ORIGINAL ARTICLE

Free Gracilis Transfer for Smile in Children

The Massachusetts Eye and Ear Infirmary Experience in Excursion and Quality-of-Life Changes

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Background: Free muscle transfer for facial reanimation has become the standard of care in recent decades and is now the cornerstone intervention for dynamic smile reanimation. We sought to quantify smile excursion and quality-of-life (QOL) changes in our pediatric free gracilis recipients following reanimation.

Methods: We quantified gracilis muscle excursion in 17 pediatric patients undergoing 19 consecutive pediatric free gracilis transplantation operations, using our validated SMILE program, as an objective measure of functional outcome. These were compared against excursion measured the same way in a cohort of 17 adults with 19 free gracilis operations. In addition, we prospectively evaluated QOL outcomes in these children using the Facial Clinimetric Evaluation (FaCE) instrument.

Results: The mean gracilis excursion in our pediatric free gracilis recipients was 8.8 mm ± 5.0 mm, which matched adult results, but with fewer complete failures of less than 2-mm excursion, with 2 (11%) and 4 (21%), respectively. Quality-of-life measures indicated statistically significant improvements following dynamic smile reanimation ($P = .01$).

Conclusions: Dynamic facial reanimation using free gracilis transfer in children has an acceptable success rate, yields improved commissure excursion, and improves QOL in the pediatric population. It should be considered first-line therapy for children with lack of a meaningful smile secondary to facial paralysis.

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SINCE THE ADVENT OF FREE TISsue transfer for head and neck reconstruction 4 decades ago,[1,2] salient improvements in technique, instrumentation, and surgical magnification have dramatically improved tissue survival rates.[3-6] In dynamic free muscle transfer for facial reanimation, the transferred muscle enjoys relatively few vascular failures, likely because of the high-flow nature of muscle compared with other composite tissues.[7] However, adequate axonal ingrowth of the donor nerve into the recipient muscle has been unpredictable, particularly when driven by a cross-face nerve graft, and still carries a regrettably high failure rate.

While myriad muscles have been transferred into the face to restore the smile,[8-11] most large series describe the use of the gracilis muscle, the latissimus dorsi muscle, or the pectorals minor.[12-16] Of these, the gracilis muscle is the most widely used, based on predictable pedicle anatomy, an acceptable donor deficit and scar, and favorable muscle microarchitectural features resulting in fast and robust excursion when activated.

Decision-making for dynamic facial reanimation is multifaceted in the pediatric population, largely because parents and caretakers face the difficult dilemma of committing their children to operations whose failure rates have typically been in the 30% range, often without substantial input from the patients themselves. We sought to examine contemporary failure rates in our center for free tissue transfer for facial reanimation in the pediatric population, quantify average excursion of the oral commissure after muscle transfer, compare these data with our results in the adult population, and identify whether a quality-of-life (QOL) improvement might be demonstrated in patients 18 years or younger. These data were sought under the hypothesis that establishing a QOL benefit would help clinicians and families make more insightful decisions regarding surgery.

METHODS

PATIENTS

Over a 5-year period from October 2004 through September 2009, a total of 23 gracilis muscles were transferred in 21 patients 18 years or younger. Four patients were eliminated from the final analysis because full recovery time had not elapsed, thus providing 17 patients with 19 muscle transfers for final analysis. Nine muscles were transferred to

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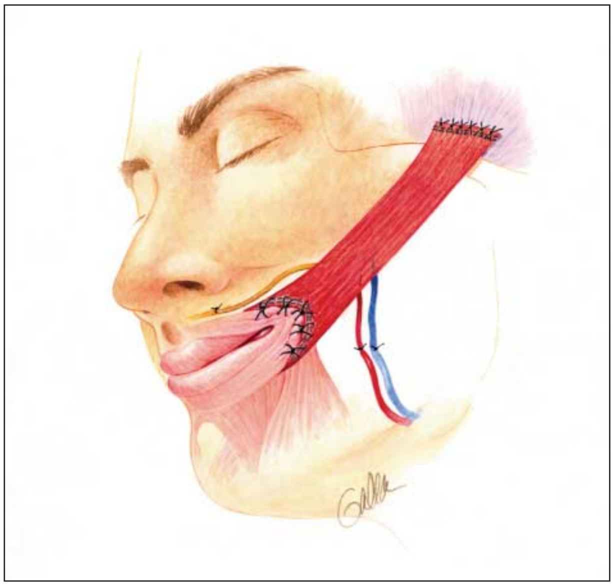

