Do Nasal Surgeries Affect Mucociliary Clearance?

Rajeshwary Aroor¹ · Zainab Sunu Ali² · K. S. Gangadhara Somayaji³

Received: 29 December 2015 / Accepted: 15 August 2016 / Published online: 18 August 2016
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Abstract The study was conducted to assess the impact of different nasal surgeries on the nasal mucociliary clearance mechanism. Mucociliary function of the nasal mucosa of patients who were undergoing various nasal surgeries was assessed by the Saccharin test by placing 5 mg saccharin granule on the anterior end of the inferior turbinate 1 day prior to the surgery. The time required for the test subject to experience a sweet taste was measured in minutes. Post-operatively the test was repeated 6 weeks after the surgery and the test times were compared. A total of 60 patients were part of this study. Of the 60 cases, 19 cases had undergone only septoplasty, 13 cases had undergone only functional endoscopic sinus surgery (FESS), 25 cases had undergone septoplasty with FESS, 2 cases underwent septoplasty with bilateral partial inferior turbinectomy (PIT) and one case was submucous resection (SMR). Significant improvement in nasal mucociliary clearance was observed in all the patients after the procedures. Out of the 19 cases of septoplasty, 57.9 % showed improvement on the right side and 47.4 % on the left side. Out of the 13 cases of FESS, 61.5 % showed improvement on the right side and 69.2 % on the left side. Out of the 25 cases of FESS with septoplasty, 76.0 % showed improvement on both sides. The case of

SMR did not show improvement. The 2 cases of septoplasty with PIT showed improvement. Statistically, highly significant improvement of test time was seen postoperatively as compared to pre-operatively. Among the surgical procedures, FESS with septoplasty showed better improvement as compared to the other procedures. Based on the study, we can conclude that nasal surgeries done for correction of septal deviation and rhino sinusitis significantly improves nasal mucociliary clearance mechanism thereby improving the physiological functions of the upper airway.

Keywords FESS · Septoplasty · Nasal mucociliary clearance · Saccharin test

Introduction

The nose and the paranasal sinuses are lined by pseudo stratified ciliated respiratory epithelium. The cilia play an important role in the mucociliary clearance. Various pathologies like rhinitis, sinusitis, deviated nasal septum, nasal polyposis, inferior turbinate hypertrophy, etc. are known to cause nasal obstruction which will reduce the efficacy of the mucociliary mechanism. Increased mucus secretion with impaired ciliary movement leads to stagnation of nasal secretions, which predisposes to recurrent infections. This is a vicious cycle [1]. Surgery relieves the nasal obstruction and hence there is less incidence of stagnation of secretions which promotes regeneration of the mucosa and thereby improves the mucociliary clearance [2]. We used saccharin method to test the mucociliary function both pre-operatively and post-operatively and the results were compared.

✉ Zainab Sunu Ali
zainabsunu@yahoo.com

¹ Department of ENT, K S Hegde Medical Academy, Nitte University, Mangalore, India

² Department of ENT, Kanachur Institute of Medical Sciences, University Road, Derlakatte, Mangalore 575018, India

³ Department of ENT, Yenepoya Medical College, Yenepoya University, Mangalore, India

Materials and Methods

The patients who were undergoing various nasal surgeries for nasal obstruction, recurrent rhino sinusitis and headache were included in this study. Medications including oral anti-histaminies and topical nasal medications (decongestant drops) were stopped 3 days prior to the test. Mucociliary function was assessed by the Saccharin test. The test was done 1 day prior to the surgery. Commercially available Saccharin (Sweetex) which is available as 10 mg tablets was used in this study. 5 mg of saccharin granule (half tablet) was placed on the anterior end of the inferior turbinate. Patients were instructed to avoid forceful blowing or sniffing. Time taken by the patient to experience the sweet taste was measured in minutes. Patients with a pre-operative saccharin clearance time greater than 120 min, patients with an acute episode of rhinitis, cases with suspected tumours were excluded from the study. The test was repeated 6 weeks after the surgery. The test times were compared. Patients with post-operative complications like synechiae, septal perforation and recurring nasal polyposis within 3 months were excluded from postoperative tests. Ethical clearance was obtained from the institutional ethics committee for the study. Informed consent was obtained from all individual participants included in the study. The statistical analysis was done by paired *t* test.

