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Evaluation of outcomes in nasal valve surgery for patients with obstructive sleep apnea syndrome (OSAS)

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ABSTRACT

Aim: The aim of our study is to evaluate the effectiveness of nasal valve surgery and its reflection on functions in patients diagnosed with Obstructive Sleep Apnea Syndrome (OSAS) by comparing the changes in pre- and postoperative magnetic resonance imaging (MRI) measurements.

Methods: Patients experiencing nasal breathing difficulties were selected for the study. Those who underwent polysomnography (PSG) and were subsequently diagnosed with OSAS were further evaluated for nasal pathology within the plastic reconstructive and aesthetic surgery department. PSG assessments were conducted both before and approximately three months after surgery to measure changes in AHI and minimum oxygen saturation levels.

Results: All 24 patients were male and the mean age was 47.5 ± 8.5 years (range: 29-63 years). Neck circumference was 45±2.9 cm (range: 41-50 cm). In terms of AHI, minimum oxygen concentration, and Epworth sleepiness scale (ESS), there were statistically differences between the pre-operation and post-operation groups ($p<0.01$, $p<0.05$, and $p<0.01$, respectively). In terms of internal nasal valve, external nasal valve of the nose, and external valve angle, there were statistically differences between the pre-operation and post-operation groups ($p<0.001$, $p<0.01$, and $p<0.01$, respectively). In our study, it was shown that changes in valve areas and angles provided a statistically significant increase in postoperative AHI and mean oxygen saturation results ($p<0.05$).

Conclusion: CPAP treatment is useless in patients with closed nasal passages. It has been observed that correct and effective nasal valve surgery techniques can increase nasal breathing functions and improve quality of life in OSAS patients with nasal obstruction.

Key words: Nasal valve surgery, rhinoplasty, magnetic resonance imaging, volumetric analysis, polysomnography.

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1. Introduction

Healthy breathing through the nose is important for general health. Because the nose plays a very important role in airflow. It warms, moisturizes and provides odor absorption of the inhaled air and, more importantly, provides air entry into the body, that is, oxygen intake. Obstructions in the nasal airway have very important effects on people's living comfort. Being able to breathe through the nose has a very complex structure physiologically, but first of all, the air passage must be anatomically open [1-3].

If there is an obstruction in the passage, it must first be opened surgically. Although many surgical treatment methods have been defined to solve the problem, finding the source of the problem can often be very difficult. Because this structure consists of many structural components such as mucosal, bone, cartilage structure or contractile muscle structure. The structural causes of obstruction can be post-traumatic, post-surgical, idiopathic or iatrogenic. The basis for this is anatomical malformation or dysfunction. In fact, 75-85% of people have nasal deformities of various shapes [4-6].

The nasal valve (NV) is an aesthetic organ located in the middle of the nose face and is also a way of taking in air. For healthy ventilation, the anatomical structure of the nose must be normal and the airway must be open. The airway consists of two main elements called the internal and external nasal valves. The external nasal valve is the opening of the nostrils that is visible from the outside [5, 7]. Normal airflow in the nasal valve depends on the Bernoulli principle and Poiseuille law. If the pressure increase overcomes the flexibility/resistance of the nasal side walls, collapse/closure that causes obstruction may occur. Clinically, the collapse of the nasal side walls during breathing is defined as “dynamic obstruction”. Although most plastic reconstructive surgeons specialize in detecting anatomical and aesthetic defects of the nose, it can often be overlooked that the source of nasal obstruction is due to NV. There are studies showing that NV is responsible for 13% of chronic nasal obstruction in adults in the community and that permanent nasal obstruction after septoplasty occurs due to NV in 95% of cases [8-10].

Nasal congestion reduces or makes impossible the effect of Continuous Positive Airway Pressure (CPAP) application, which provides treatment especially in patients who have decreased blood oxygen saturation during sleep. This reduces the quality of sleep and vital organs cannot receive sufficient oxygen during the night. This situation can cause sleepiness, fatigue, weight gain, depression and hypertension during the day. If the apnea-hypopnea index exceeds 25 in the sleep test, the clinical picture called obstructive sleep apnea syndrome (OSAS) occurs [11-13]. OSAS is a serious sleep disorder characterized by recurrent blockages of the upper airway during sleep. This situation can lead to deterioration of sleep quality, excessive daytime sleepiness and an increase in the risk of cardiovascular disease. In patients with OSAS, the decrease in airflow due to nasal congestion can increase the severity of the disease. Therefore, opening the nasal air passages with nasal valve surgery is of great importance in terms of alleviating symptoms and improving the quality of life in patients with OSAS [14, 15].

