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A Study on Effect of Nasal Obstruction on Pulmonary Function Tests in Patients with Allergic Nasal Polyposis Attending Medical College Headquarter's Hospital

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ABSTRACT

Both the upper and lower airways form a contiguous and functionally related organ. Nose performs important functions such as respiration, filtration, humidification and olfaction.[1]Nasal polyposis, is one of the common cause for nasal obstruction. Due to obstruction particles enters the lower airway through oral breathing and causes bronchoconstriction and lower airway irritation.[2] Hence, there seems a relation between upper and lower airways.[3]

Aim of the study is to evaluate the impact of nasal obstruction on pulmonary function in patients with allergic nasal polyposis by comparing pulmonary function test (PFT) results before and after surgical intervention.

Materials and Methods: This study was conducted on patients aged 20 to 45 years who attended the Department of ENT at Medical College Hospital. A total of 86 patients diagnosed with nasal polyposis were included. All participant underwent surgical intervention and pulmonary function tests (PFTs) were performed at three intervals: preoperatively, and 1 and 3 month postoperatively and results were analyzed and compared.

Results: The majority of patients affected by allergic nasal polyposis belonged to the age group around 30 years. The mean age of the study population was 31.09 years. All patients (100%) underwent functional endoscopic sinus surgery. Postoperative evaluation revealed clinically and statistically significant improvements in forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) irrespective of age, gender, or the duration of nasal obstruction.

Conclusion: Patients with bilateral nasal obstruction with decreased pulmonary function had significant improvement in pulmonary function after nasal surgery.

Keywords: *Nasal obstruction, Nasal Polyposis, Pulmonary function tests, Forced expiratory volume in one second (FEV1), Forced vital capacity (FVC), Functional Endoscopic Sinus Surgery (FESS)*

1. INTRODUCTION

Upper and lower airways form a contiguous and functionally related organ. They are frequently exposed to similar inflammatory stimuli. The role of defence mechanisms of host is vital. The cellular or humoral immune responses, physical barriers and mucociliary clearance mechanism combine and protects the lungs from damage. In upper respiratory tract, cilia propels mucus, bacteria and other particles trapped in mucus towards nasopharynx. This mucus drops to the hypopharynx and is swallowed. In lower respiratory tract, the cilia lining tracheobronchial tree move the mucus up along the trachea into the hypopharynx. If these mechanisms get affected the patient first visits the otorhinolaryngologist before bronchopulmonary involvement occurs.[1]

Among many conditions of chronic nasal obstruction Nasal polyposis is one of the common cause for chronic bilateral nasal obstruction. Nasal polyposis is a chronic inflammatory disease of nasal mucosa, characterized by non-neoplastic oedematous prolapsed masses of nasal or sinus mucosa. Nasal polyposis causes nasal obstruction, sneezing and hyposmia/anosmia..

The nose plays an important role in warming, humidifying and filtering air before it enters the lower airways. Impairment in the nasal function can impact the lower airways. Narrowing of nasal cavities due to anatomical and physiological abnormalities leads to inadequate airflow through the nose and reduces breathing capacity.

Though a relationship between upper airway, lower airway has been reported, varied pulmonary function tests in patients with upper airway diseases is yet to be understood. Not many studies are available comparing the effect of nasal obstruction on pulmonary function tests in patients with Allergic nasal polyposis.

The present study was done to evaluate the effect of nasal obstruction on pulmonary function tests in patients with allergic nasal polyposis.

2. MATERIALS AND METHODS

This study was carried out from December 2022 to May 2024 in the department of otolaryngology and respiratory medicine, at Medical college Headquarters hospital, Chittoor- Andhra Pradesh.

All the patients with chronic nasal obstruction due to allergic nasal polyposis attending the department of otolaryngology and head and neck surgery at Medical College Headquarters hospital, Chittoor in the stipulated period fulfilling the inclusion criteria were enrolled for the study.

Patients with chronic nasal obstruction due to Allergic nasal polyposis between the age group 25-40 years, willing for surgery and follow up were included in the study.

Patients not relieved with nasal obstruction after nasal surgery and history of smoking and pulmonary disease were excluded from the study.