Figure 1. Gracilis muscle inset in 2-stage procedure for facial reanimation. Note that the neurorrhaphy is performed via an intraoral approach in the ipsilateral gingivobuccal sulcus.

the right side of the face and 10 to the left side. The mean age of the patients was 11.5 years (range, 4-18 years). All patients were prospectively administered the Facial Clinimetric Evaluation (FaCE) instrument,[17] a validated, standardized QOL instrument for patients with facial movement disorders. Patients were considered candidates for gracilis transfer if they had dense facial paralysis with no chance of spontaneous recovery, or following several years of observation after posterior fossa surgery in cases where potential spontaneous recovery did not occur. Etiologies of the paralysis varied and are as follows.

Cause	Patients, No. (%)
Idiopathic	1 (5)
Temporal bone fracture	1 (5)
Brain tumor	10 (47)
Chronic otitis media	2 (10)
Lymphatic malformation	1 (5)
Congenital	4 (18)
Neurofibromatosis	1 (5)
Iatrogenic (mandibular fracture repair)	1 (5)

This study was approved by the Massachusetts Eye and Ear Infirmary (Boston) institutional review board, and written informed consent was obtained.

SURGICAL PROCEDURE

Patients underwent free gracilis muscle transfer using previously described techniques.[5,12] Briefly, under general anesthesia with nasotracheal intubation, an initial incision was made from the temporal region, through a preauricular crease, extending adjacently to the angle of the mandible. A skin flap was elevated on the parotidomasseteric fascia, extending anteriorly to the modiolus. Facial or superficial temporal vessels were identified and preserved in preparation for revascularizing the flap. Simultaneously, a 20- to 40-g segment of gracilis muscle was harvested from the medial thigh, weighed, and passed to the facial field for inset. Donor neural input varied depending on clinical circumstances. In 13 patients, neural input was provided by the contralateral healthy facial nerve. This group underwent 2-stage reanimation, in which during the first stage a sural nerve graft was placed across the face (**Figure 1**). This

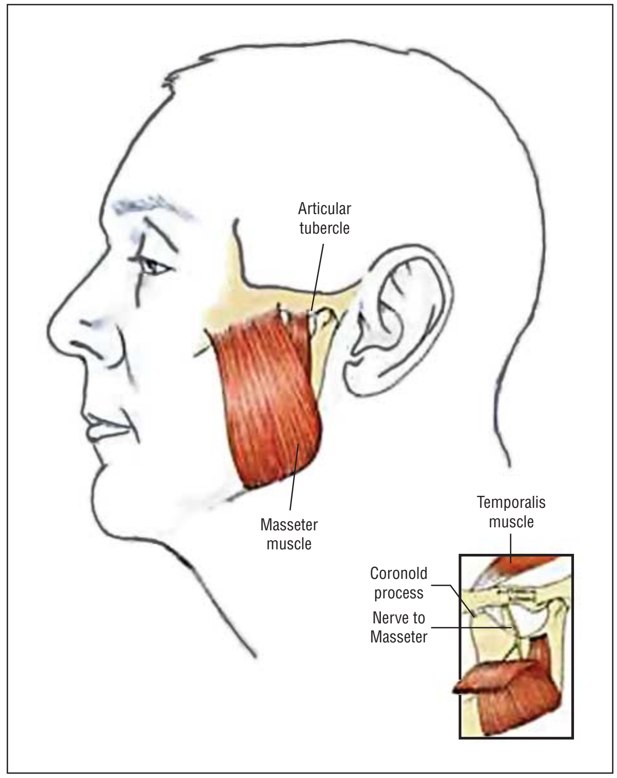

Figure 2. Schematic demonstrating location of the masseteric branch of the trigeminal nerve used during 1-stage gracilis muscle transfer for smile reanimation.

was followed 6 to 9 months later by muscle transplantation. In the other 6 cases, muscles were transplanted in a 1-stage fashion, using the trigeminal nerve as the donor neural source. The masseteric branch of the nerve was identified deep to the masseter muscle (**Figure 2**), divided, and reflected up toward the zygomatic arch for coaptation to the obturator nerve.