Long-term, effective correction of the internal nasal valve is achieved through surgical intervention. Correction typically involves the use of various grafts or suture techniques to widen the nasal valve area. The selection of the appropriate technique depends largely on the location and type of dysfunction (dynamic/static). More than one technique must often be used in the same surgical procedure. The selection of the appropriate technique presents a significant challenge for the nasal valve surgeon [16, 17]. Most techniques have been shown to have positive effects on postoperative outcomes. Even in studies examining nasal valve correction after failed septoplasty, correction of previously unaddressed deviations of the septum was often required in addition to valve surgery. These grafts, such as alar wing strip grafts, alar sutures, and alar rim grafts, primarily affect dynamic collapse [18]. To widen the internal nasal valve apex angle, spreader grafts, flaring sutures and a correct osteotomy are required. To widen the internal valve area, septoplasty, turbinate resection or cauterization, batten cartilage graft can be used as a support to eliminate weakness in the scroll area, especially during inspiration, which causes collapse. For the external nasal valve, shaping can be done with columellar strut grafts or septal cartilage grafts to lift the nose tip, dome shaping sutures, cartilage grafts or sutures to lift the lateral surfaces of the alar cartilages [19, 20].

In the treatment of people who have difficulty breathing through their nose and diagnosed with OSAS, it is necessary to eliminate nasal obstructions or stenosis with Plastic Reconstructive and Aesthetic Surgery techniques, to ensure the patency of internal and external nasal valves and to evaluate this with MR volumetric measurements and sleep test. The aim of our study is to evaluate the effectiveness of nasal valve surgery and its reflection on functions by comparing the changes in pre- and post-operative MR measurements with polysomnography and the changes in apnea hypopnea index (AHI) and mean blood oxygen saturation.

2. Materials and metods

2.1. Participants: Twenty-four male patients with nasal breathing problems were included in the study. The average age of the patients was 47.5 ± 8.5 years (range: 29-63 years). Patients diagnosed with OSAS through polysomnography (PSG) were assessed for nasal pathology at the plastic reconstructive and aesthetic surgery department. Pre-surgical evaluations by the surgeon identified and recorded nasal breathing issues. The diagnosis of OSAS followed the criteria set by the International Classification of Sleep Disorders, which included an AHI of 5 or more events per hour and oxygen saturation levels below 90%, measured via pulse oximetry. PSG assessments were repeated approximately three months post-surgery to evaluate changes in AHI and minimum oxygen saturation (We thought that at the end of 12 months, it would be difficult to call patients just for a check-up and convince them for an MRI examination under our country's conditions. The three-month period was the earliest period for evaluation, when early inflammation and edema had significantly disappeared).

2.2. Radiological and Morphometric Evaluation: Volumetric measurements were obtained and recorded from axial, coronal, and sagittal sections provided by the radiology department. Each patient underwent these procedures before and after surgery. A 1.5-T superconductive device with a circular polar head coil (Magnetom Vision Plus, Enlargen, Germany) was used. Magnetic resonance imaging (MRI) evaluations included T1-weighted imaging (repetition time (TR)/echo time (TE), 570/15 ms) in the axial plane and T2-weighted fast spin echo (TR/TE, 5400/99 ms) in the sagittal plane. The nasal area was measured using a 3D MP-RAGE sequence (TR/TE, 9.7/4 ms; field of view, 240 mm; slice thickness, 1 mm; matrix, 192x256). The images obtained from the MRI were processed using the Leonardo workstation (Siemens Medical Systems, Enlargen, Germany). Anatomical segmentation of high-resolution 3D MP-RAGE images was initially conducted on the first three planes (axial, coronal, and sagittal). Any anatomical distortions identified in these profiles were corrected. The regions to be measured were magnified by at least twofold on the workstation. For the delineation of nasal boundaries, the criteria established by Cakmak and colleagues were used as the reference. Absolute volumes of the right and left nasal cavities in patients were compared pre- and post-operatively. For each subject, we determined the angle between the hard palate and the plane chosen for the coronal section at the level of the nasal valves. Additionally, the distance from the nasal adapter to the nasal valve area was marked on a sagittal MRI image. The outer edges of the air passages were manually outlined to calculate the cross-sectional areas (Figure 1).

