Role of measurement of nasal mucociliary clearance by saccharine test as a yard stick of success of functional endoscopic sinus surgery

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Abstract

Aim The present study was done to establish normal nasal mucociliary clearance time (NMCT) in people of our region, study variations in NMCT in patients of chronic rhinosinusitis, to see change in NMCT after functional endoscopic sinus surgery (FESS) and to see whether saccharine test can be used as a yard stick of success of FESS.

Materials and methods NMCT of 100 normal individual was measured twice to establish control value. Forty-three patients of chronic rhinosinusitis were divided into polypoidal and non-polypoidal. Their symptom score, endoscopic appearance score, CT scan score and NMCT was measured preoperatively and postoperatively.

Results NMCT in control group was 6.61 ± 0.84 minutes, in unilateral (u/l) polypoidal sinusitis 13.45 ± 2.07 minutes, in bilateral (b/l) polypoidal sinusitis 21.31 ± 0.76 minutes, u/l non-polypoidal sinusitis 9.54 ± 1.00 minutes and in b/l non-polypoidal sinusitis 11.34 ± 0.93 minutes. Linear relationship was seen between preoperative NMCT and preoperative symptom score, endoscopic appearance score, CT scan score. NMCT improved significantly after FESS.

Conclusion NMCT measurement helps in selection of appropriate patients for surgery. It can be used as preoperative indicator of success of FESS.

Keywords Nasal mucociliary clearance time · Functional endoscopic sinus surgery

Introduction

Nasal mucosa has been described as a delicate structure since time immemorial. Nasal mucosa has many functions like heat exchange, humidification, protection of the lower airways, mucous secretion, maintenance of nasal neurovascular reflexes, olfaction and mucociliary clearance. Mucociliary mechanism is nature's best air conditioner, which protects the upper and lower respiratory tracts and the delicate alveoli. The mucous film, with its immunological active ingredients, its adsorbent power and its water content makes the inhaled air almost sterile, sufficiently humid and at par with the body temperature. This mucociliary mechanism can be easily impaired by structural abnormalities of the nose and paranasal sinuses and also by upper respiratory tract diseases. This disturbance in mechanism leads to stagnation of secretions and secondary infections. A permanently defected mucociliary mechanism predisposes to chronic sinusitis, chronic obstructive lung diseases and bronchiectasis. Several methods have been used to evaluate the mucociliary clearance either directly by electron microscope studies or indirectly by assessing the mucous transport or clearance. Andersen et al. [1] used a simpler method which consisted of depositing a small particle of saccharine on the nasal mucosa and noting the time that it took the subject to report a sweet taste. The values for mucociliary clearance have been reported in different parts of the world with wide variations depending upon various geographical, physiological and pathological conditions [2–13]. Thus the purpose of this prospective study was first to establish the normal values of mucociliary clearance in our own region, to study the variation in mucociliary activity in patients of chronic sinusitis, to see improvement in mucociliary activity after functional endoscopic sinus surgery (FESS) and finally to assess whether saccharine test can be used as a yard stick of success of FESS.

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Materials and methods

In the present study 100 individuals were selected for control group over a period of 40 days. They were selected from amongst medical students, hospital staff on the basis of history, clinical examination and radiological examination of nose and paranasal sinuses where required. The procedure was explained and consent was taken before conducting the test. They were all free from any apparent nasal and paranasal sinus symptoms and signs. They were all non-smokers, had no attack of upper respiratory tract infection in past 15 days. Subjects having simple asymptomatic deviated nasal septum were included in control group. Average of two readings of nasal mucociliary clearance time (NMCT) using saccharine test at an interval of 1 month was taken as control value.

