The “Beauty Arch”: a new aesthetic analysis for malar augmentation planning

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ABSTRACT

Midface is a critical area for the aesthetics of the face. Despite malar hypoplasia is often combined with a Class III malocclusion, there are few studies focusing on the results of a combined approach of malar implants and Le Fort I. We describe a new aesthetic analysis, named "Beauty Arch" analysis, for the assessment of sagittal projection of the malar region.

We took a reference group of 74 Italian women participating in a national beauty contest in 2011 on which we performed our analysis. We used the ideal values to elaborate the surgical treatment planning of a second group of 45 consecutive female patients affected by skeletal Class III malocclusion.

Twenty-three patients undergo simultaneous Le Fort I osteotomy and malar implants. From the descriptive statistical comparison of the patients’ values before and after orthognatic surgery and malar implants with the reference values we observed how all parameters considered got closer to the ideal population.

We consider our “Beauty arch” a useful help for surgeon in the treatment planning of patients with skeletal malocclusions and malar implants.
The “Beauty Arch”: a new aesthetic analysis for malar augmentation planning

Introduction

Midface is a critical area for the aesthetics of the face. Malar eminences, nose and chin are the most prominent areas of the face. Flattening of the face and alteration of the normal facial proportions are the aesthetic consequences of the malar hypoplasia. An hypoplasia of the zygomatic region causes adverse effects in facial aesthetics inducing an aged appearance to the individual. A maxillo-malar augmentation, when indicated, requires accurate planning based on both the aesthetic and cephalometric analysis.\(^{(1-4)}\) In the literature several surgical techniques of malar augmentation have been described.\(^{(5-7)}\) Traditionally zygomatic augmentation was obtained exclusively through osteotomic techniques\(^{(8-13)}\). The evolution of prosthetic materials led to the use of alloplastic malar implants.\(^{(14-18)}\) Despite malar hypoplasia is often combined with a Class III malocclusion, there are few studies focusing on the results of a combined approach of malar implants and Le Fort I.\(^{(19,20)}\) Furthermore, there is no agreement among the authors on the best method to assess and quantify the midfacial hypoplasia; the aesthetic and cephalometric analysis currently adopted, although representing a valuable aid for the surgical planning, have limitations for their practical use.\(^{(21)}\) This study aims to identify a method to precisely plan the degree of advancement of the malar region in order to obtain an ideal repositioning of the soft tissues. In this article we describe a new aesthetic analysis, named "Beauty Arch" analysis, for the assessment of sagittal projection of the malar region.
Material and Methods

In order to validate the beauty arch analysis, we took a reference group consisting of 74 Italian beautiful women participating a national beauty contest in 2011. The women, aged between 18 and 25 years, with an average age of 21 years and 6 months, were selected among thousands of other participants. Their jaw relationship was not considered. A standardized frontal and profile photograph was taken for each participant.

This group of women underwent Arnett’s Soft tissue Analysis with the Dolphin software 9.5 on lateral photographs taken with the subjects in natural head position, i.e. the position obtained with the subject standing and looking at his reflection in a mirror positioned exactly at eye level. Starting from the Arnett’s aesthetic analysis, we focused our attention on the cheekbone contour, to emphasize the aesthetic importance of the zygomatic region; subsequently we defined an empirical method to detect the ideal position of the zygomatic prominence. A line was drawn to connect the outer canthus of the eye (Cae) with the modiolus (Mo), along with the perpendicular passing through its midpoint, which we called “Fulcrum Line”. Then a parallel line to the Cae-Mo line, tangent to the Tragus intersecting the fulcra line, was drawn. The point where this line meets the fulcra line was considered Ideal Fulcrum. Pointing the compass on it we drew a circumference passing through the modiolus, the "Beauty Arch", which represents the ideal curve of the malar soft tissues. The radius of the beauty arch was defined Ideal Radius. (Fig. 1)
Between October 2011 and December 2012, 73 patients affected by maxillo-malar deformities come to our observation. We have selected 45 female patients with class III malocclusion, aged between 18 and 40 years, mean age 28 years and 4 months. The exclusion criteria were: craniofacial syndromic malformations, cleft lip and palate, maxillo-malar scars, asymmetry on frontal and vertical planes.

