Impact of Functional Endoscopic Sinus Surgery on the Pulmonary Function of Patients with Chronic Rhinosinusitis: A Prospective Study

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Abstract The study was conducted between September 2007 and March 2009 at Maulana Azad Medical College to compare the pulmonary function of patients with chronic rhinosinusitis presurgically and postsurgically. Thirty patients between 18 and 55 years of age with no prior history of respiratory illness were selected and pulmonary function test was conducted pre and post surgically. There was a significant difference between the pre and postoperative FEV₁ and FEV₁/FVC with the reading taken at 1 and 3 months post-surgically. The improvement in the PFT values signifies a decrease in the bronchial hyperresponsiveness as compared to the pre-operative condition.

Keywords Pulmonary function · Chronic rhinosinusitis · Endoscopic sinus surgery

Introduction

Coexistence of upper and lower respiratory diseases is common. Asthma and sinusitis are both recognized in ancient literature. The nasal airways and their closely associated paranasal sinuses are an integral part of the respiratory tract. In the second century, Claudius Galenus, one of the fathers of modern respiratory physiology, defined the nose as a respiratory instrument in his work “De usu partium” [1–5]. With the introduction of CT scanning in the 1970s, accurately pinpointing the location and extent of the sinus pathology became possible. Though initially in disrepute, a return to corrective surgery for individuals with sinusitis with and without asthma has occurred, thanks to the studies of Rachelefsky [6], Spector [7], and many others showing the benefits of clearing sinus pathology. In the 1980s, functional endoscopic sinus surgery (FESS) and the ability to physiologically improve sinus function became available. Further aids to treatment have included newer antibiotics and an emphasis on cilia function. Newer medications, such as the corticosteroids sprays, have given new directions for treatment. Many allergists now emphasize the role of these drugs in treating sinusitis.

Both the upper and lower respiratory tracts are continually exposed to gases and airborne particles. The importance of host defence mechanisms is vital. Physical barriers, mucociliary clearance systems and cellular or humoral immune processes combine to protect the lung from damage. Where abnormalities of these mechanisms occur, the patient may first present to the otolaryngologist before serious bronchopulmonary involvement occurs. Mucociliary clearance is the predominant clearance mechanism for both upper and lower airways. The two component of mucociliary clearance are the cilia and the

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secretions above them. The cilia beat in a coordinated fashion with a ciliary beat frequency of 12–14 beats per second. Two layers of mucus are present over the ciliated cell; an outer thick, viscoelastic, semisolid mucus layer, which the cilia do not directly strike, and an inner layer of watery serous fluid. Because of the low viscosity of the layer of watery serous fluid, the cilia can beat normally and move the watery lower layer, affecting movement of the upper thick layer. Changes in these properties affect movement of the mucus blanket and play a major role in pulmonary and sinus disease. In the upper respiratory tract, cilia propel mucus, bacteria, and the particles trapped in mucus to the nasopharynx, where the mucus drops to the hypopharynx and is swallowed. In the lower respiratory tract, the cilia that line the trachea and bronchial tree similarly move the mucus blanket up the trachea and into the hypopharynx for swallowing [8].

A close association has been suggested between sinusitis and lower respiratory disorders like bronchial asthma. It is well known that chronic sinusitis coexists in as many as 40–75 % of patients with asthma. Study done by Shaaban et al. [9], had shown that allergic rhinitis was associated with increased onset of bronchial hyperresponsiveness, and less chance for remission except in those treated for rhinitis. Treatment options for chronic rhinosinusitis (CRS) include medical therapy, surgical intervention, or a combination of both. According to current guidelines, the surgical approach is reserved for patients who fail to respond adequately to medical therapy. The most frequently used surgical technique is endoscopic sinus surgery (ESS). The objective of this study is to assess the extent of improvement of chronic sinusitis following surgical treatment in the form of ESS and also if it can bring about a significant improvement in the pulmonary function tests of patients.