A thorough ENT examination with appropriate investigations was done as required. A detailed nasal examination with diagnostic nasal endoscopy and CT-paranasal sinuses was done. Patients who are diagnosed with allergic nasal polyposis after thorough evaluation underwent spirometry pre-operatively one day before the surgery. Appropriate Surgery, functional endoscopic sinus surgery was performed under general anaesthesia. Post operative spirometry was done after 1month and 3months.

The method and procedure of the spirometry is explained to the patient and parameters forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) and FEV1/FVC were assessed.

3. STATISTICAL ANALYSIS

Data analysis was done with the help of Microsoft excel and JASP 0.18.3.0

Descriptive and inferential statistical methods were employed to evaluate changes in pulmonary function test (PFT) parameters between preoperative and postoperative periods.

Descriptive Statistics

Mean, standard deviation (SD), values were calculated for each parameter (FEV1, FVC, and FEV1/FVC ratio) at three time points: preoperatively, 1 month postoperatively, and 3 months postoperatively.

Inferential Statistics

Repeated measures ANOVA was applied to compare the parameters pre-operatively, post-operative 1 months and 3 months.

Paired t-tests were performed to assess the statistical significance of differences in PFT parameters:

1. Between Preoperative and Postoperative (1-month) values.
2. Between Preoperative and Postoperative (3-month) values.

3. Between Postoperative (1-month) and Postoperative (3-month) values.

A p-value < 0.05 was considered statistically significant.

Correlation between the parameters was calculated using Pearson's correlation. Linear regression was performed to predict Post-OP improvements based on Pre-OP values, age, sex.

4. RESULTS

The study consisted of 86 patients with nasal obstruction due to allergic nasal polyposis who fulfilled the inclusion criteria and undergone functional endoscopic sinus surgery.

86(100%) patients underwent functional endoscopic sinus surgery and pre-operative and post -operative pulmonary function tests done at 1 and 3 months after surgery.

The most common age group affected is around thirty years accounting more than 50%, with a mean age of 31.09 in that male patients are 65(75%) and females are 21(24%).

Table:1 Comparison of pre operative parameters with that in Postoperative 1 months and 3 months

PARAMETERS	Pre OP	Post OP 1 month	Post OP 3 month	P value
FEV1	2.63±0.57	2.76±0.66	2.83±0.68	<0.001
FVC	3.20±0.78	3.22±0.81	3.22±0.78	0.661
FEV1/FVC	83.28±10.68	86.54±9.94	88.54±8.89	<0.001

FEV1: Significant differences across the three time points ($p<0.001$).

FVC: No significant differences across the three time points ($p=0.661$).

FEV1/FVC: Significant differences across the three time points ($p<0.001$).

For Pre-OP FEV1, the mean value was 2.63 litres with a standard deviation of 0.57. Post OP 1-month FEV1 exhibited a mean of 2.76 litres, a standard deviation of 0.66. Post OP 3-month FEV1 exhibited a mean of 2.83 litres, a standard deviation of 0.68, with a significant p-value of less than 0.001, indicating a statistically significant difference compared to preoperative values. Similarly, for Pre-OP FVC, the mean was 3.20 litres with a standard deviation of 0.78, while Post OP 1-month FVC had a mean of 3.22 litres, a standard deviation of 0.81. Post OP 3-month FVC had a mean of 3.22 litres, a standard deviation of 0.78, with a non-significant p-value of 0.661. Additionally, the ratio of Pre-OP FEV1 to FVC had a mean of 83.28% with a standard deviation of 10.68, whereas the ratio of Post OP 1-month FEV1 to FVC exhibited a mean of 86.54%, a standard deviation of 9.94. The ratio of Post OP 3-month FEV1 to FVC exhibited a mean of 88.54%, a standard deviation of 8.89, with a significant p-value of less than 0.001. Pulmonary function between pre-operative and 1 and 3 month post-operative periods, indicating statistically significant improvements in FEV1 and FEV1/FVC parameters.

