RHINOLOGY

Evaluation of nasal airway alterations associated with septorhinoplasty by both objective and subjective methods

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Abstract The aim of functional septorhinoplasty is to create an esthetically elegant nose and harmony in the face by preserving nasal function as well as maintaining or restoring adequate airway. Since nasal complaints are usually subjective, it may be difficult to evaluate the functions objectively. In the present study, we aimed to investigate the alterations in nasal function associated with septorhinoplasty by using both objective and subjective methods. The study population consisted of 40 patients who underwent septorhinoplasty and 40 healthy controls. Before and after the operation, visual analog scale, acoustic rhinometry, rhinomanometry, and Odiosoft-Rhino test were applied to all patients and controls. There were significant differences in all parameters both before and after the operation. While a significant difference was obtained between the patient and control groups in terms of preoperative values, no significant difference was found between postoperative values of these groups. Both objective and subjective methods are important in evaluations.

Keywords Odiosoft-Rhino · Rhinoplasty ·
Rhinomanometry · Visual analog scale · Acoustic rhinometry · Rhinomanometry

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Introduction

The nose, which is the beginning of the respiratory tract, is functionally and esthetically of great importance due to its tasks and localization on the face. Today, septorhinoplasty (SRP), which aims to correct functional and esthetic situation of the nose, is one of the surgical interventions frequently performed.

The nose is a dynamic structure with a substantial contribution of nasal muscles. If the nasal muscles are damaged during the surgical procedures, their functions can also be affected. During open and close septorhinoplasty, it is important to evaluate deformity-related nasal dynamics including the nasal muscles because of their role in phonation, respiration and facial mimics [1].

Nasal obstruction is one of the most common reasons for the patients to consult an otorhinolaryngologist. The most difficult aspect of evaluating nasal obstruction is its being a subjective complaint. However, there are objective methods developed to evaluate nasal obstruction, which have been accompanied by the new ones each year. The most commonly used methods include rhinomanometry, acoustic rhinometry and Odiosoft-Rhino. Acoustic rhinometry is preferred more because of being easily applicable.

In some cases, septorhinoplasty may cause nasal obstruction as it narrows the nasal roof. Even a limited stenosis in the valve area, which is the most critical functional area in the nose, can cause serious problems in inspiration [2]. A minimal narrowing increases the transnasal pressure and causes inward movement in the lateral nasal wall and valvular collapse, particularly in case of insufficient rigidity [3]. Surgical interventions of the nose can remarkably alter the structure, function and image of the nose. The importance of the nasal functions should be known well for septorhinoplasty operations to be successful and for the

operations to show improving effect on the patient's quality of life. The aim of functional septorhinoplasty is to create an esthetically elegant nose and a harmony in the patient's face by preserving nasal function as well as maintaining or restoring adequate airway [4].

In the present study, we aimed to investigate the possible alterations in nasal function associated with septorhinoplasty by both using objective and subjective methods in order to check the correlation of objective and subjective evaluations. We also aimed to compare Odiosoft-Rhino data which is rather a new device with well-known rhinomanometry and acoustic rhinometry devices.

Materials and methods

The study population consisted of 40 patients and the control group consisted of 40 age- and gender-matched healthy volunteers. All patients were informed about the study and informed consent was obtained in each case. Ethics committee approval was obtained from the Eskisehir Osmangazi University (2010/206).

Subjects having allergic or systemic diseases, receiving medications regularly, having either sinonasal or systemic complaint, having previous nasal surgery, having active sinonasal disease, undergoing concha intervention or having septum perforation during preoperative examination were excluded from the study. All the patients underwent paranasal computerized tomography prior to the operation and no sinus pathology was obtained.

Endonasal septorhinoplasty was performed in all patients in order to correct nasal obstruction. All interventions were performed by the same surgeon and all tests and postoperative controls were performed by the same physician. Patients for whom concha or additional sinus surgery was planned were not included in the study.

Detailed preoperative anamnesis was obtained from all patients. Symptom scores were recorded. All the patients underwent routine ear–nose–throat examination and complete physical examination. Nasal cavities were examined in detail using anterior rhinoscopy and nasal endoscope, and characteristics of mucosa, presence of leakage, situation of concha and septum, localization of the deviation of the septum and condition of the columella were recorded. The presence of valve problem was evaluated by modified Cottle test and endoscopic endonasal examination. Before the surgery, six photographs of each patient were taken and their facial analyses were performed.

