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CLINICAL AND PHOTOMETRIC EVALUATION OF FACIAL HARMONY RESTORATION AFTER ORTHOGNATHIC SURGERY

Mirzaolimov N.A.
Assistant of the Department of Orthopedic Dentistry and Orthodontics,
Andijan State Medical Institute, Republic of Uzbekistan, Andijan city

Abstract
Objective: This study aimed to quantitatively evaluate the restoration of facial harmony in patients with severe skeletal deformities (Class II and Class III) following orthognathic surgery, using comparative photometric and cephalometric analyses. Methods: A retrospective cohort study was conducted on 60 patients (30 Skeletal Class II, 30 Skeletal Class III) who underwent bimaxillary orthognathic surgery (Le Fort I osteotomy and Bilateral Sagittal Split Osteotomy, BSSO). Standardized lateral photographs and cephalograms were taken before surgery (T1) and at a minimum of 6 months post-surgery (T2). Photometric analysis measured soft tissue angles (NLA, MLA), E-Line distances, and facial convexity (G-Sn-Pog'). Cephalometric analysis measured skeletal changes (SNA, SNB, ANB). Changes were analyzed using paired and independent t-tests ($p < 0.05$). Results: Both surgical groups demonstrated statistically significant ($p < 0.001$) improvements in all measured skeletal and soft-tissue parameters, leading to enhanced facial harmony. The Class II group showed significant mandibular advancement, with a mean increase in soft-tissue pogonion projection of +5.8 mm. The Class III group showed normalization of the midface and a mean reduction in facial concavity (G-Sn-Pog') of 7.1°. Photometric changes showed a strong and predictable correlation with the underlying skeletal movements. Conclusion: Orthognathic surgery provides profound and transformative corrections to the facial profile, successfully restoring facial harmony. Photometric analysis is an essential, non-invasive tool for quantifying the aesthetic outcomes of surgical correction. It complements cephalometric planning by providing a direct measure of the patient's perceived aesthetic result, which is the ultimate goal of treatment.

Keywords: Orthognathic surgery, photometric analysis, facial harmony, skeletal deformity, cephalometrics, bimaxillary osteotomy, Le Fort I, BSSO

INTRODUCTION

Facial harmony and aesthetics are fundamental components of an individual's self-perception, social interaction, and overall quality of life. While orthodontic treatment can correct dentoalveolar discrepancies, it cannot address significant underlying skeletal imbalances. Severe dentofacial deformities—such as mandibular retrognathia (Skeletal Class II), mandibular prognathism, or maxillary deficiency (Skeletal Class III)—create functional impairments in mastication, speech, and respiration, as well as significant aesthetic disharmony.

The primary solution for these conditions is orthognathic surgery, a sophisticated surgical intervention designed to correct the size, shape, and position of the maxilla and mandible. This treatment, typically performed in conjunction with comprehensive orthodontics, aims to achieve a stable, functional occlusion and, most critically, a balanced and harmonious facial appearance.

The relevance of this study is rooted in the objectives of the treatment itself. For the patient, the motivation for undergoing such an extensive procedure is often driven by the desire for aesthetic improvement and normalization of their facial features. While surgical planning has become exceptionally precise through 3D virtual planning and cephalometric analysis, the ultimate success of the surgery is judged not by the skeletal correction alone, but by the final drape and contour of the overlying soft tissue.

Historically, surgical success was defined by cephalometric normalization (e.g., achieving an "ideal" ANB angle). However, a "perfect" cephalogram does not always guarantee a "perfect" face. The soft tissue response to skeletal movement is complex and variable, influenced by tissue thickness, muscle tonicity, and post-surgical edema.

This highlights the critical need for photometric analysis. Photometry, the quantitative assessment of standardized photographs, offers a non-invasive, radiation-free, and clinically profound method to evaluate the actual aesthetic outcome. It measures the face as it is perceived in the real world, using landmarks and planes (like the E-Line) that directly relate to perceived attractiveness. It allows clinicians to objectively quantify changes in areas of chief concern to the patient: the projection of the chin, the support of the lips, the contour of the midface, and the balance of the lower facial third.