Materials and Methods

The study was conducted in the Departments of Otorhinolaryngology and Head and Neck Surgery, Maulana Azad Medical College and associated Hospitals, New Delhi between September 2007 and March 2009.

Study Design

A prospective study.

Subjects

The study was conducted on 30 adult patients who fulfill the clinical criteria for CRS according to the CRS criteria. The patients belonged to the age group 18–55 years age group.

Inclusion Criteria

Subjective symptoms and findings of CRS were based on the CRS criteria [6] and were divided into major and minor factors. In consultation with other medical disciplines, the American Academy of Otolaryngology and Head and Neck Surgery established baseline parameters in 1996 for discerning the subtypes of rhinosinusitis (acute, recurrent acute, subacute and chronic). These parameters have since become widely adopted by researchers and by health maintenance organizations [10, 11]. A CRS diagnosis requires presence of at least 2 major factors or one major factor with 2 or more minor factors, or nasal purulence on examination. Facial pain is not considered to be a symptom of CRS without other nasal signs and symptoms. The signs and symptoms must persist for at least 12 weeks to qualify as CRS.

Major factors	Minor factors
Facial pain/pressure	Headache
Facial congestion/fullness	Fever
Nasal obstruction/blockage	Halitosis
Nasal discharge/purulence/discoloured	Fatigue
Postnasal discharge	Dental pain
Hyposmia/Anosmia	Cough
Purulence in the nasal cavity	Ear pain/pressure/fullness

CT Assessment

Lund–McKay CT scoring system [12] separately assesses the extent opacification of the individual sinuses and osteomeatal complex and a score of 2, 1 or 0 is respectively allotted based on if there is complete, partial or no opacification.

During the study, NCCT scans of paranasal sinuses were done and assessed on the basis of Lund and Mackay criteria for each sinus with a maximum score of 24.

Exclusion Criteria

- Pregnant women
- Coexistent systemic diseases like diabetes, hypertension, neoplasia.
- Patients with known psychiatric illness.
- Prior paranasal sinus, nose or throat surgery.

Pulmonary Function Tests

PFT was assessed using Spirometer (RMS Helios501) 1 week prior to surgery.

In a Normal case, FVC and FEV₁ should be greater than or equal to 80 % of predicted, and the FEV₁ to FVC ratio should be no more than 8–9 absolute percentage points below the predicted ratio. The PFT values were considered to indicate significant airway obstruction when FEV₁/FVC < 0.7 and FEV₁ < 80 % of the predicted value for a patient's age, height and weight [13].

Procedure

1. The purpose and method of the test was explained to the patient (correct posture with head slightly elevated). The test involved maximal rapid inspiration, followed by forced exhalation of air through the mouthpiece sealed by mouth. It was useful to demonstrate the correct technique to the patient and ask the patient to undertake practice attempts beforehand.
2. Preparation of the patient (patient was asked about smoking, recent illness, medication use and weight, height and age were recorded).
3. A clean, disposable mouthpiece was attached to the spirometer (a fresh one for each patient).
4. After ensuring that the patient was comfortable, in particular that they were seated (in case they experience any faintness during the procedure). A clean nose clip was attached, a mouthpiece was placed in the mouth and patient was advised to close lips around this. The patient was asked to inhale completely and rapidly with a pause of no longer than 1 s at full inspiration and then to exhale maximally until no more air can be expelled while maintaining an upright posture.
 - The patient was encouraged to keep blowing out. It was ensured that patient had exhaled for at least 6 s; the blow should continue until a volume plateau was reached.
 - The flow volume curve was assessed for evidence of poor effort and hesitation.
 - The procedure was repeated until three readings of which at least two of the FVC and FEV₁ components were reproducible, i.e., within 0.15 L of each other. Ideally, the expiratory volume-time graph should be smooth and free from irregularities [13].

Surgical Plan

A written and informed consent was obtained from the patients before FESS (by Messerklinger technique) and the patients were provided with a patient information sheet which includes the details of the disease, the procedure, the

risks of the procedure and possible outcomes. The CT score based on the Lund and Mackay classification was calculated. PFT was conducted.

