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Original Research Article

# Olfactory Outcomes after Functional Endoscopic Sinus Surgery for Chronic Rhinosinusitis with Polyps

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**Abstract:**

**Background:** Chronic rhinosinusitis (CRS) is regarded as a multi factorial disease that causes different symptoms such as nasal obstruction, headache, nasal discharge and olfactory dysfunction due to inflammation of the nasal and sinonasal mucosa. It is a common health problem and has several effects on quality of life, along with high treatment costs. Nasal polyps are frequently associated with loss of smell which is a common symptom affecting 61-83% of patients of CRS with nasal polyps (CRSwNP). The ability to monitor our environment depends to a large degree on our sense of smell. The aim of the study was to evaluate olfaction in patients of CRSwNP and how functional endoscopic sinus surgery (FESS) modified olfaction in patients.

**Materials and Methods:** In our study, in 40 patients of CRSwNP, olfactory dysfunction was assessed before and after FESS. Subjective assessment of disease was done using visual analog scale of SNOT-22 questionnaire. Olfaction was tested using odor identification test and threshold tests and objective assessment of disease was done using endoscopic grading according to Lund and Kennedy endoscopic scoring. NCCT scores were also obtained using Lund and Mackay staging system. All patients underwent FESS. Symptom scores, endoscopy scores and olfaction were compared in patients before and after surgery by statistical analysis.

**Results:** Only 27 out of 40, i.e (67.5%) patients had complaints of olfactory dysfunction. 92.59% patients had improvement in olfaction post-surgery. There was a significant improvement in olfaction after surgery shown by olfactory scores assessment before and after surgery. Surgery had a positive outcome in improvement of the mental health of patients suffering from CRSwNP. 100% of the patients had improvement of SNOT-22 scores and hence a significant reduction of symptoms. Maxillary sinus was found to have the highest incidence of involvement (95%) as per CT assessment. Improvement in endoscopic scores was seen best at 1 month post op, and recurrence of polyps was seen in 8 patients at the end of 3 months.

**Conclusion:** Our study was able to establish a significant correlation between olfaction and parameters of disease severity like SNOT-22, endoscopic score and CT scores. We concluded that FESS has a positive outcome in terms of improvement of olfactory dysfunction in patients of CRSwNP.

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## Introduction

Chronic rhinosinusitis (CRS) is regarded as a multi factorial disease that causes different symptoms such as nasal obstruction, headache, nasal discharge and olfactory dysfunction. It is a prolonged inflammatory process, which may be triggered by infectious agents such as fungus and super antigens. It is a common health problem and has several effects on quality of life, along with high treatment costs.[1] The disease represents a persistent inflammation of sino-nasal mucosa that is believed to be the endpoint of different pathophysiologic pathways [2]. CRS is classified into CRS with polyps (CRSwNP) and CRS without polyps (CRSsNP).

Nasal polyps are known to be frequently accompanied by olfactory disturbances. Blocked transport of the odor molecules to the olfactory epithelium due to mechanical obstruction of the olfactory cleft by polyps as well as change in composition and function of the olfactory mucus due to hypersecretion and dysfunction of the olfactory receptor cells due to chronic inflammatory changes are thought to be the pathogenesis of olfactory impairment [2]. Other causes can be viral infections and traumatic injuries.

Symptoms related to nasal polyps are mainly nasal obstruction and loss of smell, both having a severe impact on the quality of life of affected patients.[3]

Loss of smell is a common symptom affecting 61-83% of patients with chronic rhinosinusitis (CRS). Additionally, it is one of only four signs and symptoms included in the diagnostic criteria for CRS published in the new AAO-HNS Academy guidelines, other symptoms being mucopurulent drainage, nasal obstruction (congestion) and facial pain – pressure – fullness.[4]

Polyps are soft benign growths filled with inflammatory cells and fluid that may grow large enough to block nasal passages, interfere with breathing, block sense of smell and taste, and lead to frequent infections.