SMILE QUANTIFICATION

Postoperative photographs of the patients in repose and with smiling were analyzed for commissure excursion, using previously described methods.[16] Briefly, the degree of commissure was assessed in semiautomated fashion, using the FACE-gram program, version 1, developed in our Facial Nerve Center (**Figure 3**). Preoperatively, a resting still photograph and a photograph with the largest smiling effort were compared for the change in position of the oral commissure, related to smiling effort. Postoperatively, a similar determination of the change in commissure position between rest and smiling was performed. The smile improvement (Δz) was calculated as a ratio of preoperative to postoperative commissure excursion with smiling effort (Δ denotes the change in position, and z denotes the distance from oral commisssure to midline of the lower lip). We identified a consecutive cohort of 17 adult patients undergoing 19 muscle transfers over 2 years, overlapping the same time period as our pediatric study group. Their smile excursions and failure rates were examined in a fashion identical to that used in the pediatric cohort, for comparisons.

POSTOPERATIVE QOL ASSESSMENTS

When patients were determined to have a final result with respect to free gracilis function, a postintervention FaCE survey was administered. For children younger than 10 years, this was

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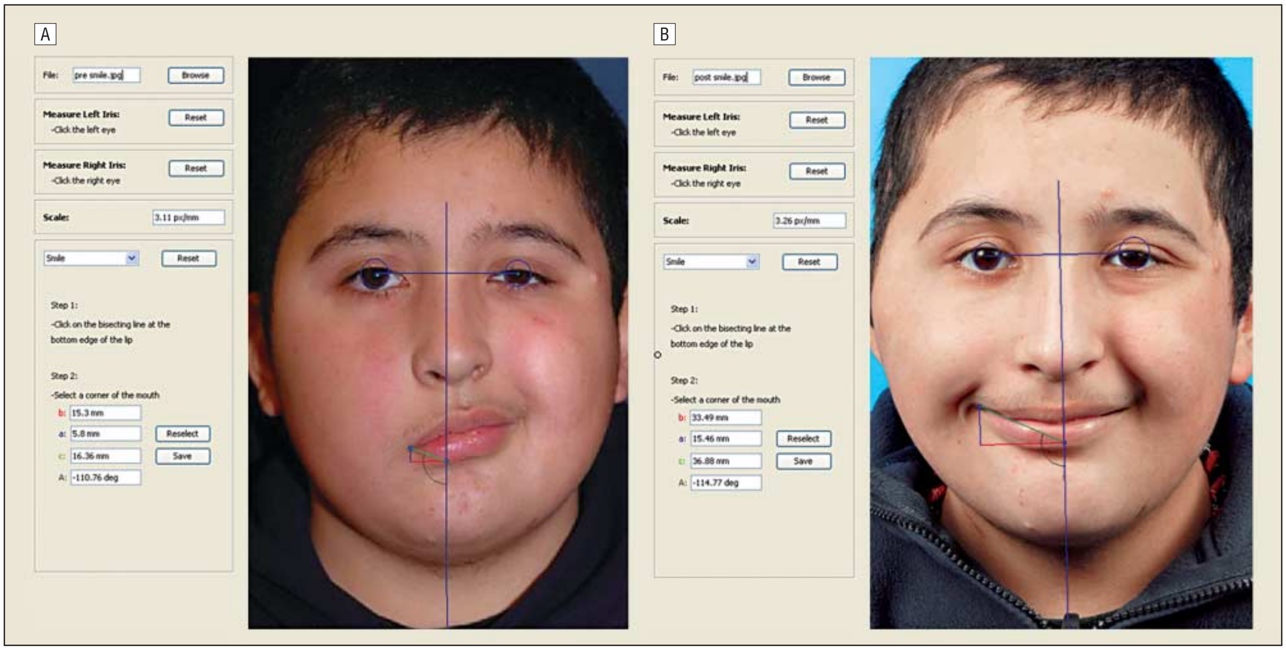

Figure 3. Computer interface for the FACEgram, version 1, developed at Facial Nerve Center, Massachusetts Eye and Ear Infirmary, Boston. Preoperative (A) and postoperative (B) photographs demonstrate commissure excursion during smiling.

