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CHANGES IN MORPHOMETRIC PARAMETERS OF THE EXTERNAL NOSE AFTER COMPLICATED SURGICAL PROCEDURES

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Abstract. Revision rhinoplasty remains one of the most challenging areas in aesthetic and reconstructive facial surgery due to the complexity of postoperative deformities and scar-related tissue alterations. The present study aimed to evaluate morphometric changes of the external nose in patients with complications after primary rhinoseptoplasty and to assess the effectiveness of revision surgical interventions. A total of 68 patients with post-rhinoplasty deformities and 50 healthy controls were included in the investigation. Comprehensive morphometric assessment was performed using direct anthropometry, digital photogrammetry, and three-dimensional scanning technologies. The evaluated parameters included linear, angular, and volumetric characteristics of the external nose. Before revision surgery, patients demonstrated significant deviations in nasal proportions, tip projection, dorsal height, and asymmetry compared with normative population values. Following revision rhinoplasty, substantial improvement in morphometric indicators was observed during 6- and 12-month follow-up periods. Three-dimensional analysis revealed restoration of nasal volume, reduction of asymmetry, and improvement of surface contour parameters in the majority of patients.

Keywords: Morphometry of the external nose, rhinoplasty, revision rhinoplasty, complications, anthropometric parameters, nasofrontal angle, nasolabial angle, 3D morphometry, FACE-Q, volumetric nasal analysis.

INTRODUCTION

Rhinoplasty is currently one of the most frequently performed procedures in aesthetic and reconstructive facial surgery worldwide. Along with the growing popularity of primary rhinoplasty, the number of postoperative complications and secondary deformities requiring revision surgery has also increased significantly during recent decades [1,2]. Revision rhinoplasty remains one of the most technically challenging procedures in facial plastic surgery due to altered anatomy, scar tissue formation, cartilage deficiency, impaired vascularization, and unpredictable tissue remodeling processes [3,4]. According to contemporary clinical studies, the frequency of revision interventions after primary rhinoplasty ranges between 5% and 15%, while dissatisfaction with aesthetic or functional outcomes may be observed in up to 20–30% of patients [5,6].

Secondary deformities of the external nose represent not only an aesthetic problem but also an important functional and psychosocial issue. Patients with unsuccessful primary rhinoplasty frequently experience impaired nasal breathing, chronic nasal obstruction, valve insufficiency, asymmetry of the nasal dorsum or tip, collapse of cartilaginous structures, tip ptosis, saddle nose deformity, and disturbances in facial harmony [7,8]. Such complications may significantly reduce quality of life, negatively affect social adaptation, and contribute to psychological distress, anxiety, decreased self-esteem, and dissatisfaction with personal appearance [9,10]. Therefore, successful revision rhinoplasty requires restoration of both anatomical integrity and psychological confidence.

The complexity of revision rhinoplasty is largely associated with postoperative fibrosis, scar contracture, altered tissue elasticity, and partial loss of native anatomical support structures [11]. Excessive resection of lower lateral cartilages, inadequate support of the columella and nasal tip, disruption of dorsal support mechanisms, and compromised vascular supply are considered among the leading causes of secondary deformities [12,13]. Furthermore, repeated surgical interventions often aggravate tissue trauma and impair regenerative processes, making secondary reconstruction significantly more difficult than primary rhinoplasty [14].

Accurate morphometric assessment of the external nose plays a key role in modern rhinoplasty planning and postoperative outcome evaluation [15]. Classical anthropometric techniques based on Farkas landmarks remain important diagnostic tools for measuring linear and angular nasal parameters [16]. However, conventional two-dimensional photogrammetry has certain limitations related to perspective distortion, variability of photographic positioning, and inability to objectively evaluate volumetric changes [17]. In this regard, the introduction of advanced three-dimensional imaging technologies has significantly improved the precision and reproducibility of nasal morphometric analysis [18].

Three-dimensional morphometry allows comprehensive quantitative evaluation of nasal volume, contour irregularities, asymmetry, surface area, and tissue redistribution after surgical intervention [19,20]. Modern 3D systems such as Vectra XT and Artec Eva provide highly reproducible measurements with excellent intraclass correlation coefficients exceeding 0.95, making them valuable tools for objective postoperative assessment [21]. In addition, color-coded surface deviation maps generated by 3D software enable detailed visualization of asymmetrical changes and tissue displacement, which are often difficult to evaluate using traditional methods [22].

