

## PAPER DETAILS

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PAGES: 25-33

ORIGINAL PDF URL: <https://dergipark.org.tr/tr/download/article-file/1961035>

# Comparison of Subjective and Objective Success of Septoplasty in Patients with Nasal Septum Deviation: A Before and After Study

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**Citation:** Uzer A, Demirhan E. Comparison of subjective and objective success of septoplasty in patients with nasal septum deviation: a before and after study. Tr-ENT 2021;31(2):25-33. <https://doi.org/10.26650/Tr-ENT.2021.40412>

## ABSTRACT

**Objective:** Aim of the study is to evaluate the subjective outcomes and objective outcomes postoperatively and investigate correlations between these measurements.

**Material and Methods:** This prospective before and after surgical study was conducted with patients admitted with symptomatic nasal septum deviation (NSD) and who underwent Cottle's septoplasty. Morphometric diameters of the nasal cavity were measured using a multi-detector computed tomography. Preoperative and postoperative one-month Nasal Obstruction Symptom Evaluation Scale (NOSE) score, acoustic rhinometry (AR), and anterior active rhinomanometry (AAR) measurements were used to evaluate the success of surgery. The correlations between these measurements were also evaluated.

**Results:** The study population consisted of 30 patients, including 19 males and 11 females, with a median age of 27.5 years. There was a statistically significant difference between pre and postoperative NOSE scores, with a mean difference of 53.17 points ( $p<0.001$ ). There were statistically significant differences between pre and postoperative AR parameters of both the deviated side (DS) and non-deviated side (NDS) of the nose both before and after decongestion. There were statistically significant improvements in all postoperative airflow and airway resistance parameters of the DS of the nose before decongestion when compared to preoperative measurements. There were moderate to large positive correlations between morphometric diameters and differences in NOSE score. Further, there were several statistically significant correlations between differences in AR and AAR measurements and differences in NOSE score.

**Conclusion:** Our findings showed that the objective measurements are strongly correlated with the NOSE score.

**Keywords:** Pyriform aperture, choana, nasal septum deviation, septoplasty

## INTRODUCTION

Nasal obstruction is one of the most common complaints in the rhinology clinical practice (1, 2). Although conservative non-surgical medical therapy is the first option for the treatment of nasal obstruction, it is usually unsuccessful in relieving complaints of nasal obstruction which resulted from a deviated or deformed nasal septum (3). Septoplasty is widely performed to correct the septal deviation or deformity, and therefore is one of the most commonly performed surgical procedures in otorhinolaryngology (4-6).

Septoplasty is the surgical correction of the deviated or deformed nasal septum, the first examples of which date back to ancient Egypt (7). Nowadays, a variety of techniques are performed by surgeons in septoplasty operations; the types of nasal septal deviation (NSD) and surgeon's preferences are important to decide which technique to be applied (8, 9). Cottle's septoplasty with a hemitransfixion incision is one of the most frequently used techniques in the world (9).

In clinical practice, there are several diagnostic tools including subjective and objective measurements (10). Subjective

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**Submitted:** 31.03.2021 • **Accepted:** 02.06.2021



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measurements use validated questionnaires and try to determine the level of the patient's discomfort before surgery and also the relief of the patient's symptoms after surgery (2). Although subjective measurements have been used widely in clinical practice, their subjective nature is an ongoing problem, especially in long-term follow-up assessments (11, 12).

Objective measurements use several analysis methods, examine the deformed anatomy of the nose, measure the degree of nasal obstruction and evaluate nasal resistance (10). These methods provide detailed objective measurements before the surgery and guide the surgeons to decide the most convenient surgical technique (2). They are also repeated after surgery to show the effectiveness of the applied surgery, such as the correction of an anatomical part or obtaining openness (lack of obstruction) of a bodily passage (6). However, several studies have demonstrated that favorable postoperative measurements did not result in the patient's satisfaction (10). Therefore, there is a long and still ongoing conflict in the reliability of objective measurements of nasal patency and patient satisfaction (2).

This study aims to compare subjective outcomes such as the Nasal Obstruction Symptom Evaluation Scale (NOSE) score and objective outcomes such as acoustic rhinometry (AR) and anterior active rhinomanometry (AAR) measurements of Cottle's septoplasty in patients with NSD, and to evaluate the correlations between morphometric measurements and the difference in those subjective and objective outcomes.

## MATERIAL AND METHODS

### Design and setting

This prospective before and after surgical study was conducted with patients admitted with symptomatic nasal septum deviation (NSD) and underwent septoplasty in the University of Health Sciences Izmir Tepecik Training and Research Hospital between October 2016 and November 2016. Ethical approval was obtained from Izmir Tepecik Training and Research Hospital Ethics Committee (Approval date:18/08/2016, No:22), and written informed consent was obtained from all patients included in the study after detailed information about the study was given.