The study group comprised of 43 confirmed patients of chronic rhinosinusitis as per the definition given by the International Rhinosinusitis Advisory Board in 1997 [2]. The patients were allocated into polypoidal and non-polypoidal groups on the basis of detailed clinical examination, nasal endoscopy and CT scan of nose and paranasal sinuses. Non-polypoidal sinusitis cases were treated by 1 week course of clarithromycin, topical and systemic nasal decongestants, levocetirizine, mucolytic and mucokinetic drugs. Polypoidal sinusitis group were given a 1 week course of prednisolone (1 mg/kg body weight) in addition to other drugs. The systemic nasal decongestant drugs were continued for a period of 90 days in non-polypoidal group. In patients of polypoidal sinusitis beclomethasone dipropionate topical nasal spray was used in addition. Patients who failed to respond to this medical treatment as assessed by subjective symptoms, CT scan and nasal endoscopy, were selected for FESS. All the 43 patients underwent FESS. Preoperative NMCT of each diseased subject was measured by saccharine test. A 1 mm diameter particle was placed approximately 1 cm posterior from the anterior end of the inferior turbinate, and the time required in perceiving a sweet taste was noted. All the patients were tested in ENT ward and they were instructed not to sniff, inhale or exhale forcefully and to refrain from any nasal manipulation. They were asked to swallow at every 30 seconds and to report the first change in their sensation of taste. A stopwatch was used for time measurement. FESS was then done and follows up clinical examination; symptom score evaluation, NMCT and nasal endoscopies were done at intervals of 6 weeks, 3 months and 6 months postoperatively. No complications were noted during the study. The total duration of study was of 1 year.

The preoperative and postoperative findings were recorded following the staging system described by Lund and Mackay in 1993 [3], where a numerical score for four aspect of the condition (i.e. symptom, endoscopic appearance score, preoperative CT findings and surgery) was given.

Results and analysis

Control group consisted of 100 individuals, 51 males and 49 females. Youngest was 18-year-old and oldest was 45 years. Mean age was 27.32 ± 6.50 years (95% confidence interval). Most of the patients suffering from chronic rhinosinusitis were in second decade of life (38%), followed by third decade (32%) and first decade (20%), respectively. Male-to-female ratio was 1.7:1. So there was male preponderance in the diseased group.

Out of 43 patients of chronic rhinosinusitis, 17 patients (39%) had polypoidal sinusitis and 26 patients (61%) had non-polypoidal sinusitis. Both diseased groups consisted of unilateral and bilateral cases. In non-polypoidal sinusitis there were 16 unilateral (61%) and 10 bilateral (39%) cases. In polypoidal sinusitis there were 14 unilateral (82%) and 3 bilateral (18%) cases.

NMCT in control group was 6.61 ± 0.84 minutes, in (u/l) polypoidal sinusitis 13.45 ± 2.07 minutes, in (b/l) polypoidal sinusitis 21.31 ± 0.76 minutes, u/l non-polypoidal sinusitis 9.54 ± 1.00 minutes and in b/l non-polypoidal sinusitis 11.34 ± 0.93 minutes. There was a statistically significant increase in NMCT in all diseased groups. Table 1a shows that significant relationship exists between control and u/l non-polypoidal sinusitis, control and b/l non-polypoidal sinusitis, control and u/l polypoidal sinusitis, control and b/l polypoidal sinusitis and with each other. Table 1b shows that significant relation exists between diseased groups, between time and time group interaction.

Patients were divided into 3 groups according to their preoperative NMCT to study the relationship between it and subsequent improvement in symptom score. Table 2 shows significant relationship between groups, between time and time group interaction. Postoperative improvement in symptom score was seen in all the 3 groups but maximum improvement in symptom score was seen in patients with highest preoperative NMCT (Fig. 1).

A statistically significant linear relationship was seen between preoperative NMCT and preoperative symptom score; preoperative endoscopic appearance score, preoperative CT score and preoperative combined sign and symptom score (Figs. 2–5).

Discussion

Different subjective and objective methods have been used to assess the outcome of fess. Subjective measures range from those applied to the diagnosis of rhinosinusitis, such as the “major criteria” established by the 1997 Task Force, to sophisticated symptom and quality-of-life (QOL) measures, specific indices such as rhinosinusitis disability index, rhinosinusitis outcome measures or chronic sinusitis

Table 1a Means for NMCT scores in control and diseased groups with 95% confidence interval