Subjective evaluation of nasal obstruction

In the subjective evaluation of nasal obstruction, the patients were asked to score their nasal obstruction complaints between 0 and 10 using visual analog scale (VAS) in the examination performed 1 week before the operation and on the postoperative sixth week, and the results were recorded.

Objective evaluation of nasal obstruction

Acoustic rhinometry, rhinomanometry and Odiosoft-Rhino were used for the objective evaluation of nasal obstruction. Prior to these tests, the nasal cavities of all patients and controls were examined and crust, if present, was removed. One week before the operation and on the postoperative sixth week, the tests were performed after the patients and controls were kept in a silent room with a temperature of 22–25°C and a humidity of 50–60% for 15 min.

Acoustic rhinometry and anterior rhinomanometry were performed using SRE 2000 Rhinometer (RhinoMetrics, Lynge, Denmark). Odiosoft-Rhino device was used for nasal sound spectral analysis. Spectral analysis of the sound in the nasal cavity via "Odiosoft-Rhino" provides information about airflow rate, airflow characteristics and severity of obstruction in the nasal cavity [5]. Figures 1, 2 and 3. Obstructions in the nasal cavity enable the nasal airflow to gain turbulent character narrowing the cross-sectional area of the nasal cavity. Spectral analysis samples of the nasal sound performed by fast Fourier transform differed from each other in the laminar and turbulent flow. Nasal intensity showed an increment between very low frequency (200–500 Hz) and low frequency (500–1,000 Hz) in laminar flow, but at high frequency (2,000–6,000 Hz) in turbulent flow.

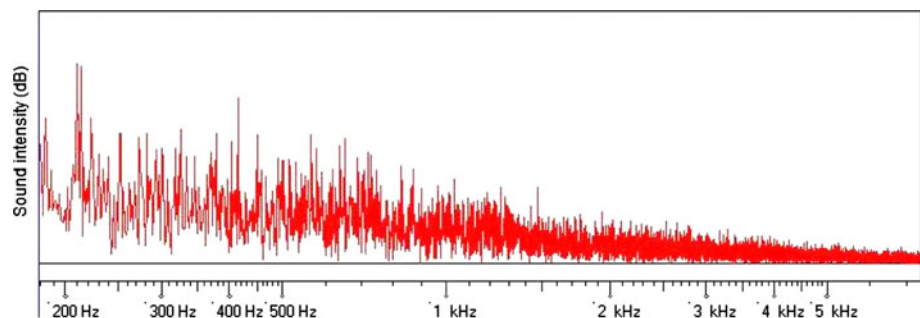Fig. 1 Expiratory nasal sound spectral analysis of the control group

Fig. 2 Preoperative expiratory nasal sound spectral analysis of the patient group
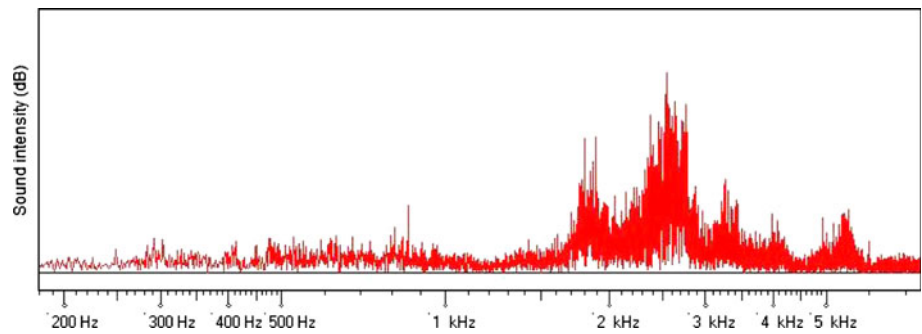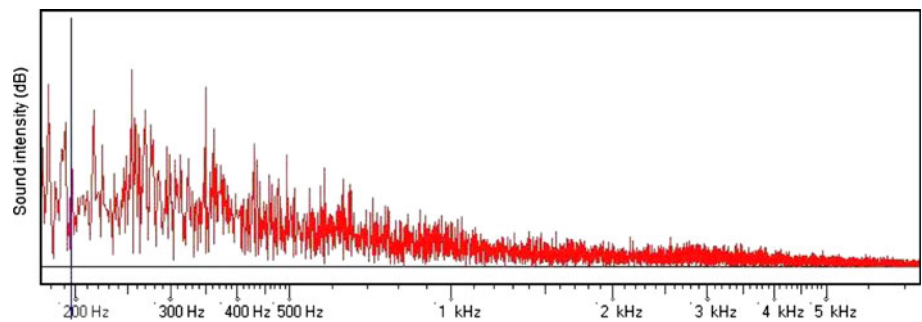