Table 2 : Comparison between pre and postoperative FEV1, FVC and FEV1/FVC at 1 month using paired t-test

Pre-OP and 1 month	N	MEAN	SD	p-value
Pre-OP FEV1	86	2.63	0.57	**< 0.001**
Post OP 1-month FEV1	86	2.76	0.66	
Pre-OP FVC	86	3.20	0.78	**0.48**
Post OP 1-month FVC	86	3.22	0.81	
Pre-OP FEV1/FVC	86	83.28	10.68	**< 0.001**
Post OP 1-month FEV1/FVC	86	86.54	9.94	

For Pre-OP FEV1, the mean value was 2.63 litres with a standard deviation of 0.57. Post OP 1-month FEV1 exhibited a mean of 2.76 litres, a standard deviation of 0.66, with a significant p-value of less than 0.001, indicating a statistically significant difference compared to preoperative values. Similarly, for Pre-OP FVC, the mean was 3.20 litres with a standard deviation of 0.78, while Post OP 1-month FVC had a mean of 3.22 litres, a standard deviation of 0.81, with a non-significant p-value of 0.48. Additionally, the ratio of Pre-OP FEV1 to FVC had a mean of 83.28% with a standard deviation of 10.68, whereas the ratio of Post OP 1-month FEV1 to FVC exhibited a mean of 86.54%, a standard deviation of 9.94, with a significant p-value of less than 0.001. Pulmonary function between pre-operative and 1-month post-operative periods, indicating statistically significant improvements in FEV1 and FEV1/FVC parameters

Table 3 : Comparison between pre and postoperative FEV1, FVC and FEV1/FVC at 3 months using paired t test

Pre-OP and 3 month	N	MEAN	SD	p-value
Pre-OP FEV1	86	2.63	0.57	**< 0.001**
Post OP 3-month FEV1	86	2.83	0.68	
Pre-OP FVC	86	3.20	0.78	**0.50**
Post OP 3-month FVC	86	3.22	0.78	
Pre-OP FEV1/FVC	86	83.28	10.68	**< 0.001**
Post OP 3-month FEV1/FVC	86	88.54	8.89	

Pre-OP FEV1 had a mean value of 2.63 litres with a standard deviation of 0.57. Post OP 3-month FEV1 exhibited a mean of 2.83 litres, a standard deviation of 0.68, with a significant p-value of less than 0.001, indicating a statistically significant improvement compared to pre-operative values. For Pre-OP FVC, the mean was 3.20 litres with a standard deviation of 0.78 , while Post OP 3-month FVC had a mean of 3.22 litres, a standard deviation of 0.78, with a non-significant p-value of 0.50. The ratio of Pre-OP FEV1 to FVC had a mean of 83.28% with a standard deviation of 10.68, whereas the ratio of Post OP 3-month FEV1 to FVC exhibited a mean of 88.54%, a standard deviation of 8.89, with a significant p-value of less than 0.001. Pulmonary function between pre-operative and 3-month post-operative periods, indicating statistically significant improvements in FEV1 and FEV1/FVC parameters.

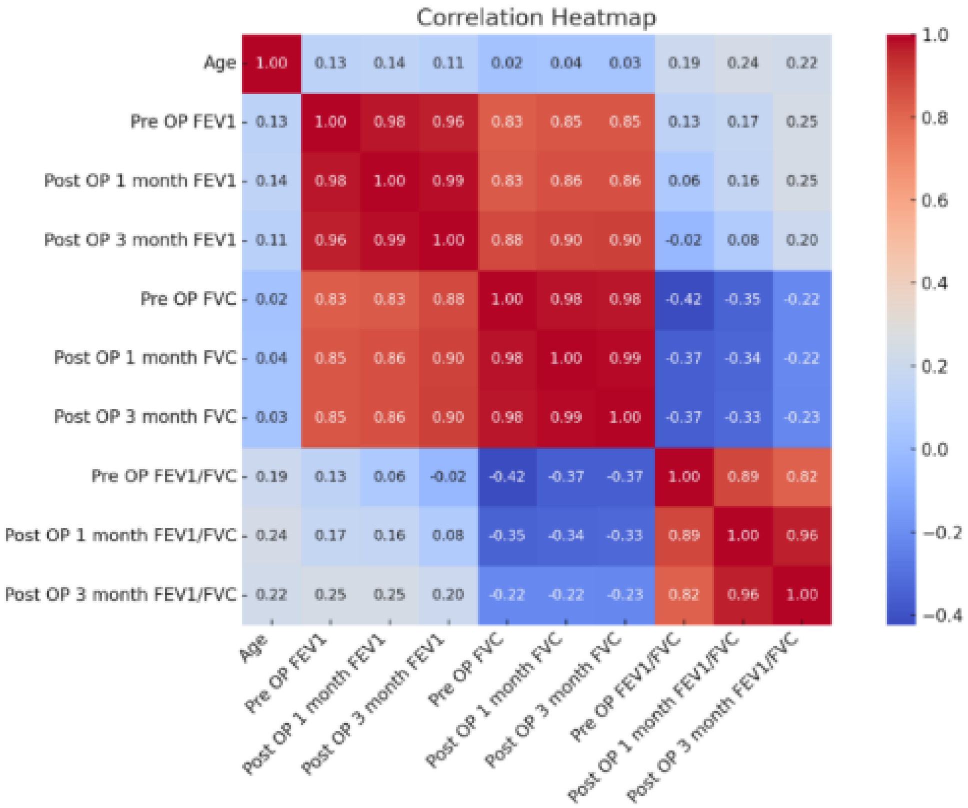
Table 4 : Comparison between postoperative 1 month and 3rd Month FEV1, FVC and FEV1/FVC using paired t test