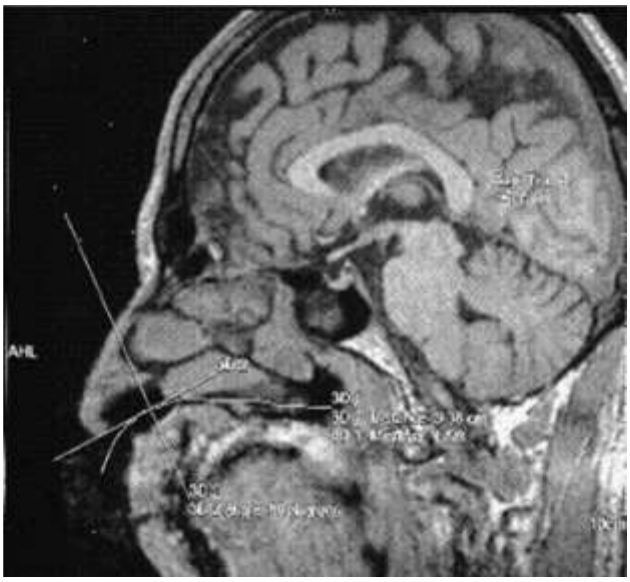

Figure 1. The boundaries of the airways were manually outlined to determine the cross-sectional areas.

2.3. Epworth Sleepiness Scale (ESS): The ESS is a self-assessment questionnaire used to assess a person's level of sleepiness during the day. It consists of eight questions. Each question is scored from 0 (never) to 3 (very likely). The total score indicates a person's overall level of sleepiness: 0-9: Normal sleepiness and 10-24: Increased sleepiness (potentially requiring treatment). The ESS test was used to diagnose sleep disorders in our study patients and to monitor progress in treatment.

2.4. Surgical Techniques and Postoperative Follow-up: All 24 patients underwent physical examinations before surgery, MRI images were taken and valve angles and areas were measured and recorded, sleep tests were performed, AHI, and mean oxygen saturations were measured and recorded, and nasal photographs of the patients were taken. 14 of the 24 patients had previously undergone nasal surgery due to difficulty breathing through the nose, but their complaints had not improved. All patients underwent septorhinoplasty surgery with an open technique under general anesthesia. Columellar and intercartilaginous incisions were made and the lower lateral cartilages and upper lateral cartilages were dissected and exposed. The nasal bone was dissected subperiosteally and exposed. The cartilage septum was dissected submucosally and the cartilage septum was exposed. In all patients, a window was removed from the middle section, leaving behind L-strut cartilage. Thus, deviated septum structures (in 8 patients) were corrected. The removed cartilage structures were used as cartilage grafts. A 2x2x15mm spreader cartilage graft obtained from the septum was used to widen the internal nasal valve apex angle in all patients (Figure 2).

Figure 2. Spreader cartilage graft placement drawing.

In 12 patients, unilateral concha cauterization (shaping) was performed to reduce the concha size. In 8 patients, both sides of the concha were cauterized. Batten grafts were placed in 8 patients, and flaring sutures were placed to open the upper lateral cartilages in 12 patients. Columellar strut grafts were placed in 12 patients to increase the tip projection. In 16 patients, the septum was used as a cartilage graft source. In two patients, a cartilage graft could not be obtained because the septum had been used in previous surgeries. A costal cartilage graft extracted subperiosteal from 9 ribs was used for these patients. One of the patients had a saddle nose deformity due to a previous rhinoplasty surgery. In order to correct the shape, the cartilage graft obtained from the rib was shaped and used as a dorsal onlay cartilage graft. After surgery, all patients were placed sterile sponge tampons impregnated with antibiotic ointment. The tampons were removed on the 3rd day. Dorsal thermoplastic splints were used in all patients and were removed within 7-10 days. No patient experienced any complications during the recovery process. MRI images and sleep tests were repeated for all patients at the 3rd month of their surgery.

2.4. Statistical analysis: Statistical evaluation was performed using SPSS 27.0 (SPSS Inc. Chicago, IL) program. Sleep score results provided mean ranges, standard deviation, and minimum and maximum values. Sleep test values were compared using Wilcoxon signed rank test before and after surgery. Paired-samples t-test was used for pre- and postoperative volumetric measurements. Statistical significance level was determined as $p<0.05$.