Quality of life is negatively correlated with olfactory dysfunction.[5] Loss of olfactory function affects the patient's appreciation of food and drink; it has impact on safety (e.g., detection of spoiled foods and gas leak); and it may also produce bodily insecurity. However, the loss of olfaction can be particularly insidious and escape detection because, unlike loss of sight or hearing, it is not apparent to others.[6]

Smell dysfunction is of considerable significance to those whose livelihood depends on its normal functioning as well as to the average individual. Many individuals decrease their food intake and lose weight because of the loss of flavor secondary to smell loss, becoming in some cases depressed as a result of lack of enjoyment of eating.[7] Loss of smell can result in significant psychological disruption and even generate feelings of physical and social vulnerability and victimization.

Routine clinical quantitative and qualitative measurement of smell function can now be easily performed in the office setting.[8] Currently, functional endoscopic sinus surgery (FESS) is the main surgical option in patients with CRS not responding to medical management.[9]

The aim of the study was to evaluate olfaction in patients of chronic rhinosinusitis with nasal polyps and how functional endoscopic sinus surgery modified olfaction in patients.

## Materials and Methods

The prospective study was conducted over 1.5 years at the Department of Otorhinolaryngology and Head and neck Surgery at our institute, with the approval of the institute's ethical committee and in accordance with the principles of the Helsinki Declaration. We aimed to study the effectiveness of FESS in improving the olfactory function in 40 patients of CRSwNP. Olfactory functions in all patients before surgery and after undergoing FESS were assessed and compared. Also, correlation of olfactory function with parameters of disease severity like Sino-Nasal Outcome Test-22 (SNOT-22) score, endoscopic score and CT score was done.

CRSwNP cases clinically diagnosed in adult age group (18-60) according to the American Academy of Otolaryngology-Head and Neck Surgery definitions, patients with persistent chronic rhinosinusitis symptoms for more than 12 weeks after medical management (topical fluticasone spray for 4-6 weeks and oral antihistamines) and

patients who are not taking steroid or antibiotic medications in the week preceding surgery, were included in the study. CRS cases with bronchial asthma, pregnant patients, immunocompromised patients, smokers, patients with impairment in muco-ciliary function diagnosed clinically (e.g. cystic fibrosis, Kartagener syndrome), and those with secondary causes of CRS, significant DNS, sino-nasal malignancies, post radiotherapy to head and neck, prior nasal surgery and sino-nasal trauma, were excluded from the study.

All patients were subjected to detailed history taking using Visual Analogue Scale (VAS) of SNOT-22 questionnaire, routine otorhinolaryngological examination including anterior rhinoscopy and posterior rhinoscopy, diagnostic nasal endoscopy (DNE), non-contrast computed tomographic (NCCT) scan of nose and paranasal sinuses-axial coronal and sagittal views and olfactory tests comprising of Threshold test and Odor identification test.

**Olfactory Test Methodology:** The test used by us was a modification of Connecticut Chemosensory Clinical Research Center (CCCRC) test and combined olfactory test (COT) test and therefore the test comprised of two components mainly:

**Threshold Testing:** The threshold test employed 1-butanol as the test odorant. 1-butanol is commonly used in odor experiments as it is low in toxicity, colorless, water soluble, readily available in high purity and has a neutral odor quality. It has obtained wide acceptance as a reference odorant in various applied settings because of these same attributes.[10] The test kit contains nine glass bottles each containing 50ml of test solution which were labelled as, solutions one to nine and another identical glass bottle filled with 50ml of sterile water**.** The 1-butanol solution was diluted by successive factors of three; the highest concentration being 4% (vapour phase of approximately 3,000ppm), designated as solution one while lowest concentration being 0.00061%, designated as solution nine.[11] Participants received two bottles at a time, one with sterile water and one with odorant (solutions one to nine) **(Figure-1).** The test began with the weakest solution in an ascending order of concentration to avoid neural adaptation. The patients had to identify the bottle containing odorant on four successive occasions. The lowest concentration of odorant that the patient had identified was defined as the threshold. Scores of

one to nine were given depending on the lowest concentration of solution successfully identified. Zero is scored if solution one is not identified.[11] After determination of the threshold in one nostril, testing was done for the other nostril in the similar manner. **(Figure-2)**