Analysis of variance table					
Groups	Number	Mean	Standard deviation	Standard error (pooled)	
Control	100	6.61	0.84	0.10	
U/L non-polypoidal sinusitis	16	9.54	1.01	0.26	
B/L non-polypoidal sinusitis	10	11.34	0.93	0.33	
U/L polypoidal sinusitis	14	13.45	2.07	0.27	
B/L polypoidal sinusitis	3	21.31	0.76	0.60	
Source	Degree of freedom	Sum of squares	Mean sum of squares	F ratio	p value
Between groups	4	1,282.0	320.49	293.22	<0.001
Within groups	138	150.81	1.093		
Total (Corr.)	1,432.8	142			

Multiple range tests show that mean scores of NMCT of all the groups are significantly different from each other

Table 1b Mean and SD of NMCT in four clinical groups over period of time

Groups	Time period				
	Pre-op NMCT	NMCT 6 weeks	NMCT 3 months	NMCT 6 months	
U/L non-polypoidal sinusitis	9.54 ± 1.01	9.25 ± 0.92	8.51 ± 0.73	7.44 ± 0.68	
B/L non-polypoidal sinusitis	11.35 ± 0.93	11.10 ± 0.86	11.22 ± 1.27	10.51 ± 0.94	
U/L polypoidal sinusitis	13.45 ± 2.07	11.23 ± 1.77	11.56 ± 1.68	9.54 ± 1.27	
B/L Polypoidal sinusitis	21.31 ± 0.76	17.14 ± 0.48	16.29 ± 0.40	13.32 ± 2.03	
Control	6.61 ± 0.84	—	—	—	
Analysis of variance table of four clinical groups					
Source	Degree of freedom	Sum of squares	Mean sum of squares	F ratio	p value
Between groups	3	744.65	186.16	82.73	<0.001
Between time	3	177.73	59.24	26.32	<0.001
Time-group interaction	9	89.21	9.91	4.40	<0.001
Error	156	351.49	2.25		
Total (Corr.)	171	1,363.08			

Table 2 Mean and SD of NMCT in three clinical groups (divided on the basis of preoperative NMCT) over period of time

Groups	Time period			
	Pre-op NMCT	NMCT 6 weeks	NMCT 3 months	NMCT 6 months
NMCT b/w 7–10 minutes	24.21 ± 3.80	20.28 ± 3.72	14.35 ± 3.00	9.07 ± 1.32
NMCT b/w 10–15 minutes	26.16 ± 4.34	15.24 ± 2.16	9.88 ± 2.71	3.31 ± 1.92
NMCT >15 minutes	34.85 ± 7.38	15.85 ± 2.54	6.57 ± 0.97	3.17 ± 0.69

Analysis of variance table of three clinical groups					
Source	Degree of freedom	Sum of squares	Mean sum of squares	F ratio	P value
Between groups	2	400.20	200.10	20.60	<0.001
Between time	3	12,057.63	4,019.21	413.92	<0.001
Time-group interaction	6	1,045.13	174.18	17.93	<0.001
Error	172	1,671.65	9.71		
Total (Corr.)	183	15,174.61

Fig. 1 Correlation between NMCT and improvement in symptom score

Fig. 2 Correlation between preoperative symptom score and NMCT ($p < 0.01$, correlation coefficient 0.63)

Fig. 3 Correlation between preoperative CT score and NMCT ($p < 0.01$, correlation coefficient 0.56)

survey [29–33]. Objective tests used are nasal culture, ciliary beat frequency, rhinomanometry, acoustic rhinomanometry, olfactory testing, saccharine test, radiographic studies and nasal endoscopies [22, 34–41]. Bhattacharya (2004) used symptom score to assess outcome of fess and noticed decrease in major and minor symptoms after surgery [42].

Fig. 4 Correlation between preoperative endoscopic appearance score and NMCT ($p < 0.01$, correlation coefficient 0.629)

Fig. 5 Correlation between preoperative combined sign and symptom score and NMCT ($p < 0.01$, correlation coefficient 0.576)