3. Results

All 24 patients were male, with a mean age of 47.5 ± 8.5 years (range: 29-63 years). The mean body mass index (BMI) was 32 ± 2.8 kg/m² (range: 27-37 kg/m²), and the average neck circumference was 45 ± 2.9 cm (range: 41-50 cm). Preoperative and postoperative sleep evaluations (AHI and minimum oxygen saturation, ESS score) of the patients are shown in Table 1. Preoperative AHI value of the patients was 45.15±5.06 and minimum oxygen concentration was 81.0±2.1%, postoperative AHI value was 23.50±5.10 and minimum oxygen saturation was 88.2±2.05%. Preoperative ESS score of the patients was 17.1±2.7, while postoperative ESS score was 11.1±2.8. In terms of AHI, Minimum oxygen concentration, and ESS score, there were statistical differences between the pre-operation and post-operation groups ($p<0.01$, $p<0.05$, and $p<0.01$, respectively) (Table 1).

PSG measurements were performed on average 117 ± 30.4 days (range: 80-189 days) after surgery. Preoperative and postoperative internal nasal valve area and apex angles and external nasal valve area mean values of the patients are shown in Table 2. While the right side internal nasal valve area was 0.85±0.25 and left side internal nasal valve area was 0.80±0.42 before surgery, it increased to 1.35±0.31 on the right side and 1.40±0.27 on the left side. While

Table 1. Comparison of preoperation and postoperation of PSG and ESS data.

Variables	Pre-operation	Post-operation	*P value*
AHI	45.15±5.06	23.50±5.10	*<0.01*
Minimum oxygen concentration	81.0±2.1%	88.2±2.05%	*<0.05*
ESS score	17.1±2.7	11.1±2.8	*<0.01*

PSG: Polysomnography; ESS: Epworth sleepiness scale; AHI: Apnea hypopnea index.

Table 2. Comparison of Internal / External Nasal Valve volume, and External Valve Angle between pre-operation and post-operation.

Variables	**Pre-operation**	**Post-operation**	***P value***
Internal nazal valv volume			
Right	0.85±0.25	1.35±0.31	*<0.01*
Left	0.80±0.42	1.40±0.27	
External nazal valv volume			
Right	1.17 ± 0.2	1.45 ± 0.3	*<0.01*
Left	1.16 ± 0.3	1.36 ± 0.3	
External valve angle			
Right	9.9±3.1	14.4±2.5	*<0.01*
Left	9.1±2.9	15.2±2.0	

the right side external nasal valve area was 1.17±0.2 and left side internal nasal valve area was 1.16±0.3 before surgery, it increased to 1.45±0.3 on the right side and 1.36±0.3 on the left side after surgery. However, preoperatively, the right side external nasal valve peak angle was 9.9±3.1 and the left side external nasal valve peak angle was 9.1±2.9, and postoperatively, the right side external nasal valve peak angle was 14.4±2.5 and the left side was 15.2±2.0. In terms of internal nasal valve, external nasal valve of the nose, and external valve angle, there were statistically differences between the pre-operation and post-operation groups ($p<0.001$, $p<0.01$, and $p<0.01$, respectively).

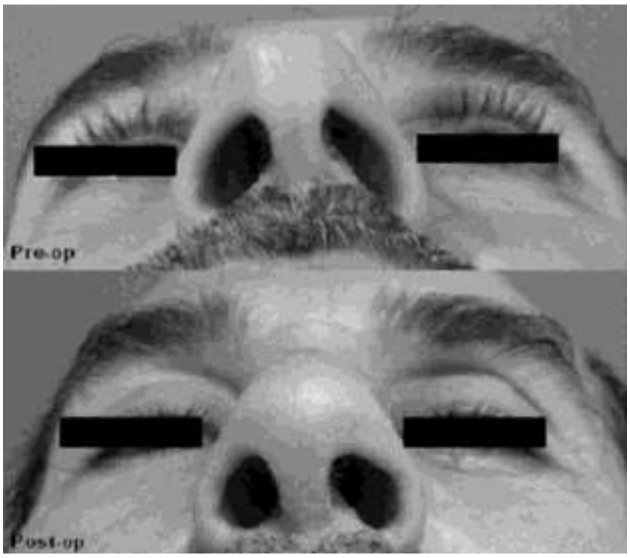

Figure 3. The external nasal valve of a patient preoperatively and postoperatively.

