

Effect of cigarette smoking on nasal mucociliary clearance: A comparative analysis using saccharin test

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ABSTRACT

Background: Nasal mucociliary clearance (NMC) system transports the mucus layer covering the nasal epithelium towards nasopharynx by ciliary beating at a frequency of 7-16 Hz. NMC is altered by septal deviations, upper respiratory infections, and drugs. Few studies have revealed significant depression of ciliary activity in smokers. We conducted this study to compare NMC and influence duration of smoking on NMC in adult smokers and nonsmokers using saccharin test. **Materials and Methods:** Our study included 30 nonsmokers and 30 smokers (21-40 years) who were not on any medications and had no history of any systemic illness. Time elapsing until the first experience of sweet taste at posterior nasopharynx, following placement of saccharin particle approximately 1 cm behind the anterior end of inferior turbinate was recorded as NMC time in minutes using standard method described by Anderson. Mean NMC of both groups were compared using Student's *t*-test and influence of duration was analyzed by one-way Analysis of variance (ANOVA). **Results:** NMC was significantly prolonged in smokers (481.2 ± 29.83 ; $P < 0.01$) in comparison to nonsmokers (300.32 ± 17.42 s). A statistically significant increase in NMC was observed with an increase in duration of smoking habit (NMC in smoking <1 year = 492.25 ± 79.93 s, 1-5 years = 516.7 ± 34.01 s, >5 years = 637.5 ± 28.49 s; F statistic = 20.8968, $P = 0.0000$). **Conclusions:** NMC measurement is a simple and useful index for the assessment of effect of smoking on the ciliary activity of respiratory mucosa. Prolonged clearance observed in smokers of our study may be due to slowed ciliary beat frequency or reduction in number of cilia and changes in viscoelastic properties of mucus.

KEY WORDS: Nasal mucociliary clearance, saccharin test, smoking, tobacco

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INTRODUCTION

Mucociliary clearance is a primary defense mechanism in the human airways. The nasal mucociliary clearance (NMC) system transports the mucus layer that covers the nasal epithelium towards the nasopharynx by ciliabeating at a frequency of 7-16 Hz at body temperature.^[1,2] The primary function of the NMC system is to protect the respiratory system from damage by inhaled substances. Mucociliary clearance is in part dependent on the physiological

characteristics of mucus and in part on ciliary functions like beat frequency and coordination.^[3,4]

Various factors like ageing, temperature ($<10^{\circ}\text{C}$ and $>45^{\circ}\text{C}$), drugs like adrenaline, acetylcholine, and corticosteroids influence the duration of NMC.^[5] Prolonged clearance time has been observed in subjects with rhinosinusitis, bronchial asthma, chronic obstructive pulmonary disease (COPD), cystic fibrosis, and other congenital or acquired defects in ciliary function.^[6-9] Further, compounds like formaldehyde, ammonia, and phenols in tobacco smoke are toxic to mammalian cilia *in vitro* and have been proved to cause ciliostasis and delayed mucociliary clearance. Also, tobacco smoke alters the viscoelastic properties of the mucus and further delays NMC.^[10,11]

Studies of Andersen and Proctor state NMC more than 30 min to be abnormal.^[12] Stanley *et al.*, states that prolonged NMC should be investigated further to diagnose pathologies related to mucus or clearance

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mechanisms.^[10] Impaired mucociliary clearance results in impaired respiratory health which in turn manifests as chronic infections of the nose, paranasal sinuses, and the lower respiratory tract.

Mucociliary clearance can be measured both in upper and lower respiratory tracts by the measuring the rate of removal of radiolabelled particles or radiopaque discs.^[13,14] Also, the ciliary beat frequency can be assessed as an indicator of ciliary function. But the saccharin test described by Andersen *et al.*, is an inexpensive, simple, and reproducible technique to assess the NMC.^[12] It is considered to be as efficacious as the measurement of clearance using radiolabelled particles.^[15] In fact, it has been proposed as an effective screening test to detect abnormal NMC.^[16]

We were interested in studying the NMC in smokers to evaluate the effect of tobacco smoke on ciliary function and also compare it with nonsmokers. Review of existing literature yielded an equivocal input and there was no consensus with regard to the effect of tobacco smoke on NMC. The inconsistencies can be attributed to differences in technique used for assessment of NMC, selection of smokers, and variations in the smoking habit amongst individuals. However, this motivated us to conduct this study to compare the NMC in nonsmokers and smokers using the saccharin test. We also further evaluated the influence of duration of the smoking habit on NMC.

