RESEARCH PAPER

Evaluation of Nasal Mucociliary Clearance by the Saccharin Test: Comparison Between Healthy Individuals and Patients with Sinonasal Diseases – A 10-Year Experience in a Tropical Population

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ABSTRACT

Background: Nasal mucociliary clearance (MCC) is a vital defence mechanism of the respiratory tract responsible for removing inhaled particles, microorganisms, and mucus from the nasal cavity. Impairment of MCC contributes to the pathophysiology of several sinonasal disorders. The saccharin test is a simple, non-invasive, and widely used method for assessing nasal mucociliary function.

Objective: To evaluate nasal mucociliary clearance using the saccharin test in patients with sinonasal diseases and compare the findings with those of healthy individuals in a tropical population.

Materials and Methods: This prospective observational study was conducted over a 10-year period (2015–2024) in the Department of ENT at a tertiary care hospital. A total of 4,826 patients with sinonasal diseases (Group A) and 9,652 healthy volunteers (Group B) aged >10 years were included. MCC was assessed using the standard saccharin test by recording the time taken to perceive a sweet taste after placement of a saccharin particle on the inferior turbinate.

Results: The mean MCC time in healthy individuals was 7.88 ± 1.47 minutes, while patients with sinonasal diseases showed significantly prolonged MCC time (17.45 ± 1.33 minutes, $p < 0.0001$). Smokers among healthy participants had higher MCC time (9.40 ± 1.02 minutes) compared with non-smokers (6.92 ± 0.57 minutes, $p < 0.0001$). Additionally, 12% of healthy individuals had MCC time >10 minutes, of whom 9% demonstrated sinusitis-related radiological changes.

Conclusion: Mucociliary clearance is significantly impaired in sinonasal diseases. The saccharin test is a simple and cost-effective tool for evaluating mucociliary function and may be useful for routine clinical screening.

Keywords: Nasal mucociliary clearance; saccharin test; sinonasal diseases; chronic rhinosinusitis; mucociliary dysfunction.

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INTRODUCTION

Nasal mucociliary clearance (MCC) is a critical defence mechanism of the respiratory system, responsible for the removal of inhaled particles, pathogens, and debris. This process depends on the coordinated activity of ciliated epithelial cells and the rheological properties of mucus.

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Impairment of MCC can result in stagnation of secretions, predisposing individuals to recurrent infections and chronic inflammation of the upper respiratory tract [1].

Sinonasal diseases, including chronic rhinosinusitis with or without nasal polyposis, are frequently associated with MCC dysfunction. Pathological changes such as reduced ciliary beat frequency, altered mucus composition, or epithelial damage prolong MCC time, highlighting the importance of evaluating mucociliary function for diagnosis, disease monitoring, and assessment of treatment response [2,3].

Various methods exist to assess MCC, including radioactive tracer tests, dye clearance tests, charcoal tests, modified saccharin tests, and the standard saccharin test [4,5]. Among these, the saccharin test is simple, non-invasive, and cost-effective. It involves placing a small particle of sodium saccharin on the inferior turbinate and recording the time until the subject perceives a sweet taste, reflecting mucociliary transport function [6].

Comparative assessment of MCC between healthy individuals and patients with sinonasal diseases provides insight into the extent of dysfunction and allows early detection of subclinical impairment [7]. Environmental and lifestyle factors, such as smoking, further compromise MCC by inducing oxidative stress, inflammation, ciliary abnormalities, mucus hypersecretion, connective tissue damage, and airflow obstruction [8].

Despite its clinical importance, limited long-term data exist on MCC in tropical populations, where environmental conditions may influence nasal physiology. Therefore, this study aimed to evaluate nasal mucociliary clearance using the saccharin test over a ten-year period in a tropical population, comparing healthy individuals with patients affected by sinonasal diseases to establish its clinical relevance in ENT practice.

MATERIALS AND METHODS

Study Design and Setting

This prospective, non-randomized observational study was conducted over a ten-year period (2015–2024) at the Department of ENT of a tertiary care centre in a tropical population. The study aimed to evaluate nasal mucociliary clearance (MCC) using the saccharin test in patients with sinonasal diseases compared to healthy controls. Two groups were included: patients with sinonasal diseases (Group A) and healthy volunteers (Group B). Ethical approval was obtained from the Institutional Ethics Committee (IEC) and the Research Advisory Committee (RAC).