Preoperative and postoperative images of the external nasal valve are shown in figure 3. In our study, it was shown that the changes in valve areas and angles provided a statistically significant increase in postoperative AHI and mean oxygen saturation results ($p<0.05$).

4. Discussion

In this study, the efficacy of nasal valve surgery in patients with OSAS was evaluated by comparing preoperative and postoperative measurements of nasal valve areas, AHI, and oxygen saturation levels. The results demonstrated significant improvements in both functional and anatomical parameters, highlighting the effectiveness of nasal valve surgery in alleviating nasal obstructions and enhancing breathing during sleep. Specifically, the statistically significant reductions in AHI and increases in oxygen saturation post-surgery underscore the critical role of precise surgical interventions in improving respiratory function and overall quality of life in OSAS patients. This study reinforces the importance of using advanced imaging techniques, such as MR volumetric analysis, alongside polysomnography, to objectively assess the outcomes of nasal valve surgeries.

According to the Health Statistics, a BMI of 28.1 kg/m² and above for women and 28.6 kg/m² for men is considered overweight, while a BMI of 32.2 kg/m² and above for women and 32.8 kg/m² and above for men is considered overweight [21]. In a study of Kim et al, in patients with OSAS, a BMI of 28 kg/m² and a neck circumference of more than 40 cm have been shown to be important risk factors [22]. In our study, neck circumference was 45 cm (41-50 cm) and BMI was 32 kg/m2 (27-37 kg/m2).

There are some studies in the literature that emphasize the significant benefits of nasal valve surgery for patients with OSAS. Studies such as Gelardi et al. and Wang et al. have reported similar outcomes, where patients undergoing nasal valve surgery showed notable reductions in AHI and improvements in oxygen saturation [23, 24]. In Gelardi et al.'s research, the average preoperative AHI of 48.3±6.2 decreased to 25.7±5.9 postoperatively, while oxygen saturation improved from 80.5% to 87.4% [23]. Similarly, Wang et al. documented a reduction in AHI from 46.7±4.8 to 24.1±5.3 and an increase in oxygen saturation from 81.3% to 88.5% post-surgery [24]. In a study of Pang et al., it was stated that 735 patients who underwent nasal surgery experienced significant improvements in both nasal breathing and AHI, supporting the idea that addressing nasal obstruction can play a role in the overall management of OSAS. The research emphasizes the importance of proper nasal function in OSAS treatment and suggests that surgical intervention can benefit patients with nasal-related sleep disturbances. The findings also highlight the need for further research to understand the full implications of nasal surgery in the broader context of OSAS management [25]. These findings closely mirror the results of our study, where the mean preoperative AHI of 45.15±5.06 dropped to 23.50±5.10 postoperatively, and the minimum oxygen saturation improved from 81.0±2.1% to 88.2±2.05%.

In our study, a key distinguishing feature is the comprehensive use of MR volumetric analysis in conjunction with polysomnography to evaluate the outcomes of nasal valve surgery in patients with OSAS. While previous studies, such as those by Gelardi and Wang et al., have primarily relied on polysomnography to assess changes in AHI and oxygen saturation, our study uniquely integrates advanced imaging techniques to provide a more detailed and precise evaluation of nasal valve changes post-surgery [23, 24]. The MR volumetric analysis enabled us to quantify the anatomical modifications in the internal and external nasal valves with high precision, offering a robust correlation between structural improvements and functional outcomes [26]. This dual assessment approach allowed for a more comprehensive understanding of how surgical interventions translate into enhanced breathing efficiency and sleep quality [27, 28]. Furthermore, our study's focus on a relatively homogeneous patient population-consisting solely of male patients with consistent baseline characteristics (average age of 47.5 years, BMI of 31 kg/m², and neck circumference of 44 cm) ensures a controlled evaluation of surgical outcomes. This controlled demographic profile helps to minimize variability and provides clearer insights into the efficacy of the nasal valve surgery. Additionally, the significant improvements observed in both AHI (from 45.15±5.06 to 23.50±5.10) and minimum oxygen saturation (from 81.0±2.1% to 88.2±2.05%) in our study are notable for their magnitude, which compares favorably with existing literature. These findings highlight the effectiveness of the surgical techniques employed and underscore the potential benefits of incorporating MR imaging into preoperative and postoperative assessments. In summary, the integration of MR volumetric analysis with traditional polysomnography, the controlled patient demographics, and the significant functional improvements observed in our study set it apart from previous research in the field. These distinctive features contribute to a more nuanced and comprehensive understanding of the benefits of nasal valve surgery for OSAS patients.

