophthalmos. Outcomes of these surgical interventions were not discussed. Some authors have also described lower lip depressor animation with locoregional muscle flaps for CFM patients with isolated marginal mandibular paralysis.[42, 43]

To our knowledge, there is only one other report of FFMT for facial paralysis in CFM patients. Takushima et al reported eight CFM patients (6M:2F, mean age 14 years, range 7 to 29 years) who underwent either a staged CFNG with gracilis FFMT or a single stage latissimus dorsi FFMT.[15] Although the authors stated that all patients achieved symmetric balance, good facial tone at rest, and active muscle contraction, no quantitative outcome evaluation was performed. The authors concluded that FFMT was reliable for smile reconstruction and for improving facial contour irregularities but advised caution for potentially hypoplastic facial vessels during microvascular anastomosis. Interestingly, one adult patient underwent LeFort I maxillary osteotomy and bilateral sagittal split osteotomy at age 27, one year prior to latissimus dorsi transfer for smile reconstruction. Although it is not stated why smile reconstruction was delayed until such an advanced age, the authors advised performing orthognathic surgery prior to facial paralysis reconstruction to camouflage soft tissue deficits.[15]

At our institution, we typically perform staged smile reconstruction in children between ages 6 and 10 years with a staged CFNG and FFMT to promote social integration at the time of increased self-image in primary school. In contrast, children requiring orthognathic surgery typically undergo surgery in adolescence, at the time of skeletal maturity. It is critical to consider the impact of order for children requiring both surgeries, as may be the case in CFM. In our experience, it became apparent that performing a LeFort I maxillary osteotomy after facial paralysis reconstruction posed a significant risk of iatrogenic injury to the CFNG in the upper gingivobuccal sulcus, which is tunneled just anterior to the cleavage line of maxillary osteotomy (Figure 4). Furthermore, advancing the maxilla

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risks disrupting the length-tension relationship of the anchored gracilis muscle transplant at the modiolus. In contrast, delaying facial paralysis reconstruction until late adolescence after skeletal maturity and orthognathic surgery could have deleterious psychosocial repercussions for children with functional impairment.

In two patients, orthognathic surgery was considered, and the benefits and risks of proceeding were crucial to analyze in the context of previous or anticipated facial paralysis reconstruction. In one patient, LeFort I maxillary osteotomy was deferred for fear of injuring a functioning CFNG, and she thus underwent mandibular setback and reduction genioplasty to improve her concave dentofacial profile. In another patient, smile reconstruction was delayed in anticipation for orthognathic surgery to be done first; ultimately, the patient was happy with orthodontic alignment, declined orthognathic surgery, and proceeded with smile reconstruction.

Although our preference is to use a CFNG from the contralateral intact facial nerve to optimize spontaneous emotional expression, using the motor nerve to masseter for neurotization of a free muscle transplant may be an alternative option in CFM patients. One patient in this series was referred to us from an outside institution after a failed CFNG. She underwent single stage gracilis free functioning muscle transfer innervated by the motor nerve to masseter and successfully gained commissure excursion. Using the motor nerve to masseter provides robust axonal innervation, reliable commissure excursion, and may evade potential injury of a CFNG in the upper buccal sulcus during later orthognathic surgery; however, it carries a trade-off of questionable smile spontaneity and performing facial reanimation prior to orthognathic surgery also risks disrupting the length-tension relationship of the anchored gracilis muscle transplant with maxillary repositioning.

While a spontaneous smile is more likely achieved with CFNG from the contralateral face, outcomes may be less predictable than the motor nerve to masseter due to the long length for axonal regeneration across the CFNG [19]. Although the median improvement in commissure excursion was 8 mm, one patient improved by 22 mm and another improved by only 3 mm. This latter patient underwent dynamic smile reconstruction in the early 1990s and our technique for CFNG has since evolved to yield more consistent results, including using a larger donor buccal branch and minimizing the length of the CFNG.