Another important aspect of modern rhinoplasty research is the integration of subjective patient-reported outcome measures into clinical evaluation protocols [23]. Validated instruments such as the FACE-Q questionnaire allow objective assessment of patient satisfaction, psychosocial adaptation, self-confidence, and perception of surgical outcomes [24]. Recent studies demonstrate that objective morphometric improvements do not always fully correspond to subjective patient satisfaction, emphasizing the importance of combining anatomical and psychological assessment in rhinoplasty evaluation [25,26].

Ethnic anatomical variations represent an additional critical factor in rhinoplasty planning and postoperative assessment [27]. Nasal morphology differs significantly among populations in terms of dorsal height, nasal width, nasal index, skin thickness, tip projection, and cartilaginous support characteristics [28]. Therefore, ethnically oriented surgical planning has become an essential principle of modern rhinoplasty, particularly in revision procedures where preservation of natural facial identity is extremely important [29]. Comparative anthropometric studies indicate that Central Asian populations, including Kazakh and Uzbek ethnic groups, commonly demonstrate mesorrhine nasal morphology with relatively moderate dorsal projection and wider nasal indices compared with European populations [30].

Patients with thick skin, severe fibrosis, or multiple previous rhinoplasty procedures represent a particularly difficult category in revision surgery [31]. Thick soft tissue envelopes may mask structural modifications, delay postoperative edema regression, and reduce the visibility of contour refinement [32]. Moreover, scar tissue contracture and the phenomenon of “tissue memory” may negatively influence long-term stability of surgical outcomes, increasing the risk of recurrent deformities [33]. Consequently, individualized surgical planning based on morphometric and tissue characteristics is necessary for optimizing revision rhinoplasty outcomes.

Recent advances in reconstructive rhinoplasty techniques, including the widespread use of autologous cartilage grafts, spreader grafts, septal extension grafts, structural tip grafting, and preservation-oriented surgical approaches, have significantly improved both functional and aesthetic outcomes in revision procedures [34,35]. Structural grafting techniques allow restoration of dorsal support, improvement of nasal valve function, correction of asymmetry, and stabilization of tip projection [36]. Nevertheless, despite substantial technological and surgical progress, complete restoration of nasal morphology remains challenging in complex revision cases due to severe scar formation and tissue deficiency [37].

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The growing application of digital technologies and artificial intelligence in facial plastic surgery also opens new perspectives for rhinoplasty planning and postoperative assessment [38]. Artificial intelligence-based systems may facilitate automated morphometric analysis, predictive simulation of postoperative results, and individualized surgical modeling [39]. Integration of machine learning algorithms with 3D morphometric databases may further improve preoperative planning accuracy and prediction of long-term tissue remodeling [40].

Despite the increasing number of revision rhinoplasty procedures worldwide, there remains a limited amount of comprehensive clinical research combining objective three-dimensional morphometric evaluation, functional assessment, and subjective patient satisfaction analysis within a single study design [41]. In addition, long-term data regarding postoperative tissue remodeling, volumetric stability, and ethnic-specific anatomical outcomes remain insufficiently investigated [42]. Therefore, further studies focused on detailed morphometric analysis, advanced imaging technologies, personalized surgical planning, and long-term follow-up remain highly relevant in modern aesthetic and reconstructive rhinoplasty research [43,44].

Aim of the study. To investigate the dynamics of morphometric parameters of the external nose in patients after complicated primary rhinoseptoplasty and to evaluate the degree of restoration of nasal shape following revision surgical interventions.

Materials and methods. The present study was designed as a prospective observational clinical investigation aimed at evaluating morphometric changes of the external nose in patients with complications after primary rhinoplasty and assessing the effectiveness of revision surgical interventions. The study was conducted in accordance with international ethical principles for biomedical research involving human subjects, including the Declaration of Helsinki. All participants provided written informed consent prior to enrollment in the study.

A total of 68 patients with postoperative nasal deformities following primary rhinoplasty were included in the investigation. The study population consisted of 42 women and 26 men aged between 19 and 48 years, with a mean age of 32.4 ± 7.8 years. The duration between primary rhinoplasty and revision surgery ranged from 8 months to 6 years. Patients were selected based on the presence of clinically and morphometrically confirmed postoperative deformities associated with functional and aesthetic impairment. The identified complications included asymmetry of the nasal dorsum and tip (n=29), drooping nasal tip (n=18), saddle nose deformity (n=12), and overcorrection or "polly-beak" deformity (n=9). In several cases, combined deformities were also observed.