### Patients

Patients between the ages of 18-45 who presented complaints of nasal obstruction, difficulty in breathing through the nose and were diagnosed with NSD after physical examination, paranasal endoscopy, and paranasal computed tomography, were evaluated for eligibility. The patients with additional nasal or paranasal pathology, history of previous nasal or paranasal surgery, craniofacial anomaly, sinonasal malignancy, adenoid hypertrophy, nasal valve collapse, additional lower and upper respiratory pathology, cardiovascular or neurological pathology were excluded from the study.

### Surgical procedure

All patients underwent Cottle's septoplasty by a 3-years experienced surgeon under general or local anesthesia. A

hemitransfixion incision was performed, and the deviated septal portion was excised after elevating the mucoperichondrium and mucoperiosteum. After surgery, a nasal packing was applied and removed on the second postoperative day. All patients were prescribed postoperative antibiotics, analgesics, and decongestants. Patients were followed-up with outpatient visits at the postoperative first and second week and first month.

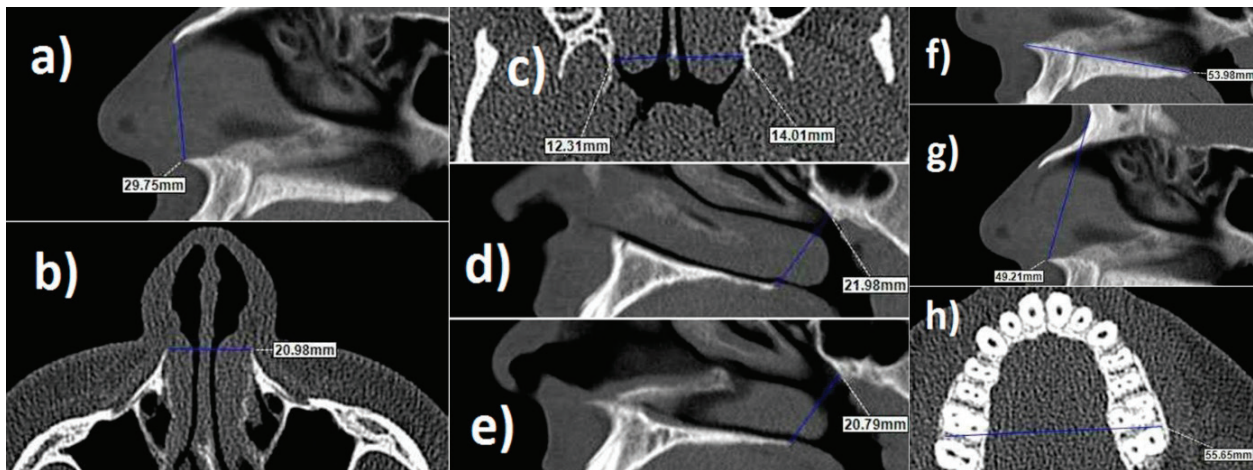
### Variables and outcomes

Patients' demographics and clinical features were recorded. The type of NSD was classified according to the Mladina classification using nasal endoscopic evaluation (Karl Storz Image 1 HUB HD camera system H3-Z Head, Germany) of the patients (13).

A multi-detector computed tomography (MDCT) (Siemens SOMATOM Definition AS 128 Slice CT scan, Germany) was used to exclude paranasal sinus pathologies preoperatively and to do morphometric measurements. The morphometric diameters were measured in millimeters (mm) based on a Turkish anatomic study by Aksu et al. (14). The morphometric variables were: (1) piriform aperture height, (PAH) which was defined as the distance between the rhinion and the anterior nasal spine; (2) piriform aperture width, (PAW) which was defined as the widest distance between the left and right bone margin on the transverse plane of pyriform aperture; (3) upper anterior face height, (UAFH) which was defined as the distance between nasion and anterior nasal spine; (4) choana height, (CH) which was defined as the distance between the furthest points on the vertical midline; (5) choana width, (CW) which was defined as the distance between the furthest points on the horizontal midline; (6) airway length, (AL) which was defined as the distance between the anterior nasal spine and the posterior nasal spine; and (7) upper palate width, (UPW) which was defined as the distance between the junction of the juga alveolaria of the first and second molar teeth (Figure 1).

There are three primary outcomes of the study. These are the Nasal Obstruction Symptom Evaluation Scale (NOSE) score, acoustic rhinometry (AR) measurements, and anterior active rhinomanometry (AAR) measurements. Preoperative and postoperative one-month measurements were compared to evaluate the success of the surgery. Also, the correlation between the morphometric measurements, the differences (as an effect size) in AR and AAR parameters between pre and postoperative measurements, and the difference between pre and postoperative NOSE scores were evaluated.