Results

Out of the 60 cases, 25 (41.7 %) cases had undergone bilateral functional endoscopic sinus surgery (FESS) with septoplasty, 19 (31.7 %) cases underwent septoplasty alone, 13 (21.7 %) cases underwent bilateral FESS, 1 (1.7 %) case underwent submucous resection of the septum, 2 (3.3 %) cases underwent septoplasty with bilateral partial inferior turbinectomy (Table 1). The youngest patient in our study was 12 years old and oldest patient was 65 years old with a mean age of 29.48 ± 11.269 . In our study 27 were females, 33 patients were males.

Among the bilateral FESS cases, 6 cases were for chronic rhinosinusitis and 7 cases were for sinonasal

polyposis. Among the rhinosinusitis cases, 5 out of the 6 cases showed improvement. Among the sinonasal polyposis cases, 4 out of the 7 cases showed improvement. Among the 25 cases who underwent bilateral FESS with septoplasty, 20 cases were for chronic rhinosinusitis and 5 cases were for sinonasal polyposis. Among the rhinosinusitis cases, 15 out of the 20 cases showed improvement. All of the sinonasal polyposis cases showed improvement (Table 2).

The 13 (21.7 %) cases who underwent bilateral FESS alone, on the right side, the pre-operative mean was 15.50 ± 4.86 min and the post-operative mean was 11.69 ± 4.68 min which was statistically significant based on *t* test with $p < 0.048$. Among the 13 cases who underwent bilateral FESS alone, on the right side, 8 (61.5 %) cases showed improvement in test time, 1 (7.7 %) case showed no change and 4 (30.8 %) cases showed prolongation of test time. On the left side, the pre-operative mean was 15.62 ± 5.24 min and the post-operative mean was 12.92 ± 6.54 min which was statistically not significant, but the patients were symptomatically better. Among them, 9 (69.2 %) cases showed improvement in test time and 4 (30.8 %) cases showed prolongation of test time (Table 2).

Among the 25 (41.7 %) cases who underwent B/L FESS with septoplasty, the pre-operative mean on the right side was 15.74 ± 6.66 min and the post-operative mean was 11.28 ± 3.78 min, which was highly statistically significant based on $p < 0.001$. On the left side 19 (76 %) cases showed improvement in test time, 1 (4 %) case showed no change, and 5 (20 %) cases showed prolongation of test time. On the left side, the pre-operative mean was 14.96 ± 6.55 min and the post-operative mean was 11.32 ± 3.67 min which was highly statistically significant based on $p < 0.003$ (Table 2).

Among the cases who underwent septoplasty alone or submucous resection or septoplasty with bilateral partial inferior turbinectomy, the pre-operative mean on the right side was 12.73 ± 6.29 min and the post-operative mean was 11.91 ± 3.76 min which was not statistically significant. Among the 19 cases of septoplasty, on the right side, 11 (57.9 %) cases showed improvement in test time and 8 (42.1 %) cases showed prolongation of test time. On the left side, the pre-operative mean was 11.98 ± 5.72 min and the post-operative mean was 12.61 ± 4.08 min which was not statistically significant. However, the patients were symptomatically better after the procedure (Table 2).

Table 1 Distribution of cases based on surgery done

Procedure done	No. of patients	Percentage
B/L FESS	13	21.7
FESS + SEPT	25	41.7
SEPT	19	31.7
SEPT + B/L PIT	2	3.3
SMR	1	1.7
Total	60	100.0

Discussion

The nasal mucosa can be affected by various pathologies like deviated nasal septum, inferior turbinate hypertrophy, nasal polyposis, etc. These conditions lead to very limited

