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Outcome Analysis Following Microvascular Free Gracilis Muscle Transfer for Multi-Vector Facial Reanimation

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Abstract: The purpose of this research to address objective excursion and symmetry results from a series of free gracilis muscle transfer (FGMT) cases and examine the predictive intraoperative number of vectors anchored during flap inset on outcomes. A retrospective analysis performs by data retrieved from the HUSM Plastic & Reconstructive Surgery OR Registry from January 2005 to June 2019. All patients who reported facial nerve palsy were recorded and re-evaluated. All characteristics in interest were epidemiologically tabulated and analyzed in detail. Subsequently, outcome assessment was performed to look for facial symmetry and smile excursion compared to the healthy side of the face—this study exempted by the Institutional Review Board of the Hospital of University of Sciences Malaysia. Out of 12 patients diagnosed with facial palsy, four patients underwent static facial reanimation. Eight patients underwent a dynamic facial reanimation, with 4 of them completed two stages of cross-facial nerve grafting (CFNG) and free gracilis muscle transfer (FGMT). One of the FGMTs patients had missed a follow-up. The mean age was 20 (range 11 to 30), one patient was male, and two were female. The mean duration for follow-up was 69 months. The mean duration of operating time was 8.67 hours. All operations without complication, and there was no microvascular re-exploration. Smile excursion and angle excursion at smile improved following FGMT. Association between the number of vectors anchored during flap inset to the outcome were identified. Dynamic facial reanimation using FGMT still the gold standard of treatment, which provides an excellent quantifiable improvement in oral commissure excursion and facial symmetry with smiling. The use of multivector gracilis flap was suggestive to associate with the good outcome on excursion and symmetrical of the smile.
Keywords: Dynamic facial reanimation; free gracilis muscle transfer; facial nerve palsy

INTRODUCTION

It well recognizes that facial paralysis can disrupt the physical, social and mental well-being of patients' life. These disruptions can be alleviated by performing dynamic smile reanimation, but there is poor understanding to direct the surgeon to select adequate reanimation treatment for respective individuals[1]. Nevertheless, the research examining patient-recorded outcomes in patients managed with facial reanimation

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procedures is very restricted[2]. Furthermore, there are presently no randomized controlled trials or controlled clinical trials available in the research concerning facial reanimation procedure[3]. The smile has been appreciated as the facial appearance with the utmost constructive feeling and has been revealed to reduce mental strain (4). When facial muscles are permanently impaired, the restoration of the smile requires the transfer of different functional muscle units that resemble the role of the affected disabled muscles. Functional muscles can be transferred as pedicle-based muscle-tendon unit (MTU) flaps or as free functional muscle flaps and when a comparison is made, the latter is more flexible and versatile[4].

As it's presented in 1976 by Harii et al, FGMT has become the benchmark procedure for dynamic reanimation of the oral commissure and is widely adopted in numerous institutions around the world[5]. Despite the regularity with which it is performed, information on FGMT’s outcomes is infrequent in researches. The main obstacle in progressing our information of the outcomes has been the shortage of an impartial and exhaustive instrument to quantify facial function succeeding the FGMT procedure[6]. For individuals who go through facial reanimation surgical intervention, long-term smile excursion results and its repercussion on craniofacial growth have not been fully investigated[7].

MATERIALS AND METHODS

A retrospective analysis was performed by data retrieved from the HUSM Plastic & Reconstructive Surgery OR Registry from January 2005 to June 2019. All patients who reported facial nerve palsy were recorded and re-evaluated. All characteristics in interest were epidemiologically tabulated and analyzed in detail. Subsequently, outcome assessment was performed to look for facial symmetry and smile excursion with comparison to the healthy side of the face. Post-operative photographs during the most recent follow-up were used to measure oral commissure excursion and angle of the oral commissure concerning the erect line in the middle of the face at rest and through a smile (Figure 1).