**Odor Identification Testing**

The odorants which were used in the CCCRC and COT odor identification tests were modified for the study according to our local dietary and cultural habits. The substances were kept in bottles and the patient's eyes were covered when the substances were presented to them. To perform the test, the cap was removed by the examiner for approximately 3 seconds, and the tip of the bottle was placed approximately 2 cm in front of the nostril and patient was asked to sniff normally without any force. There was an interval of 30 seconds between successive presentations to prevent olfactory desensitization.[12] Patients were asked to choose from a list of four choices for each substance presented. Ten items were presented in random order for monorhinic smelling.[10] To restrict the stimulus to one nostril, the participant was asked to hold the irrelevant nostril closed**.** The total odor identification score was calculated by adding the number of substances correctly identified. The sum of the odor threshold test and the odor identification test score was taken up as the combined olfactory score for the nostril being tested.[13]

Both the tests were done in a well-ventilated and quiet room. The approximate amount of time spent on the whole test was 8-10mins for each patient.

Substances used for odor identification were asafoetida, garlic, rose water, cardamom, clove oil, lemon, coffee, mint, camphor and cumin seeds. (Figure-3)

Preoperatively DNE was done for each patient and scored according to Lund and Kennedy. NCCT scan findings were graded using Lund and Mackay CT scoring system.[14] Staging by CT included anterior ethmoid, posterior ethmoid, frontal, maxillary and sphenoid sinus, plus the osteomeatal complex.

All the patients underwent functional endoscopic sinus surgery to clear blockage and patency of the osteomeatal complex was ensured during surgery.

Postoperative evaluation included data regarding outcome measures using SNOT-22 postoperatively after 2 weeks, after 1 month and after 3 months and postoperative nasal endoscopy in the follow-up period after 2 weeks, after 1 month and after 3 months.

**Statistical Analysis:** Statistical Package for Social Sciences (SPSS) version 23.0 was used to analyse the data. Data was presented in mean, SD, median and in percentage. Friedman test was used to compare pre-operative and post-operative SNOT-22 scores. Wilcoxon signed rank test was used to compare the endoscopic scores. Spearman's Rank correlation coefficient was used to correlate olfactory function with parameters of disease severity like SNOT-22 score, CT grading and endoscopy grading. P value <0.05 was considered significant.

**Results**

The median age at the time of presentation in CRSwNP patients was 29 years with range of 18 – 60 years. The study included 29 males and 11 females with male to female ratio of 2.6:1. Fifteen patients had unilateral disease, and 25 patients had bilateral disease.

In SNOT-22 questionnaire, 22 symptoms were assessed and each symptom was scored based on its severity. The score ranges from 0 to 110. The pre and postoperative scores are depicted in table 1.

Nasal obstruction was the most common complaint followed by need to blow nose. 20 patients (50%) had emotional concerns like irritability, frustration, feeling sad or embarrassed. All patients showed improvement in their emotional status after surgery.

Maximum number of patients had a SNOT-22 score in the range of (21-40) in the pre-operative period. Minimum SNOT-22 score in the pre-operative period was 5 (with nasal obstruction being the only complaint. Maximum SNOT-22 score in the pre-operative period was 77. 100% of the patients had a SNOT-22 score improvement in the post-operative period (at the end of 3 months).

The p-value was found to be .000 which is <0.05, hence significant. This implies that there is improvement in the symptoms of patients of CRSwNP following FESS.