AR (Rhinoscan®V2.6) and AAR (Rhinostream®v2.1) measurements were performed using the SRE 2000 Rhinometer before and one month after surgery, (RhinoMetrics, Lynge, Denmark) following the recommendations of the International Rhinology Society and the European Rhinology Society in 2000 and 2005 (15, 16). The measurements were made on both the deviated side (DS) and non-deviated side (NDS) of the nose before nasal decongestion (BD) and after nasal decongestion (AD). AD parameters were measured 30 minutes after applying 0.01% xylometazoline HCL to both nostrils.



**Figure 1** shows the morphometric measurements of a patient with right-sided nasal septal deviation.

a) piriform aperture height of 29.75 mm, b) piriform aperture width of 20.98 mm, c) deviated side choana width of 12.31 mm and non-deviated side choana width of 14.01 mm, d) non-deviated choana height of 21.98 mm, e) deviated side choana height of 20.79 mm, f) airway length of 53.98 mm, g) upper anterior face height of 49.21 mm, and h) upper palate width of 55.65 mm.

The variables of the AR were: (1) the first minimal cross-sectional area (MCA1), which was the narrowest cross-sectional area ( $\text{cm}^2$ ) at a distance of 0-2.2 cm from the nostril; (2) the second minimal cross-sectional area 2 (MCA2), which was the narrowest cross-sectional area ( $\text{cm}^2$ ) at a distance of 2.2-5.4 cm from the nostril (3) the first volume (Vol1) of one side of the nasal cavity, which was the unilateral volume ( $\text{cm}^3$ ) of the nasal cavity between the nostril and 2.2 cm into the cavity; (4) the second volume (Vol2) of one side of the nasal cavity, which was the unilateral volume ( $\text{cm}^3$ ) of the nasal cavity between 2.2 to 5.4 cm from the nostril; (5) total volume of one side of the nasal cavity (tVol), which was the sum of Vol1 and Vol2; and (6) Total volume of two sides of the nasal cavity (TVol).

The AAR parameters were: (1) inspiration airflow of one side of the nasal cavity ( $\text{Flow}_{\text{ins}}$ ); (2) expiration airflow of one side of the nasal cavity ( $\text{Flow}_{\text{ex}}$ ); (3) total airflow of one side of the nasal cavity (tFlow) which was the sum of  $\text{Flow}_{\text{ins}}$  and  $\text{Flow}_{\text{ex}}$ ; (4) Total airflow of two sides of the nasal cavity (TFlow); (5) inspiration airway resistance of one side of the nasal cavity ( $\text{AR}_{\text{ins}}$ ); (6) expiration airway resistance of one side of the nasal cavity ( $\text{AR}_{\text{ex}}$ ); (7) total airway resistance of one side of the nasal cavity (tAR) which was the sum of  $\text{AR}_{\text{ins}}$  and  $\text{AR}_{\text{ex}}$ ; and (8) Total airway resistance of two sides of the nasal cavity (TAR).

#### Statistical analysis

Statistical analysis was performed using SPSS 22.0 (IBM Corporation, Armonk, New York, United States). Descriptive statistics were presented as median with interquartile range (IQR) for non-normal distributed numeric variables, and frequency (n) with percentage (%) for categorical variables. The descriptive statistics of pre and postoperative numerical measurements and the differences between those two measurements were presented as mean with 95% confidence interval (95% CI). A Related-Samples Wilcoxon Signed Rank Test was used for comparing pre and postoperative numerical

measurements. The Spearman's Rank Order Correlation was used for evaluating the correlation between anatomical measurements, differences in functional measurements, and differences in NOSE scores before and after surgery. A  $p$ -value less than 0.05 was considered as the statistically significant level.

#### RESULTS

Although 37 patients were enrolled in the study, 7 patients were excluded from the study due to the development of septal perforation in 2 patients, nasal synechia in 1 patient, inadequacy of the surgery in 1 patient, inappropriate MDCT images in 1 patient, and 2 patients not coming for a control visit during the follow-up period. Finally, the study population consisted of 30 patients, including 19 males and 11 females, with a median age of 27.5 years. Of the patients, 21 (70.0%) had right-sided deviation and 9 had left-sided deviation, and most of the patients (60.0%) were classified as type 7 according to the Mladina classification. The second most common type was type 2 with a percentage of 16.7. The median PAH was 33.94 mm, the median PAW was 21.25 mm, the median UAFH was 53.25 mm, the median CH of the deviated side of the nose was 23.62 mm, the median CH of the non-deviated side of the nose was 23.33 mm, the median CW of the deviated side of the nose was 13.66 mm, the median CW of the non-deviated side of the nose was 13.60 mm, the median AL was 53.39 mm, and the median UPW was 55.57 mm (Table 1).