Lateral cephalometric X-Ray and pictures of the right profile performed before surgery of the 45 patients were analyzed. The cephalometric analysis and the "Beauty Arch" parameter were studied. The parameters analyzed were

**Ri:** Ideal Radius, measured on the Beauty Arch.

**Rr:** Real Radius, connecting the fulcrum of the Beauty Arch with the most prominent zygomatic point.
(Ri-Rr): The distance from the most prominent point of the cheekbone to the "Beauty Arch".

**Cae-Mo**: The linear distance between outer canthus and modiolo.

Through this analysis we have identified which patients needed surgical correction of both the malar and the maxillary regions. All 45 patients underwent Le Fort I osteotomy, whilst 23 patients underwent zygomatic augmentation through zygomatic implants. Thickness of the prosthesis has been decided based on Ri-Rr distance. Through a post-operative analysis, we obtained a hard tissue-soft tissue ratio based on the comparison between the planned augmentation and the real augmentation of the zygomatic region.

The patients entered then a post-operative follow-up program, with photographic and clinical assessment after 2 weeks, 1 month, 3 months and 6 months.

At 6 months follow-up we repeated the aesthetic analysis on the right profile picture.

Finally we compared patients’ values after surgery with the reference values obtained from the group of women participating the beauty contest using box plots.

To prevent inter-observer error, all processes (landmark identification and linear measurements) were performed by one author and were repeated twice during a 2-week interval.

**Results**

The Beauty Arch analysis revealed a poor projection of the zygomatic "pommel" in 23 patients out of 45. Among these 45 patients, the mean difference between the pre-operative ideal radius (8.9 mm, range: 7.9 to 9.7 mm, SD: 0.43) and the pre-operative real radius (8.6 mm, range: 7.4 to 9.5 mm, SD: 0.5) was 0.29 mm. Among the 23 patients with malar retraction, the mean difference was 0.48 mm, being the mean value of the ideal radius 8.84 mm (range: 7.9 to 9.6 mm, SD: 0.48) and the real radius mean of 8.36 mm (range: 7.4 to 9.3 mm, SD: 0.52). The mean difference of the reference group (Italian models) was 0.089 mm, with the mean ideal radius of 9.09 mm (range: 8.5 to 9.6 mm, SD: 0.31) and the mean real radius of 9 mm (range 8.3 to 9.6 mm, SD: 0.33) (Table 1).
The cheek bone contour was convex in all the patients according to the Arnett’s analysis. Orthognathic surgery entailed Le Fort I osteotomy with maxillary advancement in all cases (45 patients), combined with bilateral sagittal split osteotomy (BSSO) in 40 cases. We used Design M Malar Implants (Medpor) of 3mm, 4.5 mm and 7 mm of thicknesses.

When the difference Ri-Rr was 0.1 mm or 0.2 mm (22 patients) no zygomatic prosthesis were inserted. In 6 patients (Ri-Rr value of 0.3 mm) an implant of 3 mm of thickness was applied, while 12 patients (Ri-Rr value of 0.4 mm or 0.5 mm) had implants of 4.5 mm, and 5 patients (Ri-Rr > 0.6 mm) implants of 7 mm.

None peri- or post-operative complications were observed. In 3 cases a slight asymmetry of the face was noted six months after surgery; however it did not require surgical correction. Two patients had palpable prosthesis at the zygomatic arch region, however they decided not to undergo further surgery for correction of such a minor complication.