Table 2 Final outcome status after each procedure

Procedure done	Final outcome status right side			Final outcome status left side			Total cases
	Improved	No change	Worsen	Improved	No change	Worsen	
B/L FESS	8 61.5 %	1 7.7 %	4 30.8 %	9 69.2 %	0 0 %	4 30.8 %	13
FESS + SEPT	19 76.0 %	1 4.0 %	5 20.0 %	19 76.0 %	1 4.0 %	5 20.0 %	25
SEPT	11 57.9 %	0 0 %	8 42.1 %	9 47.4 %	0 0 %	10 52.6 %	19
SEPT + B/L PIT	2 100 %	0 0 %	0 0 %	1 50 %	1 50 %	0 0 %	2
SMR	0 0 %	0 0 %	1 100 %	0 0 %	0 0 %	1 100 %	1
Total	40 66.7 %	2 3.3 %	18 30 %	38 63.3 %	2 3.3 %	20 33.3 %	60

space between the middle turbinate and lateral wall of nose. Minimal mucosal swelling can impair the mucociliary activity and prolong the mucociliary time. This leads to a vicious cycle leading to recurrent infections [2].

Mucociliary clearance is an important defence mechanism of the nose and paranasal sinuses. Any disturbance in this mechanism will lead to stagnation of secretions, secondary infection and prolongation of the clearance time. Various other factors like smoking, viral infections, poor ventilation, are also known to affect the mucociliary clearance. The essence of the surgical procedure is to restore normal drainage and mucociliary clearance by minimal manipulation and maintain as much normal anatomy as possible. Surgery encourages regeneration of cilia and production of mucus of normal chemistry and rheological properties [2].

The mucociliary function can be assessed by various methods which consist of both in vivo and in vitro tests. In-vitro tests include roentgenography, photograph-electron technique and phase-contrast microscopy. In vivo tests include saccharin, dyes, radiopaque discs of Teflon, and radioactive substances [3]. Saccharin method is one of the simplest, safe and commonest methods to assess the mucociliary function. It does not require sophisticated equipment to perform the test and can be reproduced. It is neither digested nor metabolised by the body and does not contribute to the daily calorie intake [4, 5].

Mucociliary clearance can be effected from environmental heat, moisture, partial oxygen pressure, pH, trauma, sulphur dioxide, formaldehyde, ozone, chlorine, smoking, viral infections, chronic sinusitis, chronic and allergic rhinitis, adenoid hypertrophy, cystic fibrosis, chronic bronchitis, septal deviation, surgery, bronchial asthma, and diabetes mellitus [6].

According to studies, septal surgery, turbinectomy and endoscopic sinus surgery had improved mucociliary clearance [7, 8]. In the study by Uslu et al. [8], patients with septal deviation have a prolonged mucociliary transit time as compared with post-operative and healthy controls. Septoplasty alters mucociliary clearance at immediate post-operative period. When the entire nasal mucosa was injured mechanically, regenerative stratified epithelium covered the defect in 1 week, new ciliated cells appeared in 3 weeks and complete regeneration was observed at 6 weeks. In our study, patients showed improvement in the symptoms at the end of 6 weeks after surgery. There was a statistically significant decrease at the postoperative mucociliary clearance time among the non-smoker patients who underwent surgery when compared with preoperative mucociliary clearance time [6]. Kamaran and Tek concluded that if the septoplasty procedure is properly performed, nasal mucociliary clearance significantly improves. They also found that there is no significant difference in mucociliary clearance time between obstructed nasal cavity and the non-obstructed side. In the study by Kamaran and Tek [6], the test side was selected randomly. Similarly in our study it was found that there was no significant difference in the mucociliary clearance between the obstructed and the non-obstructed sides.

Ginzel and Illum [9] evaluated 22 patients with deviated nasal septum as the study group and 60 volunteers as a control group. In this study, it was found that with properly performed septoplasty surgery, nasal mucociliary clearance time significantly decreased. Preoperative and postoperative nasal mucociliary clearance time in non-smoking patients with septal deviation was statistically significantly higher than the nasal mucociliary clearance time of the control group. These findings reveal that nasal obstruction

caused by septal deviation alone disturbs nasal mucociliary clearance, resulting with longer mucociliary clearance time. Mucociliary clearance time was decreased at the late postoperative period, but did not reach the level of the control group at the 3rd month. It was determined that nasal mucociliary clearance was found disturbed at early postoperative periods of septoplasty.

