International Journal of Otorhinolaryngology and Head and Neck Surgery
Bhaskara PC. Int J Otorhinolaryngol Head Neck Surg. 2019 May;5(3):644-649
http://www.ijorl.com
pISSN 2454-5929 | eISSN 2454-5937

Original Research Article

DOI: http://dx.doi.org/10.18203/issn.2454-5929.ijohns20191721

Impact of active smoking on nasal functions in patients with allergic rhinitis

Pratibha Chamarajanagara Bhaskara, Anita Ross*, Neha Gupta

Department of Otorhinolaryngology Head and Neck Surgery, St. John's Medical College Hospital, Bangalore, Karnataka, India

Received: 11 October 2018
Revised: 06 March 2019
Accepted: 07 March 2019

***Correspondence:**
Dr. Anita Ross,
E-mail: canitaross@gmail.com

ABSTRACT

Background: Allergic rhinitis is an important health problem in view of its prevalence and its impact on patients' social life, school performance and work productivity. Smoking is known to affect the asthmatic airway inflammation. The additional effect of smoking in impairment of nasal functions in patients with allergic rhinitis is a subject of interest. The aim and objective of this study was to study the effect of active tobacco smoke on mucociliary clearance and olfactory thresholds in allergic rhinitis.
Methods: A descriptive observational pilot study was carried out on 40 patients of allergic rhinitis. Nasal mucociliary clearance was measured by saccharine transit time and olfactory threshold test was measured by butanol threshold test score.
Results: The saccharine transit time was significantly prolonged in smokers as compared to nonsmokers. Amongst the subgroups of allergic rhinitis mucociliary clearance was found to be more prolonged with the severity of allergic rhinitis. Butanol threshold test scores were significantly lower in smokers when compared to non- smokers. Amongst the subgroups of allergic rhinitis olfactory threshold was found to be lower with the severity of allergic rhinitis.
Conclusions: In the current study we found that nasal functions were significantly impaired in smokers with allergic rhinitis. This indicates that smoking leads to worsening of symptoms in allergic rhinitis.

Keywords: Allergic rhinitis, Smoking, Saccharine transit time, Butanol threshold test, Nasal mucociliary clearance

INTRODUCTION

Allergic rhinitis is an important health problem in view of its prevalence and its impact on patients' social life, school performance and work productivity. It represents a global health problem affecting 10% to 20% of the population. A survey conducted by Bosquet et al showed that 92.2% of patients with allergic rhinitis had an impairment of quality of life.[1]

Smoking is known to affect the asthmatic airway inflammation. The additional effect of smoking in impairment of nasal functions in patients with allergic rhinitis is a subject of interest.

In patients with allergic rhinitis, rhinorrhea aids in washing of stimulating allergens from nasal epithelium. Smoking leads to impairment of mucociliary clearance (MCC) and this leads to stasis of secretions in smokers with allergic rhinitis, thus worsening the symptoms of allergic rhinitis.[2-5] Airborne toxins from cigarette smoke cause damage to the olfactory neuroepithelium thus causing olfactory disturbance.[6]

Allergic rhinitis can hamper nasal functions which can be measured in terms of Mucociliary clearance and Olfactory Threshold scores. Through our study we have attempted to quantify impact of smoking on nasal functions including MCC and olfactory threshold.

Aims and objectives

- To study the effect of active tobacco smoke on mucociliary clearance and olfactory thresholds in allergic rhinitis.

METHODS

A descriptive observational pilot study was carried out on 40 patients of allergic rhinitis (smokers and non-smokers) presenting to outpatient department of ENT of St. John's Medical College Hospital, between 10-60 yrs of age during July 2011 to February 2013.

Patients with sinusitis, nasal polyposis, bronchial asthma, non-allergic rhinitis, pregnant females, individuals on prolonged use of topical decongestants, recent use of anti-histamines, substance abuse, psychotropic medication, those with comorbid conditions like hypertension, diabetes mellitus, chronic obstructive pulmonary disease, coronary artery disease, malignancy, immunocompromised states and thyroid disorders, conditions such as rhinitis medicamentosa, PNS malignancies and those who did not give consent were excluded from the study.

All patients were recruited on a voluntary basis after informed consent and were evaluated with nasal endoscopy, skin prick test, nasal function test as measured by saccharine transit time and olfactory threshold test as measured by butanol threshold test score.

Mucociliary clearance (MCC) as measured by saccharine transit time (STT)

Patients were instructed to avoid local anaesthetic drops, analgesics, barbiturates, tranquilizers, antidepressants and alcohol or caffeine based substances for at least 12 hours before the test.