ESS was performed under local or general anaesthesia by the Messerklinger technique. Local anaesthesia was infiltrated by injection of 2 % Lignocaine into the uncinate process, greater palatine foramen and middle turbinate. In anxious patients who were unlikely to allow the surgery under local anaesthesia, general anaesthesia was used. Zero degree 4 mm and 5 mm Hopkins rod telescope were used in the surgery as it is easy to become disoriented with angled endoscopes though the latter are necessary for inspecting recesses and performing middle meatal antrostomy or operating the frontonasal recess. An infundibulotomy was performed by incising the anterior attachment of the uncinate process. Then the ethmoidal bulla was opened and removed piecemeal. Behind the bulla, one enters a variable space, the lateral sinus, while superiorly, the skull base will be visible and the anterior ethmoidal artery can be identified. In many cases this may be all that is required and the decision to open the maxillary antrum, explore the frontal recess, the posterior ethmoids and the sphenoid will depend on the extent of the disease as evidenced by the CT scan and operative findings. In some cases middle meatal antrostomy was not necessary as the natural ostium was patent when uncovered by removal of the uncinate process. In cases where there was an accessory ostium present, it was joined to the natural ostium to avoid abnormal circulation of the mucus.

The patient was kept in the hospital overnight and discharged in the morning. Small temporary Merocel pack or antibiotic soaked gauze pack was placed in the surgical cavity. A significant component of the success of the endoscopic surgery was meticulous postoperative cleaning of the surgical cavity.

Follow Up

Packs were removed after the 48 h and patients were put on Antibiotics for 5–10 days depending on the severity of the disease. Postoperative prophylactic broad spectrum antibiotics were prescribed for 1–2 weeks along with alkaline nasal douche and an intranasal steroid spray. Patients were called for review 7–10 days following surgery and then as often as necessary [9]. Patients were reassessed after a period of 1 and 3 months based on the subjective criteria (CRS criteria) and PFT.

Statistical Analysis

For the quantitative data, to see the significance between the means paired *t* test was used.

Table 1 Age wise distribution of cases

Age (years)	Frequency	Percent
≤20	6	20.0
21–30	4	13.3
31–40	14	46.7
>40	6	20.0
Total	30	100.0

Table 2 Distribution of patients according to sex

	Frequency	Percent
Male	17	56.7
Female	13	43.3
Total	30	100.0

Table 3 Age wise distribution of males and females

	≤20	21–30	31–40	>40
Male				
Count	4	3	8	2
%	23.5	17.6	47.1	11.8
Female				
Count	2	1	6	4
%	15.4	7.7	46.2	30.8
Total				
Count	6	4	14	6
%	20	13.3	46.7	20

Observations

The study consisted of 30 patients suffering from CRS who had undergone FESS. Preoperative and postoperative PFT values were measured at 1 and 3 months postoperatively and the results analysed.

Age Distribution of Cases

The age of patients involved in the study ranged from 18 to 55 years with a mean of 33.20 ± 20.38 years. The maximum number of patients (14) were in the age group 31–40 years representing 46.7 % of the total. The age distribution is depicted in Table 1.

Distribution of Patients According to Sex

Out of the 30 patients, males constituted the majority, accounting for 56.7 % of total study group. Thus, the male to female ratio is 1.3:1. The data is represented in Tables 2 and 3.

Table 4 Demography of study group

	Age (years)	Weight (kg)	Height (cm)	BMI (kg/m ²)
Minimum	18	44	149	17.63
Maximum	55	80	182	31.16
Mean	33.20	61.97	161.93	23.5796
Std. deviation	10.189	10.659	8.702	3.35820
Median	34.00	61.00	160.00	23.3863
Std. error of mean	1.860	1.946	1.589	0.61312

Table 5 Ct findings (modified lund classification)

	Frequency	Percent
0–4	0	0
5–8	12	40.0
9–12	12	40.0
13–16	3	10.0

Demographic Profile of Patients

The weight of the patients in the study group ranged from 44 kg to 80 kg with a mean of 61.97 ± 21.3 kg. The height of the patients in the study group ranged from 149 cm to 182 cm with a mean of 161.93 ± 17.4 . The mean BMI of the patients was 23.58 ± 6.8 kg/m². The data is represented in Table 4.