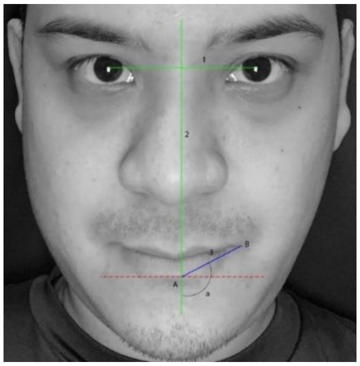

Figure 1: Landmark marking for measurement. 1, Horizontal interpupillary line; 2, vertical line intersecting and perpendicular to the horizontal interpupillary line; A, intersection of line 2 and vermillion-cutaneous boundary of the inferior lip; B, oral commissure; 3, line with distance spanning points A and B; and a, the angle between line 2 and line 3.

From this photograph, important lines & landmarks were drawn using Adobe Photoshop, and distance and angle of interest were measured. All surgical procedures were carried out as depicted in most literature. Basically, including its adductor vessels, and the obturator nerve, a portion of the gracilis muscle was raised from the inner thigh section. The harvested muscle was then refashioned and positioned into the facial incision site as described in the subsequent picture (Figure 2). One end of the muscle was split according to the number of the vectors that were planned to be anchored, creating such a finger projection on top of the affected side of the face. This split-end was sutured and anchored using non-absorbable nylon suture to the desired point of attachment.Objective assessments of post-operative pictures were accomplished using manually drawn landmark lines using Adobe Photoshop software which scaled each photograph based on the dimension of the average cornea diameter (roughly 11 mm) as a point of reference[8]. A horizontal line (line 1) was made utilizing the software over both pupils, succeeded by a vertical line (line 2) intersecting the former. The investigator then identified the juncture of the line at the right angle to the vermillion-cutaneous boundary of the inferior lip (point A). The oral commissure (point B) was identified, and the length at point A to point B (line 3), which signifies the length after the midline of the vermillion-cutaneous boundary of the inferior lip and the oral commissure were measured. The difference in this length between at-rest and smile is defined as the “smile excursion”. The difference in angle “a” between repose and smile is defined as “angle excursion.” The smile and angle excursions on the paralyzed and healthy sides were then measured in which the symmetry was obtained by determining the change in distance of line 3 to the normal and paralyzed sides, and the change in angle “a” to the normal and paralyzed sides. This measurement was executed at-rest and through a smile. A perfect symmetric smile produces an asymmetry score value of zero. All patients were taken their pictures at rest, and smile that attempts to expose teeth as much as possible. All subjects were requested to phonate the “E” sound as in “cheese” to assist the smile expression[9,10]. Differences between the variables were assessed for healthy-affected side comparisons. This study was exempted by the Institutional Review Board of the Hospital Universiti Sains Malaysia.

