RESEARCH PAPER

A PROSPECTIVE OBSERVATIONAL STUDY ON THE SEQUELAE OF LONG-TERM TRACHEOSTOMY ON NASAL MUCOSA

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ABSTRACT

BACKGROUND: Tracheostomy is a commonly performed procedure in critically ill patients requiring prolonged airway support. While its respiratory benefits are well established, the long-term effects on the nasal mucosa due to bypassing normal airflow remain underexplored. The absence of nasal airflow may lead to mucosal disuse atrophy, impaired mucociliary clearance, and structural alterations.

AIM: To evaluate changes in mucociliary clearance and structural integrity of the nasal mucosa in patients undergoing long-term tracheostomy (≥4 weeks).

MATERIALS AND METHODS: This prospective observational study included patients undergoing tracheostomy and requiring tube placement for at least four weeks. Saccharin transit time was measured soon after the procedure and repeated after four weeks. Nasal mucosal assessment was performed using scrape cytology and punch biopsy from the inferior turbinate under local anesthesia. Cytological and histopathological analyses were conducted to evaluate epithelial integrity, ciliary presence, inflammation, and structural alterations.

RESULTS: The study demonstrated a significant prolongation of saccharin transit time after four weeks, indicating impaired mucociliary clearance. Cytological analysis showed a reduction in ciliated columnar cells with an increase in squamous cells, suggestive of metaplasia. Histopathological findings revealed epithelial thinning, goblet cell depletion, inflammatory cell infiltration, and early fibrosis in some cases.

CONCLUSION: Long-term tracheostomy leads to significant functional and structural changes in the nasal mucosa, primarily due to the absence of physiological airflow. These changes may predispose patients to nasal dryness, crusting, infection, and impaired mucosal defense. Early identification and implementation of supportive measures such as humidification and nasal care are essential to mitigate these effects.

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INTRODUCTION

Tracheostomy is among the most commonly performed procedures in the Otorhinolaryngology practice. Patients with acute respiratory failure, difficult airway, in patients requiring prolonged mechanical ventilation, constitute few absolute indications for tracheostomy. Some of the indications for tracheostomy are prolonged ventilator dependence or prolonged endotracheal tube, prophylactic tracheostomy prior to head and neck cancer, subglottic stenosis. Mucociliary clearance is a very important protection system for the protection of nose from the harmful molecules and allergens. With this system, the mucus formed in the nasal mucosa is mobilised by the movement of nasal cilia, and the particles are delivered through the nose to the nasopharynx through this movement. The particle that reaches the nasopharynx is either swallowed or removed orally.[2] With a tracheostomy, specially with cuffed tracheostomy tube, the lower airway is separated from upper airway and is shortened from trachea to alveoli, reducing the dead space. Because tracheostomy bypasses the upper airway, nasal physiology is affected. Most notably, nasal mucociliary clearance is altered, along with alterations in nasal airflow and nasal cycle.[1] The important functions of nose are altered as it is not exposed to airflow or air currents thereby setting in disuse atrophy of nasal mucosa, drying of mucosa, loss of olfaction, change in pH, change in viscosity of mucous, probable altered mucociliary function.[2] While the various respiratory and mechanical ventilation related complications of tracheostomy have been studied and debated widely, little is known about the effect of tracheostomy on the nasal airway. This study helps to identify potential cases where mucociliary clearance can be altered. In such patients prophylactic and therapeutic steps can be taken to minimize alternation of mucosa and subsequently mucociliary clearance thereby reducing morbidity

AIM AND OBJECTIVES

AIM

To study the changes in mucociliary clearance and integrity of nasal mucosa in patients on tracheostomy tube for four weeks or more.

OBJECTIVES

To perform saccharin test and document saccharin transit time soon after tracheostomy and four weeks later.

To perform scrape cytology and punch biopsy from the inferior turbinate under local anesthesia soon after tracheostomy and four weeks later.

To compare mucociliary clearance time and nasal mucosal changes determined by cytology and histopathology before and after four weeks of tracheostomy.

REVIEW OF LITERATURE

The incidence of tracheostomies performed has been increasing worldwide with the advancements in critical care and growing numbers of admissions in intensive care. Among the patients admitted to intensive care unit, tracheostomy is being performed in approximately 10-15% of patients.[3]