Table 2 presents the comparison of the pre and postoperative NOSE scale scores of the patients. There was a statistically significant difference between pre and postoperative NOSE scores with a mean difference of 53.17 points ( $p < 0.001$ ).

Table 3 shows the comparison of the pre and postoperative acoustic rhinometry parameters of the patients. Except for the MCA2 measurements of the non-deviated side of the nose

**Table 1: Demographics, clinical features and nasal morphometric measurements of the patients**

Characteristics (n=30)		
Age (years), Median (IQR)		27.50 (24.75-35.00)
Sex, n (%)	Female	11 (36.7)
	Male	19 (63.3)
Deviation side, n (%)	Right	21 (70.0)
	Left	9 (30.0)
Mladina classification, n (%)	Type 1	3 (10.0)
	Type 2	5 (16.7)
	Type 3	1 (3.3)
	Type 4	1 (3.3)
	Type 5	1 (3.3)
	Type 6	1 (3.3)
	Type 7	18 (60.0)
PAH (mm), Median (IQR)		33.94 (30.98-35.25)
PAW (mm), Median (IQR)		21.25 (20.06-22.96)
UAFH (mm), Median (IQR)		53.25 (50.83-55.57)
CH (deviated side) (mm), Median (IQR)		23.62 (21.71-25.63)
CH (non-deviated side) (mm), Median (IQR)		23.33 (21.93-25.99)
CW (deviated side) (mm), Median (IQR)		13.66 (12.55-14.84)
CW (non-deviated side) (mm), Median (IQR)		13.60 (12.56-14.56)
AL (mm), Median (IQR)		53.39 (51.40-56.37)
UPW (mm), Median (IQR)		55.57 (53.27-57.96)

Note: IQR: Interquartile range; PAH: Height of the piriform aperture, PAW: Width of the piriform aperture; UAFH: Upper anterior face height; CH: Choana height; CW: Choana width; AL: Airway length; UPW: Upper palate width.

**Table 2: Comparison of the pre and postoperative NOSE scale scores of the patients**

	Preoperative, mean (95% CI)	Postoperative, mean (95% CI)	Difference, mean (95% CI)	p*
NOSE Score	60.50 (53.71 - 67.30)	7.33 (4.04 - 10.62)	-53.17 (-59.68 - -46.66)	<0.001

\*Related-Samples Wilcoxon Signed Rank Test was used.

both before and after decongestion, there were statistically significant differences between all pre and postoperative acoustic rhinometry parameters of deviated and non-deviated sides of the nose both before and after decongestion.

Table 4 presents the comparison of the pre and postoperative rhinomanometry parameters of the patients. There were statistically significant improvements in all postoperative airflow and airway resistance parameters of the deviated side of the nose before decongestion when compared to preoperative measurements. Also, there was a statistically significant difference between pre and postoperative inspiration airway resistance of the deviated side of the nose after decongestion.

Table 5 shows the statistically significant correlations between anatomical measurements, differences in functional measurements, and differences in NOSE scores of the patients.

There were moderate positive correlations between the CW of the deviated side of the nose, UPW, and difference in NOSE score (R:0.429, p:0.018 and R:0.397, p:0.030). Similarly, there was a large positive correlation between the CW of the non-deviated side of the nose and the difference in NOSE scores (R:0.514, p:0.004). There were statistically significant moderate positive correlations between differences in acoustic rhinometry measurements such as Vol1 of the deviated side of the nose before decongestion, Vol2 of the non-deviated side of the nose before deviation, tVol1 of the non-deviated side of the nose before decongestion, TVol1 before decongestion, and difference in NOSE score.

The difference in flow parameters of the rhinomanometry of the deviated side of the nose which showed moderate negative correlations with difference in NOSE scores were Flowins, Flowex, and tFlow after decongestion. However, the