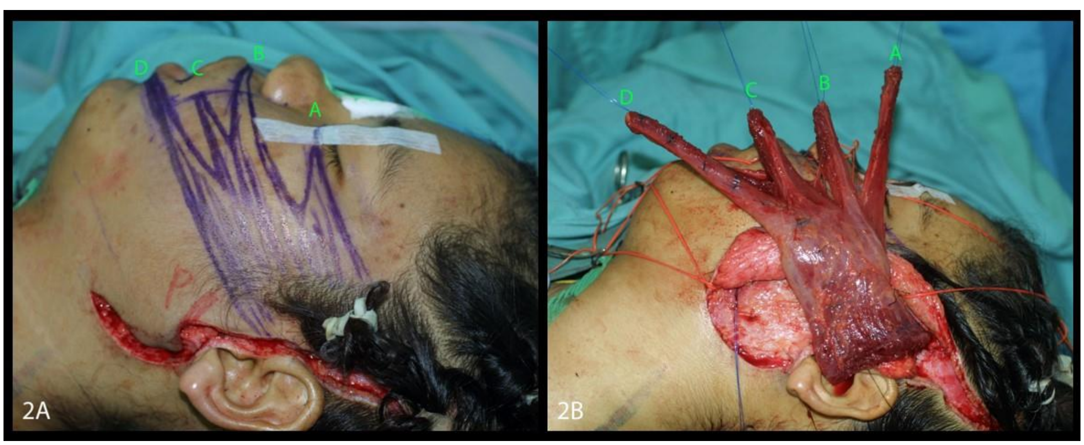

Figure 2: 2A: Design of the FGMT with 4 planned vectors to be anchored. 2B: Flap inset shows FGMT with its 4 slits. A, lower eyelid; B, superior lip; C, modiolus; and D, inferior lip.

RESULTS AND DISCUSSION

Table 1. Demographic Data (n=3 patients)

Patient Number	1	2	3
Age at FGMT procedure	19	30	11
Sex	Female	Female	Male
Etiology	Congenital	Iatrogenic	Congenital
Operation	2 stage CFNG + FGMT	2 stage CFNG + FGMT	2 stage CFNG + FGMT
FGMT Operating Time	13 Hours	7 Hours	6 Hours
Anchor Vector in Flap Inset (lower face)	3 Vectors: - superior lip - mediolus - inferior lip	3 Vectors: - superior lip - mediolus - inferior lip	2 Vectors: - superior lip - inferior lip
Complication	No	No	No
Secondary Operation	No	No	No
Duration of Follow Up	156 months	20 months	31 months

Abbreviation: FGMT, free gracilis muscle transfer. CFNG, cross facial nerve graft.

Table 2. Outcome Assessment in 4 post-operative FGMT follow up

Patient Number	1	2	3	Mean
Smile excursion[b]				
Healthy side	10	7	4	7
Affected side	6	2	0	2.67
Commissure angle[c]				
Healthy side	6	4.3	1.9	4.07
Affected side	13.2	5.4	4.3	7.63
Symmetry angle[d]				
Repose	8.8	8.4	4.2	7.13
Smile	1.6	7.3	1.8	3.57
Symmetry length[e]				
Repose	5	3	2	3.33
Smile	9	7	2	6

[b] Smile excursion refers to the difference of length of oral commissure, measured in millimeters between smile and repose at the affected and unaffected side.
[c] Δ Angle refers to change in angle with a smile, measured in degrees.
[d] Symmetry refers to the difference in angle between the vertical midline of the inferior lip and oral commissure between affected and healthy side, measured in degrees. Smaller values reflect more symmetry.
[e] Symmetry refers to a difference in position relative to the midline of inferior lip vermillion-cutaneous boundary between affected and healthy side, measured in millimeters. Smaller values reflect more symmetry.