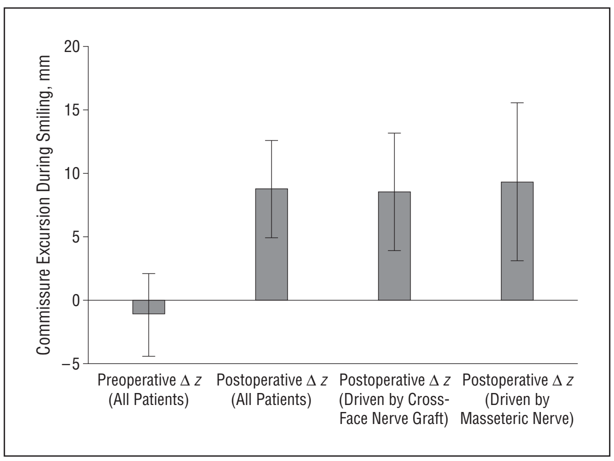

Figure 4. Average smile improvement following gracilis muscle transfer in pediatric patients. Improvement is defined by Δz, the difference in the amount of commissure excursion seen during smiling preoperatively and postoperatively. Error bars represent standard deviations.

accomplished with the assistance of a parent. For those undergoing 1-stage facial reanimation, plateau function was achieved in the 4- to 6-month range, although for 2-stage procedures, the final QOL assessment occurred after 12 to 18 months following the second surgical intervention.

STATISTICAL ANALYSIS

Both excursion data and QOL outcomes measures were analyzed in pair-wise fashion, using the *t* test to determine the statistical significance of any differences. Data were considered statistically significantly different with $P < .05$.

RESULTS

There were no serious intraoperative or perioperative complications, although there was a single arterial thrombosis recognized intraoperatively and revised. This occurred unilaterally in the only recipient of bilateral simultaneous free gracilis transfer for treatment of Möbius syndrome.[18] The patient was treated with intravenous (IV) heparin sodium, and treatment was subsequently converted to subcutaneous enoxaparin sodium for the ensuing 3 weeks. This muscle represented the single complete failure of the series, defined as no postoperative improvement in commissure excursion when position at rest and smiling were documented. We do not routinely use postoperative anticoagulation therapy, but it was used in a total of 3 patients secondary to intraoperative concerns for vessel spasm or small caliber. The single wound infection seen in this series was treated conservatively with IV antibiotics, and there were no gracilis donor site complications.

The mean commissure excursion improvement was 8.8 mm ± 5 mm (**Figure 4**), commensurate with the findings in other facial reanimation series.[19] When subdivided into those driven by a cross-face nerve graft vs those driven by the masseteric branch of the trigeminal nerve, the latter provided more excursion on average, as expected (Figure 4). Representative smiling results following free gracilis transfer in this pediatric series are shown in **Figure 5**. Of note, we did not see a notable degree of excessive bulk or inappropriately lateral vector pull, as is occasionally seen in our adult patients.

Thirteen patients completed both preintervention and postintervention FaCE surveys for final analysis. Comparisons of preintervention and postintervention FaCE scores in this age group rose from 51.3 to 65.7, demonstrating a statistically significant improvement ($P = .01$) in overall QOL following free gracilis transfer. While there were QOL improvements in both patients whose muscles were innervated by a cross-face nerve graft (average improvement in FaCE score, 12.9) and patients whose

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muscles were driven by the trigeminal nerve (average improvement, 17.7), the low numbers of patients in each cohort did not permit meaningful analysis of between-group differences.