MEASURE 1	MEASURE 2	t	df	P
Post OP 1-month FEV1	Post OP 3-month FEV1	-6.04	85	**< 0.001**
Post OP 1-month FVC	Post OP 3-month FVC	0.04	85	**0.97**
Post OP 1-month FEV1/FVC	Post OP 3-month FEV1/FVC	-6.64	85	**< 0.001**

Comparison between pre and postoperative FEV1, FVC, and the FEV1/FVC ratio at 3 months using paired t-tests. The measures are compared between the postoperative 1-month and 3-month time points. The paired t-test results indicate a statistically significant decrease in FEV1 (-6.04, $p < .001$) and FEV1/FVC ratio (-6.64, $p < .001$) from the 1-month to the 3-month postoperative period. However, there is no significant difference in FVC (0.04, $p = 0.97$) between these time points.

The heatmap provides a visual representation of the correlation between variables related to age, pre-operative, and post-operative pulmonary function test (PFT) parameters(fig1). Strong positive correlations are evident between related measures, such as pre-operative and post-operative FEV1 values ($r > 0.95$) and between FVC measures across different time points. This indicates consistent trends in lung function post-surgery. Conversely, weak correlations are observed between age and most PFT parameters, suggesting minimal age-related influence on lung function in this dataset. FEV1/FVC ratios show a modest inverse relationship with FVC, reflecting potential variations in airflow limitation.

Fig 1: Correlation Analysis



The linear regression analysis for predicting post-operative (Post-OP) FEV1 improvements based on Pre-OP FEV1, age, and sex revealed that Pre-OP FEV1 was the most significant predictor at both 1-month and 3-month intervals (fig 2 and 3). For FEV1 improvement at 1 month, the model explained 18.8% of the variance (R^2=0.188), with Pre-OP FEV1 showing a positive and significant association (p<0.001), indicating that higher Pre-OP FEV1 values are linked to greater improvements. However, age (p=0.443) and sex (p=0.909) did not significantly impact the outcomes. Similarly, for FEV1 improvement at 3 months, the model explained 15.5% of the variance (R^2=0.155), with Pre-OP FEV1 again emerging as a significant predictor (p<0.001). Age (p=0.773) and sex (p=0.551) remained non-significant. These findings highlight that Pre-OP FEV1 is the most consistent factor influencing post-operative improvement, while age and sex show no significant impact on the results.