The post-operative analysis of patients undergoing Le Fort I osteotomy and malar implants showed an improvement of the average radius from the preoperative value of 8.36 mm (range: 7.4 to 9.3

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Ideal Group of reference</th>
<th>Patients pre-op</th>
<th>Patients post-op</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cae-Mo</td>
<td>7.12 mm (0.31)</td>
<td>7.25 mm (0.63)</td>
<td>Not changed</td>
</tr>
<tr>
<td>Ideal radius</td>
<td>9.09 mm (0.31)</td>
<td>8.84 mm (0.48)</td>
<td>Not changed</td>
</tr>
<tr>
<td>Real radius</td>
<td>9 mm (0.33)</td>
<td>8.36 mm (0.51)</td>
<td>8.77 mm (0.47)</td>
</tr>
</tbody>
</table>

Table 1: Mean values of Beauty Arch analysis group compared with patients who underwent Le Fort I osteotomy and malar implants (pre- and post-op values). In brackets standard deviation.
mm, SD: 0.52) to the postoperative value of 8.77 mm (range: 7.8 to 9.5 mm, SD: 0.47), a data closer to the ideal radius (8.84 mm) and to the average value of the reference group (9 mm) (Fig. 2-3).

Fig. 2: Histogram of ideal radius and real radius in patients underwent Le Fort I and malar prosthesis in pre and post-operative period

Fig. 3: Box plot of post-operative real radius value compared with ideal radius value respect to the pre-operative real radius value.
The statistical comparison of the values of patients before and after orthognathic surgery and malar implants with the values of the sample showed that all parameters became closer to the ideal population (Fig. 4).

![Box plot](image)

Fig. 4: Box plot of the reduction of the value of the difference between ideal radius and real radius in the pre-operative and the post-operative period. The post-operative values are close to the reference sample.

All patients who underwent Le Fort I osteotomy and malar implants were fully satisfied with their appearance starting from 6 months following surgery, when the edema was resolved (Fig.5-6).
We tried to establish the relationship between hard tissues and soft tissues modification after surgery by combining in a formula the values of preoperative real radius, post-operative real radius, and the size of the prosthesis as follow:

\[ X = \frac{\text{post } Rr - \text{pre } Rr}{\text{thickness of the prosthesis}}. \]

In our treatment planning (performed on lateral pictures in 1:1 ratio), we introduced a factor of correction, that considered changes of the soft tissue after surgery (soft / hard tissues ratio), using the following formula:

\[ \text{BM} = \frac{d (\text{Re-Rr})}{x} \]

\[ \text{BM} = \text{Bone Movement, mm of bone that must be moved}. \]
X value = ratio of effective changes of the soft tissues after skeletal movement.

This ratio was found to be 0.86 mm. For example, if the real radius was 4 mm within the Beauty Arch, the surgeon would insert a 4.5 mm prosthesis to achieve the augmentation of 4.6 mm needed to obtain the planned result;

i.e. $BM = d (R_i - R_r) \times \text{ and then: } 4 \text{ mm : } 0.86 = 4.65 \text{ mm.}$

**Discussion**

The surgical planning of patients with skeletal deformities of the middle third of the face remains challenging despite of many analytical methods developed. The main challenge is to identify a simple method, characterized by quick applicability, useful in pre and intra-operative period, non-invasive for the patient, and validated on a universally accepted reference sample. The region of the middle third of the face is an important area for the aesthetics. The malar prominences represent the main structure that defines the appearance of the middle third of the face; often hypoplasia of the middle third of the face is associated with Class III due to underdevelopment of the maxillary bone.

Over the years, several methods for the assessment of the malar region have been proposed. Arnett GW et al. (21) described the cheek bone contour for the analysis of the zygomatic region; however, he did not provide clear reference data, and the evaluation of the zygomatic prominence was supplied by subjective evaluation. Terino EO (8) proposed to divide the malar region into 5 distinct anatomical areas and to act on the most affected to correct the patient deformity. Nocini et al (6) described the Gridplane, an analysis developed on the basis of a grid that divides the third medium in areas; it was formed by three vertical lines and five horizontal lines drawn on the patient's face. This grid was used as a coordinate chart to guide the placement of the malar implants. Mladick RA(5) described an analysis characterized by the use of two ideal lines, one drawn from the wing of nose to the tragus and the other from the labial commissure to the lateral canthus. These lines allowed locating the area with the defect known as "Mladick point".
Our reference sample consisted of a wide group of women selected from the Italian people during a national beauty competition, to define the ideal aesthetic standards for comparison of patients affected by midface skeletal deformities. The parameter Beauty Arch introduced in our aesthetic analysis provides simple and rapid measurements for surgical planning performed on picture in 1:1 ratio. The immediate viewing of the beauty arch allows for immediate diagnosis of zygomatic hypoplasia based on the simple analysis of either lateral pictures or clinical evaluation of the patient.

