SOFT-TISSUE FACIAL ASYMMETRY BEFORE AND AFTER ORTHOGNATHIC SURGERY: APPLICATION OF A NEW 3D PROTOCOL

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ABSTRACT

Introduction: Skeletal Class III patients often present a major facial asymmetry. In the current investigation, a quantitative method to assess 3D facial asymmetry was applied to an orthognathic surgery patient to quantify possible postsurgical modifications.
Methodology: Soft-tissue facial scans of a 20-year-old man with skeletal Class III, candidate to orthognathic surgery, were collected in the pre-surgery stage and 6, 12, 24 months post-surgery with a stereophotogrammetric system. Soft tissue asymmetry was calculated in the facial thirds according to a published protocol (J Craniomaxillofac Surg 2017;45(1):76-81), and the relevant time-related modifications described. The results were also compared to normal values from a group of 23 control subjects (10 men, 13 women, mean age 26) by using z-scores.
Results: The longitudinal analysis of the soft-tissue facial asymmetry showed a marked difference in the analysed time points: orthognathic surgery did reduce facial symmetry in the present patient. The comparison between the patient and the control subjects by using z-scores highlighted a clear difference in all-time points: the patient with facial dysmorphia had a higher degree of asymmetry than healthy subjects.
Conclusion: The measurements of soft-tissue facial asymmetry using 3D optical digitisers can provide clinically useful information. The graphical representation of results can help in the patient's understanding of the treatment phases, thus increasing compliance.
Keywords: face, soft tissues, orthognathic surgery, symmetry.

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1. Introduction

Facial dysmorphoses are not common in the western world. According to US studies, dentoskeletal Class III patients can be found in 0.6% of the general population, a much smaller value than that reported for dentoskeletal Class II patients, which is around 10% [1].
Nonetheless, Class III patients often present more complex situations than Class II ones, with a much more altered facial function and aesthetics, and the percentage of patients undergoing surgical interventions is approximately 6-7 times larger in Class III than in Class II subjects (about 33% vs. 5%) [1]. Apart from the restoration of a sound functionality and a normal occlusion, aesthetics and facial symmetry are among the most important aspects in modern orthognathic surgery [2]. The successful attainment of an aesthetically acceptable result starts from correct skeletal and dental positions [3-5], but it needs a thorough evaluation of the facial soft tissues [1,2]. The external appearance of the face is also the key point for a fruitful dialogue among the surgeons, the orthodontists and the patients, allowing the best compliance especially for treatments that require several interventions, and that need a middle term follow up to show their final results [6,7].
Current technology offers a wide range of computerized optical scanners that can be used to assess facial soft tissues not invasively, providing a 3D, quantitative reproduction of the patients' characteristics [8]. The digital images can be evaluated longitudinally to appreciate the effects of the various phases of the treatment [6] and can be compared to those obtained from normal subjects of comparable age, sex and ethnicity.
Indeed, the need for reference values is important, as a slight facial asymmetry is also present in healthy subjects [9-11], and even the best surgical and orthodontical approaches cannot restore a perfectly symmetrical appearance. In the present study, we evaluated the soft tissue facial asymmetry of a patient undergoing a combined surgical-orthodontic treatment to correct a Class III dento-skeletal malocclusion. 3D

morphometric measurements were performed on digital stereophotogrammetric images, and facial soft tissue asymmetry quantified. Data were obtained longitudinally and compared to those obtained in healthy, control subjects.

2. Materials and methods

The facial soft tissues of a 20-year-old man were imaged by using the VECTRA M3 3D Imaging System (Canfield Scientific, Fairfield, NJ, USA). The instrument is a stereophotogrammetric unit made up of three pods. In each pod, there are two cameras that photograph the subject's face from different points of view (Fig. 1). A previous calibration permits to obtain the metrical data of the facial surface (from ear to ear, from trichion to neck) in a few milliseconds. Files can be exported and elaborated with proprietary and custom software. In particular, the Mirror® Vectra Software (Canfield Scientific, Fairfield, NJ, USA) was used in the present investigation [4].

The patient had a diagnosis of skeletal Class III dysmorphism and was a candidate for a surgical intervention of bimaxillary osteotomy. The patient was analysed in 4 different stages (preoperative, at the end of orthodontic treatment, and postoperatively 6, 12 and 24 months after surgery). On each occasion, he was imaged while seating with a natural relaxed expression (closed lips, teeth in slight contact).