Patient was seated comfortably with head slightly extended, and a 6 mg particle of saccharine was placed 2 cm inside an unobstructed nostril at the anterior end of inferior turbinate under visual guidance. A timer with second's clock was used to measure transit time. The time from particle placement until the first perception of a sweet taste in the mouth was recorded. Patients were asked to maintain normal ventilation, avoiding deep breaths, talking, sniffing, sneezing, eating, or coughing. Patients were also instructed to avoid excessive swallowing. Following the test of one nostril patients were asked to rinse mouth with water. The same procedure was repeated in the other nostril.

If the sensation did not occur within 60 minutes, the test was stopped and the subject's ability to perceive the taste of saccharin was verified by placing it on the tongue. If the subject was able to taste the saccharin directly, the test procedures were repeated on another occasion.

Olfactory threshold level as measured by butanol threshold test (BTT)

This involved a forced-choice test using an aqueous concentration of butyl alcohol in one sniff bottle and water (non-odorant liquid) in the other. The BTT composed a series of 12 concentrations of *N*-butanol which were 3-fold serially diluted from 100% *N*-butanol (solvent used was water) concentration level 1(4% butanol) to concentration level 12(0.004% butanol).[7]

Patient was seated with eyes closed and non test nostril was blocked using a cotton plug. Two bottles (water & butyl alcohol in various concentration) were given to the patient to sniff. Patient selected the bottle that they believed contained the odor. A gap of 30 seconds was maintained before offering the next concentration level. After each incorrect response, the concentration of butanol was increased to two higher concentrations until the patient either achieved 3 correct responses or failed to correctly identify the bottle with 4% butanol. After each correct response the concentration was decreased to the immediate lower concentration level. A score was calculated as the average of last three correctly identified concentration levels.

BTT scores were interpreted as follows:

- Anosmia - score 0 to 3,
- severe hyposmia - score 4 to 5,
- moderate hyposmia - score 6 to 8,
- mild hyposmia - score 9 to 10,
- normosmia - score 11 to 12.

This scoring relates the patient's butanol threshold to a normal subject population. The BTT was performed in each nostril separately.

Statistical methods

All data are presented as mean±SD. Categorical data are presented as number and percentage. Data were analyzed within two groups of smokers and non –smokers. The mean difference in the STT and BTT values between smokers and non-smokers, males and females were examined using independent t-test or Mann Whitney U test as appropriate. For non-parametric variables, correlation coefficient was calculated using Spearman's rank correlation. A coefficient value <0.5 was considered as no correlation, 0.5-0.8 as good correlation and >0.8 as excellent correlation. Statistical significance was considered as $p<0.05$. All analyses were carried out in SPSS version 17.0 (SPSS Inc, Chicago, III).

RESULTS

Among the 40 patients included in the study 20 were smokers (group I) and 20 non smokers (group II). Average age of population was 33.98±10.2 years, with the majority (50% smokers & 65%nonsmokers) being in 25-40 year age group. The average number of cigarettes smoked per day was 10.3± 7.8 with average number of years of smoking being 9.9±8.9 years. The average number of pack years smoked was 6.3±7.6 pack years. We compared the STT and BTT among smokers and nonsmokers, in the entire group and in same age group, in same subtype of allergic rhinitis, between males of both the groups and females of both the groups. These parameters were also compared within smokers with reference to the number of pack years smoked.

The saccharine transit time was significantly (p=0.01) prolonged in smokers as compared to non smokers (Figure 1).

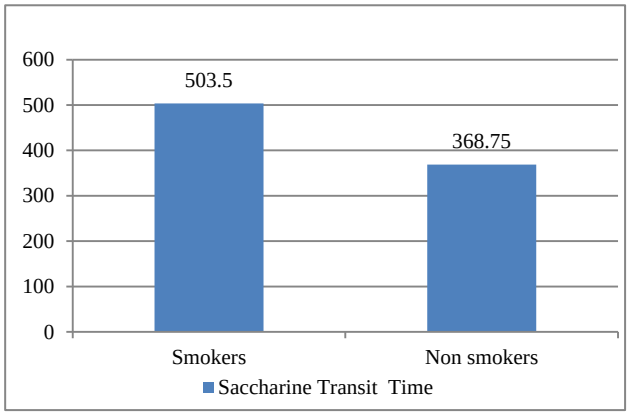

Figure 1: Saccharine transit time (in seconds) comparison between smokers and nonsmokers.

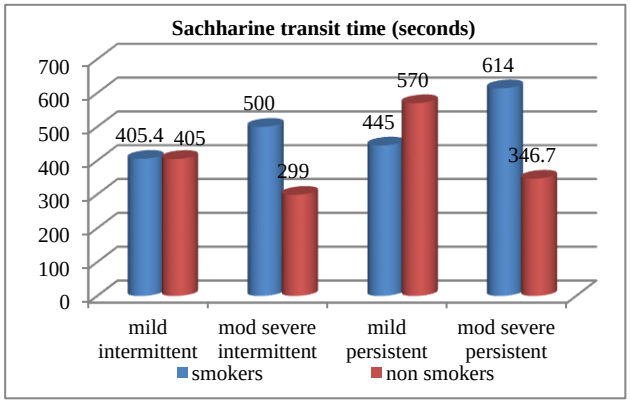

Figure 2: STT (seconds) comparison between smokers and nonsmokers in each subtype of allergic rhinitis.