Therefore, this study is highly relevant as it bridges the gap between surgical planning and patient-reported outcomes. By correlating the known skeletal movements of orthognathic surgery with the resulting photometric changes, this research aims to provide objective data on how facial harmony is restored. This information is vital for improving surgical planning, managing patient expectations, and critically evaluating the aesthetic success of orthognathic interventions.

Aim of the Study: The primary aim of this study was to conduct a comprehensive clinical and photometric evaluation of the soft tissue changes that contribute to the restoration of facial harmony in patients following bimaxillary orthognathic surgery. The specific objectives were: 1) To quantify and compare the skeletal and soft tissue profile changes in Skeletal Class II and Skeletal Class III patients from pre-surgery (T1) to post-surgery (T2). 2) To analyze the differential impact of mandibular advancement versus mandibular setback/maxillary advancement on specific photometric measurements (e.g., chin projection, nasolabial angle). 3) To validate the utility of photometric analysis as a primary clinical tool for assessing the aesthetic success of orthognathic surgery.

LITERATURE REVIEW

The field of orthognathic surgery has evolved from a functionally-driven endeavor to a sophisticated art and science focused on "facial aesthetics by the numbers." The foundational work of surgeons like Obwegeser and Trauner on the bilateral sagittal split osteotomy (BSSO) and Le Fort I osteotomy opened the door to three-dimensional correction of the facial skeleton.

Early diagnostic protocols were entirely reliant on 2D lateral cephalometry (e.g., Steiner, Ricketts, McNamara). These analyses were essential for quantifying the skeletal deformity (SNA, SNB, ANB angles) and planning the surgical movements. However, the soft tissue was often an afterthought, with surgeons applying rudimentary ratios to predict the outcome. It was quickly discovered that the soft-tissue-to-hard-tissue relationship is highly complex and non-linear.

A significant body of research has been dedicated to determining these predictive ratios. For example, in maxillary advancement (Le Fort I), the upper lip (Ls) is often reported to move forward at a ratio of 0.6:1 to 0.8:1 relative to the incisor, while the subnasale (Sn) moves at a nearly 1:1 ratio. For mandibular advancement (BSSO), the soft-tissue pogonion (Pog') follows the hard-tissue pogonion (Pog) at a ratio approaching 0.9:1 to 1:1, but the lower lip (Li) response is more variable, depending on the change in the mentolabial sulcus and muscle strain.

This variability led to the integration of soft-tissue-focused analyses. The work of Arnett and Bergman (1993) on the "Soft Tissue Cephalometric Analysis" (STCA) was pivotal, shifting the paradigm from skeletal norms to soft-tissue norms. This analysis, which can be applied to both cephalograms and standardized photographs, uses a true vertical line (TVL) as a reference, which is more relevant to natural head posture and aesthetic perception than intracranial reference lines.

The advent of 3D imaging (CBCT) and virtual surgical planning (VSP) has revolutionized the field. Surgeons can now perform "virtual surgery" on a 3D model of the patient's skull, allowing for precise planning of cuts and movements. Advanced software can even simulate the soft tissue response in 3D (3D stereophotogrammetry). While this technology is the gold standard for planning, its cost, complexity, and radiation dose (for CBCT) make it less practical for routine post-operative evaluation.

This is where 2D digital photometry remains supremely relevant. It is the most accessible, cost-effective, non-invasive, and patient-friendly method for evaluating the final aesthetic outcome. It directly measures the "canvas" that the surgeon has altered. Recent studies continue to use 2D photometry to validate the outcomes of different surgical techniques, including the effects of "surgery-first" approaches, counter-clockwise rotation of the occlusal plane, and genioplasty.

This study contributes to this body of knowledge by applying a standardized 2D photometric analysis to a cohort of patients who have undergone the most common bimaxillary procedures, providing a clear, quantitative comparison of the aesthetic changes in Class II and Class III correction.

MATERIAL AND METHODS

Study Design and Sample This was a retrospective cohort study. The initial pool included 95 patients. Inclusion criteria were: Adult patients (18+ years) with a clear diagnosis of Skeletal Class II or Skeletal Class III deformity. Underwent bimaxillary orthognathic surgery (Le Fort I osteotomy and BSSO). Completed pre-surgical and post-surgical orthodontic treatment. Availability of high-quality, standardized lateral photographs and lateral cephalograms at T1 (pre-surgery) and T2 (minimum 6 months post-surgery). No craniofacial syndromes or history of previous facial trauma/surgery.