**Table 3: Comparison of the pre and postoperative acoustic rhinometry parameters of the patients**

Parameter	Side	Decongestion	Preoperative, mean (95% CI)	Postoperative, mean (95% CI)	Difference, mean (95% CI)	p*
MCA1 (cm <sup>2</sup> )	Deviated	Before	0.443 (0.383-0.502)	0.569 (0.522-0.616)	0.127 (0.091-0.162)	<b>&lt;0.001</b>
		After	0.487 (0.434-0.540)	0.605 (0.561-0.650)	0.118 (0.077-0.159)	<b>&lt;0.001</b>
	Non-deviated	Before	0.587 (0.544-0.630)	0.679 (0.643-0.715)	0.092 (0.049-0.135)	<b>&lt;0.001</b>
		After	0.598 (0.558-0.638)	0.684 (0.651-0.717)	0.087 (0.057-0.116)	<b>&lt;0.001</b>
MCA2 (cm <sup>2</sup> )	Deviated	Before	0.495 (0.393-0.598)	0.580 (0.500-0.661)	0.085 (0.014-0.156)	<b>0.006</b>
		After	0.502 (0.432-0.571)	0.636 (0.556-0.716)	0.134 (0.071-0.197)	<b>&lt;0.001</b>
	Non-deviated	Before	0.783 (0.712-0.854)	0.838 (0.751-0.925)	0.055 (-0.023-0.133)	0.198
		After	0.853 (0.760-0.947)	0.940 (0.845-1.036)	0.087 (-0.018-0.192)	0.245
Vol1 (cm <sup>3</sup> )	Deviated	Before	1.810 (1.666-1.953)	1.987 (1.852-2.122)	0.177 (0.058-0.297)	<b>0.001</b>
		After	1.766 (1.651-1.881)	2.007 (1.880-2.135)	0.241 (0.162-0.320)	<b>&lt;0.001</b>
	Non-deviated	Before	1.792 (1.676-1.908)	2.061 (1.948-2.175)	0.269 (0.192-0.346)	<b>&lt;0.001</b>
		After	1.785 (1.659-1.911)	2.070 (1.961-2.179)	0.285 (0.211-0.358)	<b>&lt;0.001</b>
Vol2 (cm <sup>3</sup> )	Deviated	Before	4.513 (3.460-5.566)	6.405 (5.667-7.143)	1.892 (1.102-2.681)	<b>&lt;0.001</b>
		After	5.265 (4.392-6.137)	7.600 (6.796-8.404)	2.335 (1.441-3.230)	<b>&lt;0.001</b>
	Non-deviated	Before	5.570 (4.638-6.502)	6.677 (6.017-7.337)	1.107 (0.204-2.010)	<b>0.002</b>
		After	6.905 (5.915-7.895)	8.014 (7.331-8.697)	1.110 (0.264-1.955)	<b>0.024</b>
tVol (cm <sup>3</sup> )	Deviated	Before	6.323 (5.203-7.442)	8.392 (7.636-9.147)	2.069 (1.266-2.872)	<b>&lt;0.001</b>
		After	7.031 (6.123-7.939)	9.607 (8.781-10.434)	2.577 (1.675-3.478)	<b>&lt;0.001</b>
	Non-deviated	Before	7.362 (6.404-8.320)	8.738 (8.091-9.385)	1.377 (0.458-2.296)	<b>0.001</b>
		After	8.690 (7.683-9.696)	10.084 (9.399-10.769)	1.394 (0.515-2.273)	<b>0.010</b>
TVol (cm <sup>3</sup> )		Before	13.684 (12.085-15.283)	17.130 (15.984-18.276)	3.446 (2.224-4.667)	<b>&lt;0.001</b>
		After	15.720 (14.204-17.237)	19.691 (18.356-21.027)	3.971 (2.726-5.216)	<b>&lt;0.001</b>

Note: MCA1: Minimal cross-sectional area 1 of one side of nasal cavity; MCA2: Minimal cross-sectional area 2 of one side of nasal cavity; Vol1: Volume 1 of one side of nasal cavity; Vol2: Volume 2 of one side of nasal cavity; tVol: Total volume of one side of nasal cavity; TVol: Total volume of two sides of nasal cavity.

\*Related-Samples Wilcoxon Signed Rank Test was used.

difference in flow parameters of the rhinomanometry of the non-deviated side of the nose which showed moderate positive correlations with the difference in NOSE scores were Flowex, and tFlow after decongestion. Additionally, the difference in airway resistance parameters of the deviated side of the nose which had moderate positive correlations with the difference in NOSE scores were ARins after decongestion, ARex before decongestion, ARex after decongestion, and tAR before decongestion.

## DISCUSSION

The major expectancy of patients who have a septoplasty operation due to nasal septum deviation is to have more comfortable nasal breathing (5, 17). However, the main postoperative outcome is the satisfaction and improvement of the quality of life of the patient. The effectiveness of the performed surgery is evaluated by the patients and can be accepted as a success if their preoperative symptoms related to nasal septum deviation are completely improved and they feel an apparent increase in life quality (6). Therefore, the patient's feelings and welfare evaluated by the subjective measurements

provide a more meaningful picture of the effectiveness of the applied surgery than the objective methods (17). However, the subjective nature of these methods is a challenge, especially in repeated measures. Follow-up measures are performed by the surgeons to show the ongoing effectiveness of the performed surgery at 3, 6, or 12 months after septoplasty. Therefore, lots of investigators use objective measurements besides the subjective ones, and also investigate their correlations (5, 18).