In the picture, the tragus of the patient must be visible otherwise our analysis cannot be done.

A limit of our Beauty Arch is to focus it on the analysis of the profile, without allowing the assessment of the transversal measure of the zygomatic region in frontal plane.

In Literature several techniques of malar augmentation have been described and classified into two groups: osteotomic techniques and grafts placements.

The former include: 1) the "Lamellar split osteotomy" described by Salyer KE \(^{(10)}\) with the purpose of obtaining an antero-lateral augmentation of the cheekbone; 2) the Zigomatic Sagittal Split Osteotomy or ZSSO described by Gasparini et al.\(^{(11)}\) that allows for correction and stabilization of the midface without the use of distraction devices; 3) Sandwich Zygomatic Osteotomy introduced by Mommaerts et al.\(^{(12)}\), which consists in the anterior and lateral dislocation of the zygomatic bone after the vertical and oblique-horizontal osteotomy, 4) Le Fort III Advancement of the midface \(^{(13)}\), which has been widely codified and has been applied for decades to correct the hypoplasia of the middle third of the face. However, it implies the movement of the median nasal region, which sometimes is not necessary in patients affected by non-syndromic malformation. In addition, the invasiveness of the technique restricts its application to patients with severe hypoplasia.

Among the techniques exploiting the use of grafts, several autologous, heterologous and alloplastic materials to increase the projection of the zygomatic region have been proposed. Silicon, Proplast and Supramed \(^{(15,16,18,23)}\) do not represent good choices because of their frequent complications such as: formation of foreign body granulomas, displacement of the implant, and post-operative infective
complications.

Autologous bone graft is an excellent material, but has the not negligible drawback of the donor site morbidity. In our study we have used Medpor implants of different size depending on the characteristics of the zygomatic hypoplasia. Medpor has proven to be a highly biocompatible material. Furthermore, the firm nature of this material allows a simple modeling and adaptation to the underlying tissues. Because of the white color, Medpor implants are not visible through the overlying tissue; the surface is rough in order to facilitate its anchoring to the tissue in the desired position.

This material ensures results in long-term stability because it is insoluble in tissue fluid. (17)

Approaches for placement of implants/grafts in the malar region have also evolved over time. The intraoral approach, (8) performed by incision of the superior vestibular fornix, is the most used. In our study we used this approach, exploiting the incision performed for the Le Fort I osteotomy. Robiony M et al. (19) has already described the correction of malar hypoplasia and dento-skeletal malformation by combination of Medpor malar implants and orthognathic surgery.

The Author planned the malar implant to be positioned using the Mladick analysis. (5) Unlike other Authors, we have realized our surgical planning on the basis of Beauty Arch which provides accurate informations about the ideal placement and size of the implants for each patient. It also allowed for proper establishment of the hard/soft tissue ratio of the midface to obtain a predictable aesthetic result of the soft tissues.

Several values about hard tissue / soft tissue ratio of different facial structures have been described in Literature; however, up to date, no studies focusing on surgical planning for the correction of the malar hypoplasia providing both the entity of the advancement required and the size of the implant to be placed, have been proposed. The choice of the prosthesis size and shape, in fact, was basically empirical because there was a lack of data on hard/soft tissue movement ratio for the malar region. Analysis of post-operative results has shown a value of hard tissue/soft tissue ratio of 0,86.

Through the Beauty Arch analysis, the surgical planning and selection of the prosthesis for
correction of malar hypoplasia have switched from an artistic act to a scientific approach.
REFERENCES