Patients were clinically examined and anterior rhinoscopy revealed presence of pale or pinkish polypoidal masses in nasal cavity which were either unilateral or bilateral. These polyps were insensitive to touch, did not bleed on touch and were free from nasal septum. Anterior rhinoscopy also revealed presence of edematous mucosa or thick purulent nasal discharge in some cases. Posterior rhinoscopic examination showed in some cases, pale polypoidal mass obstructing the choana either unilaterally or bilaterally along with presence of postnasal discharge. Routine blood investigations of all the patients were within normal limits. Raised absolute eosinophilic count was present in 7 patients (17.5%).

The NCCT scans of paranasal sinuses for all 40 patients, showed characteristic homogenous opacity in the involved ethmoidal sinuses. In some patients, it showed heterogeneity of signal in the involved sinuses (given many names as the 'starry-sky', 'ground-glass' or 'serpiginous' patterns, 'double-

density' sign) and were best appreciated in the soft tissue CT scan sections. Maxillary sinus was the most commonly involved (95%), followed by osteomeatal complex (90%), anterior ethmoids (80%), posterior ethmoids (62.5%), sphenoid sinuses (60%) and frontal sinus (52.5%). Mean CT scores have been shown in table-2.

The preoperative mean endoscopic score was 2.48±0.751.

Cases were assessed for olfactory dysfunction using a test with two components namely, threshold detection and odor identification. Composite score was then calculated by combining both the scores (Table-3). Composite scores were calculated for each nostril. Composite olfactory score of 0 on both sides was considered as anosmia. Maximum composite olfactory score was calculated to be 19 on either side. Patients with a composite olfactory score of 19 on both sides were considered to have normal olfaction. Patients with scores between 1 to 18 on either side were considered to have hyposmia.

In our study 13 out of 40 patients had no subjective olfactory complaints. These patients could identify all the odors in the odor identification test and also the minimum threshold of 1-butanol. This could be due to the non-involvement of olfactory cleft area or the variation in severity of disease. Post operatively, 4 out of 5 anosmic patients had improvement, however only 1 patient had complete recovery to normal olfaction (20%). (Table-4). 21 out of 22 hyposmic patients had improvement in olfaction, however, olfaction returned to normal in 14 patients (63.63%).

Olfactory score in the pre-operative and post-operative period on both sides were compared. It was found that there is no significant relation between age and olfactory dysfunction.

The difference in the mean scores of olfaction on either side of nose in patients before and after undergoing FESS was found to be statistically significant [p value=.000(<0.05)]. (Table-5). 27 out of 40 patients (67.5%) had complaints of olfactory dysfunction. At the 3 month follow-up period, 4 patients with anosmia (80%) had significant improvement in olfaction post-surgery, however 1 anosmic patient (20%) had no improvement in olfaction. 1 patient with ansomia had a complete recovery in olfaction. 21 out of 22 hyposmic patients (95.45%) had improvement in olfaction. 1 patient (4.54%) had no change in the olfactory score after surgery. 92.59% patients had improvement in olfaction post-surgery.

Post-FESS, all patients were followed up at 2 weeks, 1 month and 3 months. At each visit SNOT-22 score was documented and nasal endoscopic scores calculated. Olfaction was tested post-operatively after 1 month.

Sino-nasal symptoms and emotional status of all patients were improved in immediate postoperative period with some patients complaining of nasal obstruction due to crusting and edema which was relieved with cleaning. Most of patients were relieved of symptoms but few patients again developed some symptoms on third month of postoperative visit.

Comparing the pre-operative SNOT-22 scores with each of the visits the p-value was found to be significant in each visit (Table-6). Significant improvement in symptoms was seen. However, comparison of mean of SNOT-22 scores in the post-operative period did not yield a significant p-value despite the improving trend in scores over time. This implies that there is significant improvement in patient symptoms following FESS.

Comparing the pre-operative endoscopic scores with each of the visits, the p-value was found to be significant in each visit. (Table-7)

Comparison of scores of first visit with the second and third visits also yielded a significant p-value [0.00 which is <0.05]. This can be attributed to the crusts, edema and secretions in the first couple of weeks after surgery which gradually subsides over a period of one month. There was no significant difference in the scores at the second and third visit. There was an increase in the mean endoscopic score in the third month. This is due to recurrence of polyps, seen in 8 patients at the end of 3 months.