COMMENT

The inability to express oneself via facial movement can have serious social consequences because it is the dominant nonverbal expression of happiness and contentment.[20] The additional functional and esthetic issues associated with facial paralysis[21] can be devastating to a child's development, or to their recovery following treatment for a central nervous system (CNS) tumor resulting in facial paralysis. Free tissue transfer for facial reanimation has been described for approximately 4 decades, although the operation has been plagued with inconsistent results, earning a reputation as an intervention that "doesn't work."[12]

Of note, globally there have been large series of seemingly impressive results following free tissue for facial reanimation, with reports from Japan, the United Kingdom, Europe, Canada, and the United States.[13-16,19,22,23] These reports gave credence to the fact that consistent results were possible but that the operation was likely sufficiently nuanced that subtle harvest, inset, and neural input and coaptation details were critical to achieving acceptable results. In our Facial Nerve Center, we have attempted to catalog these surgical details to identify factors important to the final outcome. As part of this endeavor, we have begun to examine cohorts of patients with respect to age, underlying disease, and comorbidities to see whether these variables affect smile outcome and/or QOL outcome. In this report, we present our 5-year experience with smile excursion and QOL in the pediatric population.

In this study, we found that the results following free gracilis transfer in the pediatric population essentially match those that we achieve in our adult population. Commissure excursion results are commensurate with those of other large series and likewise demonstrate more commissure excursion on average when performed in a single stage, using the trigeminal nerve.

We identified fewer failures, defined as a change in oral commissure excursion smaller than 2 mm, in our pediatric cohort (2 patients [11%]) compared with a similar cohort of adult cases (4 [21%]). We attribute 1 failure to arterial insufficiency despite revision arterial anastomosis and anticoagulation for intraoperatively recognized arterial thrombosis. There was no obvious explanation for the lack of success in the second failed muscle transfer. Because smaller vessel diameter is frequently encountered in younger patients, there is a theoretical increased risk of thrombosis for which anticoagulation may prevent failures.

Families with children affected by facial paralysis confront complex clinical decisions. Because these are young patients, usually with an excellent prognosis from a disease survival standpoint, it is critical that appropriate therapy be offered and executed in a way that results in the highest chance of long-term restoration of smile. Occasionally patients experience multiple cranial neuropathies from CNS manipulation, with balance and diplopia issues dominating. For this reason, providing a reconstructive modality that minimizes other cranial nerve morbidities and/or provides spontaneous or easy-to-initiate smiling movement is equally imperative. For those with cognitive issues, it is important to assess whether the capacity to learn to use a gracilis muscle driven by chewing activity is present. Showing a QOL benefit to facial reanimation in the pediatric age group reinforces the potential value of this type of intervention in children and may further inform the decision as to whether to proceed.

In conclusion, free gracilis transfer for smile reanimation in children carries an acceptable failure rate, significantly improves smiling, and seems to improve QOL with respect to facial function. It should be a cornerstone intervention in the appropriately counseled patient and family. Because it carries a lower failure rate than a similar cohort of adult patients, there is no need to wait until patients reach adulthood to offer dynamic reanimation. Early facial reanimation provides the advantage of permitting children to express themselves nonverbally through smiling and may in fact lead to fewer negative social consequences as they interact with peers.

Figure 5. Representative smiling results in 2 patients following free gracilis transfer in this series. Shown are preoperative smiles (A and C) and postoperative smiles (B and D). Gracilis driven by a cross-face nerve graft (A and B), or by the trigeminal nerve (C and D).

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Author Contributions: Dr Hadlock had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Hadlock, Cheney, and Henstrom. *Acquisition of data:* Malo and Henstrom. *Analysis and interpretation of data:* Hadlock, Malo, and Henstrom. *Drafting of the manuscript:* Hadlock and Henstrom. *Critical revision of the manuscript for important intellectual content:* Malo, Cheney, and Henstrom. *Statistical analysis:* Hadlock, Malo, and Henstrom. *Administrative, technical, and material support:* Hadlock. *Study supervision:* Hadlock, Cheney, and Henstrom.
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