A group of 23 subjects were selected from the Laboratory archive to form the control group (13 females and 10 males, mean age 26, SD 6.8 years); they all had a diagnosis of dentoskeletal Class I and no history of traumas or alterations in the facial bones. Acquisitions were obtained after the patients' written informed consent and did not involve any invasive, painful or dangerous procedure. All procedures were performed as previously described in the literature [12,13]. In brief, on each facial image, a set of 50 anthropometric landmarks were identified and digitized. Afterwards, following the protocol validated by Codari et al. [3], the anterior part of the face was delimitated by the following 10 landmarks: trichion (tr); right and left frontotemporal (ft); right and left zygion (zy); right and left tragion (t); right and left gonion (go); gnathion (gn) (Fig. 2).

Each half-face was split into three thirds (upper, middle and lower part); the mid facial plane of maximum symmetry was automatically obtained, and the two facial halves superimposed. The software automatically calculated the Root Mean Square (RMS) distance values among the two facial halves separately for each facial third, thus providing a set of symmetry values. The lower the value, the higher the symmetry. Ideally, very symmetrical areas should have an RMS value of 0.

To assess the longitudinal modifications, the preoperative image was superimposed on those obtained at 6, 12 and 24 months after the intervention, and RMS values obtained. The software also produced colorimetric maps which highlight the modifications in an intuitive way.

The same procedures were followed for the subjects of the control group, and descriptive statistics (mean, SD) were obtained for regional facial asymmetry and used to calculate z-scores (Patient value minus reference mean value divided by reference SD). The smaller the z-score, the similar the patient is to the control group.

IRB Approval

Figure 1. VECTRA M3 3D Imaging System (Canfield Scientific, Fairfield, NJ, USA): the three pods that surround the subject can be seen.

Figure 2. Landmarks used for symmetry analysis. (Written consent for the publication of this image was obtained).

The work described was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). Informed consent was obtained from all patients, and their privacy rights observed. Ethical approval was given by University ethics review board.

3. Results

Table 1 illustrates the time-related variations in facial asymmetry in the analysed patient. A trend of improvement in his facial symmetry was observed during the follow-up examinations.

With regards to the lower third of the face, the RMS value obtained from the overlap of the pre-surgical images of the two hemifaces was 1.2 mm; this value decreased in the subsequent acquisitions made after 6, 12 and 24 months. A reduction in the RMS values was also found in the middle and upper facial thirds.

When the facial asymmetry of the patient was compared to that of healthy, reference subjects using z-scores, a trend of improvement was seen after surgery (Fig. 3). The

Table 1. Time-related variations in facial asymmetry in the analysed patient (mm). The larger the value, the more asymmetrical the patient.

	RMS PRE	RMS 6 months	RMS 12 months	RMS 24 months
Upper third (forehead)	0.887	0.753	0.831	0.876
Middle third (maxilla)	1.300	0.640	0.691	0.813
Lower third (mandible)	1.213	0.699	0.699	0.974

Figure 3. Z-scores of the analysed patient during the 24-months follow up.

z-score value calculated in pre-surgical acquisitions was 1.28 SD for the lower third, 1.79 SD for the middle third and 0.38 SD for the upper third; 24 months after surgery the z-score was 0.52 SD for the lower third, 0.18 SD for the middle and 0.37 SD for the upper one.

To better assess the localised facial asymmetry, Fig. 4 presents the asymmetry divided in the upper, middle and lower parts of the face in the analysed patient. The pre-surgical image is compared to that obtained at the 24 months follow up. The software produces a colorimetric map which highlights the variations in an intuitive manner. The major differences are represented in red and in blue, respectively by default and in excess. The unvaried areas are coloured in green. As expected the degree of asymmetry is reduced in every third of the face and the best results are seen in the lower third.

4. Discussion

In the current investigation, we performed a longitudinal evaluation of soft-tissue facial asymmetry in a patient candidate for bimaxillary surgery for a skeletal Class III malocclusion. The method used a set of stereophotogrammetric facial scans, and it allowed a complete picture of the modifications of the patients' soft tissues: orthodontists and surgeons are thus provided with an extra tool to plan and monitor the clinical outcome. An additional advantage is the patient-friendly depiction of the results which can enhance the patient's comprehension of the various treatment phases, with increased compliance [6].

