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Incomplete facial paralysis - The use of the ipsilateral residual facial nerve as a donor nerve for facial reanimation.

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Abstract

Background: The reconstructive approach for *incomplete* facial paralysis is not yet determined. In this article we present a new surgical approach for patients with incomplete facial paralysis in which residual, ineffective movement is detected pre-operatively in the ipsilateral bucco-zygomatic territory of the paretic facial nerve.

Methods: Sixteen patients with incomplete facial paralysis were found eligible for the procedure and underwent one-stage facial reanimation by the senior author (E.G.). Reanimation was performed using free gracilis muscle transfer with neural coaptation to an active facial nerve branch/es responsible for the pre-detected bucco-zygomatic residual movement. Patients were reviewed in a systematic fashion using a combined still photo and video scoring scale for symmetry at rest and at dynamic states.

Results: Following surgery, improved symmetry was observed in the majority of observations of the mouth region at rest and while smiling and nasolabial fold region while smiling. There was no significant change in symmetry in the majority of observations of the eye region at rest and while smiling and nasolabial fold region at rest. Video assessment of dynamic facial symmetry while smiling demonstrated improved symmetry in 91% of the observations (n=191 observations). Comparison of mean scores for dynamic smile symmetry produced a statistically significant improvement of 1.68 points following surgery ($p<0.001$).

Conclusion: Based on this series, the authors recommend to consider using the ipsilateral facial nerve bucco-zygomatic residual branch, as donor nerve for facial reanimation using a free gracilis muscle transfer in patients with incomplete facial paralysis with residual pre-operative movement in the mid-face.

Key Words: Incomplete facial paralysis; facial reanimation; free gracilis muscle transfer; cross-face nerve graft; Bell’s palsy

Introduction

Background

Incomplete facial paralysis has been defined as a state of facial paralysis in which some degree of residual facial nerve function is present [1]. Clinically, it is a state of facial paralysis in which the affected hemi-face produces some muscle activity however the movement it provides is ineffective and obviously asymmetrical. It is more common than its complete counterpart and most commonly secondary to Bell's palsy [2-6]. The residual function observed in incomplete paralysis derives from the presence of some functional facial nerve axons on the affected hemi-face. In the context of facial reanimation, these functional axons can be utilized and their neural power augmented, thus maintaining and even enhancing spontaneous facial movement [1, 7].

Rationale

To date, there is no consensus regarding the most appropriate clinical and reconstructive approach for incomplete facial paralysis. Static procedures are used to improve symmetry at rest in both complete and incomplete cases [2, 8, 9]. Dynamic facial reanimation procedures may be employed and various reports exist regarding the use of standard methods for incomplete paralysis [1, 3-5, 10-17]. Modification of the cross-face nerve grafting method and masseteric-facial nerve transposition have been described as appropriate reconstructive options for incomplete paralysis [3, 4, 7, 18].

Objectives

In this article we present our experience with a new surgical approach for treating patients with incomplete facial paralysis in which some movement is identified in the ipsilateral bucco-zygomatic territory of the paretic facial nerve. It is a one-stage procedure that utilizes active ipsilateral axons on the paralyzed hemi-face to activate a free gracilis muscle for smile augmentation. Operative details and clinical outcome was assessed in a series of 16 patients.

Patients and Methods

Patients eligible for this procedure are those who present with incomplete facial paralysis characterized by the ability to produce some movement in the bucco-zygomatic region of the affected hemi-face however with no effective lateral movement of the modiolus. This is identified via a thorough physical examination of facial mimic function. Any degree of movement in the mid-face zone of the affected hemi-face is satisfactory as it indicates the presence of some functional facial nerve axons (See Video 1, Supplemental digital content 1, which displays a pre-operative video depiction of the patient presented in Figure 4 while smiling. Note motion in the bucco-zygomatic region of the paralyzed hemi-face producing mild elevation of the nasolabial fold and lateral upper lip on the left, INSERT HYPER LINK) (Video Graphic 1) (See Video 2, Supplemental digital content 2, which displays a pre-operative video depiction of the patient presented in Figure 5 while smiling. Note upward pull of right upper lip during attempt to smile with no effective action on the modiolus, INSERT HYPER LINK) (Video Graphic 2). It is of utmost importance to evaluate whether the residual motion is spontaneous or intentional. In the latter case this method is not recommended since the smile will not be a spontaneous one. There is no age limit to the procedure since the distance for the nerve to grow is relatively short.

Surgical technique

The procedure described here aims to utilize the partially active bucco-zygomatic branches and augment the spontaneous facial mimic function they produce via a free gracilis muscle transfer. The gracilis muscle is harvested and tailored in size to the patient's proportions. The bucco-zygomatic branches responsible for the pre-operatively detected movement are identified intra-operatively using a nerve stimulator. There is usually more than one small branch responsible for that residual motion. One of these branches is transected and coapted to the gracilis motor nerve via an end-to-end anastomosis (see Fig. 1). When only one partially functional nerve is found, it is not transected but split longitudinally. The free end of the nerve to gracilis in split as well. End to end coaptation is performed between the free end of the split bucco-zygomatic branch and one of the two split ends of the nerve to gracilis. The other split end of the nerve to gracilis is coapted by end to side coaptation to the remaining fascicles of the bucco-zygomatic nerve that were left uninterrupted. This is in order to maximize facial nerve axonal lode to the gracilis flap. In order to avoid damaging the existing residual motor function, the dissection zone is limited to the region between the zygomatic arch and stenson duct. In contrast to the standard procedures, the vascular pedicle is preferably anastamosed with the superficial temporal vessels and not the facial vessels, thus donor vessels dissection is limited and marginal or mandibular facial nerve branches, if active, are not at risk. In cases in which the superficial temporal vessels are inappropriate for vascular anastomosis, dissection is extended and the facial vessels are used instead. Arterial and venous anastomoses may vary in the same patient according to anatomy and gracilis flap inset properties.

Study design

Sixteen patients were found eligible for the procedure during the years 2001 through 2016. All operations were performed by the senior author (E.G.) at Tel-Aviv Sourasky Medical Center. Data regarding demographic details, etiology and duration of paralysis, co-morbidities, operative and post-operative course were retrospectively collected. Operative data included the donor nerve, arterial and venous anastomoses, intraoperative and postoperative complications, time interval to first muscle motion, secondary procedures and duration of follow-up. Static and dynamic facial symmetry were assessed pre- and post-operatively by clinical evaluation according to a review of photographs and videos at rest and while smiling. Evaluation was performed by a group of 19 independent reviewers (eight plastic surgery specialists, eight plastic surgery residents and three medical students). Static facial symmetry was assessed by comparing pre- and post-operative photographs of the face at rest and while smiling. For each photograph, reviewers assessed facial symmetry according to the following facial zones: eye, nasolabial fold (NLF) and mouth. For each facial zone, symmetry was assessed by comparing the normal and paretic sides and giving a score for symmetry according to the following scale: 1, very poor symmetry; 2, poor symmetry; 3, fair symmetry; 4, good symmetry; and 5, excellent symmetry. Dynamic facial animation was assessed by comparing pre- and post-operative videos of the patients smiling. Videos were assessed for global symmetry of the face while smiling according to the same scale.