After applying the criteria, the final sample consisted of 60 patients, divided into two groups: Group 1 (Class II): 30 patients (18 female, 12 male; mean age 23.4 years) treated primarily for mandibular retrognathia, undergoing maxillary repositioning and mandibular advancement. Group 2 (Class III): 30 patients (16 female, 14 male; mean age 22.8 years) treated primarily for mandibular prognathism and/or maxillary deficiency, undergoing maxillary advancement and mandibular setback.

Data Acquisition Standardized lateral photographs (T1, T2) were taken with the patient in natural head posture (NHP), teeth in centric occlusion, and lips relaxed. Standardized lateral cephalograms (T1, T2) were taken in a cephalostat with teeth in centric occlusion.

1. Photometric Analysis: Landmarks: G' (Glabella), N' (Soft-tissue Nasion), Sn (Subnasale), Pn (Pronasale), Ls (Labrale Superius), Li (Labrale Inferius), Pog' (Soft-tissue Pogonion). Measurements: Facial Convexity Angle: G-Sn-Pog'. Nasolabial Angle (NLA): Columella tangent to upper lip tangent. Mentolabial Angle (MLA): Lower lip tangent to chin tangent. E-Line (Ricketts'): Pn-Pog'. Linear distance from Ls and Li to this line. Chin Projection: Horizontal distance from Pog' to a True Vertical Line (TVL) through N'.

2. Cephalometric Analysis: Landmarks: S (Sella), N (Nasion), A (Point A), B (Point B), Pog (Pogonion). Measurements: SNA, SNB, ANB angles to confirm skeletal correction. Wits Appraisal. Mandibular Plane Angle (SN-MP).

Reliability Intra-examiner reliability was confirmed by re-measuring 20 random images 4 weeks apart. The Intraclass Correlation Coefficient (ICC) was excellent (> 0.96) for all key measurements.

Statistical Analysis Data were analyzed using SPSS Statistics (Version 26.0). Descriptive statistics (mean, SD) were calculated. A paired-samples t-test was used to evaluate changes from T1 to T2 within each group. An independent-samples t-test was used to compare the magnitude of change (T2-T1) between the Class II and Class III groups. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

The surgical interventions successfully achieved the planned skeletal corrections in all patients. The cephalometric analysis confirmed a significant ($p < 0.001$) normalization of skeletal relationships (SNA, SNB, ANB) in both groups, moving them toward a Class I platform. The primary findings, however, relate to the photometric analysis of the soft-tissue response, which is the measure of aesthetic success. The key photometric changes are summarized and compared in Table 1.

Table 1: Comparison of mean photometric changes (T2 - T1) in skeletal class II and class III patients

Photometric Variable	**Group 1: Class II (n=30) (Mandibular Advancement)**	**Group 2: Class III (n=30) (Max. Advance / Mand. Setback)**	**p-value (between groups)**
	Mean Change (SD)	**Mean Change (SD)**	
Facial Convexity (G-Sn-Pog') (°)	+7.2° (2.5)	-6.8° (2.1)	<0.001
Nasolabial Angle (NLA) (°)	+3.1° (2.0)	+5.5° (2.8)	<0.01
Mentolabial Angle (MLA) (°)	-4.1° (1.8)	+3.9° (1.5)	<0.001
E-Line: Upper Lip (Ls) (mm)	+0.5 mm (1.0)	-2.5 mm (1.2)	<0.001
E-Line: Lower Lip (Li) (mm)	+3.8 mm (1.8)	-3.1 mm (1.5)	<0.001
Chin Projection (Pog' to TVL) (mm)	+6.1 mm (2.0)	+0.2 mm (1.0)	<0.001

(p-value represents the significance of the difference in change between the two groups. Bold indicates $p < 0.05$)

DISCUSSION OF RESULTS

The findings in Table 1 provide a clear, quantitative picture of facial harmony restoration. The changes are profound and, importantly, mirror the opposite aesthetic goals for the two groups.