CT Findings

Scoring of the CT findings as per the Lund and Mackey classification revealed that the maximum number of cases had the score of 5–8 (40 % cases) and 9–12 (40 % cases). Details of the distribution of scores is given in Table 5.

Preoperative PFT Values

The preoperative FEV1 values ranged from 1.19 (68.01 % of predicted) to 4.33 (117.97 % of predicted) with a mean of 2.83 ± 1.54 . The standard error of mean is 0.14. FVC values varied from 2.07 (69.73 % of predicted) to 4.98 (119.78 % of predicted). The standard error of mean was 0.16. The mean FEV1/FVC was 0.86 with no values below 0.7. The above data is represented in Table 6.

Postoperative PFT Values at 1 Month

The FEV1 values at 1 month ranged from 1.28 (73.99 % of predicted) to 4.34 (119.57 % of predicted) with a mean of 2.87 ± 1.42 . The standard error of mean is 0.14. FVC

values varied from 1.52 (69.72 % of predicted) to 4.91 (114.53 % of predicted). The standard error of mean was 0.16. The mean FEV1/FVC was 0.86 with no values below 0.7. The above data is represented in Table 7.

Postoperative PFT Values at 3 Months

The FEV1 values at 3 months ranged from 1.22 (70.52 % of predicted) to 4.45 (120 % of predicted) with a mean of 2.95 ± 1.55 . The standard error of mean is 0.14. FVC values varied from 1.49 (68.35 % of predicted) to 4.87 (115.7 % of predicted). The standard error of mean was 0.16. The mean FEV1/FVC was 0.87 with no values below 0.7. The above data is represented in Table 8.

Table 6 Preoperative Pft values

	FEV1	FEV1 %*	FVC	FVC %*	FEV1/ FVC
Minimum	1.19	68.01	2.07	69.73	0.84
Maximum	4.33	117.97	4.98	119.78	1.11
Mean	2.8267	89.9026	3.3597	92.0586	0.8584
Std. deviation	0.7702	11.1	0.8764	10.2548	0.10005
Median	2.83	89.3464	3.24	91.7644	0.82962
Std. error of mean	0.1406	2.0265	0.16	1.87227	0.018267

* Percentage of predicted

Table 7 1 month post operative pft values

	FEV1	FEV1 %*	FVC	FVC %*	FEV1/ FVC
Minimum	1.28	73.99	1.52	69.72	0.72
Maximum	4.34	119.57	4.91	114.53	1.13
Mean	2.8680	87.7989	3.3367	91.0167	0.8639
Std. deviation	0.74425	18.87860	0.90133	9.80064	0.08932
Median	2.8000	89.6913	3.2650	91.6701	0.8463
Std. error of mean	0.13588	3.44674	0.16456	1.78934	0.01631

* Percentage of predicted

Table 8 3 month post operative pft values

	FEV1	FEV1 %*	FVC	FVC %*	FEV1/FVC
Minimum	1.22	70.52	1.49	68.35	0.66
Maximum	4.45	120	4.87	115.70	1.15
Mean	2.9490	92.8095	3.3820	92.5188	0.8722
Std. deviation	0.7752	10.0027	0.85863	9.88398	0.09062
Median	2.985	93.847	3.3600	92.2299	0.8578
Std. error of mean	0.1415	1.8262	0.15676	1.80456	0.01654

Comparison Between Pre and Postoperative FEV1 Values

The mean difference in FEV1 values at 1 month post operative and preoperative was 0.0413. The mean difference in FEV1 values at 3 and 1 month post operative was 0.081. The mean difference in FEV1 values at 3 month post operative and preoperative was 0.02113. The difference was found to be statistically significant in all the three cases using 2 tailed *t* test (*p* value <0.05). The above data is represented in Table 9.