Amongst the subgroups of allergic rhinitis MCC was found to be more prolonged with the severity of allergic rhinitis. STT was significantly (p=0.016) prolonged in patients with moderate severe persistent allergic rhinitis when compared to other subgroups (Figure 2).

The prolongation of MCC was found to have a good positive correlation (Pearson correlation coefficient 0.639) with the number of pack years and this correlation was found to be significant (p=0.002).

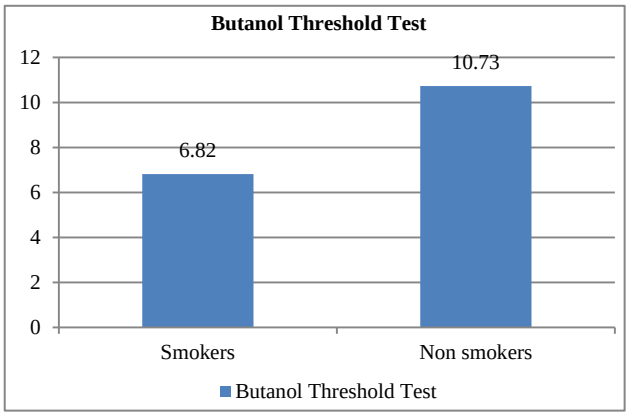

Figure 3: Butanol threshold test comparison between smokers and non smokers.

Butanol threshold test scores were significantly (p≤0.001) lower in smokers when compared to non- smokers (Figure 3). 10% of smokers had anosmia, and 40% had severe hyposmia. Among non-smokers i.e. patients who were only suffering from allergic rhinitis 50% were normosomic and 35% had mild hyposmia.

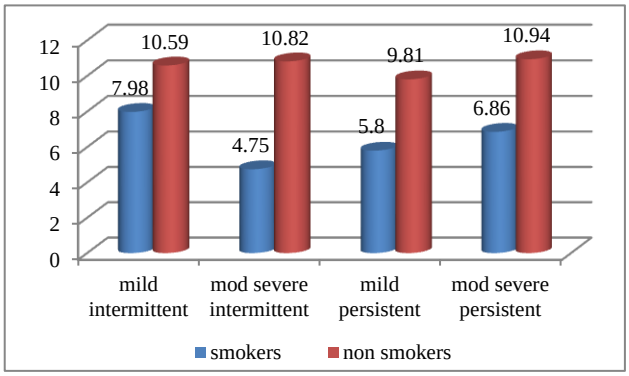

Figure 4: BTT score comparison between smokers and nonsmokers in each subtype of allergic rhinitis.

Amongst the subgroups of allergic rhinitis olfactory threshold was lower with the severity of allergic rhinitis (significantly decreased in patients with moderate severe persistent allergic rhinitis when compared to other subgroups) (p=0.003) (Figure 4). The decrease in olfactory threshold score was found to have a good negative correlation (correlation coefficient =-0.611) with the number of pack years smoked (p=0.004).

Amongst the male subjects with allergic rhinitis, olfactory threshold scores were significantly lower in smokers as compared to non smokers. Among the smokers average Butanol threshold test score for males was 7.6±2.9 and for females was 10.7±1.2. Among nonsmokers average Butanol threshold test score for

males was 10.7±1.4 and for females was 10.7±1.3. The difference in BTT between smokers (male) and nonsmokers (male) was found to be significant (p=0.002). The comparison between female smoker and nonsmokers was not done due to lack of adequate numbers (one female in group I).

DISCUSSION

Allergic rhinitis is one of the most common forms of rhinitis. In patients with allergic rhinitis, rhinorrhoea aids in the washing of stimulating allergens from nasal epithelium. Smoking leads to impairment of MCC by toxin induced inhibition of ciliogenesis, blunting of ciliary epithelium, ultrastructural distortion and increased mucus production.[2,3,8-15] This leads to stasis of secretions in smokers with allergic rhinitis, thus worsening the symptoms of allergic rhinitis. [4,5]

Airborne toxins from cigarette smoke causes damage to the olfactory neuroepithelium thus causing olfactory disturbance.[6] Through our study we have attempted to quantify impact of smoking on nasal functions including MCC and olfactory threshold.

Mucociliary clearance

Nasal mucociliary clearance can be measured by two methods- direct and indirect. Direct method includes stroboscopic, microcinematographic, or micro-ossilographic methods to observe ciliary movements. Indirect methods include the saccharine test and Tc 99m studies in which the movement of the mucosal layer from anterior to posterior is observed with various indicators and the clearance time is calculated.