Nonetheless, the major disadvantage of a CFNG unique to this CFM patient population is the risk of injury to the CFNG during later LeFort I maxillary exposure, osteotomy, and advancement, which may prompt some

surgeons to delay facial paralysis reconstruction until after orthognathic surgery. An alternative option is placement of the CFNG across the lower lip or in a submental tunnel, which would mitigate the risk of subsequent maxillary manipulation; however, this would require a longer distance for axonal regeneration, which could impair the axonal density that reinnervates the FFMT, and furthermore, it could result in similar iatrogenic risks for patients requiring future mandibular repositioning or genioplasty. The appropriate treatment decision will depend on the patient and his or her family, in consultation with the facial paralysis surgeons and craniofacial surgeons. A proposed treatment algorithm for CFM patients with facial paralysis likely to require both orthognathic surgery and facial paralysis reconstruction is shown in Figure 5. Given the low incidence of this specific patient population, the algorithm reflects a broad and general treatment approach that may be modified accordingly with increasing multicentre experience and with the development of newer techniques. For example, our institution is developing and refining techniques to enable reanimation of eyelid sphincter and lower lip depressor functions, and these may eventually be incorporated into the proposed algorithm. Of note, the bulk provided by a free muscle transplant may help camouflage the soft tissue deficiency, and further augmentation may be effectively achieved with serial sessions of autologous fat grafting.

Limitations of this study include a small sample size, cases with incomplete follow up or missing outcomes data, retrospective study design, and lack of patient reported outcomes. The study was not designed to analyze the association of facial nerve dysfunction with the presence and severity of other features of CFM, which has been previously investigated.[7] Furthermore, although the MEEI FACE-Gram is validated for use in facial paralysis, it may not be specifically validated for use in CFM patients. Future studies would be strengthened by utilizing multiple objective evaluation scales in addition to 2D photograph analysis, such as video capture, electrodiagnostics, and magnetoencephalography.

In conclusion, our study of facial paralysis in craniofacial microsomia reports an incidence of 22% of facial nerve dysfunction of variable severity, demonstrates that free functioning muscle transfer is an effective and safe means of smile reconstruction with a median improvement of 8 mm for commissure excursion, and underscores the importance of operative timing of orthognathic surgery and facial paralysis reconstruction to optimize patient outcomes by proposing a novel treatment algorithm.

Tables

Table 1. Demographics of facial nerve deficits in craniofacial microsomia database. OMENS classification for facial nerve dysfunction, N0: no facial nerve involvement; N1: upper facial nerve involvement (temporal and/or zygomatic branches); N2: lower facial nerve involvement (buccal, mandibular, and/or cervical branches); N3: all branches of facial nerve affected.

Characteristics	*n* (%)
Craniofacial microsomia patients	186
Patients with facial nerve deficits	41/186 (22%)
Male	21/41 (51%)
Female	20/41 (49%)
Goldenhar syndrome	13/41 (7.0%)
Laterality	
Unilateral	39/41 (95%)
Bilateral	2/41 (5%)
Branches affected	
All branches	21/41 (51%)
Complete paralysis (no visible muscle contractions)	7/21 (33%)
Incomplete paralysis (faint muscle contractions visible but no meaningful mimetic movement)	14/21 (67%)
Mandibular only	10/41 (24%)
Buccal only	6/41 (15%)
Buccal and mandibular	2/41 (5%)
Temporal and zygomatic	1/41 (2%)
Temporal, zygomatic, and mandibular	1/41 (2%)
OMENS Classification	
N0	n/a
N1	1/41 (2%)
N1/N2 mixed	1/41 (2%)
N2	19/41 (46%)
N3	21/41 (51%)

Table 2. Demographics and surgical details of patients who underwent free functioning muscle transfer. OMENS classification for facial nerve dysfunction, N0: no facial nerve involvement; N1: upper facial nerve involvement (temporal and/or zygomatic branches); N2: lower facial nerve involvement (buccal, mandibular, and/or cervical branches); N3: all branches of facial nerve affected. Severity refers to whether there was complete paralysis of the affected branches (no visible muscle contraction) or incomplete paralysis of the affected branches (faint visible muscle contraction but with no meaningful facial movement).