Spearman's test was used to find the correlation co-efficient between olfactory score and the various parameters of disease severity. (Table-8 and 9)

We inferred that there is a significant correlation between olfactory scores, SNOT-22 scores and endoscopic scores. The negative value of the co-efficient implies an inverse correlation between all scores, i.e., the more severe the disease, lesser the olfactory score.

**Tables**

**Table 1: Mean value of SNOT-22 scores in pre-operative and post-operative patients.**

| SNOT 22 score | Pre-operative | Post-operative |
|---|---|---|
| Mean | 30.43 | 18.023 |
| Standard deviation | 1.83 | 3.366 |
| p-value | 0.000 | |

**Table 2: Preoperative Mean CT scores**

| CT score | Right side | Left side |
|---|---|---|
| Mean score | 6.3 | 7.0 |
| Standard deviation | 4.840 | 4.498 |

**Table 3: Olfactory dysfunction in patients of CRSwNP**

| Olfaction (pre-operative) | Number of patients | Percentage (%) |
|---|---|---|
| Anosmia | 5 | 12.5 |
| Hyposmia | 22 | 55 |
| Normosmia | 13 | 32.5 |

**Table 4: Post-operative improvement in olfaction in patients of CRSwNP after endoscopic sinus surgery***

| Olfaction | Improvement seen in (Number of patients) | Percentage of improvement (%) |
|---|---|---|
| Anosmia | 4 out of 5 | 80 |
| Hyposmia | 21 out of 22 | 95.45 |

* This table includes only patients with olfactory dysfunction prior to surgery (27 patients).

**Table 5: Mean values of composite olfactory score in pre-operative and post-operative patients**

| Composite Olfactory Score | Pre-operative (Right side) | Post-operative (Right side) | Pre-operative (Left side) | Post-operative (Left side) |
|---|---|---|---|---|
| Mean score | 12.65 | 17.78 | 11.35 | 17.55 |
| Standard deviation | 7.116 | 3.541 | 8.100 | 3.623 |
| p-value | | 0.000 | | 0.000 |

**Table 6: Comparison of SNOT-22 scores pre-operatively and at each visit in the post-operative period**

| SNOT 22 score | Pre-operative | Visit 1 (2weeks) | Visit 2 (1 month) | Visit 3 (3months) |
|---|---|---|---|---|
| Mean | 30.43 | 2.23 | 1.88 | 1.83 |
| Standard deviation | 18.023 | 3.833 | 3.360 | 3.366 |

**Table 7: Comparison of Endoscopic scores pre-operatively and at each visit in the post-operative period**

| Endoscopic score | Pre-operative | Visit 1 (2weeks) | Visit 2 (1 month) | Visit 3 (3months) |
|---|---|---|---|---|
| Mean | 2.48 | 1.60 | 0.23 | 0.43 |
| Standard deviation | 0.751 | 0.672 | 0.423 | 0.549 |

**Table 8: Correlation of olfaction with various parameters of disease severity pre- operatively:**

| Olfaction* | SNOT-22 score | Endoscopic score* | CT score* |
|---|---|---|---|
| Correlation coefficient | -0.354 | -0.313 | -0.452 |
| p-value | 0.025 | 0.049 | 0.003 |
| Significant if | <0.05 | <0.05 | <0.01 |
| Significance | Yes | Yes | Yes |

*Pre-operative values of the right side of nose were compared.