Fig. 3 Postoperative expiratory nasal sound spectral analysis of the patient group

Statistical analysis

IBM SPSS 19.0 for windows and Statgraphics plus for Windows 5.0 program (Manugistics Inc., Rockville, MD, USA) were used in statistical analysis of the data obtained. The normality of the distribution was checked with Shapiro–Wilk's test. In the comparison of the groups, independent sample t test and paired sample t test were used in the findings with normal distribution. Mann–Whitney U test and Wilcoxon t test were used in the comparison of the findings without normal distribution.

The data was summarized as mean + SD. $p < 0.05$ value was accepted as statistically significant.

Results

The study population consisted of 40 patients aged between 20 and 40 years who underwent septorhinoplasty in the Department of Ear–Nose–Throat of Eskişehir Osmangazi University Medical Faculty between 2009 and 2010. The control group consisted of 40 age- and gender-matched healthy volunteers. In both patient and control groups, 50% were females. All the patients had preoperative nasal obstruction complaint. The patients had no complaint concerning ear–nose–throat, except for nasal obstruction and dissatisfaction from external appearance of the nose. Anterior rhinoscopy and nasal endoscopy revealed septum deviation in all of the patients. Septum deviation was right sided in 27 patients and left sided in 13 of the cases. Correction of nasal obstruction was taken into consideration in all patients. Endonasal septorhinoplasty was performed and primarily septum deviations were corrected; thereafter, hump resection and lateral osteotomy were performed. Narrowed nasal valve area was widened by applying various techniques to the nasal tip and bilateral nasal valves.

The results of the subjective evaluation of nasal obstruction are presented in Table 1. Nasal obstruction complaint was alleviated in all of the patients on the postoperative control visit as compared to the preoperative period. Postoperative VAS scores of the patients revealed a significant reduction in nasal obstruction on the deviation side as compared to the preoperative scores ($p < 0.05$). No

Table 1 Visual analog scale scores of the patients for their nasal obstruction complaint

	Visual analog scale scores of right side			Visual analog scale scores of left side		
	Preoperative	Postoperative	p	Preoperative	Postoperative	p
Patients who have right nasal septal deviation	8.12 ± 1.07	1.37 ± 0.92	<0.05	1.53 ± 0.96	2.12 ± 0.70	>0.05
Patients who have left nasal septal deviation	1.48 ± 0.97	1.22 ± 0.75	>0.05	8.07 ± 0.95	2.23 ± 0.86	<0.05

statistically significant difference was found between the preoperative and postoperative VAS scores on the side without deviation ($p > 0.05$).

The results of the first and second minimal cross-sectional areas (MCA1 and MCA2) measured by acoustic rhinometry are presented in Tables 2 and 3. It has been considered that alterations in the nasal valve are best reflected by MCA1, and alterations in the nasal septum and concha are best reflected by MCA2 [5–7]. The mean preoperative MCA values of the patients were significantly lower than that of the controls ($p < 0.05$). However, no significant difference was obtained between the patients and controls with respect to the mean postoperative MCA values ($p > 0.05$). When the mean preoperative and postoperative MCA values were compared, postoperative MCA values on the deviation side were found to be significantly increased as compared to the preoperative values ($p < 0.05$). However, no significant difference was found between the postoperative and preoperative values on the side without deviation ($p > 0.05$).

Expiratory nasal resistance values of the patient and control groups measured by rhinomanometry are presented in Table 4. The mean preoperative expiratory nasal resistance of the patients was significantly higher than that of the controls ($p < 0.05$). However, there was no significant difference between the patient and control groups in terms of mean postoperative nasal resistance values ($p > 0.05$). When the preoperative and postoperative expiratory nasal resistance values on the deviation side were compared, postoperative expiratory nasal resistance values were found to be significantly decreased as compared to the preoperative values ($p < 0.05$). However, no significant difference was found between the preoperative and postoperative expiratory nasal resistance values on the side without deviation ($p > 0.05$).

