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Magnetic Resonance Imaging Volumetry of Facial Muscles in a Face Transplant Recipient

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Summary: Face transplantation has evolved into a viable reconstructive option for patients with extensive facial disfigurement. Because the first face transplant procedure was described in 2005, the safety and feasibility of the procedure have been validated, and the focus of the field has shifted toward refining functional and esthetic outcomes. Recovery of muscle function following facial transplantation is critical to achieving optimal facial function and restoring facial expression. Assessment of facial muscle function in face transplant recipients has traditionally relied on clinical evaluation. In this study, we describe longitudinal changes in facial muscle volumes captured through quantitative magnetic resonance imaging in a face transplant recipient and compare these findings with functional outcomes evaluated through clinical assessment. *(Plast Reconstr Surg Glob Open 2019;7:e2515; doi: 10.1097/GOX.0000000000002515; Published online 25 November 2019.)*

INTRODUCTION

Face transplantation (FT) has evolved into a viable reconstructive option for patients with extensive facial disfigurement.[1] Since the first FT was described in 2005, the safety and feasibility of the procedure have been validated, and the focus of the field has shifted toward refining functional and esthetic outcomes.[1] Recovery of muscle function following FT is critical to achieving optimal facial function and restoring facial expression. Assessment of facial muscle function in FT recipients has traditionally relied on clinical evaluation.[2] In this study, we describe longitudinal changes in facial muscle volumes captured through quantitative magnetic resonance imaging (MRI) in a FT recipient and compare these findings with functional outcomes evaluated through clinical assessment.

METHODS

Patient

The FT recipient was a 41-year-old male firefighter who sustained a full facial and total scalp burn injury in 2001 while in the line of duty. The extent of the defect included the entirety of the face, bilateral superior and inferior eyelids, bilateral external ears, lips, and the entire scalp resulting in diffuse contractures of the neck, perioral, and periorbital regions. The patient had significant functional limitations and experienced decreased interincisal opening resulting in limited mastication, smiling and puckering, and impairment in eyelid apposition for both reflexive and volitional blink. Following his initial injury, the patient had undergone >70 reconstructive procedures without improvement in functional or esthetic outcomes (Fig. 1). In August 2015, the patient underwent a total face, eyelids, ears, scalp, and skeletal subunit transplant (Figs. 1–3).[3] The recipient facial nerve was intact, and a nerve stimulator was used to confirm facial innervation and muscular function. Facial nerve coaptations were not performed given that the recipient nerve was intact. Sufficient length of recipient supraorbital and infraorbital nerves was unable to be dissected due to extensive scarring, and the donor supraorbital and infraorbital nerves were subsequently placed over the respective foramina. The recipient mental nerve was dissected and identified, and donor mental nerve coaptations were performed using donor hypoglossal interpositional nerve grafting.

MRI Volumetry

MRI of the brain was performed pre- and 3, 6, 13, and 20 months post FT using a 3T system (Skyra; Siemens, Erlangen, Germany). All images were transferred to a dedicated image postprocessing program (Mimics 19.0; Materialise, Leuven, Belgium). A T2-weighted 3D turbo spin echo sequence was selected for the image postprocessing. The orbicularis oculi, orbicularis oris, and masseter muscles were segmented using a combination of manual and semiautomatic techniques. Each segmented region of

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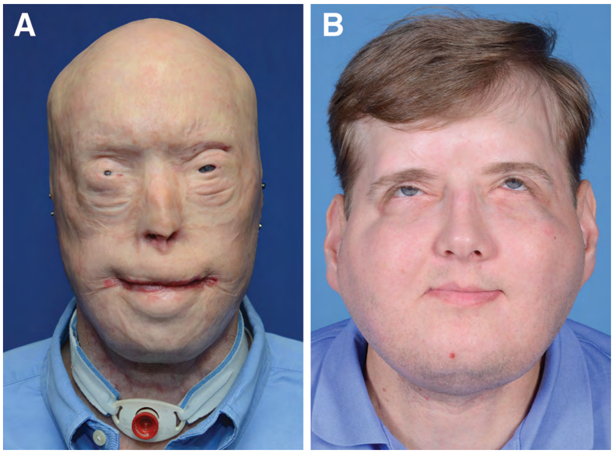

Fig. 1. Patient preoperative (A) and postoperative (B) pictures. The postoperative picture is at 20 months following facial transplantation. Printed with permission and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

interest was converted to a 3D surface raster for optimized visualization. This allowed volumes of orbicularis oculi, orbicularis oris, and masseter muscles were quantified.

Outcomes Evaluated

Facial movement was graded using the Sunnybrook facial grading system, and synkinesis scores, symmetry of voluntary movement scores, resting symmetry scores, and composite Sunnybrook scores were calculated.[4] Eye closure, open mouth smile, snarl, and lip pucker were clinically evaluated.