The control group consisted of 50 healthy volunteers matched for age and sex who had no history of rhinoplasty, nasal trauma, congenital facial anomalies, or previous rhinosurgical interventions. Control participants underwent the same anthropometric and imaging evaluations to establish normative morphometric reference values.

Inclusion criteria for the study were the presence of postoperative nasal deformity after primary rhinoplasty, patient age above 18 years, complete wound healing after the primary intervention, and absence of acute inflammatory processes in the nasal cavity. Exclusion criteria included severe systemic diseases, active infectious conditions, congenital craniofacial syndromes, history of oncological pathology affecting the facial region, psychiatric disorders associated with body dysmorphic perception, and refusal to participate in follow-up examinations.

All patients underwent comprehensive preoperative clinical examination, including detailed history taking, evaluation of nasal breathing function, endoscopic examination of the nasal cavity, and standardized photographic documentation. Functional assessment of nasal airflow was additionally performed in selected patients using anterior rhinomanometry and acoustic rhinometry to evaluate the condition of the internal and external nasal valves.

Morphometric analysis was performed using a multimodal approach combining direct anthropometry, digital photogrammetry, and three-dimensional scanning technologies. Direct anthropometric measurements were obtained according to classical Farkas landmarks using

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calibrated sliding calipers and flexible anthropometric rulers. Measurements were performed under standardized conditions with patients in a natural head position and relaxed facial musculature.

Digital photogrammetry included standardized frontal, lateral, oblique, and basal projections obtained under identical lighting and camera settings. Images were analyzed using specialized software capable of calculating angular and proportional facial parameters.

Three-dimensional morphometric assessment was performed using advanced optical scanning systems such as Vectra XT, Artec Eva, or equivalent devices. The 3D method enabled highly accurate evaluation of volumetric and surface characteristics of the external nose. Parameters analyzed included nasal tip volume, dorsal volume, surface area of the radix, dorsum, and nasal tip, as well as asymmetry indices generated through color-coded surface deviation maps. Three-dimensional imaging also allowed visualization of contour irregularities and comparison of preoperative and postoperative anatomical changes.

The following morphometric parameters were evaluated in all participants:

Linear parameters: nasal length (n-sn), nasal projection (sn-prn), alar base width (al-al), alar width (al-al'), columellar height (sn-c'), dorsal height, and soft tissue thickness in the nasal tip and dorsum regions.

Angular parameters: nasofrontal angle (NFA), nasolabial angle (NLA), nasofacial angle, tip rotation angle, tip definition angle, and columellar-labial angle.

Morphometric indices: nasal index (width/height × 100), width-to-length ratio, tip projection-to-length ratio (Goode's ratio), and nasal projection index.

Evaluation was performed before revision surgery and repeated at 6 and 12 months postoperatively. In selected patients, long-term follow-up examinations were additionally conducted after 18–24 months in order to evaluate the stability of surgical outcomes and delayed tissue remodeling processes.

Revision rhinoplasty procedures were performed using individualized surgical planning according to the type and severity of deformity. Surgical techniques included autologous cartilage grafting from the nasal septum, auricle, or costal cartilage, spreader graft implantation, structural tip grafting, osteotomies, valve reconstruction, and advanced suture techniques such as interdomal and transdomal sutures. In patients with severe scar tissue contracture, soft tissue release and reconstruction procedures were additionally performed.

Subjective patient satisfaction and quality of life were assessed using the validated FACE-Q questionnaire, including the Satisfaction with Nose and Satisfaction with Nostrils scales. Questionnaire assessment was performed before surgery and during postoperative follow-up periods.

All morphometric measurements were independently performed by two experienced investigators who had undergone preliminary calibration training. Reliability and reproducibility of measurements were evaluated using intraclass correlation coefficients, which exceeded 0.90 for most parameters.