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Rao A, Prerit et al[4] performed a study on nasal mucus ciliary clearance in prolonged tracheostomized patients and found that there is prolonged saccharin test indicating a reduction of nasal mucociliary clearance following tracheostomy. Nasal mucociliary clearance is an important primary defense mechanism in nose and paranasal sinus, which is dependent on various factors and can be impaired due to environmental factors, patient factors, and disease factors[4] A study by Mohammad El-Sharouby et al.[5] discovered that following tracheostomy, there was an increase in quantity of mucous glands and their secretions as well as an increase in mucociliary clearance of the nose. However, over time, the opposite happens as a result of prolonged airflow restriction on the mucosa, which increases the likelihood of nasal mucosal atophy. Saccharin has been described as a quick, easy, reliable, and secure way to assess mucociliary clearance. Saccharin transit time can be measured with a reasonable degree of sensitivity and repeatability. According to the study, this test is a crucial physiological effect indicator for identifying early changes in respiratory health.[6] Since nose is no more a part of respiratory system, the nasal functions are altered. Functionally nasal cycles are abolished, decreased olfactory acuity, raised mucosal temperature and nasal pH changes towards alkaline side.[7] The temperature of inferior turbinate in tracheostomised patients is 12° C above normal healthy person. These changes in nose are responsible for improvement of mucociliary activity and decrease in nasal mucociliary activity thereby decrease in nasal mucociliary function.[7,8]

METHODOLOGY

This prospective observational study was conducted in the Department of Otorhinolaryngology at Sri Devaraj Urs Medical College and Research Centre, after obtaining ethical clearance (SDUAHER/KLR/R&D/CEC/S/PG Dissertation/106/2024-2025). The study included 50 patients aged above 18 years who underwent tracheostomy and required the tracheostomy tube to remain in place for at least four weeks. Ethical approval was obtained from the institutional ethics committee before commencement of the study.

INCLUSION CRITERIA

Patients aged ≥18 years

Patients undergoing tracheostomy who provided informed consent

EXCLUSION CRITERIA

Pre-existing sinonasal pathology

Known ciliary motility disorders

Previous head and neck radiotherapy

Altered taste sensation

Baseline evaluation included detailed history, clinical examination, and nasal endoscopic assessment. Mucociliary clearance was assessed using the saccharin transit time (STT) test. A 1-mm saccharin particle was placed on the anterior end of the inferior turbinate under endoscopic visualization, and the time taken for the patient to perceive a sweet taste in the throat was recorded.

Nasal mucosal samples were collected using scrape cytology from the inferior turbinate and stained using Leishman and hematoxylin-eosin stains. Additionally, punch biopsy of the inferior turbinate was performed under local anesthesia for histopathological examination. These assessments were performed at baseline and repeated at four weeks after tracheostomy. Statistical analysis was performed using SPSS software. Continuous variables were expressed as mean ± standard deviation and analyzed using paired t-tests and ANOVA. A p-value <0.05 was considered statistically significant.