Statistical analysis

Statistical analysis was performed using SPSS for Windows, version 22 (SPSS, Inc., Chicago, IL). Post-operative improvement was assessed by calculating the difference (delta) between post- and pre-operative scores, for each category (static symmetry at rest and while smiling for each facial anatomical zone and global facial dynamic symmetry while smiling). Delta of 0 indicates no change between post- and pre-operative symmetry score by one observer, delta of -1 indicates worsening of 1 point, delta of 1 indicates improvement of 1 point, etc. For each category, frequencies of the various delta values was assessed and plotted on histograms. Due to the small sample size of the study group and the distribution of the symmetry score scale, aparametric tests were conducted to compare mean scores between the study groups. Overall mean scores for each category was compared using the Mann-Whitney paired sample test for aparametric variables. Wilcoxon signed rank test was used to compare the scoring delta of each category to zero. Results were considered statically significant when P values were less than 0.05

Results

Patients and operative details

The majority of patients were female (n=10, 63%) with mean age at surgery of 26.2 years (range 5 – 59 years) (Table 1). The most common etiology for paralysis was resection of head and neck tumors or other facial surgical procedures (n=5, 31%). Mean interval from palsy onset to surgery was 11.5 years (range 1 – 49 years) and mean post-operative follow-up was 88.3 months (range 16 – 132 months). Documented preoperative facial dysfunctions included eating or speech dysfunction in six patients (38%), synkinesis in six patients (38%), dry eye symptoms or epiphoria in four patients (25%) and brow movement difficulties in three patients (19%). Time interval from surgery to first muscle motion was documented for 7 patients with a mean interval of 2.8 months (range 1 – 6 months).

All patients underwent one-stage free gracilis muscle transfer (Table 2). The donor nerve included one ipsilateral bucco-zygomatic branch in 15 patients (94%) and two ipsilateral bucco-zygomatic branches in one patient (6%). The superficial temporal artery was the common donor artery (n=7, 44%) and the facial vein was the common recipient vein (n=7, 44%). Mean gracilis ischemia time was 90 minutes (range 45 - 150 minutes).

There were no major post-operative complications in this study cohort. Minor complications (surgical site infection, mild wound dehiscence) appeared in four patients (26%). Ten patients (63%) underwent secondary static procedures during the follow-up period, all of which were performed for fine-tuning of the aesthetic result. These included fat injection and suction, scar revision, adhesiolysis, blepharoplasty and gracilis re-anchoring (Table 2). One patient (6%) required a secondary dynamic procedure.

Clinical outcome

Clinical outcome was assessed for 11 patients. Assessment was performed by 19 reviewers so that each patient had 19 scoring observations and overall there were 209 observations. Dynamic video smile assessment produced a statistically significant improvement of 1.679 points in mean score for symmetry following surgery ($P<0.001$). In regard to static assessments, improvement was observed in all categories and anatomical facial zones. All of the results were statistically significant ($P<0.001$) (Table 3).

Frequencies of the difference between post- and pre-operative scores (delta), for all observations, are presented as histograms in Fig. 2 and 3. There was no difference between static post- and pre-operative scores in the majority of observations when assessing symmetry of the eye at rest and while smiling (n=147, 70% and n=111, 53% respectively). For the NLF region, most observations showed no difference in symmetry at rest (n=102, 49%) however, symmetry was improved by 1 point in the majority of observations while smiling (n=110, 53%). Symmetry of the mouth region was improved by 1 point in the majority of observations at rest and while smiling (n=93, 44% and n=77, 37% respectively) with some degree of improvement (delta of 1, 2, 3 or 4) observed in 157 (75%) and 185 (89%) of observations at rest and while smiling, respectively.

Of the total 209 observations, downgrading of the score by one point was seen in nine observations of eye symmetry both at rest and while smiling (4% each), 18 observations of NLF symmetry at rest (8%), nine observations of NLF symmetry while smiling (4%), six observations of mouth symmetry at rest (3%) and one observation of mouth symmetry while smiling (0.4%).

Analysis of dynamic symmetry of the face while smiling by video assessment demonstrated improvement (delta of 1, 2, 3 or 4) in the majority of observations (n=191, 91%). Downgrading by one point was seen in one observation (0.04%). The mean scoring delta of each category were compared to zero, showing a statistically significant difference in all categories ($P<0.001$).

Discussion

Key Results

Statistical analysis of our results demonstrated improvement in facial symmetry at rest and while smiling in all patients of the cohort that underwent assessment. Since our grading method consists of subjective assessment, we were mainly interested in the difference (delta) between post- and pre-operative scoring per observer rather than the score itself as this represents a clinical trend rather than an absolute figure. Of note, the figures presented refer to the number of *observations* rather than patients and take into account multiple symmetry scoring observations per patient and category.

There was no difference in the score for symmetry of the eye region following surgery in the majority of observations at rest and while smiling (see Fig. 2). NLF symmetry was unchanged in the majority of observations at rest and improved in the majority of observations while smiling. Mouth symmetry was improved in majority of observations at rest and while smiling. These findings demonstrate that the procedure did not harm or worsen the paralysis in the majority of observations and reflect the concept of limiting the dissection zone to the bucco-zygomatic region and avoiding manipulations of other facial anatomical zones.

Downgrading of symmetry was observed in a small percentage of observations, mainly in the sub-categories of resting symmetry. After reviewing the media, we assume that this is mostly due to the gracilis flap's presence and movement in the area. Resting symmetry was somewhat interrupted by bulkiness of the gracilis flap. The minority of downgrading observations were seen on dynamic states. This is mainly due the gracilis flap's axis of pull on the NLF and not due to native facial nerve injury since symmetry was interrupted by new lateral movement in the midface and not by new lack of movement.

This new movement of the gracilis flap may indeed create some degree of asymmetry in the lateral midface however global symmetry of the face while smiling is still dramatically improved (See Video 3, Supplemental digital content 3, which displays a post-operative video depiction of the patient presented in Figure 5 while smiling. The pre-operatively identified bucco-zygomatic motion is now accompanied by new lateral pull of right modiolus by the gracilis flap, INSERT HYPER LINK) (Video Graphic 3) (See Video 4, Supplemental digital content 4, which displays a post-operative video depiction of the patient presented in Figure 4 while smiling. Note improved symmetry of nasolabial fold and mouth regions at rest and while smiling in comparison to pre-operative function as demonstrated in Video 1, INSERT HYPER LINK) (Video Graphic 4). Moreover, asymmetry caused by the flap's presence is amendable by secondary fine-tuning procedures.

The observations demonstrating worsening of eye symmetry were distributed among nine patients with most of them being downgraded by one observer only. NLF symmetry was downgraded by one point in 18 observations at rest and nine observations while smiling. These observations were distributed among eight patients with two of them being downgraded by one observer only. Resting mouth symmetry was downgraded by one point in six observations with one patient being downgraded by five observers. Mouth symmetry while smiling was downgraded by one observer in one patient.