Fig 2: FEV1 Improvement at 1 month vs Pre OP FEV1

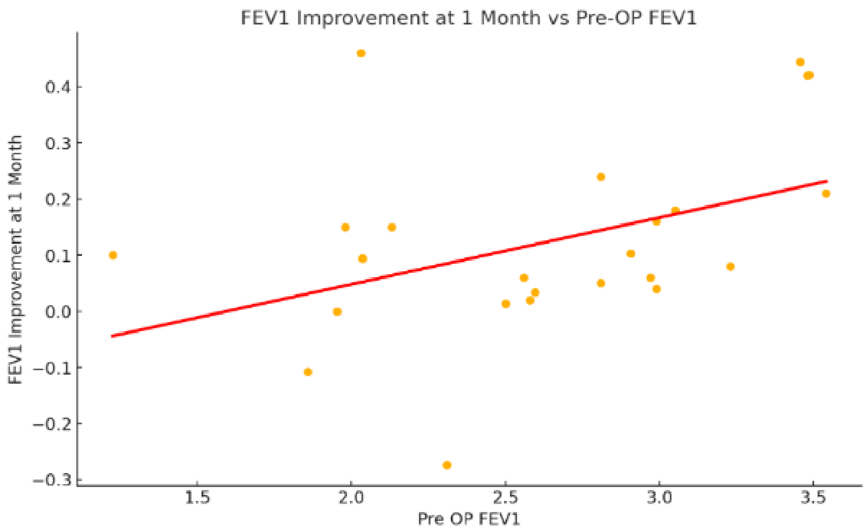
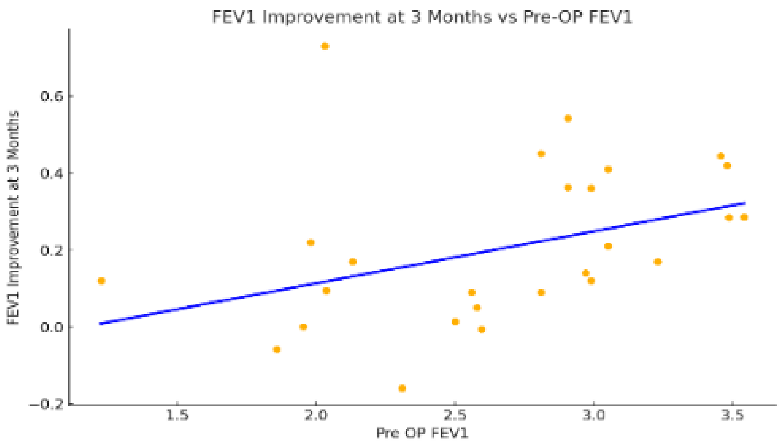


Fig 3: FEV1 Improvement at 3 month vs Pre OP FEV1



The extended regression analysis incorporating additional predictors, such as Pre-OP FVC and FEV1/FVC ratios, improved the explanatory power of the models for predicting post-operative FEV1 improvements. At 1 month, the model explained 36.9% of the variance ((R^2=0.369), with significant predictors including Pre-OP FEV1 (positive association, $p<0.001$), Pre-OP FVC (negative association, $p=0.001$), and Pre-OP FEV1/FVC (negative association, $p<0.001$). For 3-month improvements, the model explained 42.7% of the variance ((R^2=0.427), with Pre-OP FEV1/FVC showing a significant negative association ($p=0.045$). In both models, age and sex remained non-significant predictors. These findings highlight that Pre-OP lung function metrics, particularly FEV1/FVC and FVC, play an important role in predicting the magnitude of post-operative improvements.

5. DISCUSSION

The current study was a prospective study done to evaluate the effect of nasal obstruction on pulmonary function tests in patients with allergic nasal polyposis over a duration of 18 Months at the Department of ENT in Medical college Headquarters hospital. Due to the fact that the nose and lungs are both located in the same airway and have similar histological components, such as the basement membrane, lamina propria, ciliary epithelium and glands[4]. While the connection between these upper and lower airways has been emphasized before, there is limited understanding regarding the correlation between pulmonary function and the recurrence of nasal polyposis and sinusitis. The nose serves as the main pathway for respiration in humans and performs important activities such as moisturizing, heating, and purifying the inhaled air. Under typical circumstances, the nasal airway is responsible for at least 50% of the overall airway resistance. The majority of this resistance comes from the front region of the nose. However, in abnormal conditions, this resistance is further elevated. Nasal resistance varies between the two sides of the nose due to fluctuations in nasal mucosal changes in the nasal turbinate, following a cyclical pattern known as the nasal cycle.[5] This phenomenon is observed in around 80% of the adult population and it serves as a mechanism for respiratory protection. Oral breathing caused by nasal blockage can lead to alterations in respiratory mechanics and arterial blood gases. The presence of permanent unilateral nasal blockage might lead to a notable elevation in the overall airway resistance due to the nasal cycle.[6] This correction has the potential to enhance the physiological alterations in pulmonary function and arterial blood gases that are linked to nasal blockage.[7].

Distribution of patients across different age groups

In the 20-29 age group, there were 45 patients, constituting 52.33% of the total sample. Patients aged between 30 and 39 comprised 26 individuals, representing 30.23% of the total. Lastly, the age group of 40-45 years had 15 patients, accounting for 17.44% of the total sample size.