In the literature, lots of studies have used symptom score questionnaires such as the NOSE score, which is one of the most widely used. These questionnaires provide valuable information about the severity of nasal obstruction from a patient's point of view, and also about the degree of postoperative satisfaction (5, 19). Eren et al. reported a significant decrease in the NOSE score of patients with nasal obstruction after septoplasty (20). Mondina et al. stated that all NOSE scores of patients with nasal obstruction decreased significantly after an applied septoplasty operation (10). Lodder et al. reported that the mean preoperative and postoperative NOSE score was 78.4 and 23.0, respectively, and the mean improvement was 55.4 (21). We found similar results in the literature that the mean

**Table 4: Comparison of the pre and postoperative rhinomanometry parameters of the patients**

Parameter	Side	Decongestion	Preoperative, mean (95% CI)	Postoperative, mean (95% CI)	Difference, mean (95% CI)	p*
Flow <sub>ins</sub> (cm <sup>3</sup> /s)	Deviated	Before	269.70 (238.35-301.06)	344.93 (329.98-359.89)	75.23 (41.60-108.87)	<b>&lt;0.001</b>
		After	318.67 (297.40-339.93)	340.63 (331.53-349.74)	21.97 (-1.49-45.43)	0.052
	Non-deviated	Before	329.43 (321.66-337.20)	348.23 (324.05-372.42)	18.80 (-9.32-46.92)	0.616
		After	364.33 (330.68-397.99)	357.17 (333.42-380.91)	-7.17 (-51.88-37.55)	0.854
Flow <sub>ex</sub> (cm <sup>3</sup> /s)	Deviated	Before	296.87 (267.61-326.12)	363.77 (347.18-380.35)	66.90 (36.10-97.70)	<b>0.003</b>
		After	355.53 (330.27-380.80)	358.20 (346.16-370.24)	2.67 (-24.75-30.08)	0.787
	Non-deviated	Before	347.93 (338.03-357.83)	371.50 (341.70-401.30)	23.57 (-13.07-60.20)	0.673
		After	394.30 (355.00-433.60)	383.93 (353.86-414.01)	-10.37 (-63.16-42.43)	0.880
tFlow (cm <sup>3</sup> /s)	Deviated	Before	566.57 (507.84-625.30)	708.70 (677.52-739.88)	142.13 (79.51-204.76)	<b>0.001</b>
		After	674.20 (629.56-718.84)	698.83 (677.91-719.75)	24.63 (-24.25-73.52)	0.309
	Non-deviated	Before	677.37 (660.36-694.37)	719.73 (665.85-773.62)	42.37 (-22.05-106.79)	0.666
		After	758.63 (686.54-830.73)	741.10 (687.42-794.79)	-17.53 (-114.34-79.27)	0.948
TFlow (cm <sup>3</sup> /s)		Before	1243.93 (1182.18-1305.69)	1428.43 (1350.71-1506.16)	184.50 (89.30-279.70)	<b>0.001</b>
		After	1432.83 (1343.25-1522.42)	1439.93 (1372.74-1507.12)	7.10 (-103.32-117.52)	0.116
AR <sub>ins</sub> (150Pa/cm <sup>3</sup> /s)	Deviated	Before	0.685 (0.529-0.840)	0.440 (0.425-0.455)	-0.245 (-0.400 - -0.089)	<b>&lt;0.001</b>
		After	0.496 (0.445-0.546)	0.442 (0.432-0.453)	-0.053 (-0.105 - -0.001)	<b>0.048</b>
	Non-deviated	Before	0.457 (0.447-0.467)	0.442 (0.421-0.462)	-0.016 (-0.042 - -0.011)	0.649
		After	0.432 (0.402-0.462)	0.431 (0.410-0.452)	-0.002 (-0.042-0.039)	0.787
AR <sub>ex</sub> (150Pa/cm <sup>3</sup> /s)	Deviated	Before	0.579 (0.477-0.682)	0.417 (0.403-0.432)	-0.162 (-0.263 - -0.061)	<b>0.002</b>
		After	0.437 (0.408-0.467)	0.422 (0.410-0.433)	-0.016 (-0.047-0.016)	0.658
	Non-deviated	Before	0.434 (0.421-0.448)	0.416 (0.396-0.436)	-0.018 (-0.049-0.013)	0.704
		After	0.402 (0.373-0.431)	0.404 (0.382-0.426)	0.002 (-0.037-0.041)	0.957
tAR (150Pa/cm <sup>3</sup> /s)	Deviated	Before	0.309 (0.249-0.369)	0.214 (0.207-0.221)	-0.095 (-0.155 - -0.036)	<b>0.001</b>
		After	0.231 (0.213-0.249)	0.216 (0.211-0.221)	-0.015 (-0.034-0.003)	0.284
	Non-deviated	Before	0.223 (0.217-0.228)	0.214 (0.204-0.224)	-0.008 (-0.022-0.006)	0.688
		After	0.208 (0.193-0.223)	0.208 (0.198-0.219)	0.000 (-0.019-0.020)	0.905
TAR (150Pa/cm <sup>3</sup> /s)		Before	0.123 (0.116-0.131)	0.107 (0.103-0.111)	-0.017 (-0.025 - -0.009)	<b>0.001</b>
		After	0.107 (0.102-0.113)	0.106 (0.102-0.109)	-0.002 (-0.008-0.005)	0.116