These results correspond with the main objective of the procedure which is to improve symmetry of the smile while not harming other facial anatomical regions (see Fig. 4 and 5).

Accomplishment of this objective is clearly reflected in the video assessment that showed improvement in global facial symmetry while smiling in the majority of observations (91%) with only one observation of downgrading by one point (0.04%) and 17 observations of no change (8%) (see Fig. 3).

Comparison of post- and pre-operative mean scores demonstrated a statistically significant improvement in all categories and anatomical regions (Table 3). This stresses the fact that in the majority of cases, clinical improvement was observed by all of the reviewers (see Videos, Supplemental Digital Content 1, INSERT HYPER LINK and Supplemental Digital Content 4, INSERT HYPER LINK, which demonstrate pre- and post-operative appearance while smiling in a patient of the cohort).

The majority of patients in this series had a successful operative and post-operative course. In one patient, neural coaptation was performed between the gracilis motor nerve and two ipsilateral bucco-zygomatic branches. This was performed since these branches were found to be relatively small intra-operatively. Although perusing the superficial temporal vessels for vascular anastomosis in all patients, this was achieved in 44% of arterial anastomoses and 31% of venous anastomoses. This is in part due to the fact that the etiology of paralysis in 43% of the patients included head and neck tumors, infections or other facial operative procedures, all of which resulted in distorted anatomy that interfered with identifying and/or using the superficial temporal vessels. Of note, although dissection was extended to the facial vessels territory in 44% of the patients, no cases of marginal mandibular nerve injury were observed.

Four patients (26%) developed surgical site infection and mild dehiscence, all of which resolved with conservative measures. After mean follow-up of 7.3 years, only one patient (6%) required a secondary dynamic procedure. This patient showed only static improvement after 14 months of follow-up. The gracilis flap did contract however the movement it produced was weak and review of pre-operative videos showed that only minimal improvement was gained. During revision surgery the gracilis flap was found to be viable however its motor nerve had undergone atrophy. Cross-face nerve grafting was performed with direct motor neurotization of the gracilis flap.

Interpretation

Several authors have presented their approach to reanimation of incomplete facial paralysis. **Fattah et al** [1] described the cornerstones in formulating a reconstructive strategy for patients with facial paralysis. According to that review, in cases of partial paralysis where some residual function is present, one may augment the activity present on the affected side in order to achieve symmetry. **Frey et al [7]** presented their distal end-to-side approach that involves one-stage cross-face nerve grafting with an end-to-end suture to a divided zygomatic branch on the healthy side and an end-to-side suture to the partially functioning zygomatic branch on the partially paralyzed side. The distal end-to-side approach is designed to prevent injury to the preexisting functional axons of the partially active branch. The authors presented good long-term results in a series of three patients.

Other authors presented their experience with applying standard facial reanimation procedures in patients with incomplete facial paralysis [2-4, 15-17, 19, 20]. These include one- or two-stage cross-face nerve grafting with and without a muscle flap, masseteric-facial nerve transposition, one-stage mini-latissimus dorsi transfer, temporalis muscle transposition and autogenous fascia lata transfer with or without temporalis muscle turnover. These publications indicate that incomplete paralysis may show improvement with a surgical approach similar to that taken for complete paralysis.

In this study we addressed the sub-group of patients with incomplete facial paralysis that do not present complete paralysis of the midface zone. As so, any degree of pre-operative movement in the midface is necessary for the procedure to succeed. The extent of paralysis is a crucial element in the assessment of any patient with facial paralysis, and the presence of even the slightest spontaneous movement on the paralyzed hemi-face indicates that some axons are still active. In such cases, applying reconstructive methods aimed to augment the function of these remaining axons, may provide the advantage of maintaining spontaneity of movement, a critically important aspect of dynamic reanimation [1, 4, 7].

The rationale behind our approach is that utilization of the active ipsilateral axons by coaptation to the gracilis muscle will augment the activity they were previously responsible for. This is because the motor units they were previously activating were too small or atrophic. By using the new muscle, a spontaneous and stronger movement, targeted to the modiolus will be achieved in a one-stage procedure. The segmental gracilis flap is used as it is nowadays the preferred choice for smile reanimation [1, 5, 9, 13, 21, 22]. We observed that the use of the ipsilateral residual nerve, leads to a significantly improved and stronger commissure excursion in contrast to the improvement that can potentially be achieved with cross face nerve grafting. Our experience shows that the functional branch can be used even when only hardly noticeable motion is observed pre-operatively.

The main risk in this approach is that the existing residual motor function, especially if it is still functional in areas of the face such as orbicularis occuli or oris, may be damaged during the procedure, thus worsening the paralysis [4, 7, 23]. Dissection near the facial vessels puts the marginal and mandibular facial nerve branches at risk. Our results demonstrate that this can be avoided by limiting the dissection zone as specified above.

The main advantage obtained by this approach is that spontaneity of facial mimic function may be enhanced, along with preservation of the residual motor function in the incompletely paralyzed hemi-face (see Fig. 5). According to our experience and to the literature, asymmetry of the smile is usually the main concern of these patients and the use of a free gracilis flap addresses this issue by providing a strong and efficacious source for commissure excursion [2, 3, 7].

The objective of our study was to accurately assess the efficacy of the procedure by means of a systematic clinical outcome evaluation. Since objective metric measurement tools for facial symmetry assessment are not used at our institute, we used a subjective clinical facial symmetry analysis method as described above. A recent review of the literature on the various facial paralysis grading instruments recommended the uniform use of the Sunnybrook Facial Grading Scale [24]. Since we used media that were obtained over the years, we did not have the exact data required in order to systematically use the Sunnybrook Facial Grading Scale. Therefore we used our local grading scale that uses the same anatomical zones for resting symmetry and assesses dynamic facial symmetry while smiling as in the Sunnybrook Facial Grading Scale. We included 19 independent observers and thus produced a large amount of observations.

Further studies are required in order to better describe the procedure's efficacy and the sub-group of patients that are most likely to benefit from it. Computerized facial symmetry software will provide more objective data regarding pre- and post-operative facial symmetry. Pre-operative nerve conduction studies may aid in localization of an appropriate bucco-zygomatic branch to be used and provide prognostic data that may aid in patient selection. In future studies, additional strength may also be provided by using a group of non-plastic surgeons, preferably lay persons, for subjective clinical outcome assessment.

Conclusions

One-stage free gracilis muscle transfer with coaptation of its motor nerve to an ipsilateral functional bucco-zygomatic branch is an appropriate option for facial reanimation in patients with incomplete facial paralysis who present with residual spontaneous movement in the bucco-zygomatic region of the paralyzed hemi-face.

The main advantages of this method are that (1) it is a safe and effective one-stage procedure; (2) coaptation to a branch of the ipsilateral facial nerve will allow a spontaneous smile; (3) the gracilis flap creates significant improvement in commissure excursion; (4) in case the procedure does not provide satisfactory results, secondary neurotization procedures such as masseter nerve transfer will utilize and activate the already viable gracilis flap.