In a separate study conducted by Sobh et al. in 2021, a total of fifty-nine patients underwent surgery to treat the underlying cause of nasal obstruction. The study was conducted from March 2018 to February 2019. The average age of the individuals was 26.6 ± 10.1 years, with men accounting for 50.8% of the cases.[8]

Sex distribution

Among the study participants, 21 individuals were identified as female, representing 24.42% of the total sample. In contrast, there were 65 male participants, accounting for 75.58% of the total population. Most of of patients in our study were male, which aligns with a study conducted by Amer et al. that reported a 65% prevalence in males and 35% in females. Rao et al. also discovered comparable results, with a male to female ratio of 69% to 31%.[9]

Pre-operative pulmonary function test values of the study participants

For Pre-OP FEV1, the mean value was 2.63 liters with a standard deviation of 0.57, ranging from 1.23 to 3.54 liters. Pre-OP

FVC had a mean of 3.20 liters and a standard deviation of 0.78, varying between 1.83 and 4.62 liters. The Pre-OP FEV1/FVC ratio exhibited a mean of 83.28 with a standard deviation of 10.68, ranging from 61.12 to 96.46. In a separate study conducted by Tanaka et al. in 2014, it was found that 13% of patients with CRSwNP and 20% of CRSwNP patients with an increase in eosinophils in their peripheral blood showed obstructive lung dysfunction (defined as FEV1/FVC less than 70%).

Post-operative Pulmonary function tests values of the study participants

In the Post-operative 1-month pulmonary function tests values of the study participants, Mean Post OP 1-month FEV1 value was 2.76 liters, with a standard deviation of 0.66, ranging from 1.32 to 3.91 liters. Post OP 1-month FVC had a mean of 3.22 liters and a standard deviation of 0.81, varying between 1.84 and 4.63 liters. The Post OP 1-month FEV1/FVC ratio exhibited a mean of 86.54%, with a standard deviation of 9.94%, ranging from 61.12% to 97.40%.

In the Post-operative 3-month pulmonary function tests values of the study participants, Mean Post OP 3-month FEV1 value was 2.83 litres, with a standard deviation of 0.68, ranging from 1.34 to 3.90 litres. Post OP 3-month FVC had a mean of 3.22 litres and a standard deviation of 0.78, varying between 1.85 and 4.63 litres. The Post OP 3-month FEV1/FVC ratio exhibited a mean of 88.54%, with a standard deviation of 8.89%, ranging from 61.12% to 99.30%.

In a study conducted by Liu in 2015, it was found that the severity of sinusitis and nasal polyps in patients was directly associated with a decrease in pulmonary function ($r = 2.431$, $P < 0.05$). Additionally, the extent of sinusitis lesions in patients was also directly correlated with a reduction in pulmonary function ($r = 2.641$, $P < 0.05$). There was a correlation seen between the severity of patients with Rhinosinusitis and bronchial asthma, along with the pulmonary function of patients[10].

In a separate study conducted by Kariya et al. in 2014, it was discovered that individuals with chronic rhinosinusitis saw a notable impact on their pulmonary function. There was a strong correlation between the amount of interleukin-5 in nasal secretions and the pulmonary function of patients with chronic rhinosinusitis[11].

Rix et al conducted a systematic analysis and found that ESS (endoscopic sinus surgery) and medicinal therapies using systemic anti-inflammatory medicines were effective in improving nasal outcomes. However, the effectiveness of these interventions in regard to the lower airways is still uncertain[12]. Significantly, our patients experienced a notable enhancement in the FEV1/FVC value one month after the surgery, indicating that ESS effectively alleviated the asymptomatic blockage in the lower airway.[12]

Baharmand et al. (2023) conducted a systematic review and meta-analysis that yielded similar findings. The study observed statistically significant improvements in pulmonary function test (PFT) outcomes. The standard mean difference for FEV1 was 0.72 (95% CI 0.31–1.13), for FVC was 0.63 (95% CI 0.26–1.00), and for PEF was 0.64 (95% CI 0.47–0.82). The study indicates that nasal surgery for Deviated Nasal Septum leads to an improvement in pulmonary function[13].

6. CONCLUSION

Our study discovered the correlation between nasal surgery and enhancements in lung function among the patients with allergic nasal polyposis. Significant improvements were observed in the PFT, FEV1, FVC, PEF, FEF 25-75% irrespective of age, gender, or the duration of nasal obstruction.

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