The results of expiratory nasal sound spectral analyses in the patient and control groups measured by Odiosoft-Rhino are presented in Tables 5 and 6. The preoperative nasal sound spectral analysis revealed that the mean intensity at 1,000–2,000 Hz was significantly increased at

Table 2 MCA1: preoperative and postoperative minimal cross-sectional areas of the patients and control groups measured by acoustic rhinometry

	MCA1(cm^2) scores of right side			MCA1(cm^2) scores of left side		
	Preoperative	Postoperative	p	Preoperative	Postoperative	p
Patients who have right nasal septal deviation	0.36 ± 0.14	0.59 ± 0.15	<0.05	0.54 ± 0.16	0.56 ± 0.12	>0.05
Patients who have left nasal septal deviation	0.47 ± 0.18	0.46 ± 0.17	>0.05	0.28 ± 0.16	0.51 ± 0.16	<0.05
Control group	0.49 ± 0.11			0.48 ± 0.12		

MCA1 minimal cross-sectional area (distance to nostril 2.2 cm)

Table 3 MCA2: preoperative and postoperative minimal cross-sectional areas of the patients and control groups measured by acoustic rhinometry

	MCA2(cm^2) scores of right side			MCA2(cm^2) scores of left side		
	Preoperative	Postoperative	p	Preoperative	Postoperative	p
Patients who have right nasal septal deviation	0.39 ± 0.18	0.63 ± 0.22	<0.05	0.62 ± 0.28	0.60 ± 0.33	>0.05
Patients who have left nasal septal deviation	0.56 ± 0.21	0.57 ± 0.21	>0.05	0.40 ± 0.22	0.58 ± 0.16	<0.05
Control group	0.58 ± 0.21			0.59 ± 0.18		

MCA2 minimal cross-sectional area (distance to nostril 5.5 cm)

Table 4 Preoperative and postoperative expiratory nasal resistance of the patient and control groups measured by rhinomanometry

	Expiratory nasal resistance (Pa/cm^3/s) scores of right side			Expiratory nasal resistance (Pa/cm^3/s) scores of left side		
	Preoperative	Postoperative	p	Preoperative	Postoperative	p
Patients who have right nasal septal deviation	0.68 ± 0.38	0.27 ± 0.31	<0.05	0.25 ± 0.23	0.23 ± 0.21	>0.05
Patients who have left nasal septal deviation	0.24 ± 0.35	0.28 ± 0.14	>0.05	0.72 ± 0.36	0.28 ± 0.32	<0.05
Control group	0.27 ± 0.26			0.31 ± 0.11		

Table 5 Preoperative and postoperative expiratory nasal sound spectral analyses scores of the right side of the patient and control groups measured by Odiosoft-Rhino

	Expiratory nasal sound spectral analyses scores of the right side										p
	Preop					Postop					
	200–500 Hz	500–1,000 Hz	1,000–2,000 Hz	2,000–4,000 Hz	4,000–6,000 Hz	200–500 Hz	500–1,000 Hz	1,000–2,000 Hz	2,000–4,000 Hz	4,000–6,000 Hz	
Patients who have right nasal septal deviation	26.34 ± 5.42	17.56 ± 5.76	16.22 ± 6.34	26.76 ± 4.87	13.76 ± 2.56	29.45 ± 5.35	23.43 ± 5.62	15.78 ± 8.21	10.76 ± 4.45	7.45 ± 4.67	<0.05 In 2,000–4,000 Hz
Patients who have left nasal septal deviation	27.34 ± 5.84	20.16 ± 6.82	16.56 ± 7.65	13.56 ± 3.17	8.54 ± 3.45	32.11 ± 6.23	24.45 ± 7.56	18.65 ± 7.54	11.56 ± 5.17	7.97 ± 3.25	>0.05
Control groups	36.65 ± 6.32	28.45 ± 7.65	20.23 ± 5.78	13.45 ± 5.67	7.45 ± 1.89						

Table 6 Preoperative and postoperative expiratory nasal sound spectral analyses scores of the left side of the patient and control groups measured by Odiosoft-Rhino