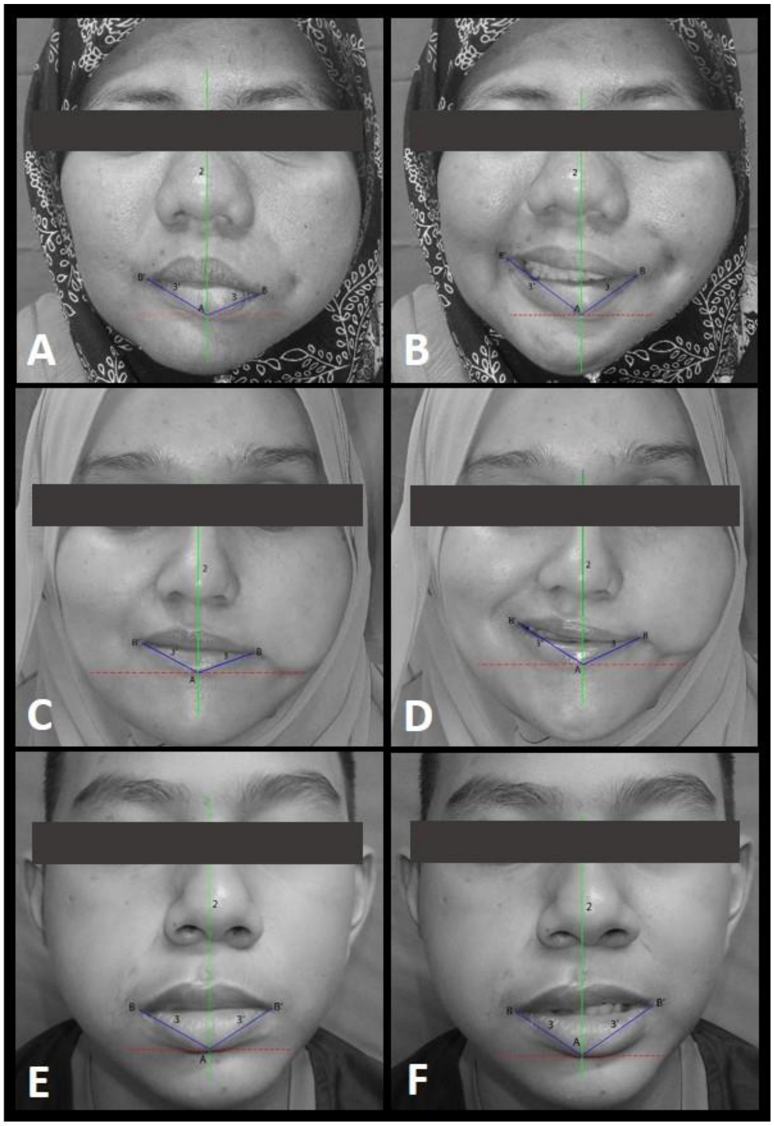

Figure 3: Photographs were taken at pose (A, C & D) and smile (B, D & E) during the latest follow up. Patient 1 (A & B) had 3 vectors of the FGMT at 156 months' post-operation, patient 2 (C & D) had 3 vectors of the FGMT at 20 months' post-operation and patient 3 (E & F) had 2 vectors of the FGMT at 31 months' post-operation.

Out of 12 patients operated on with facial palsy, 4 patients underwent static facial reanimation and 8 patients underwent dynamic facial reanimation with 4 of them completed 2 stages of cross facial nerve grafting (CFNG) and free gracilis muscle transfer (FGMT). One of the FGMTs had missed a follow-up. The mean age was 20 (range 11 to 30), 1 patient was male and 2 were female. Two patients with congenital facial nerve palsy and 1 patient with iatrogenic cause. The mean duration for follow up was 69 months. The mean duration of operating time was 8.67 hours (range 6 to 13). All operations without complication and there was no microvascular re-exploration (Table 1). Smile excursion on the affected side was found to be declining at 6 mm, 2 mm, and 0 mm respectively for patients 1, 2, and 3 with a mean of 2.67 mm. Similarly, the outcome for the commissure angle while smiling on the affected side decreased respectively at 13.2, 5.4, and 4.3 degrees for patients 1, 2, and 3 with a mean of 7.63 degrees (Table 2).

Symmetry at repose concerning angle for patients 1, 2, and 3 decreased respectively at 8.8, 8.4, and 4.2 degrees while symmetry during smiling at 1.6, 7.3, and 1.8 degrees respectively. Symmetry at a smile concerning the length decreased at 9 mm, 7 mm, and 2 mm difference for patients 1, 2, and 3 respectively. We found that the number of vectors during flap inset plays a role in increasing the smile excursion and commissure angle wherein these patients the longer the post-operative duration can lead to higher excursion and angle. However, we found that the number of vectors did not contribute to the symmetrical length either in repose or at a smile (Table 2). The clinical photograph obtained during follow up showed that the smile was improved with merely unnoticeable asymmetry compare from the affected to the healthy side. Noted the bulkiness of the gracilis muscle flap for all patients which the author thinks quite acceptable (Figure 3).