The acquisitions were made with a middle term follow up, starting in the preoperative (post orthodontic) phase, and subsequently 6, 12 and 24 months after surgery. The 24-months stage allowed stable facial images of the patients to be obtained, without the transient effects of surgery on soft tissues edema and the post-surgical orthodontic treatment [1,14]. Indeed, despite the variety of studies on 3D facial asymmetry after bimaxillary orthognathic surgery, few were longitudinal and lasted

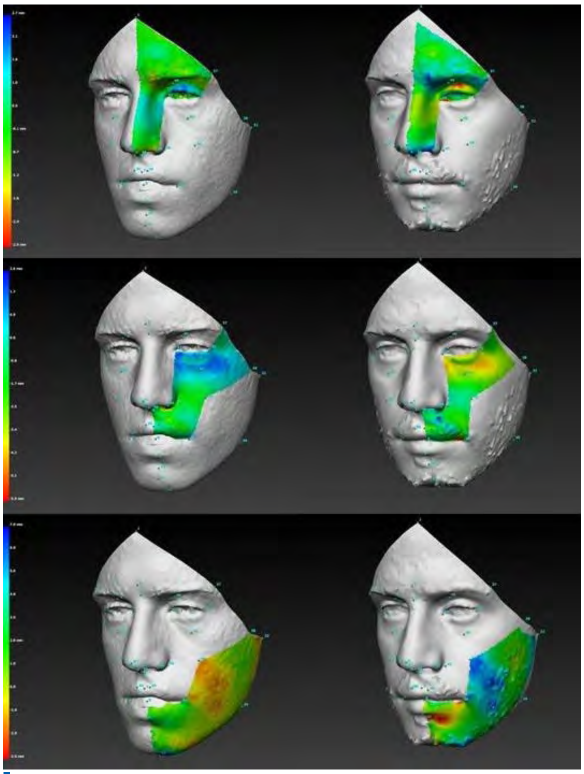

Figure 4. Localised asymmetry in the upper, middle and lower parts of the face in the analysed patient. The pre-surgical image is compared to that obtained at the 24 months follow up..

more than 6 months [15].

Generally, patients with skeletal dysmorphia are more asymmetrical than healthy subjects without malocclusions [9,16], as shown in the current analysis that allowed to localize those parts of the face showing a higher degree of left-right imbalance. The present method can, therefore, be coupled with the conventional analyses of facial esthetics [17], thus increasing the quantitative description of the patient, and helping in treatment planning and monitoring of follow up.

5. Conclusion

The measurements of soft-tissue facial asymmetry using 3D optical digitisers can provide clinically useful information. The graphical representation of results can help in the patient's understanding of the treatment phases, thus increasing compliance.

Author Contributions

FP: Conception and design of the study; Acquisition of data; Analysis and interpretation of data collected; Drafting of the article; Final approval. FMER: Acquisition of data; Analysis and interpretation of data collected; Drafting of the article; Final approval. GAB: Acquisition of data; Analysis and interpretation of data collected; Drafting of the article; Final approval. DMG: Acquisition of data; Analysis and interpretation of data collected; Drafting of the article; Final approval. VP: Analysis and interpretation of data collected; Drafting of the article; Final approval. ABG: Conception and design of the study; Analysis and interpretation of data collected; Critical revision of article; Final approval. CS: Conception and design of the study; Analysis and interpretation of data collected; Critical revision of article; Final approval.

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CV

Filippo Da Pozzo, MD, graduated in 2017 with the highest grades in Medicine and Surgery at the University of Milan. Since 2015 he has been attending the university department of Oral and Maxillofacial surgery at the polyclinic hospital Fondazione IRCCS Ca' Granda in Milan. He is currently a member of the research staff in the Laboratory of Functional Anatomy of the Stomatognathic System - LAFAS, Department of Biomedical Sciences for Health at the University of Milan, Milan, Italy. His fields of research are the morphological and metrical assessment of anatomical characteristics of craniofacial structures, including their modifications with pathology and treatment.

Questions

1. Which instruments can be used to measure soft tissue facial asymmetry?

❑a. Bite wing radiographs;
❑b. Lateral plane teleradiographs;
❑c. Stereophotogrammetric units;
❑d. Conventional orthopantomographs.

2. How was facial asymmetry measured?

❑a. Using Root Mean Square distances among images;
❑b. Using surface electromyography;
❑c. Superimposing facial photos to Computerized Tomography reconstructions;
❑d. Measuring the distances between selected skeletal landmarks.

3. In the current study we investigated

❑a. Three-dimensional modifications in dental arch diameters;
❑b. The effect of operator experience in making facial measurements;
❑c. The use of Computerized Tomography to measure facial asymmetry;
❑d. A new protocol to assess localized soft-tissue facial asymmetry.

4. In the current investigation, we found that:

❑a. Soft-tissue facial asymmetry increased after dental extraction;
❑b. Skeletal facial asymmetry decreased after implant placement;
❑c. Soft-tissue facial asymmetry decreased after orthognathic surgery;
❑d. Dental arch asymmetry increased after functional orthodontic treatment.