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Supplemental Digital Content Legends

Video Graphic 1. Supplemental digital content 1, displays a pre-operative video depiction of the patient presented in Figure 4 while smiling. Note motion in the bucco-zygomatic region of the paralyzed hemi-face producing mild elevation of the nasolabial fold and lateral upper lip on the left, INSERT HYPER LINK.

Video Graphic 2. Supplemental digital content 2, displays a pre-operative video depiction of the patient presented in Figure 5 while smiling. Note upward pull of right upper lip during attempt to smile with no effective action on the modiolus, INSERT HYPER LINK.

Video Graphic 3. Supplemental digital content 3, displays a post-operative video depiction of the patient presented in Figure 5 while smiling. The pre-operatively identified bucco-zygomatic motion is now accompanied by new lateral pull of right modiolus by the gracilis flap, INSERT HYPER LINK.

Video graphic 4. Supplemental digital content 4, displays a post-operative video depiction of the patient presented in Figure 4 while smiling. Note improved symmetry of nasolabial fold and mouth regions at rest and while smiling in comparison to pre-operative function as demonstrated in Video 1, INSERT HYPER LINK.

Figure Legends

Figure 1

Illustration of the one-stage free grailis muscle transfer with coaptation of the gracilis motor nerve to an ipsilateral functional bucco-zygomatic facial nerve branch. P, paralyzed side; N, normal side; FN, ipsilateral facial nerve main trunk; BZFN, ipsilateral functional bucco-zygomatic facial nerve branch; GF, gracilis flap; GN, gracilis motor nerve; VA, vascular anastomoses.

Figure 2

Static clinical outcome assessment of patient photographs. Frequency of differences (delta) between post- and pre-operative scoring of all observations, according to anatomical facial zone, at rest and while smiling. **Figure 2a** – eye symmetry at rest; **Figure 2b** - eye symmetry while smiling; **Figure 2c** – nasolabial fold (NLF) symmetry at rest; **Figure 2d** - nasolabial fold (NLF) symmetry while smiling; **Figure 2e** – mouth symmetry at rest; **Figure 2f** - mouth symmetry while smiling.

Figure 3

Dynamic clinical outcome assessment of patient videos. Frequency of differences (delta) between post- and pre-operative scoring of all observations, for global symmetry of the face while smiling.

Figure 4

A 43 year-old patient who presented with incomplete left facial paralysis secondary to Bell's palsy. Surgery was performed 25 years following palsy onset. **Figure 4a** - pre-operative photo at rest; **Figure 4b** - post-operative photo at rest; **Figure 4c** - pre-operative photo while smiling; **Figure 4d** - post-operative photo while smiling.

Figure 5

A 49 year-old patient who presented with incomplete right facial paralysis secondary to resection of a tumor from the right cheek at early childhood. **Figure 5a** - pre-operative photo at rest; **Figure 5b** - post-operative photo at rest; **Figure 5c** - pre-operative photo while smiling; **Figure 5d** - post-operative photo while smiling.

Table 1 – Patient Characteristics

	N (%)	Mean (Range)
Female gender	10 (63%)	
Paralysis side – left	10 (63%)	
Age over 50 at surgery	1 (6%)	
Etiology of paralysis		
Resection of tumor / Facial Surgery	5 (31%)	
Congenital	4 (25%)	
Bell's palsy / viral	4 (25%)	
Other	2 (13%)	
Missing	1 (6%)	
Pre-operative disturbances		
Eating / speech	6 (38%)	
Synkinesis	6 (38%)	
Dry eye / epiphoria	4 (25%)	
Brow	3 (19%)	
Age at surgery (Years)		26.2 (5-59)
Time palsy-surgery (Years)		11.5 (1-49)
Follow-up (Months)		88.3 (16-132)

Table 2 – Operative Details

	N (%)	Mean (Range)
Primary procedure		
One stage free Gracilis muscle transfer	16 (100%)	
Donor nerve		
One ipsilateral zygomatic branch	15 (94%)	
Two ipsilateral zygomatic branches	1 (6%)	
Donor artery		
Superficial temporal artery	7 (44%)	
Facial artery	6 (44%)	
Unclear anatomy / missing data	2 (13%)	
Maxillary artery	1 (6%)	
Recipient vein		
Facial vein	7 (44%)	
Superficial temporal vein	5 (31%)	
Unclear anatomy / missing data	2 (13%)	
External jugular vein	1 (6%)	
Maxillary vein	1 (6%)	
Gracilis ischemia time (Minutes) *****		90 (45 – 150)
Time interval to first muscle motion (Months) ‡		2.8 (1-6)
Secondary procedures		
Static †	10 (63%)	

Dynamic ‡	1 (6%)
Post-operative complications	
Major °	0 (0%)
Minor °°	4 (26%)

* Data was obtained for 11 patients

‡ Data was obtained for 7 patients

† Fat injection and suction, scar revision, adhesiolysis, blepharoplasty, Gracilis flap re-anchoring

‡ Cross-face nerve grafting with direct Gracilis flap neurotization

° Partial flap necrosis, flap loss, flap congestion, hemorrhage

°° Surgical site infection, mild wound dehiscence

Table 3 – Comparison of mean pre- and post-operative facial symmetry scores for all observations, according to media category and anatomical zone†

	Pre-operative mean facial symmetry score (+/- Std. deviation)	Post-operative mean facial symmetry score (+/- Std. deviation)	P value	Mean delta (Post-op – Pre-op)
Static symmetry, Eye At rest	4.02 (+/-0.96)	4.27 (+/-0.77)	< 0.001	+0.24
Static symmetry, NLF‡ At rest	3.32 (+/-1.03)	3.77 (+/-0.88)	< 0.001	+0.44
Static symmetry, Mouth At rest	2.78 (+/-1.13)	3.90 (+/-0.92)	< 0.001	+1.12
Static symmetry, Eye While smiling	3.42 (+/-1.22)	3.93 (+/-0.91)	< 0.001	+0.51
Static symmetry, NLF‡ While smiling	2.90 (+/-0.86)	3.68 (0.82)	< 0.001	+0.78
Static symmetry,	2.13 (+/-0.80)	3.73 (+/-0.84)	< 0.001	+1.60

Mouth **While smiling**				
Dynamic symmetry, **While smiling**	1.93 (+/-0.78)	3.61 (+/-0.85)	< 0.001	+1.68

† Static symmetry refers to still photograph assessment; Dynamic symmetry refers to video assessment