Statistical analysis was conducted using SPSS software (version XX). Data normality was assessed using the Shapiro–Wilk test. Quantitative variables with normal distribution were analyzed using Student's t-test and repeated-measures ANOVA, while nonparametric variables were analyzed using Mann–Whitney U and Kruskal–Wallis tests. Pearson correlation analysis and multiple regression analysis were applied to determine relationships between morphometric changes and clinical variables. Differences were considered statistically significant at $p < 0.05$.

Results and discussion. Before revision surgery, patients with postoperative complications demonstrated statistically significant deviations from normative morphometric values of the control group and population-based anthropometric standards, including ethnically related populations such as the Kazakh population, characterized by a nasal index of approximately 79–81 corresponding to mesorrhine morphology. An increase in the nasolabial angle by 8–12° (mean 104.2 ± 6.8° compared with the normative range of 96–98° and population averages of

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99–102°) was observed in patients with tip ptosis, leading to visual shortening of the nose and disruption of facial profile harmony. In addition, tip projection (sn-prn) was reduced by 2.5–4.1 mm, while Goode's ratio decreased below 0.50 in 62% of patients, indicating significant impairment of nasal tip support.

Patients with asymmetry or "polly-beak" deformity demonstrated an increase in alar base width (al-al) by 3–5 mm, whereas alar asymmetry exceeding 2 mm was detected in 67% of observations. Saddle nose deformity was associated with a reduction of the nasofrontal angle by 7–10° (mean 130–135° compared with 138–142° considered normal in males and females), decreased dorsal height, and a reduction of dorsal volume by 15–25% according to 3D analysis. Three-dimensional scanning additionally revealed a decrease in nasal tip surface area by 12–18% and uneven distribution of soft tissue volume, confirming the high diagnostic value of volumetric morphometric assessment.

These findings indicate that complications after primary rhinoplasty affect not only the aesthetic proportions of the nose but also functional aspects of nasal breathing. Valvular dysfunction and impaired airflow were observed in a considerable proportion of patients, mainly due to excessive resection of lower lateral cartilages, inadequate structural support of the tip region, postoperative fibrosis, and scar tissue contracture. The obtained results are consistent with published studies reporting that revision rhinoplasty is required in approximately 5–15% of patients after primary rhinoplasty, especially in individuals with thick skin and pronounced scar formation.

Following revision rhinoplasty using structural grafting techniques, including autologous cartilage grafts from the septum, auricle, or ribs, as well as interdomal and transdomal sutures, osteotomies, spreader grafts, and valve support procedures, statistically significant positive dynamics were observed during the follow-up period. At 6 months after surgery, the nasolabial angle decreased by an average of 4.2°, and by 6.8° after 12 months ($p < 0.01$), approaching the physiological range of 96–102°. Nasal tip projection increased by 2.1–3.4 mm ($p < 0.001$), while Goode's ratio recovered to 0.56–0.59 in 78% of patients, reflecting substantial restoration of nasal tip support and profile balance.

The width of the nasal base decreased by 2.7 ± 1.2 mm, and alar asymmetry was reduced to less than 1 mm in 79% of observations. The nasal index approached normative values in 82% of patients. According to 3D morphometric analysis, nasal tip volume increased by 18–28%, whereas the surface area of the dorsal region increased by 14–22%. These findings confirm that revision rhinoplasty combined with structural grafting techniques provides effective restoration of both linear and volumetric nasal parameters.

Residual postoperative changes persisted in 14% of cases and included mild tip asymmetry, residual edema, or fibrosis. These alterations were primarily associated with excessive skin thickness greater than 3 mm in the tip region, soft tissue scarring, and the phenomenon commonly referred to as "tissue memory." Correlation analysis demonstrated a moderate relationship between the severity of initial deformities and the degree of postoperative restoration ($r = 0.48$–0.62, $p < 0.01$), while a stronger association was observed between skin thickness and persistent postoperative edema ($r = 0.55$). These findings emphasize the importance of individual anatomical characteristics in predicting surgical outcomes.

Three-dimensional morphometry proved to be the most objective and reproducible assessment method, surpassing conventional photogrammetry due to its ability to quantitatively evaluate volume, surface area, and asymmetry using deviation maps. Studies employing Vectra and analogous systems demonstrate excellent reproducibility with ICC values exceeding 0.95. Furthermore, the comparison of obtained data with population-specific anthropometric standards highlights the necessity of ethnically oriented planning even in revision rhinoplasty.