Note: Flow<sub>ins</sub>: Inspiration airflow of one side of nasal cavity; Flow<sub>ex</sub>: Expiration airflow of one side of nasal cavity; tFlow: Total airflow of one side of nasal cavity; TFlow: Total airflow of two sides of nasal cavity; AR<sub>ins</sub>: Inspiration airway resistance of one side of nasal cavity; AR<sub>ex</sub>: Expiration airway resistance of one side of nasal cavity; tAR: Total airway resistance of one side of nasal cavity; TAR: Total airway resistance of two sides of nasal cavity.

\*Related-Samples Wilcoxon Signed Rank Test was used.

preoperative and postoperative NOSE score was 60.50 and 7.33, respectively, with a mean difference of 53.17 points. This difference was found to be statistically significant.

In a study, it was reported that an improvement in NOSE score of approximately 40% or higher was required to define the surgery as successful (22). Also, changes in NOSE scores after surgery were evaluated in a systematic review and meta-analysis, and the mean improvement was found as 50.0 points at the early evaluation (12). Stewart et al. demonstrated a 31 to 37 points change in NOSE score in their original septoplasty study (23). In our study, all patients had improvements of more than 30 points in NOSE scores, except two patients with improvement scores of less than 30 points.

AR and AAR measurements have been performed after decongestion of the nose with a topical decongestant in the studies that investigated the effectiveness of the septoplasty (6, 11, 21). The use of nasal decongestants eliminates vascular causes of nasal obstruction and provides a more appropriate evaluation chance for the hard tissue components of nasal obstruction (6). In our study, we measured all parameters BD and AD and took part in AR and AAR measures. We have demonstrated a comparison of preoperative and postoperative results in Tables 3 and 4 and exhibited the statistically significant correlations between the differences in objective measurements and the differences in NOSE scores of the patients. In our study, we found statistically

**Table 5: Statistically significant correlations between anatomical measurements, differences in functional measurements and differences in NOSE scores**

		Difference in NOSE score		
		R	n	p*
Anatomical measurements	CW (DS)	0.429	30	<b>0.018</b>
	CW (NDS)	0.514	30	<b>0.004</b>
	UPW	0.397	30	<b>0.030</b>
Difference in functional measurements	Vol1 (cm <sup>3</sup> ) (DS/BD)	-0.438	30	<b>0.015</b>
	Vol2 (cm <sup>3</sup> ) (NDS/BD)	-0.377	30	<b>0.040</b>
	tVol1 (cm <sup>3</sup> ) (NDS/BD)	-0.401	30	<b>0.028</b>
	TVol1 (cm <sup>3</sup> ) (BD)	-0.372	30	<b>0.043</b>
	Flow <sub>ins</sub> (cm <sup>3</sup> /s) (DS/AD)	-0.409	30	<b>0.025</b>
	Flow <sub>ex</sub> (cm <sup>3</sup> /s) (DS/AD)	-0.396	30	<b>0.030</b>
	Flow <sub>ex</sub> (cm <sup>3</sup> /s) (NDS/AD)	0.367	30	<b>0.046</b>
	tFlow (cm <sup>3</sup> /s) (DS/AD)	-0.396	30	<b>0.030</b>
	tFlow (cm <sup>3</sup> /s) (NDS/AD)	0.365	30	<b>0.047</b>
	AR <sub>ins</sub> (150Pa/cm <sup>3</sup> /s) (DS/AD)	0.418	30	<b>0.022</b>
	AR <sub>ex</sub> (150Pa/cm <sup>3</sup> /s) (DS/BD)	0.366	30	<b>0.047</b>
	AR <sub>ex</sub> (150Pa/cm <sup>3</sup> /s) (DS/AD)	0.412	30	<b>0.024</b>
	AR <sub>ex</sub> (150Pa/cm <sup>3</sup> /s) (NDS/AD)	-0.368	30	<b>0.045</b>
	tAR (150Pa/cm <sup>3</sup> /s) (DS/BD)	0.405	30	<b>0.026</b>

Note: CW: Choana width; UPW: Upper palate width; Vol1: Volume 1 of one side of nasal cavity; Vol2: Volume 2 of one side of nasal cavity; tVol: Total volume of one side of nasal cavity; TVol: Total volume of two sides of nasal cavity; Flow<sub>ins</sub>: Inspiration airflow of one side of nasal cavity; Flow<sub>ex</sub>: Expiration airflow of one side of nasal cavity; tFlow: Total airflow of one side of nasal cavity; AR<sub>ins</sub>: Inspiration airway resistance of one side of nasal cavity; AR<sub>ex</sub>: Expiration airway resistance of one side of nasal cavity; tAR: Total airway resistance of one side of nasal cavity; DS: Deviated side; NDS: Non-deviated side; BD: Before decongestion; AD: After decongestion.