Facial reanimation goals to reestablish facial dynamic movement and resting symmetry. These intricate static and dynamic surgeries frequently encompass numerous surgical stages and are best executed in a multidisciplinary strategy[2]. For the reconstructive surgeon, improving outcomes in dynamic facial reanimation always present a huge challenge. No particular reanimation technique is adequate for replicating the subtle actions of the mimetic muscles of the face that are important for adequate role, action and expression[1]. Facial reanimation aims to attain symmetry at repose, and over dynamic expressions minus any latency and synkinesis. Most works at smile reanimation, nevertheless, have concentrated only on the superior lip on the movement of the oral commissure and its expression, instead of on the restoring symmetry of the inferior lip, resulting it as an abandoned area[10]. Terzis and Kalantarian reported the inferior lip as a neglected area of facial reanimation and tried to solve these concerns. In their study comprising 74 patients, they presented various techniques for dynamic reanimation of the inferior lip, such as transfer of the platysma muscle, transfer of the anterior belly of the digastric muscle, direct neurotization of the depressor muscle, utilizing a mini-hypoglossal nerve transfer to the cervicofacial branch, and facial-to facial nerve transfer[10].

Since its introduction in the second half of the 1970s by Harii, micro-neurovascular muscle transfer in facial reanimation, which, frequently conducted in 2 stages with a CFNG, has turned out to be the most favored preference for the all-inclusive management of long-standing facial paralysis[11]. In 1997, Labbe et al proposed a regional muscle transfer procedure, specifically lengthening temporalis myoplasty (LTM), as a variation of the temporalis myoplasty corresponding to McLaughlin (1953), with the certain benefits of being one-stage, technically easier and comparatively fast[3,11,12]. A systemic review in 2016 comparing the outcomes of LTM and FGMT in restoring smile animation showed that LTM attains outcomes that are at least equivalent to those achieved by gracilis transfer, having a lesser extend of smiling with controversial evidence of spontaneity, however, may be a practical alternative in some cases since it is less extensive, does not necessitate muscle harvesting, and does not involve microvascular procedures[3].

Herein, we present data indicating that in a single institution, there were 3 cases of dynamic reanimation which were operated by including the inferior lip as part of the procedure where the number of vectors was different for each patient. We found that anchoring 3 vectors for lower face flap inset as depicted in patient 1 may give a smile excursion up to 6 mm. This value, however, does not signify total excursion, however, it is comparable to smile excursion described in the common population at 8 mm[6]. A dependable method with fewer failure proportions, FGMT may yield a substantial smile (at least 3 mm of smile excursion) in 84% of recipients when driven by facial nerve through a CFNG and in 94% via trigeminal nerve[6,7]. Furthermore, as shown in patient 3 who had undergone only 2 vectors FGMT did not show improvement at all at 31 months postoperative period as compared to patient 2 who had 3 vectors FGMT which was found to have her smile excursion at 2 mm even at 20 months follow up. Similar findings were obtained for the commissure angle during a smile.

The finding only gives objective 2-dimensional outcomes and a scale from which to evaluate attainment in the future. From a sternly anatomic and physiologic perspective, excursion with smile provides a worthwhile instrument for evaluating surgical outcome for the reason that gracilis contraction after the inset is reliant on the number of successful surgical steps, allowing good flap revascularization and reinnervation and ultimately translation of muscle contraction to the modiolus and oral commissure. Although many of the outcome variables improved following FGMT, symmetry at rest and smile concerning angle and length did not, most probably due to lack of statistical power that may have concealed a potential true difference in a greater population.