ID	Age	Side	Affected branches	OMENS	Severity	Surgery	Dates of Surgery	Complications	Surgeries Before	Surgeries After (Date of Surgery)
1	10M	L	All	N3	Complete	CFNG + gracilis	1986, 1988	None	-	Auricular reconstruction (simultaneous)
2*	4F	R	All	N3	Complete	CFNG + gracilis	1988, 1989	None	Auricular reconstruction	-
3	5F	L	T/B/M	N1/N2	Incomplete	CFNG + gracilis	1989, 1992	None	Tonsillectomy	-
4	17F	L	All	N3	Complete	MNTM + gracilis	2007	None	Auricular reconstruction, failed CFNG	-
5	18F	R	All	N3	Incomplete	CFNG + gracilis	2007, 2008	None	Cleft lip repair, cleft palate repair, auricular reconstruction	Bilateral sagittal split osteotomy of mandible, genioplasty (2013)
6	4F	L	All	N3	Incomplete	CFNG + gracilis	2012, 2013	None	Preauricular tag excision	Upper eyelid gold weight, otoplasty (2018)
7	17F	R	T/B/M	N1/N2	Incomplete	CFNG + gracilis	2015, 2016	None	-	Autologous fat grafting (2017, 2018)
8*	8M	R	All	N3	Complete	CFNG + gracilis	2017, 2018	None	Myringotomy	-

*Goldenhar syndrome; M, male; F, female; L, left; R, right; T, temporal; Z, zygomatic; B, buccal; M, mandibular; CFNG, cross face nerve graft; MNTM, motor nerve to masseter. Age indicates age at time of facial paralysis surgery.

Table 3. Quantitative digital facial analysis using MEEI FACE-Gram of affected side of face. Asterisk (*) indicates value was obtained from clinical note rather than FACE-Gram due to unavailability of frontal photograph. Patient 4 had successful commissure excursion but was lost to follow up and thus post-operative measurements of commissure position were not available. NR, not recorded. Δ, change. All values are measured from the midline.

ID	Age	Surgery	Commissure Position		Commissure Excursion	Change
			Neutral (mm)	Smile (mm)	(mm)	(mm)
1	10M	CFNG + gracilis	Pre: 25 Post: NR	Pre: 20 Post: NR	Pre: -5 Post: 2	7
2	4F	CFNG + gracilis	Pre: 18 Post: 18	Pre: 11 Post: 33	Pre: -7 Post: 15	22
3	5F	CFNG + gracilis	Pre: 22 Post: 22	Pre: 20 Post: 23	Pre: -2 Post: 1	3
4	17F	MNTM + gracilis	Pre: 20 Post: NR	Pre: 25 Post: NR	Pre: 5 Post: NR	--
5	18F	CFNG + gracilis	Pre: NR Post: 22	Pre: NR Post: 29	Pre: 0 Post: 7	7
6	4F	CFNG + gracilis	Pre: 29 Post: 29	Pre: 25 Post: 35	Pre: -4 Post: 6	10
7	17F	CFNG + gracilis	Pre: 28 Post: 29	Pre: 26 Post: 35	Pre: -2 Post: 6	8
8	8M	CFNG + gracilis	Pre: 22 Post: 23	Pre: 16 Post: 28	Pre: -6 Post: 5	11