\* Spearman's rank-order correlation was used.

significant differences between all pre and postoperative acoustic rhinometry variables (Except for the MCA2 of NDS) of DS and NDS of the nose both before and after decongestion. We also found significant improvements in all postoperative airflow and airway resistance parameters of DS of the nose before decongestion, when compared to the preoperative measurements.

Although AR provides detailed information about the geometry of nasal structures, it does not provide any information about the flow field and physiology of nasal pressure (5, 17). These parameters have critical importance because the evaluation of the physiology of the nasal airway helps surgeons to decide which patients would get better from performing a septoplasty operation (17). AAR provides detailed information about the physiology of nasal airflow and demonstrates abnormal measurements in nasal airflow and nasal pressure. Also, studies have reported that patients with severe anatomic deviation may have mild symptoms, whereas other patients with a small septal deviation have significant nasal obstruction symptoms (1). It is thought that these characteristics of AAR complete the missing parts of other objective measurements such as morphometric variables and AR measures (24).

Lara-Sanches et al. reported that performed surgery resulted in statistically significant differences with the NOSE score and

AAR measures. They did not, however, observe any correlation between the NOSE score and AAR, and concluded that the objective and subjective measurements complete each other and provide useful information from a different point of view (25). Currently, the correlation between the subjective evaluation scores and detailed objective measurements is still debated. Several studies showed correlation, whereas others did not (2, 5, 17, 26). It was pointed out that the correlation between NOSE score and objective evaluations could be affected by study design, such as having a small sample size, non-homogenous groups, or the surgical techniques performed (12, 27). Jones et al. observed no correlation between the objective nasal resistance measurements and subjective measures (28).

It has been stated in the literature that the lack of correlation between the objective and subjective measurements related to nasal function may be due to surgeons focusing on the nasal passage of the deviated side and ignoring the fact that the nose has two separate nasal passages (5). In a study, a significant nasal airflow increase was observed on the deviated side, but a significant airflow decrease was not observed on the non-deviated (wide side) part (29). In another study, during follow-up measurements, a significant increase in nasal resistance was observed in the non-deviated nasal cavity in 23 of 30



patients with nasal obstruction (30). In the presented study, surgery significantly increased nasal airflow and reduced nasal resistance in the deviated side of the nasal septum, but did not cause any significant airflow or nasal resistance changes in the non-deviated side. It has been thought in the literature that asymmetrical nasal airflow resulting from deviated nasal septum may create spontaneous changes in the nasal cycle and that may lead to the symptoms related to nasal congestions (5).

NOSE score refers to subjective feelings about the nasal patency, AR and AAR provide additional objective detailed information on the anatomy of the nasal cavity, nasal airflow, and nasal resistance, respectively (5). In our study, we performed both objective measurements in all patients and investigated the existence of a correlation between NOSE score, AR, and AAR measurements. We then demonstrated significant correlations between the NOSE score and lots of AR and AAR parameters.

There are several limitations in the presented study. First, we could have studied a relatively smaller group of patients. Also, we did not include a control group. Another limitation of our study was the short follow-up time because several studies have reported that the improvement in symptoms and subjective evaluations at early stages decreased at the long term observation (31). In the presented study, the control measures of patients were performed at the end of the first month and therefore, we cannot comment on the long-term consequences of the surgery.

## CONCLUSION

Many different follow-up and evaluation methods have been proposed to evaluate the effectiveness of the performed operations in septoplasty surgery. Some of them include subjective measurements and others include objective measurements. We performed both methods in the presented study, and then investigated the correlation of these tests. We showed that objective measurements correlate strongly with the subjective one, and further studies should be conducted to evaluate positive or negative preoperative predictors of surgical outcomes.

**Ethics Committee Approval:** Ethical approval was obtained from Izmir Tepecik Training and Research Hospital Ethics Committee (Approval date:18/08/2016, No:22)

**Informed Consent:** Written informed consent was obtained from all patients included in the study after detailed information about the study was given.

**Peer-Review:** Externally peer-reviewed.

**Author Contributions:** Conception/Design of Study- A.U., E.D.; Data Acquisition- A.U., E.D.; Data Analysis/Interpretation- A.U., E.D.; Drafting Manuscript- A.U., E.D.; Critical Revision of Manuscript- A.U., E.D.; Final Approval and Accountability- A.U., E.D.

**Conflict of Interest:** Authors declared no conflict of interest.

**Financial Disclosure:** Authors declared no financial support

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