	Expiratory nasal sound spectral analyses scores of left side										p
	Preop					Postop					
	200–500 Hz	500–1000 Hz	1,000–2,000 Hz	2,000–4,000 Hz	4,00–6,000 Hz	200–500 Hz	500–1,000 Hz	1,000–2,000 Hz	2,000–4,000 Hz	4,000–6,000 Hz	
Patients who have right nasal septal deviation	32.23 ± 5.6	22.32 ± 6.3	13.56 ± 4.32	11.34 ± 2.78	8.45 ± 3.34	31.56 ± 6.26	21.15 ± 5.8	14.04 ± 5.56	12.26 ± 3.03	7.56 ± 3.77	>0.05
Patients who have left nasal septal deviation	26.40 ± 6.34	16.56 ± 7.25	15.54 ± 6.12	25.43 ± 6.56	12.24 ± 4.35	29.37 ± 5.13	21.73 ± 6.43	19.56 ± 8.24	12.34 ± 6.34	9.23 ± 4.45	<0.05 in 2000–4000 Hz
Control groups	33.26 ± 4.32	23.59 ± 6.78	22.96 ± 5.23	10.78 ± 3.56	8.56 ± 2.12						

2,000–4,000 Hz in the patient group. Moreover, there was a significant difference between the mean intensities of the patients and controls at the same ranges ($p < 0.05$). On the other hand, the postoperative nasal sound spectral analysis of the patient group revealed a significant decrease in the intensity at high frequencies; however, no statistically significant difference was found between the mean nasal intensities of the patient and controls ($p > 0.05$). When the intensities of the nasal passages obtained by preoperative and postoperative nasal sound spectral analysis at high frequencies were compared with each other, a significant decrease was observed at the postoperative high frequency on the deviation side ($p < 0.05$). However, no significant difference was found between the preoperative and post-operative intensities of the nasal passages on the side without deviation ($p > 0.05$).

Discussion

In addition to being an organ that prepares and moistens the air for the lungs, the nose is also an esthetically important organ due to its location. Inadequate or excessive changing of the bone–cartilage framework by giving particular importance to the esthetic image may result in impaired function as well as impaired esthetic outcome [6]. Post-operative improved respiratory functions in the present patient series show the extent of sensitivity that we displayed on this issue. Airway problem should not be over-looked by only focusing on the cosmetic outcome [8].

The study performed by Berry et al. [9] on 43 patients evaluated the nasal obstructions after rhinoplasty, and nasal airway obstruction was detected in seven patients. The causes of nasal obstructions after rhinoplasty include failure to correct septal pathologies and excessive resection of the upper and lower lateral cartilages. Additionally, fracture of the lateral nasal wall may narrow the nasal valve angle. Scar formations after the surgeries performed by cleaving the upper lateral cartilage from the septum may lead to obstruction. Minimal resection of upper or lower cartilage during rhinoplasty is a good method to be protected from postoperative inspiratory valve collapse [10].

Gyrmer [11] used acoustic rhinometry in 37 patients prior to and 6 months after the rhinoplasty and reported the changes in the internal size of the nose. In that particular study, decreases by 25% at nasal valve level and by 13% at the pyriform aperture level were reported in the section area after rhinoplasty. Cole et al. [12] suggested that very small changes, even as small as 1 mm, at the nasal valve level could cause a dramatic increase in the nasal resistance. These results have highlighted that nasal valve has quite an important role in the nasal function. Nasal valve problems cause severe nasal respiratory distress [13]. One

of the most difficult aspects of septorhinoplasty is solving the problems in nasal valve area. Nasal valve is the main area for the subject to breathe comfortably. Various methods including batten grafts, spreader graft and flare sutures have been defined to support nasal valve area and to prevent nasal obstruction [14].

Acoustic rhinometry is a non-invasive, repeatable, easily applicable and cheap test. It is possible with this method to objectively evaluate and demonstrate the surgical success by comparing preoperative and postoperative (septoplasty, polypectomy, turbinectomy, inferior meatal antrostomy, rhinoplasty and anterior turbinoplasty) values using the section area and volume of the nasal cavity as a criterion.

Tatlıpınar et al. [15] used acoustic rhinometry to show the alterations in nasal functions following septal deviation surgery and concluded that acoustic rhinometry could be used to specify the indications for surgery and to evaluate the postoperative success of the operation in patients with septal deviation. In their study, Gilain et al. [16] compared the results of acoustic rhinometry and the images of computed tomography (CT) and suggested that acoustic rhinometry was a beneficial method particularly in evaluating anterior nasal space. Moreover, in a study that evaluated the correlation between the results of acoustic rhinometry and CT, it was reported that acoustic rhinometry was a valuable method in the evaluation of nasal valve region [17]. Acoustic rhinometry has an important role in making diagnosis and particularly in the post-treatment follow-up. The accuracy of acoustic rhinometry measurements were demonstrated in the cadavers by Hillberg by comparing with CT [18].