‡ NLF – Nasolabial fold

Figure 1

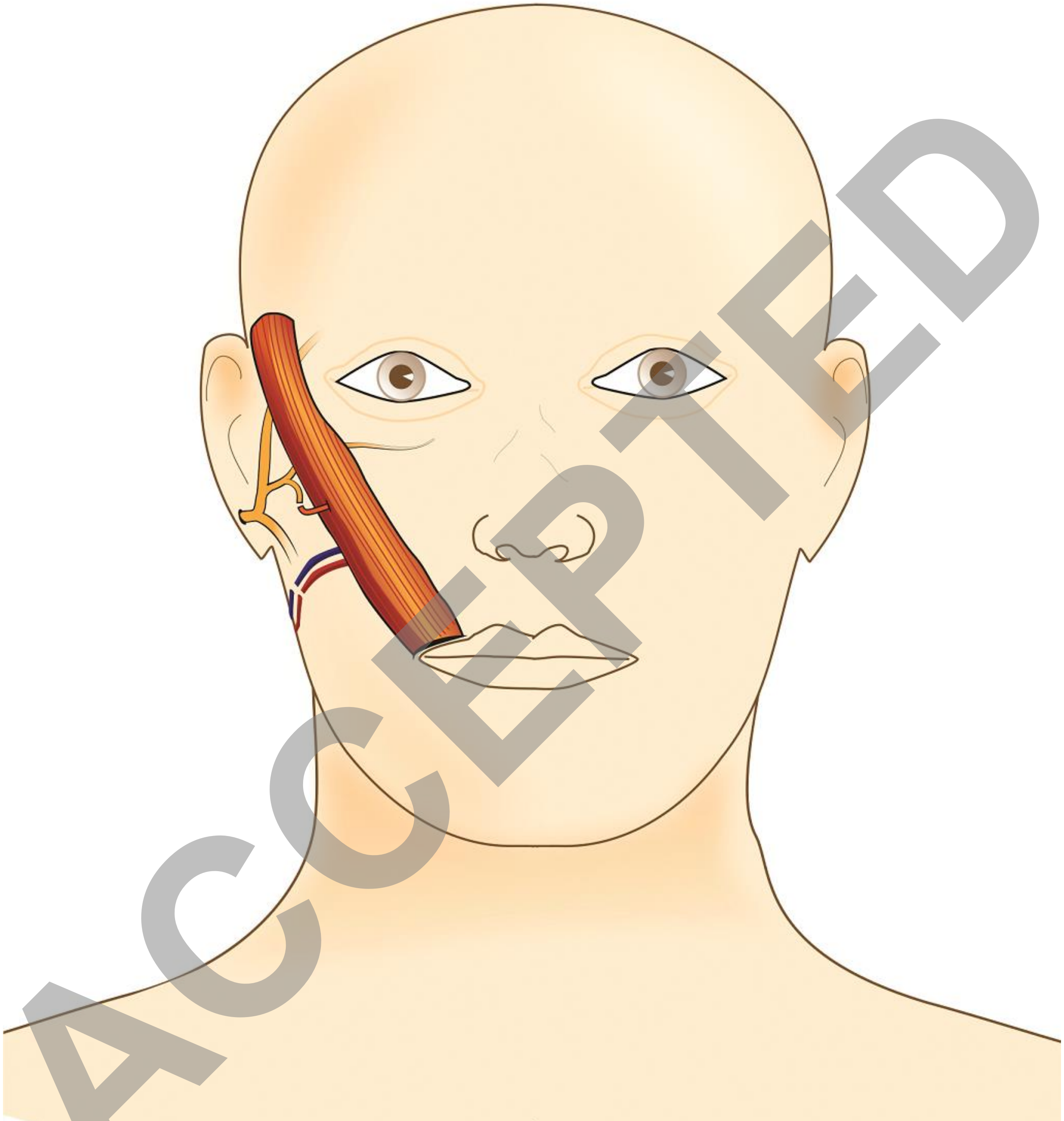
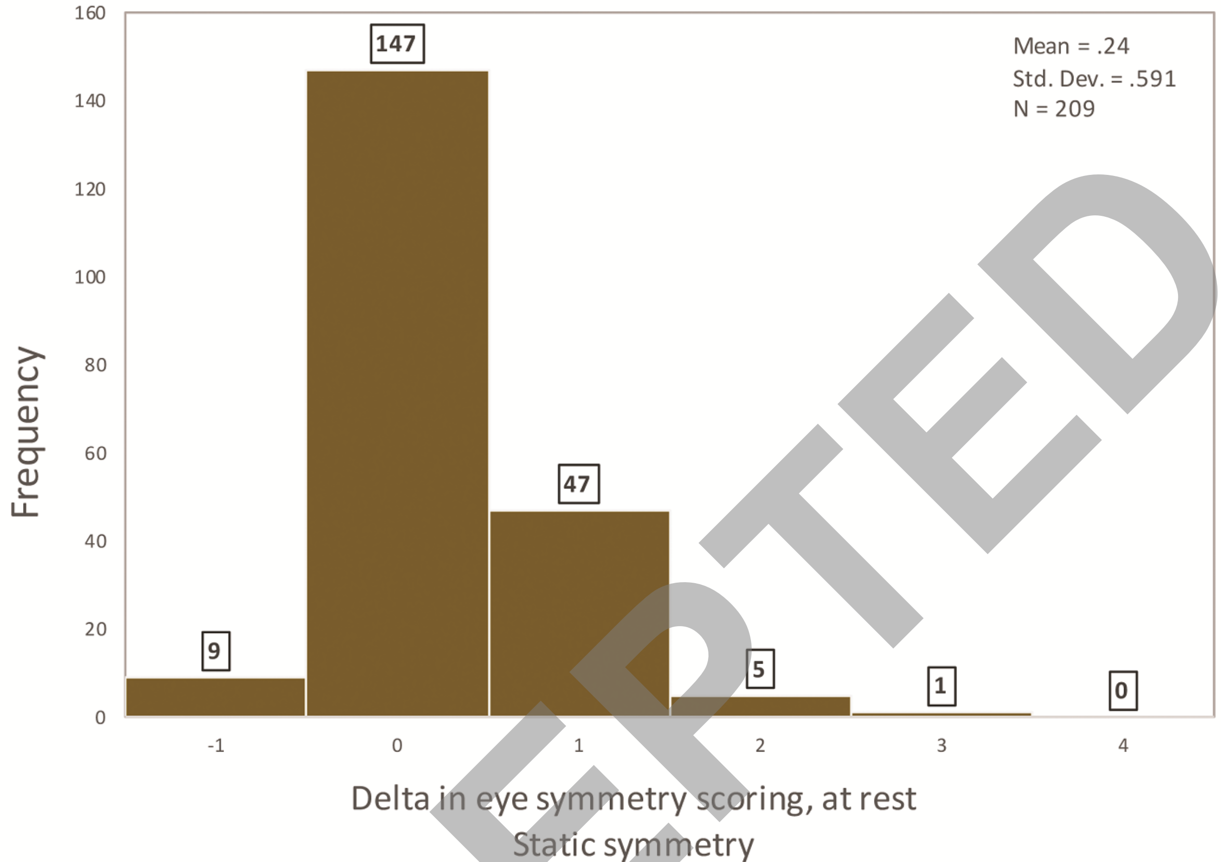
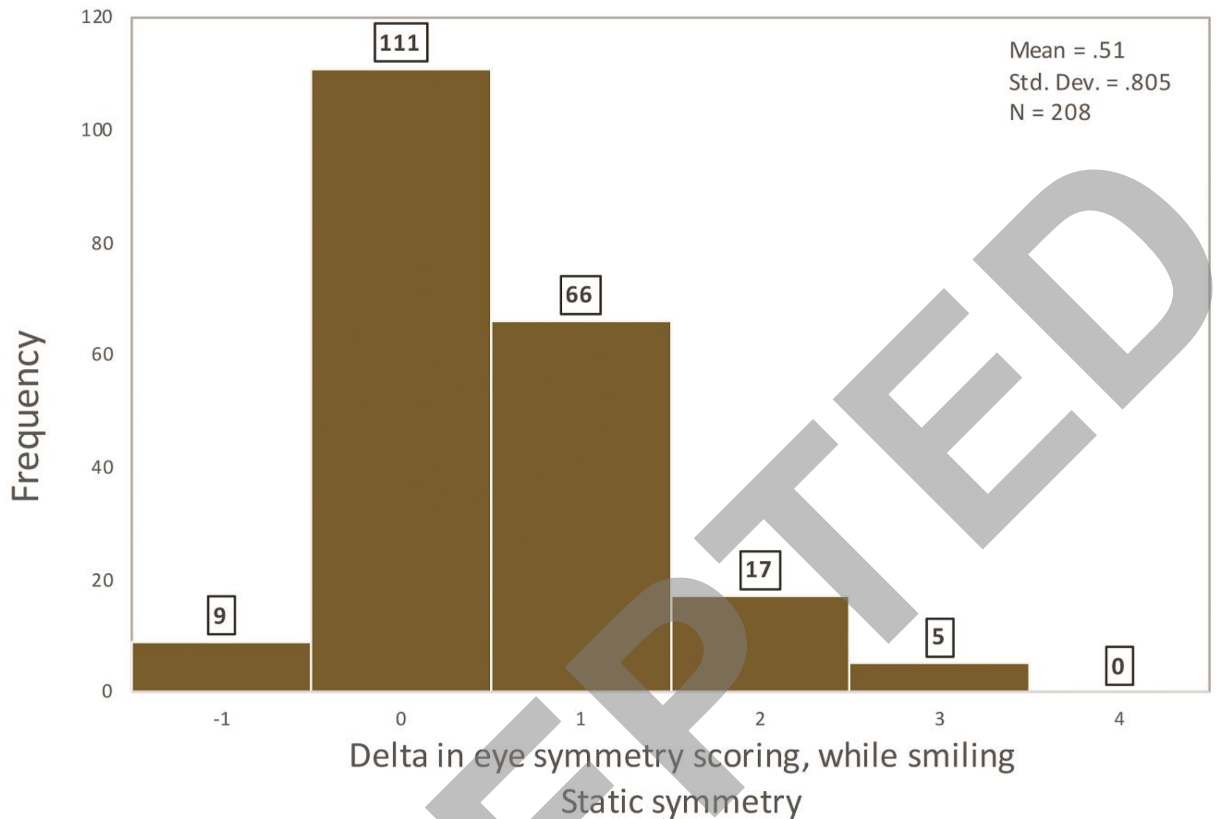