Study Participants

Group A comprised 4,826 patients (both genders, aged >10 years) diagnosed with various sinonasal diseases presenting to the ENT department. **Group B** included 9,652 healthy volunteers, including hospital staff, relatives, and patient companions, aged >10 years, who consented to participate.

Inclusion Criteria:

- Age >10 years.
- Diagnosed sinonasal disease for Group A or healthy volunteer status for Group B.
- Written informed consent for study participation and use of photographs for research purposes.

Exclusion Criteria:

- Acute rhinosinusitis or allergic rhinitis.
- Prior sinonasal surgery.
- Current use of medications affecting the nasal mucosa (antihistamines, anticholinergics, nasal steroids, or long-term decongestants).
- Uncontrolled diabetes mellitus.
- Incomplete or unreliable clinical data.

All participants underwent a detailed clinical history and ENT examination prior to saccharin testing.

Saccharin Test Procedure

Nasal MCC was assessed using the standard saccharin test. A 1 × 1 mm sodium saccharin particle was placed 1 cm posterior to the anterior end of the inferior turbinate to avoid the squamous epithelium. Participants were seated with the head slightly inclined forward and instructed to breathe normally, avoiding sneezing, nose blowing, or consuming substances that could interfere with the test.

Participants indicated when they perceived a sweet taste, and the time was recorded using a stopwatch. If no taste was detected within 60 minutes, a saccharin particle was placed on the tongue to rule out taste dysfunction. The most patent nostril was selected based on visual inspection, cold spatula test, or cotton wool test.

Saccharin placement was performed under direct visualization (Figure 1), and endoscopic images were captured to document particle position on the inferior turbinate (Figure 2). All tests were performed and analysed by a single observer using a standardized protocol to ensure consistency.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD) and range. Normality of data distribution was assessed prior to analysis. Independent sample t-tests were used to compare mean MCC times between groups, while categorical variables were compared using the Chi-square test. A two-sided p-value <0.05 was considered statistically significant. All analyses were conducted using **SPSS version 21.0** (IBM Corp., Armonk, NY, USA). Missing data and outliers were addressed according to standard statistical protocols.

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Figure 1: Placement of saccharin particle under direct visualization during assessment of nasal mucociliary clearance

Figure 2: Endoscopic view demonstrating saccharin particle positioned 1 cm posterior to the anterior end of the inferior turbinate

OBSERVATION & RESULTS

A total of 4826 patients with various sinonasal diseases and 9652 healthy controls were recruited in the study. In diseased group 45% patients were males and 55% were females where as in healthy group 58% individuals were males and 42% were females and the difference between genders in both the groups was statistically significant.

Table 1. Age-wise distribution and mean nasal mucociliary clearance (MCC) time in patients with sinonasal diseases

Age Group (years)	Number of Patients	Percentage (%)	Mean Saccharin Test Time (minutes)
10–20	482	10	15.21
21–30	1640	34	19.02
31–40	1206	25	18.21
41–50	724	15	16.04
51–60	580	12	16.66
61–70	194	4	17.49
Total	4826	100	17.45

The study included patients in the diseased group aged 10–70 years, with age distribution and mean nasal mucociliary clearance times as detailed in Table 1.

Table 2. Occupational distribution and mean nasal mucociliary clearance (MCC) time in patients with sinonasal diseases

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Occupation	Number of Patients	Percentage (%)	Mean Saccharin Test Time (minutes)
Students	1,447	30	16.98
Housewives	1,547	32	18.20
Labourers	482	10	17.69
Farmers	386	8	17.01
Not working	289	6	18.43
Business/Office job	675	14	17.41
Total	4,826	100	17.45

In the diseased group, participants belonged to various occupational categories, with the majority being housewives (32%) and students (30%). The distribution of occupations along with their mean nasal mucociliary clearance (MCC) times is presented in Table 2.