**Table 9: Correlation of olfaction with various parameters of disease severity post- operatively:**

| Olfaction** | SNOT-22 score** | Endoscopic score** |
|---|---|---|
| Correlation coefficient | -0.384 | -0.536 |
| p-value | 0.014 | 0.000 |
| Significant if | <0.05 | <0.01 |
| Significance | Yes | Yes |

**post-operative values of the right side of nose were compared at the end of 1month (as olfaction was tested during the second visit at 1 month)

**Figures:**

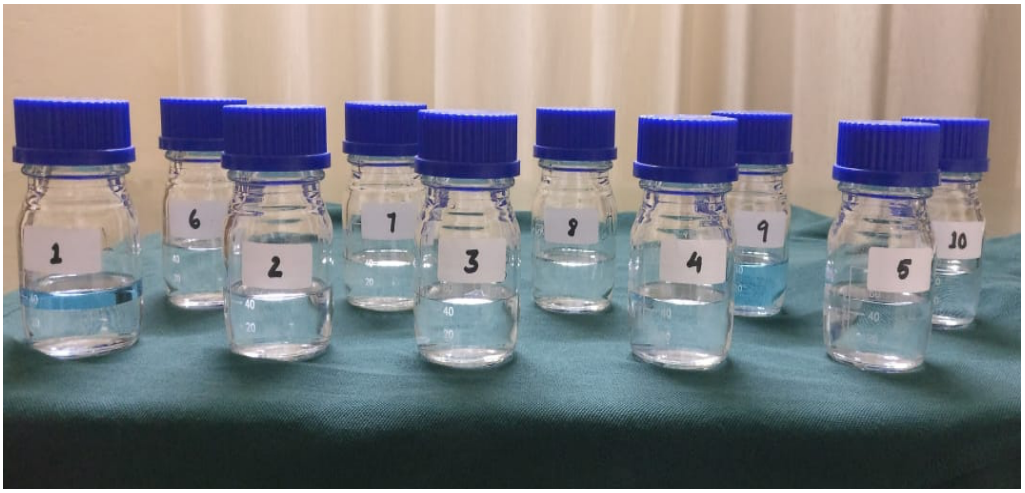


**Figure 1: The odor threshold test employed using 1-butanol as the test odorant.**

The test kit contains nine glass bottles each containing 50ml of test solution which were labelled as, solutions one to nine and another identical glass bottle filled with 50ml of sterile water.

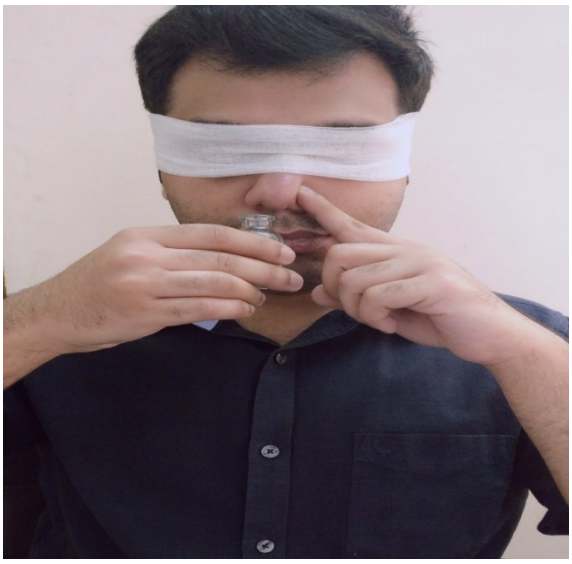

**Figure 2: Testing olfaction using odor identification test.**

To perform the test, the cap was removed by the examiner for approximately 3 seconds, and the tip of the bottle was placed approximately 2 cm in front of the nostril and patient was asked to sniff normally without any force.