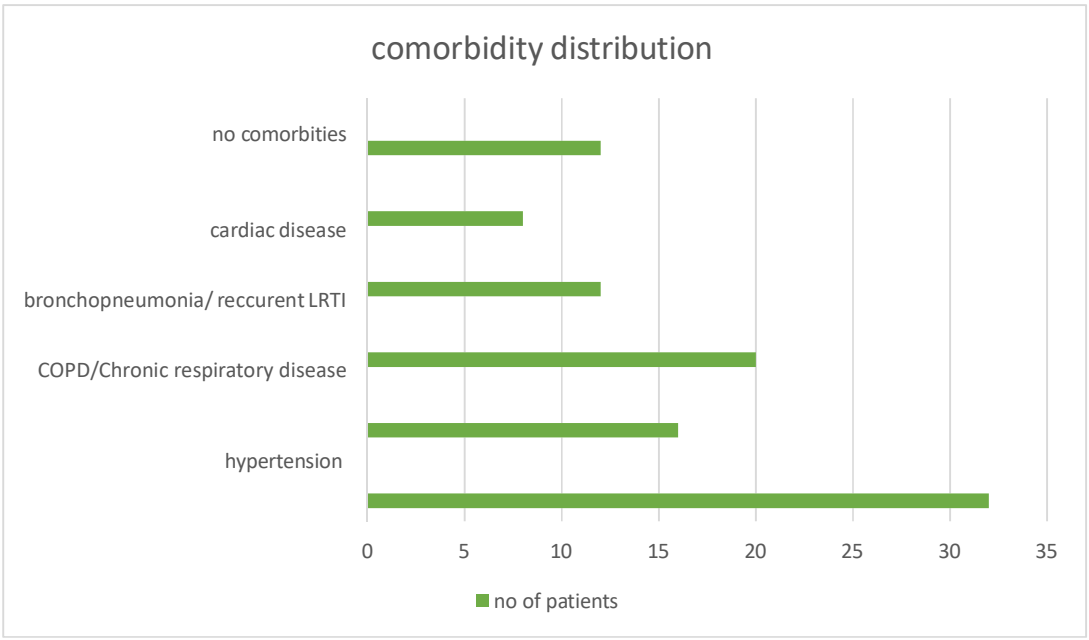
RESULTS

Diagnosis Category	Elective tracheostomy (%)	Emergency tracheostomy (%)	Total
Organophosphorus (OP) poisoning	8 (16%)	0	8
Other poisoning	2 (4%)	0	2
Bronchopneumonia / aspiration pneumonia	3 (6%)	0	3
COPD / status asthmaticus	3 (6%)	0	3
Stroke / CVA with neurological deficit	5 (10%)	0	5
Head injury / neurosurgical causes	5 (10%)	0	5
Ludwig's angina	0	4 (8%)	4
Deep neck space infections	0	4 (8%)	4
Cut throat injuries	0	4 (8%)	4
Upper airway tumors / growths	0	4 (8%)	4
Subglottic stenosis	0	3 (6%)	3
Laryngotracheal injury	0	1 (2%)	1
Post-operative airway complication	0	1 (2%)	1
Other medical causes (electrocution, septic encephalopathy, cord compression)	3 (6%)	0	3
Total	29 (58%)	21 (42%)	50 (100%)

A total of 50 patients were included in the study. The mean age of the participants was 46.04 ± 16.17 years, indicating a wide distribution across adult age groups. Patients with poisoning, trauma, neurological disorders, and deep neck space infections constituted the majority of tracheostomy indications. However, no strong association was observed between the underlying diagnosis and epithelial type at week 4.

Diagnosis wise distribution of study participants

Among patients with diabetes mellitus, 75% showed prolonged saccharin transit time, whereas patients with chronic respiratory disease demonstrated 80% prevalence of impaired mucociliary clearance. In contrast, patients without comorbidities showed relatively preserved mucociliary function.



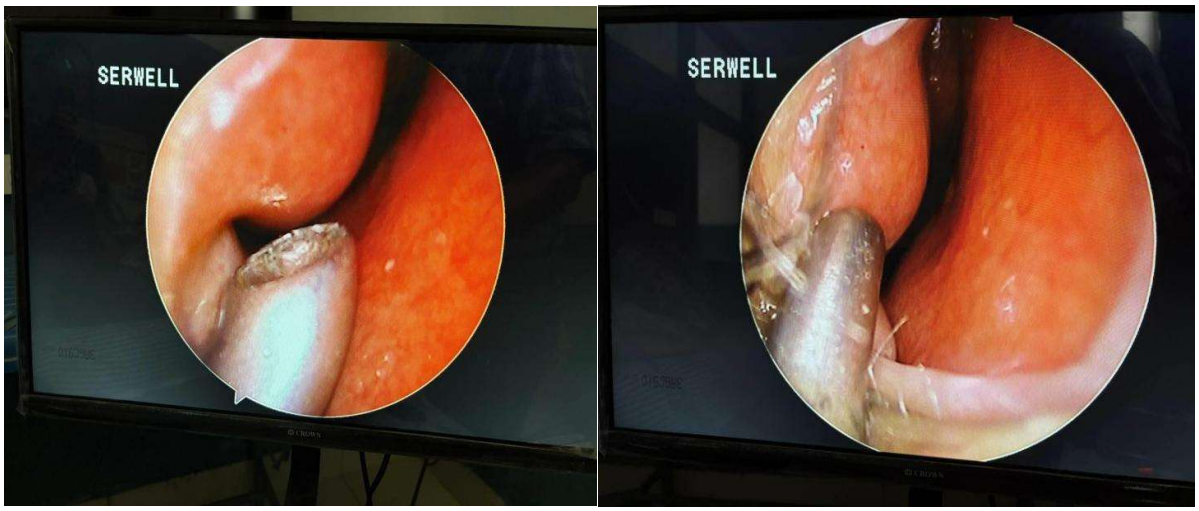
Comorbidity wise distribution of participants

The mean saccharin transit time showed a progressive increase over the study period. At baseline (Day 0), the mean STT was 28.94 ± 2.06 minutes. This increased to 30.86 ± 2.16 minutes at Week 1, 32.78 ± 2.20 minutes at Week 2, and 35.82 ± 2.32 minutes at Week 4. The increase was statistically significant ($p < 0.0001$).

Variable Comparison	**Mean ± SD**	**t-value**	**p-value (2-tailed)**
Saccharin Transit Time Day 0 – Week 4	-6.88 ± 1.42	-34.178	<.001

Paired t-test analysis between Day 0 and Week 4 showed a mean difference of −6.88 ± 1.42 minutes, with a t-value of −34.178 ($p < 0.001$), indicating a significant deterioration in mucociliary clearance over time.

Post-hoc analysis demonstrated significant differences between all time points, confirming progressive impairment of mucociliary clearance during the four-week period following tracheostomy.



At baseline, pseudostratified ciliated epithelium was present in all patients (100%). After four weeks of tracheostomy, pseudostratified epithelium was observed in 26 patients (52%), whereas 24 patients (48%) showed stratified squamous epithelium, indicating squamous metaplasia.