Table 3. Distribution of sinonasal diseases and mean nasal mucociliary clearance (MCC) time

Nasal Pathology	Number of Patients	Percentage (%)	Mean Saccharin Test Time (minutes)
Chronic rhinosinusitis	1,979	41	17.27
Chronic rhinosinusitis with nasal polyposis	1,544	32	19.41
Antrochoanal polyp	965	20	16.01
Inverted papilloma	48	1	18.49
Nasal malignancy	290	6	16.78
Total	4,826	100	17.45

This study included patients with various sinonasal diseases, categorized into specific subgroups as shown in Table 3. The majority of patients were diagnosed with chronic rhinosinusitis (41%) and chronic rhinosinusitis with nasal polyposis (32%). The distribution of sinonasal pathologies along with their mean nasal mucociliary clearance (MCC) times is presented below.

Table 4. Mean nasal mucociliary clearance time in healthy individuals and patients with sinonasal diseases

Group	Number of Participants	Mean MCC Time (minutes)	Standard Deviation (SD)	P-value
Healthy	9,652	7.88	1.47	<0.0001
Sinonasal Diseases	4,826	17.45	1.33	

This study compared nasal mucociliary clearance (MCC) time between patients with sinonasal diseases and healthy individuals. The mean MCC time in healthy individuals was 7.88 ± 1.47 minutes, whereas patients with sinonasal diseases had a significantly prolonged mean MCC time of 17.45 ± 1.33 minutes. This difference was statistically significant ($p < 0.0001$), indicating impaired nasal mucociliary function in the diseased group (Table 4).

Table 5. Mean nasal mucociliary clearance time in smokers and non-smokers among healthy individuals

Smoking Status	Number of Participants	Percentage (%)	Mean MCC Time (minutes)	Standard Deviation (SD)	P-value
Non-smokers	5,888	61	6.92	0.57	<0.0001
Smokers	3,764	39	9.40	1.02	

The study also assessed the effect of active smoking (current and former smokers) on nasal mucociliary clearance (MCC) in healthy individuals. The mean MCC time was significantly higher in smokers (9.40 ± 1.02 minutes) compared to non-smokers (6.92 ± 0.57 minutes), indicating that smoking adversely affects nasal mucociliary function ($p < 0.0001$) (Table 5).

Table 6. Distribution of healthy individuals based on saccharin test time

Saccharin Test Time in Healthy Individuals	Number	Percentage (%)	Mean Time (minutes)	Standard Deviation (SD)	P-value
≤10 minutes	8,494	88	7.42	0.81	<0.0001
>10 minutes	1,158	12	11.27	0.48	

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Upon evaluation of the results, it was observed that in the control group, 88% of individuals had a nasal mucociliary clearance (MCC) time of ≤10 minutes, whereas 12% of healthy individuals had an MCC time of >10 minutes. This difference was found to be statistically significant (Table 6). Further evaluation of the 12% (n = 1,158) individuals with MCC time >10 minutes revealed that 9% (n = 869) demonstrated sinusitis-related changes on X-ray of the paranasal sinuses.

DISCUSSION

Nasal mucociliary clearance (MCC) is a critical defence mechanism of the respiratory tract, facilitating the removal of inhaled particles, pathogens, and mucus. Impairment of MCC contributes significantly to the development and persistence of sinonasal disorders. This study assessed MCC using the saccharin test in a large cohort of patients with sinonasal diseases and healthy individuals over ten years in a tropical population.

The concept of MCC was first described by **Sharpey W. (1835)**,[9] highlighting the role of ciliary activity in mucus transport, and later expanded by **Hilding A, (1932) [10]** through experimental studies on sinus drainage. Subsequent research has emphasized its clinical importance in maintaining sinonasal physiology and preventing infection.

In this study, **4,826 patients with sinonasal diseases** and **9,652 healthy individuals** were evaluated. Patients exhibited significantly prolonged MCC times (**17.45 ± 1.33 min**) compared with healthy individuals (**7.88 ± 1.47 min; p < 0.0001**), indicating substantial mucociliary impairment. These results are consistent with prior reports by Pandya V, **et al. (2006)**, [11] **R C, and Mishra P, (2023),** [12] and **Caponnetto P, et al. (2024)**,[13] supporting the saccharin test as a reliable clinical tool.