The gracilis muscle is a type two muscle according to the classification by Mathes and Nahai. The motor nerve comes from the obturator nerve and goes into the muscle together with the vascular pedicle which separates and goes longitudinally parallel to the arterial branches and muscle fibers. This anatomic arrangement renders the gracilis muscle appropriate for segmental harvest[4]. Innervations may be done from either the contralateral facial nerve through a CFNG, that is positioned in a first-stage process at 6-9 months before, or the masseteric branch of the trigeminal nerve. Advantages of FGMT innervated by trigeminal nerve comprise a one-stage technique and a greater success percentage; though, patients are advised that facial rehabilitation will be essential to stimulate a smile by performing a biting action. FGMT innervated by the contralateral facial nerve through a CFNG convenes a great benefit of smile spontaneity, however, it has a slightly lesser success percentage and necessitates a two-stage procedure and requiring harvesting of the sural nerve[7].

From the literature search, the use of multivector free functional flap for dynamic reanimation has been previously described but much not using the gracilis muscle. Few examples of such were, Whitney et al[4,13], who reported 100 cases of reanimation utilizing several slips of the serratus muscle, Allevi et al[4,14] described the result of using double-bellied latissimus dorsi free flap, and Ueda et al[4,15] reported a combined latissimus and serratus flap cases utilized for superior and inferior lip animation. Commonly, the use of gracilis flap is generally planned as a solitary paddle by way of uni-vector excursion frequently imitating the external contraction of the zygomaticus major muscle in which the resultant smile is more constantly yield a Mona Lisa smile but restricted in the grade of lip elevation and dental show and missing in periorbital animation. Another technique of multivector facial reanimation was by utilizing a dual paddle of gracilis muscle flap which was described in 2018 to attain a Duchenne type of smile[4]. Even though a different type of dynamic reanimation such as the LTM brings benefits of lesser operating time, faster recuperation, and an earlier noticeable result but is restricted by a static vector of smile excursion, absence of spontaneity, and facial asymmetry. FGMT has the capability for spontaneous initiation and further chances to alter the vector of smile and commissure site however is restricted through the requirement for particular microsurgical skill and tools, involves lengthier surgical and recovery time, has a longer time to early movement, implicates a second surgical site, and may increase further bulk to the midface as shown in our cases[1]. Additionally, compared with the latissimus and serratus flaps, the gracilis is a more robust[4]. The progress in smile excursion is found to be greater in those managed with FGMT and, on average, the excursion approximates the contralateral healthy side[1].

Synchronous animation of the inferior lip with the superior lip can intensely enhance symmetry. Merely denervating the depressor muscles on the unaffected side is inadequate for dynamic action. Fixating the FFMT to the mouth angle has a possibility of generating a disfiguring dimpling in a smile[10]. This is why we performed multi-vectoral reconstruction of the lower face including the inferior lip by utilizing of gracilis aponeurosis to pull the inferior lip to assist in achieving dynamic smile excursion & symmetry.

Its number of cases restricted some limitations recognized in this brief study, thus lacking the power to identify minor associations that could be statistically significant. Smile excursion may not be the most appropriate outcome of smile reanimation. Facial anatomic variances and differences in zygomaticus major muscle dimension may contribute to considerable changes in smile excursion among persons. Cultural dissimilarities in smile form likewise exist and can account for quantifiable variances in smile excursion among individuals. Nevertheless, studies have found a relationship between smile intensity and life expectancy, demonstrating that better smile excursion may confer a health advantage[6]. We did not compare the postoperative outcome to the preoperative stage as there was incomplete data. We also did not compare the other technique of using multivector gracilis flaps such as double paddle gracilis flap or FGMT with a static sling or any other type of FGMT.

CONCLUSION

Dynamic facial reanimation using FGMT still the gold standard of treatment which provides a good quantifiable improvement in oral commissure excursion and facial symmetry with smiling. Used of multivector gracilis flap was suggestive to associate with the good outcome on the excursion and symmetrical of the smile.

CONFLICT OF INTEREST

There are no conflicts of interest

AUTHOR'S NOTE

These data were presented as oral free paper presentation in the 9th International Congress Pan Asia Academy of Facial Plastic and Reconstructive Surgery 2019 held at Kuala Lumpur, Malaysia.

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