Cellularity, which was moderate in all cases initially, was reduced in all patients by week 4. Similarly, mucous glands that were adequate at baseline were found to be mildly reduced in all patients at the end of four weeks.

No significant association was found between nasal mucosal condition and epithelial type at week 4 ($p = 0.918$). Similarly, septal deviation and turbinate changes did not demonstrate a statistically significant correlation with epithelial changes.

Cytomorphology			Number of Patients	Percentage	P value
Cellularity	Day 0	High	50	100.0%	NA
	Week 4	Moderate to low	50	100.0%	
	Day 0	Adequate squamous & mucinous	50	100.0%	
	Week 4	Reduced squamous & mucinous	50	100.0%	
	Day 0	Lymphocytes & plasma cells	50	100.0%	
	Week 4	Few lymphocytes	50	100.0%	

Overall, the results indicate progressive mucociliary dysfunction and structural changes in nasal mucosa following prolonged tracheostomy.

DISCUSSION

A study by Prerit Rao et al. [4] evaluated nasal mucociliary clearance in patients with prolonged tracheostomy using the saccharin test and reported significantly prolonged saccharin transit time in tracheostomized patients compared with healthy controls (mean 934.97 s vs 447.4 s; $p < 0.001$). The findings of the present study are consistent with these observations, demonstrating that absence of normal nasal airflow leads to decreased stimulation of nasal mucosa and reduced ciliary activity.

Restrepo et al.[9] also demonstrated that bypassing the upper airway leads to decreased mucosal hydration and reduced ciliary activity, contributing to impaired mucociliary clearance. These findings support the present study, which showed a progressive increase in saccharin transit time over four weeks.

Studies evaluating nasal mucociliary clearance using the saccharin test have demonstrated that several factors influence mucociliary transport time, including smoking, infections, environmental factors, and mucosal pathology. For instance, Dülger et al.[10] reported that exposure to irritants such as cigarette smoke significantly prolongs mucociliary clearance time due to toxic effects on ciliary activity and mucus properties. These findings support the concept that environmental and physiological changes affecting the nasal mucosa can alter mucociliary function.

Similarly, conditions that disrupt the integrity of nasal mucosa or ciliary function have been shown to prolong mucociliary transport time. Structural alterations of the mucosa following surgery or chronic inflammation may also influence mucociliary clearance. A study by Aroor et al.[11] evaluating mucociliary clearance following nasal surgery demonstrated that mucosal injury and healing processes may temporarily affect mucociliary function, further emphasizing the importance of intact nasal mucosa for normal clearance mechanisms.

Histological examination in the present study revealed transformation of pseudostratified ciliated epithelium into stratified squamous epithelium in nearly half of the patients. Such squamous metaplasia represents an adaptive response to chronic mucosal dryness and absence of physiological airflow. Similar epithelial changes have been noticed by ibrahim et al.[2]

Furthermore, reduced cellularity and glandular activity observed in the current study suggest mucosal atrophy and decreased mucus production. These changes can compromise mucosal defense mechanisms, predisposing patients to infections and crusting.

The influence of systemic comorbidities on mucociliary clearance was also evident in this study. Patients with diabetes mellitus and chronic respiratory diseases demonstrated a higher prevalence of mucociliary dysfunction, these findings are consistant with study by Muller et al.[12] This also may be attributed to underlying metabolic and inflammatory alterations affecting mucosal structure and ciliary activity as observed by Raby. et al,.[13]

Overall, the findings of this study emphasize that prolonged tracheostomy not only affects the lower airway but also leads to significant functional and structural alterations in the nasal mucosa.

STRENGTHS AND LIMITATIONS

STRENGTHS

Prospective observational design

Combined functional and histopathological assessment

Serial follow-up evaluation over four weeks

LIMITATIONS

Relatively small sample size

Short follow-up duration

Lack of control group for comparison

FUTURE SCOPE

Future research should include larger multicentric studies with longer follow-up periods to better understand the long-term effects of tracheostomy on nasal mucosa. Additionally, evaluating preventive strategies such as humidification therapy, nasal saline irrigation, and mucosal protective agents may help reduce mucosal damage in tracheostomized patients.

CONCLUSION

The present study demonstrates that long-term tracheostomy results in significant functional and structural alterations in the nasal mucosa. Progressive prolongation of saccharin transit time indicates deterioration of mucociliary clearance. Histopathological examination revealed epithelial changes including squamous metaplasia, reduced cellularity, and decreased glandular activity.

These findings suggest that diversion of normal airflow through tracheostomy leads to mucosal disuse atrophy and impaired mucosal defense. Early recognition and appropriate supportive measures such as humidification and nasal care may help minimize these adverse effects and improve patient outcomes.

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