Comparison Between Pre and Postoperative FEV1/FVC Values

The mean difference in FEV1/FVC values at 1 month post operative and preoperative was 0.024. The mean difference in FEV1/FVC values at 3 and 1 month post operative was 0.008. The mean difference in FEV1/FVC values at 3 month post operative and preoperative was 0.032. The difference was found to be statistically significant only in the third group using 2 tailed *t* test (*p* value < 0.05). The above data is represented in Table 10.

Discussion

Sinusitis has a self-reported incidence of 135 per 1,000 of the population per year and was the principle reason for almost 12 million physician office visits during 1995 [14–17]. Sinusitis significantly impacts quality of life measures (e.g., the Medical Outcomes Study SF-36) with decrements in general health perception, vitality and social functioning comparable with that observed in patients who have angina or chronic obstructive pulmonary disease [14]. Sinusitis is one of the main reasons for which an antibiotic is prescribed and for lost productivity in the work force [18].

The present work was undertaken in the Department of Otorhinolaryngology & Head and Neck surgery, Maulana Azad Medical College to study the impact of FESS on the pulmonary function of 30 patients suffering from CRS. The

Table 9 Comparison between pre and post operative FEV1 (% of predicted) values

	Paired differences				T value	df*	2 tailed <i>t</i> test (p value)
	Mean	Std. error of difference	95 % confidence interval of the difference				
			Lower	Upper			
(FEV1 1 month) versus (FEV1 pre-surgical)	0.0413	0.019	0.0029	0.0798	2.1970	29	0.0362
(FEV1 3 month) versus (FEV1 1 month)	0.0810	0.026	0.0281	0.1339	3.1321526	29	0.0039
(FEV1 3 month) versus (FEV1 presurgical)	0.01223	0.018	0.0849	0.1597	6.6920	29	0.0001

* Degree of freedom

Table 10 Comparison between pre and post operative FEV1/FVC values

	Paired differences				<i>t</i>	df*	2 tailed <i>t</i> test (p value)
	Mean	Std. error of difference	95 % confidence interval of the difference				
			Lower	Upper			
(FEV1/FVC 1 month) versus (FEV1/FVC presurgical)	0.02365	0.012	−0.00019	0.0475	2.0288	29	0.0516
(FEV1/FVC 1 month) versus (FEV1/FVC 3 month)	0.008327	0.013	−0.01922	0.03587	0.6182	29	0.5412
(FEV1/FVC 3 month) versus (FEV1/FVC Presurgical)	0.03198	0.012	0.0078	0.0561	2.7100	29	0.0112

* Degree of freedom

clinical and laboratory data from the study cases were recorded as per the proforma. The study included patients of varied age groups, of varied socio-economic status, of both sexes. The results were then compared with available literature.

Age Distribution

The commonest age group affected in this study belonged to the age group 31–40 years (46.7 %). The age ranged from 18 to 55 years with the mean age of 33.2 ± 20.38 years. In a study carried out by Chaudhary et al., age ranged from 14 to 66 years [19]. Similarly Winsted et al. also found the mean age to be 34 years [20]. In a 5-year study of 63 nasal polyposis patients was conducted by Ogunleye et al. the mean age was 34 years [21].

Sex Distribution

This study showed that males (56.7 %) are more commonly affected as compared to the females (43.3 %). Many studies have found a male preponderance [14, 15]. In a 5-year study of 63 nasal polyposis patients was conducted by Ogunleye et al. the male:female ratio was 1.6: 1 [21].