Figures

Figure 1. Pre- and post-operative commissure excursion following dynamic facial paralysis reconstruction for craniofacial microsomia patients using the MEEI FACE-Gram (*n* = 7*)*. Commissure excursion increased significantly following facial paralysis reconstruction a median of 8 mm (IQR [3,10]). Note that Patient 4 was lost to follow up and post-operative commissure measurements were not available.
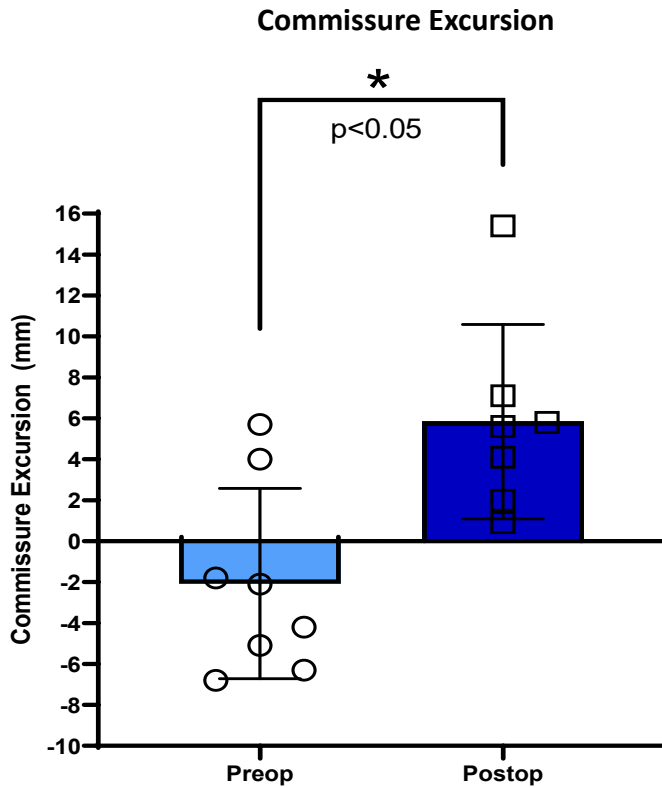
Commissure Excursion