In our study, the saccharin transit time for cases undergoing functional endoscopic sinus surgery alone pre-operatively on the right side was 15.50 ± 4.86 min. This was significantly slower than the post-operative time which was 11.69 ± 4.68 min. On the left side, the pre-operative mean was 15.62 ± 5.24 min and post-operatively was 12.92 ± 6.54 min. Hence there was an improvement in the saccharin transit time on both sides. In the study by Elwany et al. [2], pre-operative findings of the mean saccharin transit time of the patients with chronic sinusitis were 37.0 ± 15.7 min. This was significantly slower than the 12.8 ± 7.9 min of the control group. In the post-operative findings of this study, mean saccharin transit time was decreased to 20.3 ± 7.5 min after functional endoscopic sinus surgery. This was significantly faster than the pre-operative mean. The results of the study demonstrated several points. First, chronic sinusitis is associated with prolongation of saccharin transit time. Second, this prolongation is due to ciliary damage or loss and possibly other factors related to the character of mucus. Third, these changes can be reversed with proper treatment of sinus infection. Shortening of the saccharin transit time postoperatively in the study patients indicated that functional endoscopic sinus surgery had successfully restored normal drainage and ventilation of the maxillary sinuses.

In the study by Sakthikumar et al. [4] consisting of 20 patients, the mean pre-operative saccharin test time was found to be 16.20 min with post-operative mean value of 10.30 min. This proved to be highly significant. The mucociliary transport mechanism of the sinus mucosa improved 6 weeks following surgery. Subjective improvement at 6 weeks following surgery was confirmed by decrease in saccharin test time. Functional endoscopic sinus surgery increased the density of the cilia both in the superolateral wall of the maxillary sinus and in the ostial region 6 weeks after surgery.

There was statistically significant increase in nasal mucociliary clearance time in patients with sinusitis and polyposis [10].

In our study, among the 13 cases who underwent bilateral functional endoscopic sinus surgery alone, 6 cases were for chronic rhinosinusitis and 7 cases were for sino-nasal polyposis. Among the rhinosinusitis cases, 5 out of the 6 cases showed improvement. Among the sinonasal polyposis cases, 4 out of the 7 cases showed improvement.

Among the 25 cases who underwent bilateral functional endoscopic sinus surgery with septoplasty, 20 cases were for chronic rhinosinusitis and 5 cases were for sino-nasal polyposis. Among the rhinosinusitis cases, 15 out of the 20 cases showed improvement. All of the sinonasal polyposis cases showed improvement. So, functional endoscopic sinus surgery has improved the mucociliary clearance time in both chronic rhinosinusitis and sinonasal polyposis cases and there is no difference in the functional outcome. Our results are similar to another study showing the benefit of Functional endoscopic sinus surgery for chronic rhinosinusitis in improving the mucociliary clearance time post-operatively [11].

According to Sapci et al. [12] partial turbinectomy is effective in improving nasal obstruction objectively and in preserving nasal mucociliary function. In our study patients, only two cases underwent septoplasty with bilateral partial inferior turbinectomy. Both the patients showed 100 % improvement in the mucociliary clearance. However there are only two cases of partial inferior turbinectomy in our study. As the sample size is too small, it is difficult to draw a conclusion.

Conclusion

1. Various nasal surgeries like septoplasty, functional endoscopic sinus surgery (FESS), septoplasty with bilateral partial inferior turbinectomy give the symptomatic improvement and improve the physiological functions of the nose and paranasal sinuses. Surgery improves the nasal mucociliary clearance.
2. Functional endoscopic sinus surgery combined with septoplasty gives a better functional outcome than either procedure alone.
3. There is no significant difference in the mucociliary function both pre-operatively and post-operatively when considering the side of nasal obstruction.
4. Functional endoscopic sinus surgery when done for rhinosinusitis or for nasal polyposis improves mucociliary clearance time. Hence, functional outcome does not depend on the indication for functional endoscopic sinus surgery.
5. In our study, we have observed that the patients symptoms and the nasal mucociliary clearance time by saccharin method are correlating. All patients who showed improvement in the nasal mucociliary clearance time after surgery also showed improvement in their symptoms (like nasal obstruction, head ache, etc.) So we come to the conclusion that saccharin method is an effective method in measuring the nasal mucociliary clearance time.

Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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