Figure 2a



160
140
120
100
80
60
40
20
0
Frequency
147
47
9
5
1
0
Mean = .24
Std. Dev. = .591
N = 209
-1
0
1
2
3
4
Delta in eye symmetry scoring, at rest
Static symmetry

Figure 2b



Mean = .51
Std. Dev. = .805
N = 208
Frequency
120
100
80
60
40
20
0
111
66
17
9
5
0
-1
0
1
2
3
4
Delta in eye symmetry scoring, while smiling
Static symmetry

Figure 2c

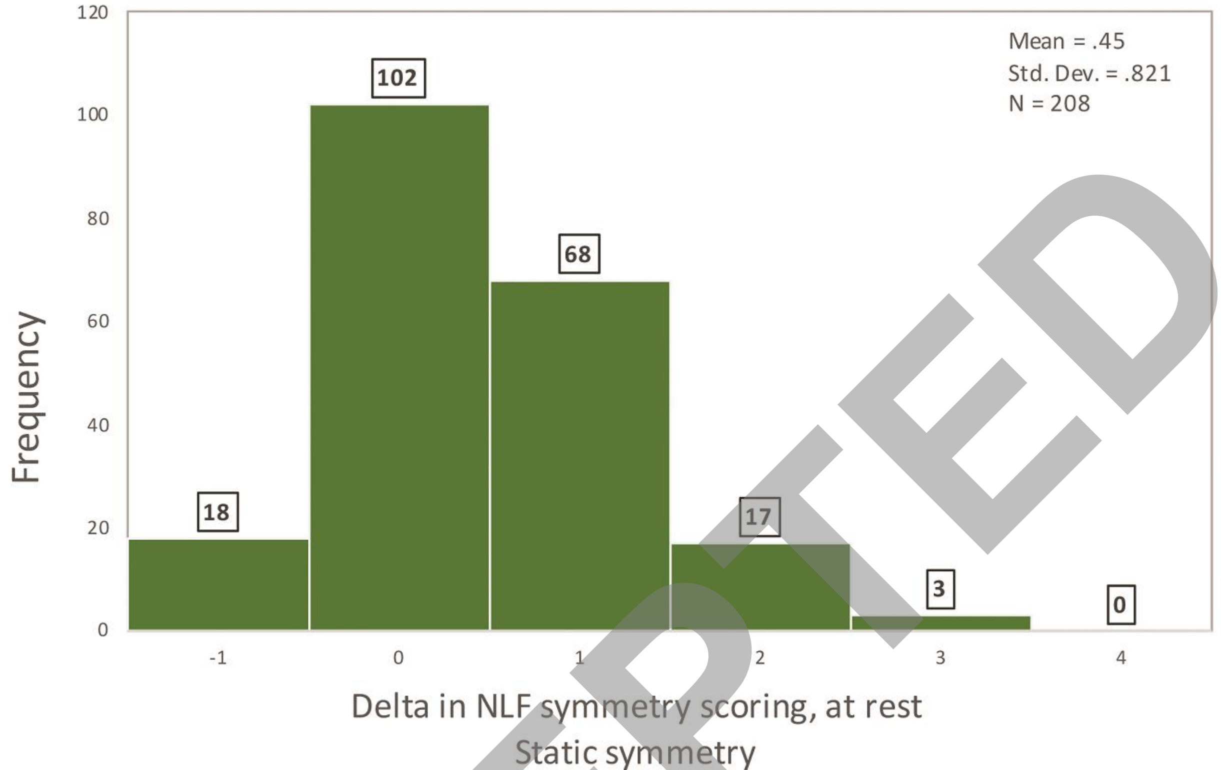
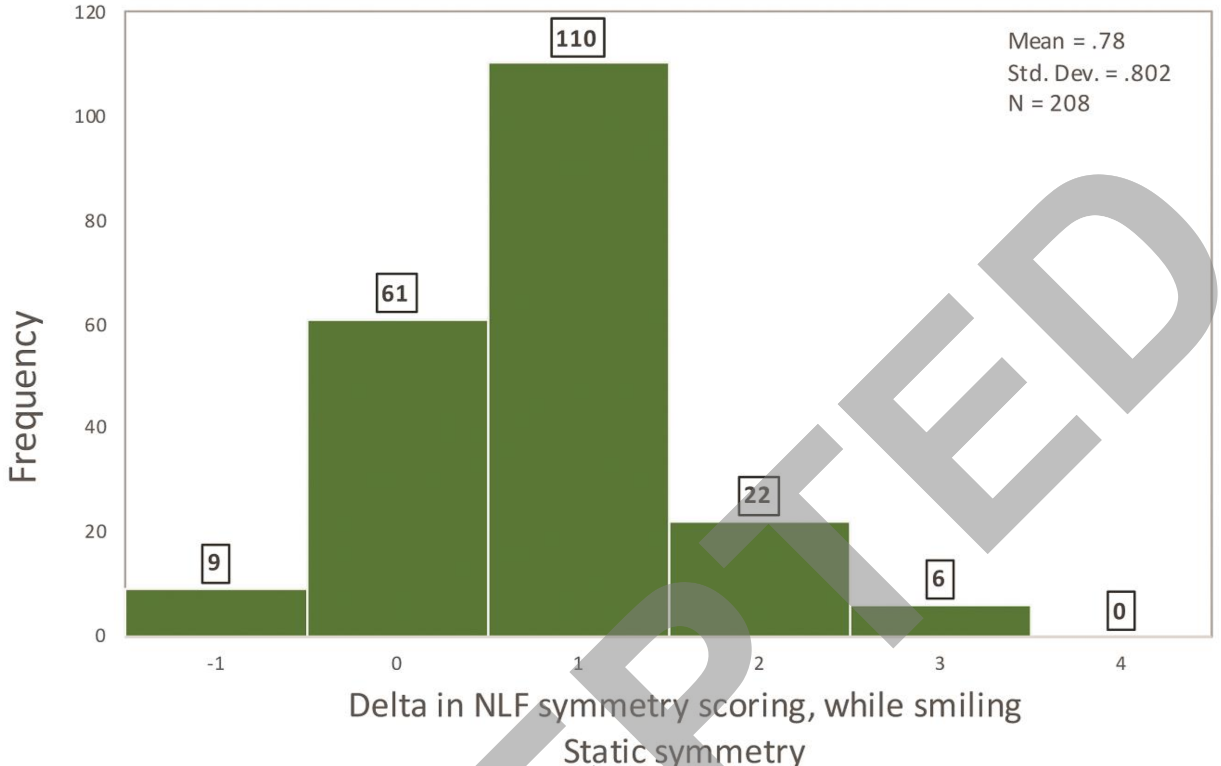
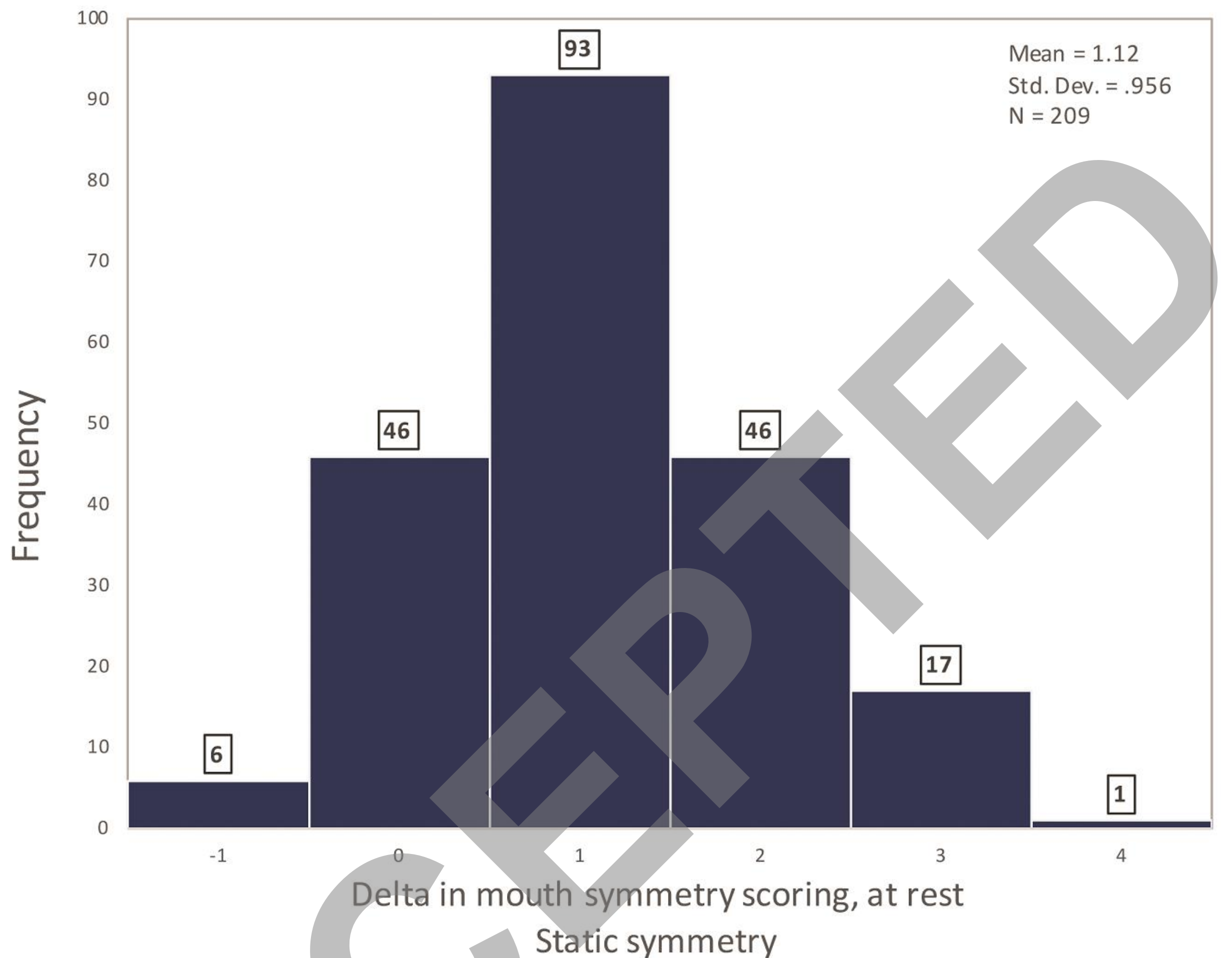

Mean = .45
Std. Dev. = .821
N = 208
Frequency
120
100
80
60
40
20
0
18
102
68
17
3
0
-1
0
1
2
3
4
Delta in NLF symmetry scoring, at rest
Static symmetry