**Figure 3: Odor identification testing kit.**

## Discussion

Olfaction is affected in various sino-nasal disorders. The olfactory neuro-epithelium is situated in a small area in the upper nasal cavity and studies have attributed olfactory dysfunction to inflammation in this area, or due to obstruction to airflow due to factors like nasal polyps. FESS aims at removal of any mechanical obstruction at the osteomeatal complex for the proper drainage, ventilation and resolution of mucosal changes secondary to sinusitis without disturbing the mucosa of the sinuses thereby leading to better olfactory function. In our study, it was found that age had no significant correlation with degree of olfactory dysfunction in patients with CRSwNP. Studies have also shown that age and gender have no significant effect on olfactory dysfunction. [15,16] A study by Thiago et al yielded a significant relation between FESS and disease-specific quality of life of CRS patients through questionnaire SNOT-20. In our study the SNOT- 22 questionnaire was used and the scores showed significant improvement in the postop period. Study by Litvack et al has shown that endoscopic scores moderately correlate with olfactory scores.[17] In a study by Gupta et al, the mean nasal endoscopy score prior to surgery was 2.95, which improved to 0.43 at 1 month and 0.26 at 3 months after surgery respectively, and the change was found to be statistically significant.[18] In our study, improvement in endoscopic scores can be attributed to the subsiding of edema and crusting in course of time. However, it showed a mild increase in scores to 0.43 ± 0.54 at the end of 3 months due to recurrence of polyps. Study of 178 patients by Perry and Koutakis, correlated the clinical severity of sinusitis with the CT scan findings and nasal endoscopic findings. The higher the CT scores, the higher the olfactory dysfunction and a higher rate of recovery after surgery.[19] Studies by Litvack et al, has shown that there is a direct relation between the severity in olfactory dysfunction and CT score and nasal examination. [17]

We found that there is significant correlation between CT scores and the severity in olfactory dysfunction. In a study by Dua et al they found the involvement in the order of anterior ethmoid, posterior ethmoid, maxillary, frontal sinus and then sphenoid.[20]

In the CT scan analysis of our study, maxillary sinus involvement had the highest incidence (95%) followed by osteomeatal complex (90%). Smith et al, evaluated 320 patients with rhinosinusitis over a period of 4 years, and found improved olfaction after endoscopic nasal surgery. Their study included patients with allergic rhinosinusitis and chronic sinusitis and had seen a recovery of 15.8 percent and 12.2 percent respectively.[21] Litvack's long-term study, evaluated the effect of FESS on improvement in olfactory sense in patients with CRS and he observed 111 patients for a period of 6 to 12 months. His results also showed a positive improvement in olfaction but he noticed that the patients who had hyposmia, did not show any gross improvement in their sense of smell after surgery. However, anosmic patients showed a remarkable improvement after endoscopic sinus surgery. The patients who showed improvement were followed up for 12 months and the improvement in olfaction achieved remained significant.[22] In comparison to his study, our study included only 40 patients and the duration of the follow up period was also less (three months) which is a limitation. However, our study shows an improvement in olfaction in both anosmic and hyposmic patients who underwent FESS.

A similar study of 115 patients was conducted by Delank and Stoll, which included 50 patients with an olfactory complaint before surgery. Olfactory tests revealed hyposmia in 52% and anosmia in 31% of the patients. Olfactory recovery after surgery was observed in 70% of cases.[23] Unlike the previous study by Litvack they observed improvement to the normal olfaction in 25% of hyposmic patients compared to only 5% in anosmic patients. They also observed a worsening in 8% of the patients after FESS. In our study, 55% patients had hyposmia and 12.5% patients had anosmia. Olfactory improvement was observed in 92.59% of patients. Improvement to normal olfaction was seen in 63.63% of hyposmic patients and 20% of anosmic patients after endoscopic sinus surgery. Worsening of olfaction was not seen in any patients.

Schriever et al. studied the effect of nasal surgery on olfactory function for 12 months. 157 cases were followed up for 3.5 months and 52 cases were followed up for 12 months. Olfactory function was remarkably improved 3.5 months after FESS, while he did not notice much of olfactory improvement after 12 months. However, olfactory recovery after 3.5 and 12 months was reported in 19% and 17% of patients, respectively.[15] Since our study had time constraints, olfactory improvement over long term could not be assessed. Perry and Koutakis, evaluated 178 patients and determined the effect of FESS on subjective olfactory dysfunction in patients with CRS. The mean score of olfactory dysfunctions prior to surgery was 4.9, and reduced to 0.9; one year post surgery. [19] In our study, we used a combination of olfactory tests like Odor identification test and olfactory threshold tests. The composite scores were calculated and the mean scores on right improved from 12.65±7.11 to 17.78±3.54 and on the left improved from11.35±8.10 to 17.55±.623. In a prospective study, Hummel and Pade investigated the determinant factors of olfaction after nasal surgery. They included 775 patients within the age of 10–81 years. Their results showed olfaction recovery only in 23% of patients after FESS. 68% of the patients