$p < 0.05$

Figure 2. Proportion of patients with vertical asymmetry of the philtrum (A), upper lip (B), lower lip (C), and commissure (D) during smile. Asymmetry was defined as a greater than 3 mm difference in measurements of the ipsilateral and contralateral face, as the observed threshold of perception of facial asymmetry has been determined to be 3 mm.[25] The proportion of patients with asymmetry decreased for each parameter but this did not reach statistical significance (p>0.05). Note that preoperative measurements were not available for one patient and postoperative measurements were not available for two patients.
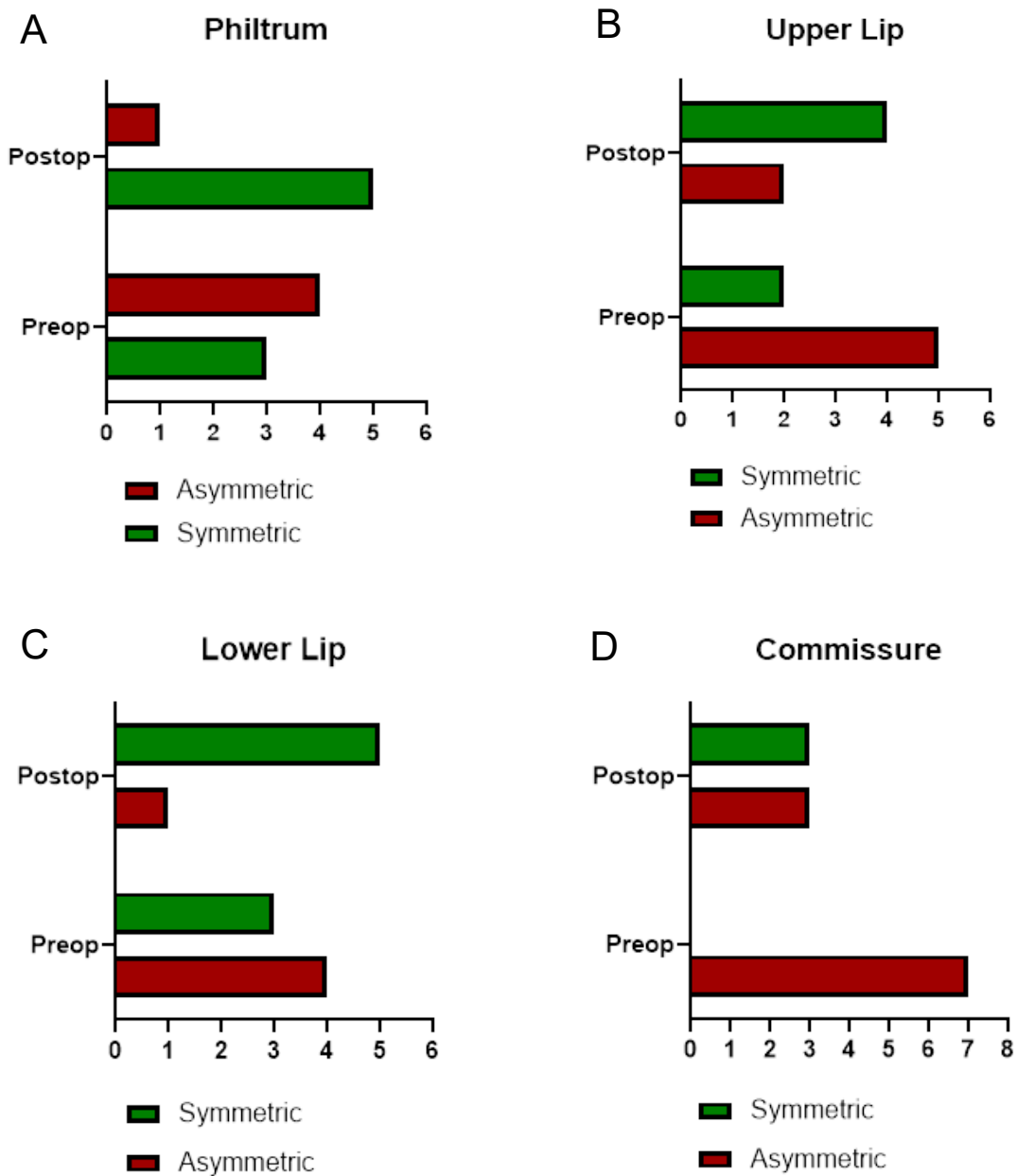
Figure 3. Pre-operative (A) and post-operative (B) frontal photographs of Patient 7 who underwent staged CFNG and gracilis free functioning muscle transfer. Preoperatively, her commissure excursion was -2 mm, indicating that her affected commissure was pulled towards the midline with animation. At 2 year follow up, she had 6 mm of commissure excursion with smile, representing an 8 mm improvement. She subsequently underwent two sessions of autologous fat grafting to augment her soft tissue bulk.