CT Findings

According to modified Lund scoring system, in the present study, 12 (40 %) cases had the score in the range of 5–8. Similar findings were noted by Bhattacharya et al. [22]. Whereas, in a study conducted by Wang et al., 118 (51.3 %) cases had the score in the range of 0–4 [23]. These findings suggest that majority of the patients have presented to the hospital at a relatively early stage of the disease. The commonest sinus involved in the present study was the maxillary sinus, seen in all cases (100 %). In a study conducted by Ogunleye et al. also, the commonest sinus involved was maxillary (43.33 %) [21].

Pulmonary Function Tests

In the present study, it was noted that there was increase mean postoperative FEV1 percentage (3 months—92.8 %) from the preoperative value (89.9 %). The difference between the FEV1 values measured at

1. 1 month and pre-surgical value
2. 3 and 1 month values
3. 3 month and presurgical value

were all found to be significant by the 2 tailed *t* test ($p < 0.05$). There was also an increase in the FVC percentage from the mean preoperative value (92.06 %) to the

3 month (92.51 %). The difference in the measured FEV at different periods (preoperative, 1 and 3 months) were found to be non-significant. The mean difference in FEV1/FVC values at 1 month post operative and preoperative was 0.024. The mean difference in FEV1/FVC values at 3 and 1 month post operative was 0.008. The mean difference in FEV1/FVC values at 3 month post operative and preoperative was 0.032. The difference in the FEV1/FVC ratio was found to be statistically significant only between 3 month post operative and preoperative period using 2 tailed *t* test (*p* value < 0.05). This improvement can be attributed mainly to the surgery with steroid sprays and antibiotics also playing a role. The absence of a significant difference between the preoperative and 1 month values may be due to postoperative inflammation. In a study done by Ragab et al. [24], it was found that the 6- and 12-month post operative FEV₁ percent (% of predicted) showed significant increase. In a similar study conducted by Nakamura et al. [25] on the effects of sinus surgery on asthma in aspirin triad patients, an important correlation was found between the preoperative and postoperative FEV1 scores and asthma severity. In another study by Goldstein et al. [26], there was no statistically significant change in group mean asthma symptom scores, asthma medication use scores, pulmonary function test results, and the number of emergency department visits or hospital admissions following FESS. Only a few patients demonstrated statistically significant improvement after FESS in asthma symptom scores (1 patient), medication use scores (1 patient), or pulmonary function test results (2 patients). In another study by Ikeda et al. [8] which evaluated the clinical efficacy of endonasal ESS in patients with asthma associated with chronic sinusitis, the average peak expiratory flow 6 months following surgery improved in the ESS patients significantly (*p* < 0.05). In a similar study conducted on asthmatic patients by Dhong et al. there was no significant change in pulmonary function [27]. Batra et al. found significant improvement in post operative FEV1 and a reduction in systemic steroid usage in a study conducted on asthmatic patients with nasal polyps [18].

Conclusions

The cases included in the present study cases comprised of 30 patients who fulfilled the CRS criteria. The pre-operative PFTs were compared with the post-operative values. The following conclusions can be drawn from the present study.

- CRS affected persons of young age with maximum number of patients in their fourth decade.
- CRS of this region showed a male predominance with a male:female ratio of 1.3:1.

- Pre-operatively seven of the patients had abnormal FEV1 values and this improved in five of them by the third month. There was a significant improvement in the mean FEV1 values post-surgically (*p* < 0.05).
- Out of the four patients who had abnormal FVC values pre-operatively only one showed improvement. There was no significant improvement in the mean FVC values post-operatively.
- The FEV1/FVC values were initially abnormal in two of the patients and this improved in one. It was observed that there was a significant improvement in the FEV1/FVC ratio (*p* < 0.05) post-operatively in the third month.
- The improvement in the PFT values signifies a decrease in the bronchial hyperresponsiveness as compared to the pre-operative condition. It is to be noted that there is no significant improvement in the FEV1/FVC value 1 month post-operatively. This may be due to post-operative inflammation and crusting. FESS along with the post-operative use of antibiotics and local steroid sprays may have led to a significant improvement in the same at 3 months.

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