didn't show any significant change. On the contrary, they found a worsening of olfactory function in 9% of patients. They also found that age and gender had no considerable effect on surgical outcome in terms of olfactory function.[15] In a study by Jiang et al., the effects of FESS on olfactory outcomes in patients with chronic rhinosinusitis were evaluated and they did not find a significant improvement in the olfaction as the rate of patients with olfactory dysfunction before and after surgery was reported as 74.3% and 68.6%, respectively. Surgery had minimal effect on the sense of smell in patients with severe rhinosinusitis. This study concluded that endoscopic sinus surgery has no effect on olfaction.[29] Likewise Perry et al found a significant decrease in the subjective olfaction of patients 1 year post surgery.[19] In our study, 92.59% of the patients showed improvement in olfaction after sinus surgery. 7.47% had no improvement in olfaction. However, none of the patients had a worsening of olfaction. Olfactory outcomes were not assessed over a longer period; hence decrease in olfaction 1-year post-surgery could not be commented upon. The variation in results of the studies mentioned above could be due to the sample selection and the number and severity of the problems.

Litvack et al. observed that age, smoking, nasal polyposis and asthma are important factors in generating olfactory problems. [24] In our study, patients with asthma, smokers were excluded. This could be a reason for variation of results. Kohli et al. reported that FESS improves nearly all subjective and objective measures of olfaction in CRS patients.[25] In a meta-analysis into the use of pre- and postsurgical olfactory outcomes to assess the impact of FESS on CRS related olfactory impairment, patients with nasal polyposis or preoperative olfactory dysfunction improved to a greater degree.[25] Studies showed that basal olfactory condition and nasal polyposis are closely related to the rate of olfaction improvement after surgery.[22]

We found that FESS has a positive impact on olfaction and symptom reduction patients of chronic rhinosinusitis.

Our study shows 67.5 % patients of CRSwNP, had complaints of olfactory dysfunction. The evidence suggests that improvement of CRS related olfactory dysfunction following FESS is variable and challenging to predict. Some studies showed conflicting evidence that anosmic patients with nasal polyps have higher likelihood of improving their sense of smell as compared to the hyposmic patients. But our studies show significant improvement in both cases (95.4% in hyposmic and 80 % in anosmic).

The main limitation in our study was the follow up period. Patients could not be followed up beyond 3 months; hence olfaction could not be assessed over a longer period. We cannot reasonably conclude that the improvement in olfactory score was sustained in the post-operative period. Another limitation was lack of a post-operative radiological investigation. As a result, we could not compare post-operative CT score and its correlation with olfaction.

## Conclusion

The ability to monitor our environment depends to a large degree on our sense of smell. This sense alerts us to dangerous situations, such as natural gas leaks or fires, while allowing us to identify and locate the source before seeing it. Our sense of smell provides us with clues to the freshness of food and contributes to the majority of the flavor perception of a meal. Loss of sense of smell affects the person's ability to appreciate the environment and leads to impairment of quality of life. Our study was able to establish a significant correlation between olfaction and parameters of disease severity like SNOT-22, endoscopic score and CT scores. Hence with all the obtained data, we can conclude that endoscopic sinus surgery has a positive outcome in terms of improvement of olfactory dysfunction in patients of chronic rhinosinusitis with nasal polyps.

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**Ethical Consideration (Research involving human participants):** This study has been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The study has been approved by ethical committee of the institution.

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