Figure 4. Exposure, osteotomy, and advancement of the maxilla via LeFort I osteotomy risks iatrogenic injury to the CFNG which is tunneled just anterior to the LeFort I osteotomy plane of the maxilla in the upper gingivobuccal sulcus. FN, facial nerve. CFNG, cross face nerve graft. Figure courtesy of Shirley Deng, BHSc.
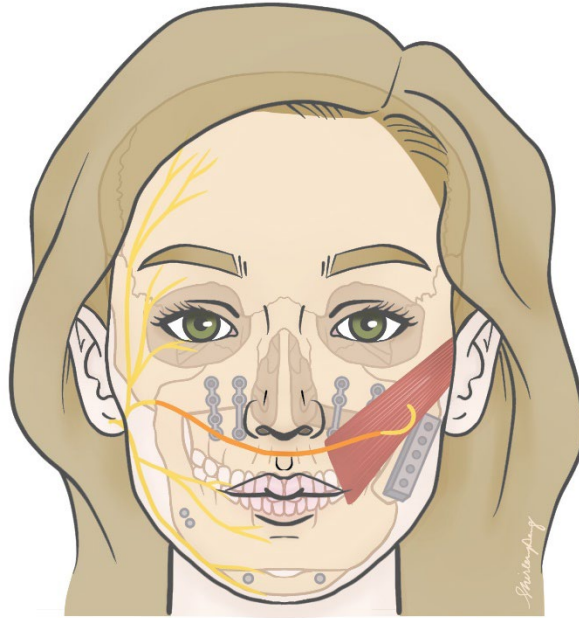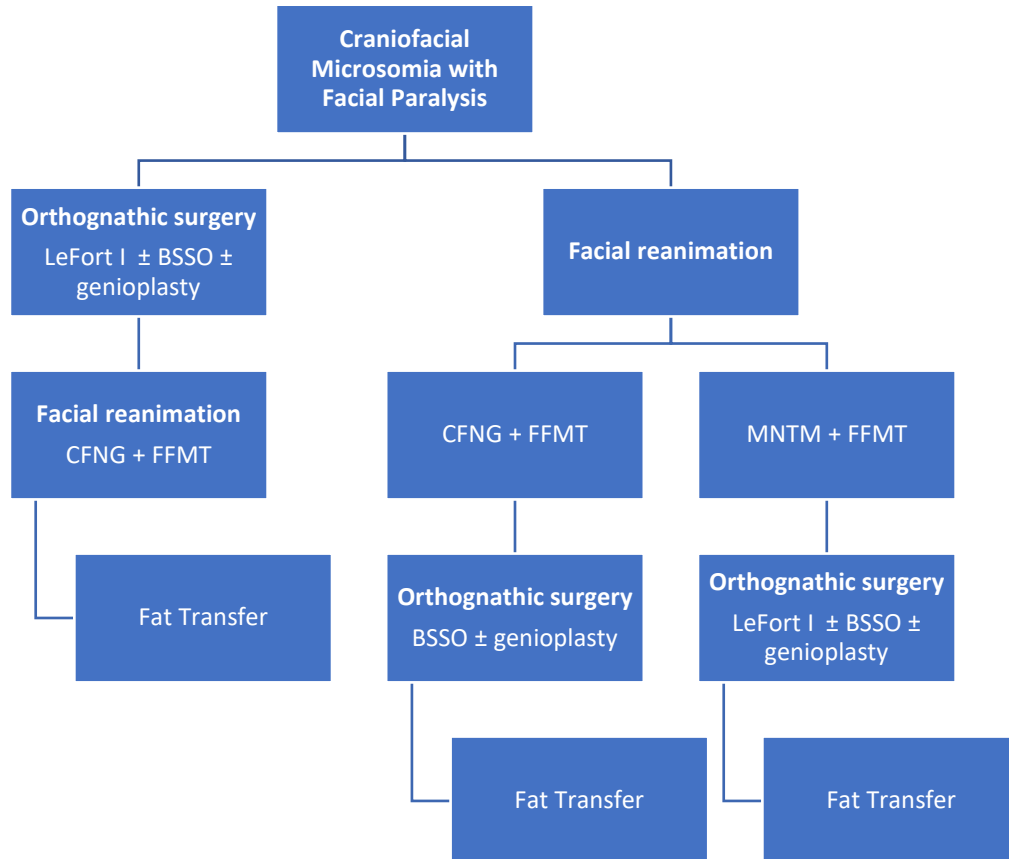
Figure 5. Proposed treatment algorithm for craniofacial microsomia patients with facial paralysis likely to require both facial paralysis reconstruction and orthognathic surgery. CFNG, cross face nerve graft; FFMT, free functioning muscle transfer; MNTM, motor nerve to masseter; BSSO, bilateral sagittal split osteotomy.

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