MATERIALS AND METHODS

The study was conducted in Sri Ramachandra University, Chennai. A total of sixty males (30 smokers and 30 nonsmokers; $n = 60$) belonging to the age range of 21-40 years were selected by convenient sampling to participate in the study. We included only males in the study since literature search yielded information in favor of a lesser prevalence of smoking amongst females in the study area.^[17] Subjects who were suffering from any upper respiratory tract infections, COPD or systemic illnesses; or having history of intake of any medications (particularly antihistaminics and antidepressants) were excluded from the study. Other exclusion criteria included the presence of deviated nasal septum, nasal polyp, and nasal allergy; which were identified by the investigator who also conducted a routine ear, nose, and throat (ENT) examination. A detailed history regarding their smoking habits (self-reported) as to the duration of smoking in years, form of tobacco smoked (e.g., cigarette and bidi), and the number of cigarettes or bidis smoked per day was elicited.

The saccharin test was carried out on all subjects by the method described by Andersen *et al.*, in 1974 and later modified by Rutland and Cole.^[18,19] Saccharin test is considered to be the standard method of measuring NMC. A 0.5 mm of saccharin particle was placed approximately

1 cm behind the anterior end of inferior turbinate. The test is carried out in sitting position with head fixed about 10 degrees to avoid the particle from falling backwards into any posterior nasal stream and patient should not be told about the nature of particle. It is important not to place it too far anterior, as clearance time is forwards rather than backwards. The subject should be instructed not to snuff, eat, drink, or swallow and to avoid coughing and sneezing if possible. The room environment should be devoid of dust and must not be breezy. The time elapsing until the first experience of sweet taste at posterior nasopharynx is recorded as NMC time in seconds. In our test, a single examiner performed the test, once in all subjects to avoid interobserver variation in measurement technique. We requested the study subjects to refrain from smoking from 10 pm (previous night) to 9 am (next day), after which the test was performed. Subjects who had defaulted were excluded from the study. The test was performed in all subjects in 3 days between 9 and 11 am in the same examination lounge.

Having collected the data, statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 15. Student's *t*-test was used to compare the mean NMC duration between smokers and nonsmokers. One-way A nalysis of variance (ANOVA) was used to analyze the influence of duration of the smoking habit on NMC amongst smokers. $P < 0.05$ was considered to be statistically significant.

RESULTS

The mean age of the participants ($n = 60$) of the study was 26.8 ± 1.2 years for nonsmokers ($n = 30$) and 24.96 ± 1.0 years for smokers ($n = 30$). Mean NMC of the smokers (481.2 ± 29.83 s) was significantly higher than that of nonsmokers (300.32 ± 17.4 s; $P < 0.01$) [Figure 1]. It was also observed that the mean NMC increased as the duration of smoking increased (NMC in smoking <1 year = 492.25 ± 79.93 s, NMC in smoking for 1-5 years = 516.7 ± 34.01 s, and NMC in smoking >5 years = 637.5 ± 28.49 s; F statistic = 20.8968, $P = 0.0000$) [Figure 2].

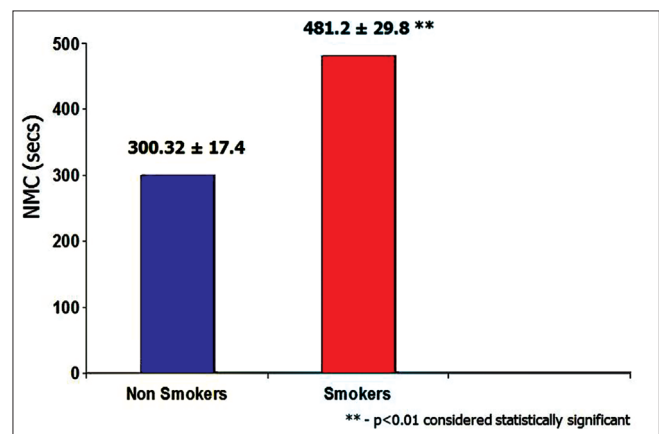


Figure 1: Comparison of nasal mucociliary clearance (NMC; nonsmokers vs smokers)