Subjective patient satisfaction, assessed using the validated FACE-Q instrument (Satisfaction with Nose and Satisfaction with Nostrils scales), improved significantly after revision surgery. FACE-Q scores increased from 25–35 points preoperatively to 65–80 points

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postoperatively ($p < 0.001$), positively correlating with objective morphometric improvements. This demonstrates that restoration of nasal anatomy and symmetry contributes not only to functional improvement but also to psychological well-being and quality of life.

Conclusions.

The results of the present study demonstrated that complicated primary rhinoseptoplasty is associated with significant morphometric, volumetric, and functional alterations of the external nose, affecting not only facial aesthetics but also nasal breathing physiology and overall patient quality of life. Pronounced deviations in angular, linear, and volumetric parameters confirmed the complexity of secondary nasal deformities and highlighted the importance of comprehensive diagnostic evaluation in patients requiring revision surgery.

The study established that revision rhinoplasty performed using structural grafting techniques, advanced suture methods, osteotomies, and nasal valve support procedures provides substantial restoration of nasal anatomy and morphometric balance. Significant improvement was observed in nasal projection, dorsal contour, alar symmetry, and angular parameters during postoperative follow-up. The majority of morphometric indicators approached normative values within 12 months after surgery, demonstrating the high effectiveness of modern reconstructive approaches in revision rhinoplasty.

The obtained findings also emphasize the importance of individualized surgical planning based on detailed preoperative morphometric assessment. Anatomical factors such as skin thickness, scar tissue formation, and the severity of initial deformities significantly influenced postoperative outcomes and long-term tissue remodeling. Patients with thicker skin and pronounced fibrosis demonstrated slower regression of edema and less complete restoration of contour symmetry, confirming the necessity of personalized operative strategies.

Three-dimensional morphometric analysis proved to be one of the most reliable and objective diagnostic methods for evaluating postoperative nasal deformities and surgical outcomes. In comparison with conventional photogrammetry, 3D technologies provided more accurate visualization of contour irregularities, asymmetry, volumetric deficiencies, and surface deviations. The use of 3D scanning systems enabled quantitative assessment of tissue restoration and facilitated objective monitoring of postoperative dynamics. Therefore, integration of 3D technologies into routine rhinoplasty practice may significantly improve diagnostic precision, surgical planning, and long-term outcome prediction.

An important finding of the study was the strong correlation between objective morphometric improvements and subjective patient satisfaction assessed using the FACE-Q questionnaire. Significant postoperative improvement in satisfaction scores confirmed that restoration of nasal harmony and symmetry positively influences psychosocial well-being, emotional stability, and self-perception. This underlines the importance of combining objective anatomical assessment with patient-reported outcome measures in aesthetic and reconstructive facial surgery.

The study additionally demonstrated that revision rhinoplasty should not be considered solely an aesthetic procedure, as restoration of structural support and nasal valve integrity also contributes to functional rehabilitation of nasal airflow. The improvement of nasal breathing observed in many patients highlights the functional significance of preserving anatomical support structures during both primary and revision rhinoplasty procedures.

Despite the positive outcomes obtained in the majority of patients, residual deformities and minor asymmetries persisted in a limited number of cases due to fibrosis, scar contracture, tissue memory, and individual anatomical variability. These findings indicate that complete normalization may not always be achievable, particularly in patients with severe postoperative scarring or multiple previous interventions. Therefore, realistic preoperative counseling and long-term follow-up remain essential components of patient management.

From a clinical perspective, the results of this investigation support the use of combined multimodal evaluation methods, including direct anthropometry, digital photogrammetry, 3D

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morphometric analysis, and patient-reported satisfaction scales, for comprehensive assessment of revision rhinoplasty outcomes. Such an integrated approach allows more accurate diagnosis, objective monitoring, and optimization of surgical strategies.

In conclusion, revision rhinoplasty using modern reconstructive techniques and advanced morphometric assessment methods provides effective restoration of nasal structure, symmetry, and function in patients with complications after primary rhinoplasty. The integration of individualized surgical planning, structural support techniques, and objective 3D analysis significantly improves both aesthetic and functional outcomes. Future multicenter studies with larger patient populations and longer follow-up periods are necessary to further evaluate long-term stability, ethnic anatomical variations, tissue remodeling processes, and the potential role of artificial intelligence in automated morphometric analysis and surgical simulation.

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