Damm et al. (2002) concluded that restricted QOL in patients of chronic rhinosinusitis can be improved by FESS, achieving better QOL in the long-term [43]. Symptom score are totally based on how the patients perceive their problems. Underlying co-morbid conditions (e.g. asthma, allergy) can also affect symptom scoring. Furthermore, some patients have been found to be asymptomatic despite having objective evidence of sinus pathology either on CT scan or by nasal endoscopy. Schaitkin (1993) concluded that the only test that seemed to correlate with improved symptom score was ciliary beat frequency amongst all the other objective measurements [23]. Acoustic rhinomanometry and rhinomanometry suffers from challenges and lack of standardization; however, in experienced hands, these reflect an objective measure of nasal congestion, albeit with a wide normal range [44]. Another indicator is the olfactory test; however, data indicates that medical or surgical interventions in patients with rhinosinusitis do not always lead to full recovery of olfactory function regardless of the response to treatment [44]. Bhattacharya et al. (1997) observed that CT scan cannot be used an independent arbiter of the extent

Table 3 Nasal mucociliary clearance measured by various authors in different parts of the world

Country	Author	NMCT (minutes) in control group
Milan (Italy)	Corbo (1989)	<24 minutes
Florida (USA)	Stringer (1995)	5 minutes
Uruguay (South America)	Schuhl (1995)	8.8 minutes
Mainz (Germany)	Hafner (1997)	14.9 ± 8.4 minutes
Birmingham (UK)	Prior (1999)	<20 minutes
Tokyo (Japan)	Asai (2000)	35.7 minutes
Istanbul (Turkey)	Deniz (2006)	14.5 ± 3.55 minutes
Nagpur (India)	Golhar (1986)	7 minutes 10 seconds
Patiala (India)	Birdi (1998)	6.99 ± 0.26 minutes
Rohtak (India)	Ranga (2000)	8.55 ± 2.11 minutes
Rohtak (India)	Yadav (2001)	5.70 ± 2.59 minutes
Allahabad (India)	Singh (2009)	6.61 ± 0.84 minutes

of patient's disease because radiological findings do not correlate with symptoms [25]. Bradley (2005) concluded that CT scan score fails to predict the amount of symptomatic improvement after FESS [26]. Bhattacharya (2006) found that although CT scan is widely accepted as an accurate diagnostic tool for chronic sinusitis, CT scan alone does not significantly predict symptom outcome after FESS [27]. Singh and Chandra (2006) in their study found CT scan was more important in predicting the outcome of the polypoidal sinusitis cases and less important in non-polypoidal sinusitis cases [28]. CT scans are helpful in diagnosing and follow up of patients of chronic rhinosinusitis but repeated exposure of radiations and its cost, limits its use as a prognostic indicator of FESS. Singh and Chandra (2006) in their study found that preoperative endoscopic appearance score was not found to be important in the prediction of symptomatic improvement following FESS [28]. There can be inter physician variability in appreciating the endoscopic appearance of the nasal and sinus mucosa before and after surgery. Moreover nasal endoscopic findings do not always correlate with patient symptoms that result from co-morbid conditions such as inhalant sensitivities or the patient's own perception of the normal nasal airway, secretions, pain/discomfort or other symptoms [44]. Kaluskar (1997) reported reduction in saccharine clearance time after FESS [24]. Several other studies have reported improvement in saccharine clearance time after FESS [8, 10, 16–21]. Measurement of NMCT by saccharine method can be easily performed, is free from observer variations, has no side-effects, cheap, simple to carryout and requires no elaborate equipments. So saccharine test can be used as a single important prognostic factor in predicting the outcome of FESS.

In our study a linear relationship was seen to exist between preoperative NMCT and preoperative symptom score, preoperative endoscopic appearance score, preoperative

CT scan score, and combined sign and symptom score. This linear relationship between variables can help in selecting the patients for surgery. Patients in whom this linear relationship does not exist should be evaluated nicely before conducting any type of surgery as chances of surgical failure is high in these cases due to exaggeration of symptoms or due to any accompanying psychiatric distress.

Key message

- Normal values for mucociliary clearance can differ from place to place due to different environmental conditions like temperature, humidity and pollution. (Table 3)
- This work further consolidates that FESS improves NMCT.
- Preoperative measurement of NMCT can be used as an most important prognostic factor in predicting the outcome of FESS.
- Correlation between symptom score, endoscopic appearance score, CT scan score and NMCT can help the surgeons to select the appropriate patients for surgery, who would be maximally benefited from it.

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