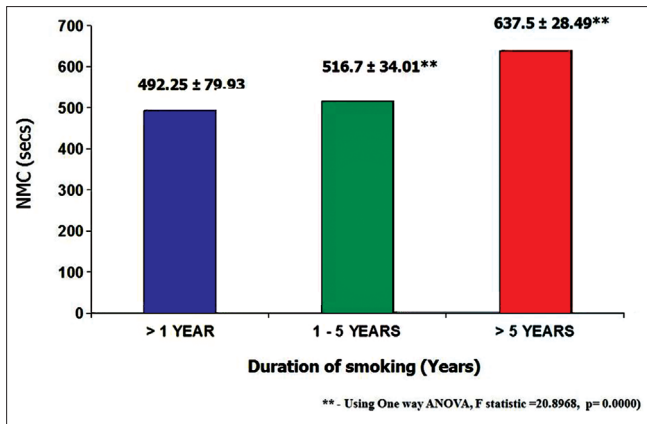


Figure 2: Comparison of NMC based on duration of smoking

DISCUSSION

Various reports reveal an impaired mucociliary clearance in people with allergic tendencies, bronchial asthma, chronic rhinitis, sinusitis and women with prolonged biomass fuel exposure with the impaired clearance usually attributed to ciliary damage as well as altered secretions.^[1,20] Whilst techniques to measure clearance time in trachea and bronchi are time consuming, cumbersome and expensive, measurement of NMC using saccharin test serves as a good alternative and is representative of clearance in trachea and bronchi.^[18] Various studies state that the saccharin test is a simple, inexpensive technique to measure NMC with good coefficient of repeatability.^[12]

NMC of smokers was significantly prolonged ($P < 0.01$) in comparison to smokers in our study. Similar results were also observed in three other reports.^[13,21,22] The prolonged NMC in smokers may be attributed primarily to the ciliostatic effect of tobacco smoke.^[23] The defective clearance seen in cigarette smokers may also be due to reduction in number of cilia or changes in the viscoelastic properties of mucus. Prolonged NMC causes stagnation of mucus and impaired mucus drainage, thereby predisposing to infections. Further, impaired drainage causes altered levels of complements, lysozymes, and immunoglobulins resulting in poor immunological protection and increased incidence of nasal allergies.^[24] However, Quinlan *et al.*, did not observe any such difference in NMC.^[25]

Further, the NMC increased with an increasing duration of smoking with subjects who had smoked for more than 5 years having a much more delayed clearance time. This was also evident in the studies of Ranga *et al.*, who has reported an increase in clearance time as the duration and number of cigarettes smoked increased.^[26]

It can be also inferred from other studies that the persons smoking bidi/unfiltered cigarettes had significant depression of ciliary activity. But we could not arrive at inferences in this regard as all our subjects smoked only

cigarettes. We failed to objectively assess the effect of passive smoking in nonsmokers who also worked in the same work atmosphere as smokers. We also did not attempt to assess the correlation between NMC and the number of cigarettes smoked per day. Also, there are few reports which contradict our views by stating that prolonged NMC in smokers is less likely to be due to slowed ciliary beat frequency. Large-scale studies incorporating electron microscopic study of the cilia could throw more light on as to what could be the more precise reason for a prolonged NMC in smokers.

CONCLUSIONS

NMC measurement is a simple and useful index for the assessment of effect of smoking on the ciliary activity of respiratory mucosa. Prolonged clearance observed in smokers of our study may be due to slowed ciliary beat frequency or reduction in number of cilia and changes in viscoelastic properties of mucus. Our study impresses upon the important role of mucociliary clearance in the health of sinonasal cavities.

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