Age and occupation influenced MCC. Most patients were aged **21–30 years (34%)**, followed by **31–40 years (25%)**, reflecting higher disease burden among young adults. Housewives demonstrated longer MCC times (**18.20 min**) than students (**16.98 min**), likely due to greater exposure to indoor pollutants such as cooking fumes and dust, in line with **Gül Soylu Özler (2019)** [14].

Among sinonasal disorders, **chronic rhinosinusitis (41%)** and **chronic rhinosinusitis with nasal polyposis (32%)** were most prevalent. Patients with nasal polyposis had the highest MCC times (**19.41 min**), reflecting severe mucociliary dysfunction from chronic inflammation, mucosal edema, ostial obstruction, and altered mucus properties, consistent with study by **Afolabi OA, et al. (2024)**. [15] Geographic and climatic factors may also contribute; faster MCC in this tropical cohort likely reflects higher humidity and temperature supporting optimal mucus viscosity and ciliary activity.

Smoking was identified as a significant factor influencing MCC. In the present study, 39% of healthy individuals were smokers, with mean MCC time of 9.40 ± 1.02 minutes versus 6.93 ± 0.56 minutes in non-smokers ($p < 0.0001$). This supports previous findings by **Mahmud A, et al (2022)** [8] and **Proença M, et al. (2010),** [16] demonstrating that tobacco smoke reduces ciliary beat frequency, increases mucus viscosity, and induces mucosal inflammation, resulting in delayed mucociliary transport.

Austero RM et al. (2022) [4] reported comparable MCC times between saccharin (14.48 minutes) and charcoal (14.78 minutes) tests ($p = 0.531$), supporting the reliability and practicality of the saccharin test in clinical assessment. In the present study, 88% of healthy individuals had MCC time ≤10 minutes, whereas 12% exhibited prolonged MCC (>10 minutes), and 9% of these individuals showed sinusitis-related radiological changes, suggesting that MCC assessment may detect subclinical sinonasal pathology.

Although advanced techniques such as radioisotope scanning and high-speed video microscopy provide precise evaluation, the saccharin test remains a simple, non-invasive, and cost-effective tool. Despite the large sample size and long study duration, limitations include the indirect nature of saccharin testing and potential environmental influences. Future studies incorporating objective measurement techniques may further elucidate mucociliary dysfunction in sinonasal diseases.

Overall, this study demonstrates that mucociliary clearance is significantly impaired in patients with sinonasal disorders and influenced by pathology, smoking, occupational, and environmental factors. Early assessment using the saccharin test facilitates timely diagnosis, identification of subclinical disease, and improved management of sinonasal conditions in routine otorhinolaryngological practice.

CONCLUSION

The present study emphasizes the important role of nasal mucociliary clearance (MCC) as a primary defence mechanism of the nasal cavity and demonstrates its significant impairment in various sinonasal diseases. Over a 10-year period, 4,826 patients with sinonasal diseases and 9,652 healthy individuals were evaluated using the saccharin test. Patients with sinonasal diseases demonstrated significantly prolonged MCC time compared with healthy controls (17.45 ± 1.33 minutes vs. 7.88 ± 1.47 minutes; $p < 0.0001$), indicating substantial mucociliary dysfunction in these conditions.

Among healthy individuals, smokers demonstrated significantly prolonged MCC time compared with non-smokers, highlighting the adverse impact of smoking on mucociliary function. Furthermore, some apparently healthy individuals with prolonged MCC time showed radiological evidence of sinusitis, suggesting that impaired mucociliary clearance may serve as an early indicator of underlying sinonasal pathology. Overall, the findings indicate that the saccharin test is a simple, non-invasive, and cost-effective method for assessing nasal mucociliary function and may serve as a valuable screening tool in routine otorhinolaryngological practice.

Funding, Conflict of Interest, and Ethical Approval

This study received no external funding, and the authors declare no conflicts of interest. Written informed consent was obtained from all participants for study participation and the use of clinical images; for minors, consent was provided by parents or legal guardians. The study protocol

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was approved by the Institutional Ethics Committee (IEC) and the Research Advisory Committee (RAC), and all procedures were conducted in accordance with institutional and national ethical standards for human research.

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