RESULTS

The duration of follow-up was 20 months. Muscle volumes demonstrated a decrease in volume in the initial postoperative period, followed by a progressive increase

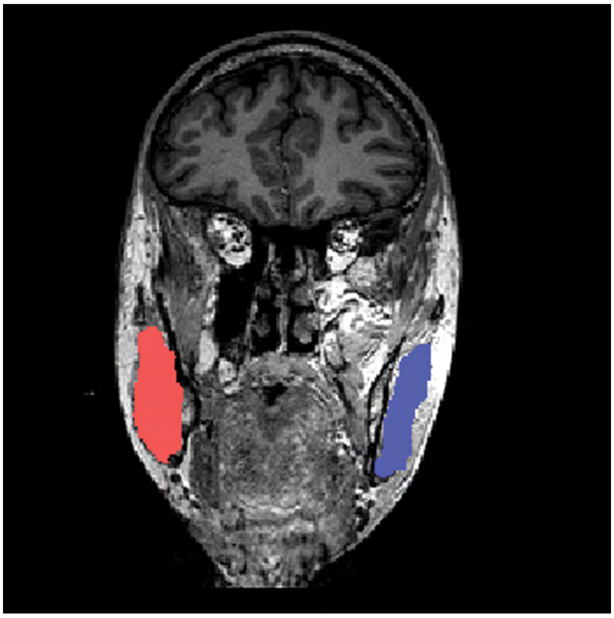

Fig. 2. Example of magnetic resonance imaging volumetric analysis.

Fig. 3. Volumetry of orbicularis oculi, orbicularis oris, and masseter muscles at 20 months postoperatively.

starting 6 months, with all muscle volumes exceeding pretransplant values at the latest time point (Table 1).

The composite Sunnybrook score also increased progressively and reached its maximal value of 77 at 20 months following transplantation (Table 1). Resting symmetry scores, symmetry of voluntary movement scores, and synkinesis scores are shown in Table 1. Clinical examination findings for eye closure, open mouth smile, snarl, and lip pucker are also described in Table 1.

DISCUSSION

Facial muscle recovery without synkinesis following FT is critical for optimal functional outcomes.[2,3,5] Assessment of facial muscle function in FT recipients has predominantly relied on clinical evaluation.[2] In this study, we sought to evaluate longitudinal changes in facial muscle volumes through quantitative MRI data in a patient who received a total face, eyelids, ears, scalp, and skeletal subunit transplant. We also reviewed clinical assessments in the same patient.

Quantitative MRI volumetry of facial muscles has previously been described in patients with facial palsy and was found to be useful as an adjunct tool for monitoring the functional status of facial muscles before and following facial nerve reconstruction.[6] The data that we present in this study suggest that increases in facial muscle volume accompany improvement in facial muscle function as described through clinical assessments. We believe that these findings are interesting given that facial nerve coaptations were not performed in the FT described here, in light of the intact function of the recipient facial nerve. The increase in facial muscle volume could potentially be

Table 1. Patient Clinical Data Stratified by Time Point

Time Point	Synkinesis	Voluntary Movement Symmetry	Resting Symmetry	CSS	Eye Closure	Open Mouth Smile	Snarl	Lip Pucker	Orb. Or. (mm³)	Rt Orb. Oc. (mm³)	Lt Orb. Oc. (mm³)	Rt Masseter (mm³)	Lt Masseter (mm³)
Pre	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6,500	3,089	3,348	16,822	14,779
3 mo	0	64	10	54	Initiates movement	Initiates movement	Initiates slight movement	Initiates movement	3,062	2,733	3,111	12,466	10,783
6 mo	0	72	15	57	Movement complete	Movement almost complete	Initiates slight movement	Movement almost complete	7,406	3,356	3,670	17,384	16,664
13 mo	0	84	15	69	Movement complete	Movement almost complete	Movement almost complete	Movement almost complete	8,178	3,971	41,578	18,053	16,778
20 mo	0	92	15	77	Movement complete	Movement almost complete	Movement complete	Movement almost complete	9,142	6,977	6,530	18,178	18,318

CSS, Composite Sunnybrook Score; Lt, left; N/A, not applicable; Orb. Oc., orbicularis oculi; Orb. Or., orbicularis oris; Rt, right.

explained by release of the overlying soft-tissue contractures resulting from the patient's burn injury, after FT was performed. This is supported by the initially observed decrease in muscle volume in the first 3 postoperative months, during which edema is most pronounced and can limit facial functions, followed by a progressive increase in muscle volume from 6 to 20 months. This is further supported by similar trends observed in muscles innervated by the facial nerve and the masseter, suggesting that the variations observed in muscle volumes are more likely related to mechanical rather than neurogenic factors.

There are several limitations to this study that we hope to address through future research. Most importantly, we hope to stratify our volumetric measurements based on donor versus recipient muscle tissue. Moreover, volumetric segmentation of thin and atrophied muscles can be challenging and further increases the risk of measurement errors, which we attempted to mitigate in our study by repeated measurements of the same muscle to confirm that comparable values were being generated. We also limited this pilot analysis to orbicularis oculi, orbicularis oris, and masseter muscles but hope to perform a more extensive analysis of facial muscles in the future. Moreover, normative MRI muscle volume data obtained through analysis of a large sample size can help establish baselines and standardize measurements.

CONCLUSIONS

This longitudinal pilot study shows increases in facial muscle volumes captured through MRI volumetry following FT and suggests that they correlate with improved facial functions. Future research is needed to determine the role of MRI volumetry as an adjunct tool for monitoring facial functions following facial transplantation.

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