In the present study, symptom scores of the patients were consistent with the data obtained from acoustic rhinometry. Total MCA values were significantly increased as compared to the preoperative values with a dramatic increment on the septal deviation side. It has been proposed that septorhinoplasty may narrow the nasal roof and worsen nasal functions. [10, 11]. In the present study, the mean postoperative MCA values were increased on the septal deviation side as compared to the preoperative values, whereas no significant difference was observed on the side without deviation. These results suggested that septum deviation was effectively corrected and valve space was preserved in the opposite nasal passage.

Rhinomanometry is used to detect dynamic alterations that lead to obstruction in the nasal airway and that cannot be determined during rhinoscopic examination. Rhinomanometry is a method that detects the nasal airway resistance via quantitative measurement of the nasal airflow and pressure and that objectively evaluates nasal obstruction [19]. Studies have revealed that nasal airway resistance is the most valuable data of rhinomanometric measurements, the normal value of which is accepted to be between 0.12 and 0.33 Pa/mL/s [20].

Schumacher et al. [21] indicated that anterior rhinomanometry was the gold standard in the evaluation of nasal obstruction. The Mayo Clinic evaluated 50 patients with nasal valve area obstruction caused by anterior septal deformity using rhinomanometry preoperatively and postoperatively. A considerable subjective improvement was determined in the complaints of the patients. Rhinomanometric evaluation of the patients revealed a remarkable decrement in the nasal resistance of 45 patients [22]. In their study, Chandra et al. [23] evaluated patients with nasal obstruction using rhinomanometry in addition to anterior rhinoscopy and endoscopic examination and they reported that rhinomanometry was quite a valuable method in determining the degree of obstruction. In the present study, we observed that nasal resistance of the patients was significantly decreased after the operation. We, as well, concluded that alterations in nasal functions associated with the correction of septal pathologies that caused nasal valve obstruction could be evaluated by anterior rhinomanometry.

Spectral analysis of the sound in the nasal cavity via Odiosoft-Rhino provides information about rate and features of nasal cavity airflow and the severity of nasal cavity obstruction [5]. Seren [24] first defined Odiosoft-Rhino, which is a non-invasive method for the analysis of nasal airflow, by analyzing the expiratory nasal sounds and reported a relationship of airflow with amplitude and frequency. Moreover, in that particular study, it was demonstrated that airflow displayed more turbulent character along with decrement in the cross-sectional area of the nasal cavity and shift to higher frequencies (1,000–6,000 Hz) on the spectral sound analysis. Tahamiler et al. [6] objectively evaluated the daily changes in nasal cycle by Odiosoft-Rhino. In another study performed using Odiosoft-Rhino and acoustic rhinometry, Tahamiler et al. [7] concluded that there was a correlation between MCA values and the results of expiratory nasal spectral sound analysis of the patients after septoplasty. In the present study, we observed that the data obtained via Odiosoft-Rhino were consistent with those obtained via acoustic rhinometry and rhinomanometry, as well as the subjective results. We assume that evaluation of nasal obstruction both by subjective and objective methods will be the issue of many studies in the future and will be used frequently.

In the present study, we tried to evaluate preoperative and postoperative nasal functions of the patients that underwent septorhinoplasty via three different objective methods as well as a subjective method. The results of the objective and subjective tests revealed significant improvement in the nasal functions after the surgery. Moreover, we determined that the results of these three objective methods were consistent with each other and correlated with the results of the subjective evaluation.

Poor nasal function on the septal deviation side before the operation measured by all methods was attributed to the deviation and influence of the deviation on the nasal valve area. Dramatic postoperative improvement in the nasal functions on the septal deviation side indicated that the septum and nasal valve were effectively corrected by septorhinoplasty, there was no significant change in the opposite nasal passage the valve was preserved despite the narrowed nasal roof.

Conclusion

In patients undergoing septorhinoplasty, accurate planning and selecting appropriate surgical technique that would preserve and, if required, restore the nasal valve have critical importance in terms of the postoperative alterations in nasal functions. Preoperative and postoperative alterations in nasal functions can be measured both objectively and subjectively. Odiosoft-Rhino may be a new and effective method that can be used to show the nasal functions. In the present study, the data obtained by Odiosoft-Rhino showed correlation with the subjective data as well as the results of other objective tests.

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