The findings of our study, which include significant improvements in both internal and external nasal valve areas and angles following nasal valve surgery, align with and extend the existing body of research on surgical interventions for patients with OSAS. Our results are particularly noteworthy for several reasons that distinguish our study from prior research. Chadha et al. documented a reduction in AHI from 48.3±6.2 to 25.7±5.9 and an improvement in oxygen saturation from 80.5% to 87.4% [29]. Similarly, Lai et al. reported reductions in AHI and increases in oxygen saturation that are consistent with our findings. However, the emphasis in these studies was on the overall respiratory outcomes rather than the precise anatomical changes assessed using advanced imaging techniques [30]. In a study of Jahandideh et al., it was stated that the use of imaging techniques to assess nasal valve surgery outcomes but focused on CT scans rather than MR volumetric analysis. Rhee et al. reported significant anatomical improvements and correlated these with functional outcomes, similar to our approach [31]. In a study of Cillo et al., they focused on the long-term outcomes of nasal valve surgery and reported sustained improvements in AHI and patient-reported sleep quality. Their study showed a reduction in AHI from 42.5±5.4 to 21.3±4.9 over a follow-up period of 6 months [32]. In a study of Sawa et al., it was investigated the outcomes of nasal valve surgery using both subjective and objective measures, including AHI and nasal obstruction symptom evaluation (NOSE) scores. They reported significant improvements in AHI (from 38.2±6.1 to 22.5±5.3) and NOSE scores post-surgery. Their study did not utilize advanced imaging techniques like MR volumetric analysis [33]. In a study of Shafik et al., they focused on the use of CT scans to evaluate anatomical changes in the nasal valve area post-surgery. They found significant improvements in nasal airflow and patient-reported outcomes [34]. Their use of imaging is similar to our approach, but MR imaging, as used in our study, provides more detailed volumetric measurements.

In a study of Pottel et al., they explored the long-term efficacy of nasal valve surgery in OSAS patients, using polysomnography and patient questionnaires. They reported sustained reductions in AHI and improvements in quality-of-life metrics over a 12-month period. Their findings, with a reduction in AHI from 41.0±5.2 to 21.8±4.7, are comparable to our results. However, they did not include advanced imaging for anatomical assessment, which limits the anatomical insight provided [35]. In a study of El-Anwar et al., they examined the impact of nasal valve surgery on nasal patency and sleep quality using both subjective (NOSE scores) and objective (polysomnography) measures. They were stated that significant improvements in both domains, with AHI decreasing from 39.5±5.5 to 24.2±4.9 post-surgery [36]. While their study offers a robust evaluation of functional outcomes, the lack of detailed anatomical measurements via MR imaging distinguishes our study. A distinctive feature of our study is the use of MR volumetric analysis to measure internal and external nasal valve areas and angles pre- and post-surgery. This approach allowed for a more precise and objective evaluation of the anatomical changes resulting from the surgery. The detailed measurements provided insights into how these anatomical improvements correlate with functional outcomes such as AHI and oxygen saturation. Additionally, our study included a specific follow-up period of approximately 117 days (80-189 days) post-surgery for the PSG measurements, providing a well-defined timeframe for assessing the long-term benefits of the surgical interventions. This follow-up period is crucial for understanding the sustained impact of the surgery on nasal valve function and overall respiratory health.

4.1. Limitations

There are some limitations in our study. The small number of cases in our study, the fact that all patients were male, and that it was a single-center study are our limitations. We believe that working with larger groups to support the study will make the results more meaningful.

4.2. Conclusions

In conclusion, previous studies have not used MR as effectively as we have in nasal volumetric calculations. Our study advances the understanding of nasal valve surgery outcomes by providing detailed anatomical data alongside functional improvements. The use of MR volumetric analysis sets our research apart from previous studies and highlights the value of combining advanced imaging techniques with clinical assessments to achieve a holistic view of surgical efficacy in OSAS treatment. CPAP is the first choice for treatment in patients with OSAS. CPAP treatment is useless in patients with closed nasal passages. Nasal valve surgery and correctly performed rhinoplasty may be beneficial in patients with narrow or closed nasal passages. Some patients may not improve despite surgery.

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