Figure 2d



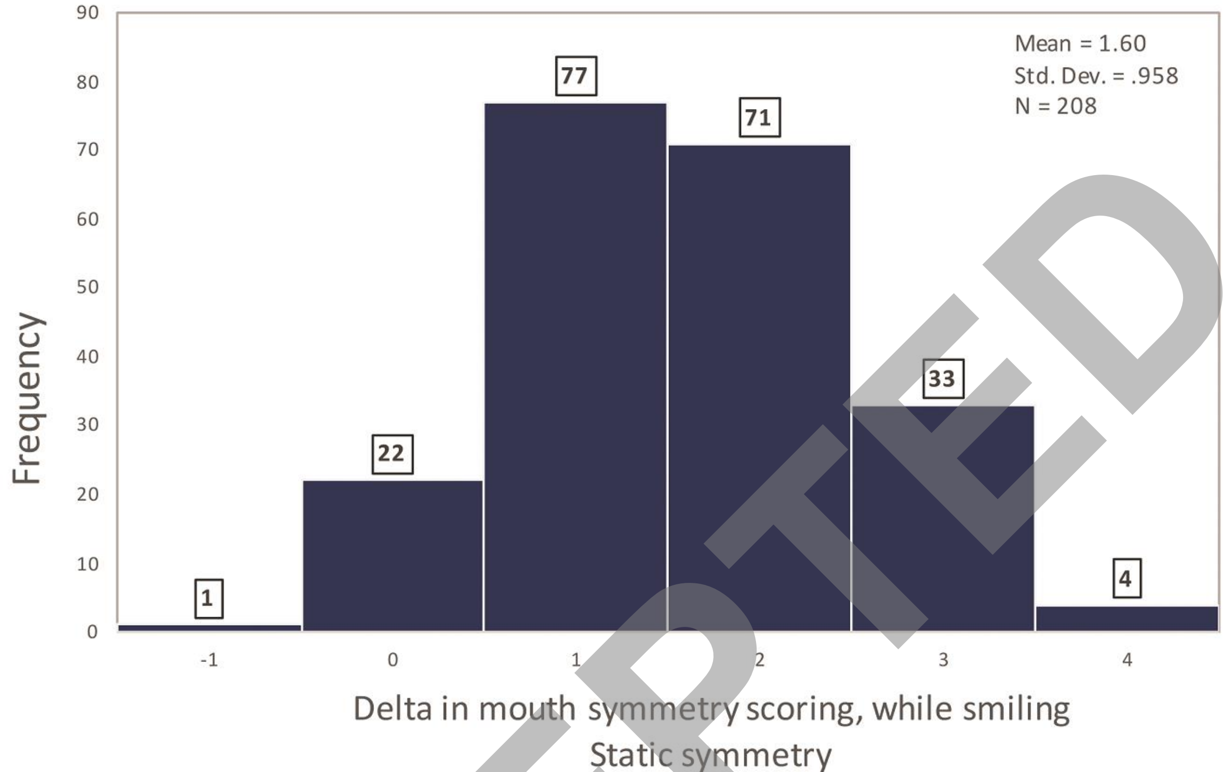
Mean = .78
Std. Dev. = .802
N = 208
Frequency
120
100
80
60
40
20
0
9
61
110
22
6
0
-1
0
1
2
3
4
Delta in NLF symmetry scoring, while smiling
Static symmetry

Figure 2e



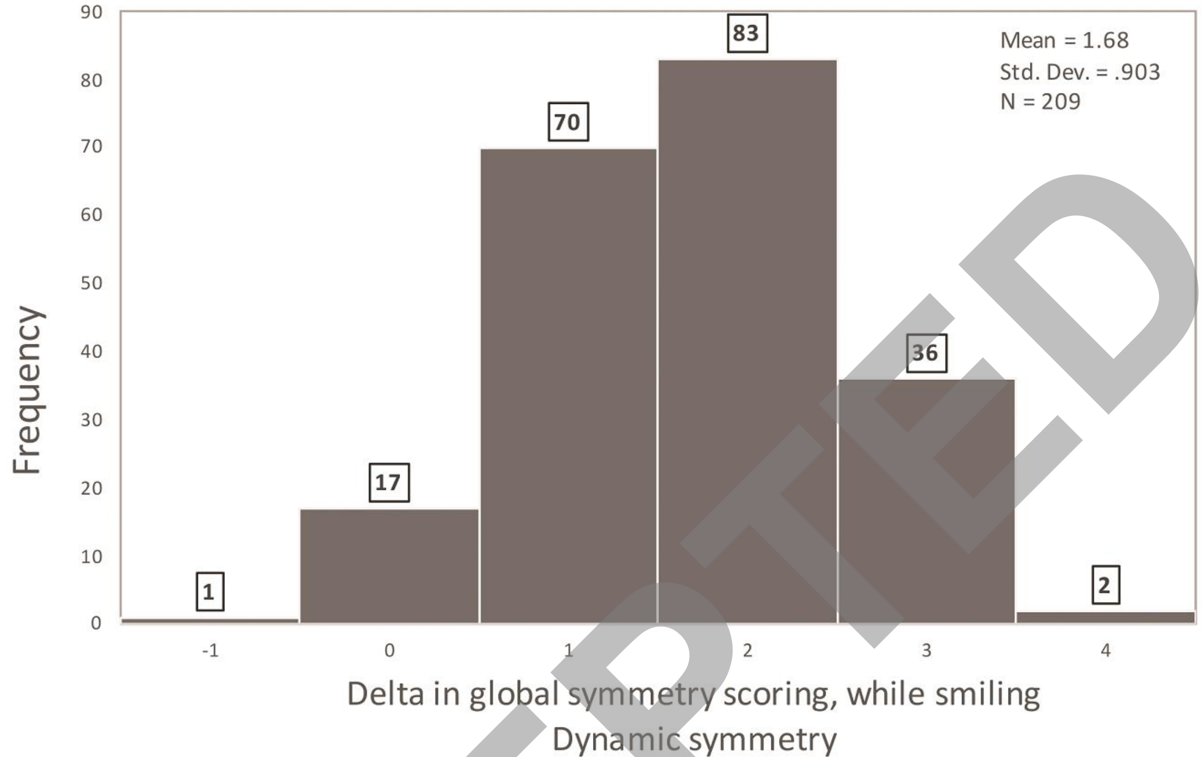
Mean = 1.12
Std. Dev. = .956
N = 209
Frequency
100
90
80
70
60
50
40
30
20
10
0
6
46
93
46
17
1
-1
0
1
2
3
4
Delta in mouth symmetry scoring, at rest
Static symmetry

Figure 2f



Mean = 1.60
Std. Dev. = .958
N = 208
Frequency
90
80
70
60
50
40
30
20
10
0
1
22
77
71
33
4
-1
0
1
2
3
4
Delta in mouth symmetry scoring, while smiling
Static symmetry

Figure 3



Mean = 1.68
Std. Dev. = .903
N = 209
Frequency
90
80
70
60
50
40
30
20
10
0
1
17
70
83
36
2
-1
0
1
2
3
4
Delta in global symmetry scoring, while smiling
Dynamic symmetry

Figure 4

Figure 5

Video.graphic1

Video.graphic2

Video.graphic3

Video.graphic 4