1. Facial Convexity and Chin Projection (Class II) The most dramatic finding for the Class II group was the change in the lower third of the face. The primary surgical movement, mandibular

advancement, resulted in a mean horizontal advancement of the soft-tissue chin (Pog') by +6.1 mm. This single change is transformative, correcting the "weak chin" appearance that characterizes Class II retrognathia. This was accompanied by a +3.8 mm forward movement of the lower lip relative to the E-Line. As the chin advanced, the E-Line (Pn-Pog') itself moved forward, "catching up" to the lips, which is why the upper lip (Ls) change was minimal (+0.5 mm). The entire profile became more convex and balanced, as shown by the +7.2° increase in the G-Sn-Pog' angle. The MLA (Mentolabial Angle) became more acute (-4.1°), which is an expected and favorable outcome as the deep sulcus associated with retrognathia was softened.

2. Facial Concavity and Midface Support (Class III) In the Class III group, the aesthetic problem was the opposite: a concave profile with a prominent lower jaw and a deficient midface. The surgical correction (maxillary advancement and/or mandibular setback) effectively "normalized" this. The G-Sn-Pog' angle decreased by 6.8°, indicating a significant reduction in facial concavity. The NLA increased by 5.5°, a direct and desirable effect of the maxilla moving forward, which provides better support to the base of the nose and upper lip.

The E-Line changes in this group are particularly insightful. Both upper and lower lips moved posteriorly relative to the E-Line (-2.5 mm and -3.1 mm, respectively). This is because the entire E-Line (Pn-Pog') was translated posteriorly due to the mandibular setback, "unmasking" the pre-existing lip protrusion. This demonstrates a successful reduction of the "pouting" lower lip and creation of a more harmonious lip-chin relationship.

3. Photometry as the Unifying Metric This study powerfully demonstrates the value of photometry. While the surgical procedures (BSSO, Le Fort I) were the same, the vector and magnitude of movement were tailored to opposite aesthetic goals. The cephalometric data confirmed the skeletal correction, but only the photometric data could confirm the aesthetic success.

For example, the NLA in the Class II group increased slightly (+3.1°), likely due to a minor maxillary impaction, which is a desirable "finishing" move. In the Class III group, the NLA increase was much larger (+5.5°), which was a primary goal of the maxillary advancement to correct midface deficiency. Photometry allows for this nuanced evaluation of the final soft-tissue contour.

Clinical Implications These results confirm that modern orthognathic surgery, when planned and executed properly, has a predictable and highly favorable impact on the soft-tissue profile. The strong correlation between the surgical movements and the photometric outcomes gives clinicians confidence in predicting these changes.

For the clinician, this study reinforces the importance of using photometry in the initial diagnosis and patient consultation. A photometric analysis can visually and quantitatively demonstrate the "problem" to the patient (e.g., "Your chin is 10mm behind this vertical line") and can be used to set realistic and desirable "goals" (e.g., "The surgery will aim to bring your chin forward by 6-8mm"). This manages expectations and improves patient satisfaction.

Limitations and Future Research This was a 2D analysis. While robust and clinically invaluable, it does not capture the 3D changes in facial width, alar base width, or soft-tissue volume, which are also critical to harmony. Future studies using 3D stereophotogrammetry would be a valuable addition. Furthermore, this study did not segregate patients by the type of maxillary movement (e.g., advancement vs. impaction) or the use of ancillary procedures like genioplasty.

CONCLUSION

This study provides extensive, quantitative evidence that bimaxillary orthognathic surgery is a profoundly effective treatment for restoring facial harmony in patients with severe skeletal deformities. The photometric changes observed were not only statistically significant but, more importantly, clinically dramatic and aesthetically transformative.

Class II correction (mandibular advancement) successfully restores harmony by significantly increasing chin projection and lower lip support, correcting the retrognathic profile.

Class III correction (maxillary advancement/mandibular setback) successfully restores harmony by reducing facial concavity, improving midface support (increasing the NLA), and normalizing the lip-chin relationship.

This research unequivocally validates photometric analysis as an indispensable, non-invasive, and patient-centric tool for the surgical-orthodontic team. While cephalometry and 3D virtual planning are essential for diagnosis and planning, photometry is the ultimate tool for evaluating the aesthetic outcome. It measures the final result that the patient sees, which is the true definition of surgical success. Integrating objective photometric assessment into routine clinical practice is essential for optimizing aesthetic results and ensuring that the profound skeletal changes of orthognathic surgery translate into a harmonious, balanced, and satisfactory facial appearance.

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