MCC measurement using Saccharine was described by Anderson et al later modified by Rutland and Cole.[16,17] It has been reported that there was no significant difference between the results of technetium Tc 99m technique and STT measurement.[18,19] In our study, we preferred the saccharine test because it can be obtained more easily and it is more economical than Tc99m.

Mehra et al reported the normal value of nasal mucociliary clearance in healthy Indian subjects as 5.06 minutes; however range of 3.3 to 3.5 minutes has been reported in western countries in adults.[20,21]

Mahakit et al studied MCC using saccharine granules in smokers, patients with allergic rhinitis, sinusitis and normal healthy subjects.[22] A significant ($p<0.05$) difference was found in MCC between patients with allergic rhinitis and normal subjects. They found a significant difference in MCC of smokers and patients with sinusitis when compared to the normal subjects ($p<0.05$). In our study too, we found that MCC (measured as STT) was significantly (p=0.01) prolonged in smokers as compared to non smokers.

Sun et al evaluated nasal MCC using technetium 99M-labeled macro aggregated albumin (tc-99m MAA) rhinoscintigraphy in patients with allergic rhinitis.[23] By tracing the course of Tc-99m MAA using gamma camera they found that MCC is decreased in patients with allergic rhinitis.

Proenca et al studied the STT in nonsmokers and smokers (immediately after smoking and eight hours after smoking).[24] The STT values eight hours after smoking was significantly prolonged (p=0.005 versus non-smokers, and p=0.003 versus immediately after smoking).

Stanley et al, Cohen et al and Leopald et al studied the pathophysiology of increase in MCC in smokers.[2,15,25] Cohen et al showed that ciliary beats were diminished as a result of exposure to tobacco smoke, thus impairing MCC.[2] Stanley et al described that mucociliary transport was slower in regular smokers.[25] Leopald et al demonstrated that cilia of smokers are 10% shorter than those of nonsmokers thus decreasing the MCC.[15]

In the present study STT values among smokers and nonsmokers were compared within each subgroup of allergic rhinitis. In patients with moderate severe persistent allergic rhinitis this difference in STT values was significant. This could be attributed to a greater number of patients in this subgroup of allergic rhinitis. Future studies can be done with more number of patients in each subgroup of allergic rhinitis so as to get a uniform data for comparison.

In our study we did not find any statistically significant difference in STT values of smokers (p=0.12) and nonsmokers (p=0.9) of different age groups. Our study results were similar to Mortensen et al who found that there is no statistically significant correlation between age and nasal MCC.[26] On the contrary, James et al have shown that over the age of 40 years nasal MCC is prolonged.[27] Puchell et al also indicated that mucociliary activity in volunteers aged >54 years is lower than younger volunteers due to mucosal atrophy.[28]

Olfactory threshold test

During the past two decades, a number of standardized olfactory tests have been developed. Both subjective and objective test are available. Subjective test include test for odor identification, odor discrimination and olfactory threshold. University of Pennsylvania Smell Identification Test (UPSIT), Connecticut Chemosensory Clinical Research Center Test (CCCRC), Cross-Cultural Smell Identification Test (CC-SIT), Sniffing Sticks test (using n butanol in various dilutions) and Smell Identification Test (SIT) are some of the kits available. In the present study butanol threshold test was used to determine the olfactory threshold.

Objective test for olfaction includes electro physiologic tests using olfactory event related potentials. This tool is a diagnostic method to confirm anosmia. It is more valuable as a research tool, as is functional MRI.[29]

Cowart et al conducted a study of olfactory function in allergic rhinitis patients.[30] Detection thresholds were significantly elevated for patients when compared with controls (23.1% of patients with allergic rhinitis exhibited clinically significant olfactory decrements).

Doty et al studied odor identification ability in a group of 638 subjects (179 smokers, 197 ex-smokers and 262 normal subjects) using 40-odorant UPSIT.[6] They showed that current smokers were nearly twice as likely to have an olfactory deficit in comparison to the persons who have never smoked. They also concluded that smoking adversely influences odor identification ability in a dose-related manner in both present & past smokers.

BTT in various subgroups of allergic rhinitis

According to allergic rhinitis and its impact on asthma guidelines, patients with allergic rhinitis have been divided into various subgroups namely mild intermittent, mild persistent, moderate severe intermittent and moderate severe persistent allergic rhinitis.

In the present study majority (42.5%) belonged to moderate severe persistent allergic rhinitis subgroup. Least (15%) number of patients were in moderate severe intermittent allergic rhinitis subgroup.

The BTT score was found to worsen with the increasing severity of allergic rhinitis. The BTT score in moderate severe persistent allergic rhinitis smokers was 6.85 and in mild intermittent allergic rhinitis smokers was 7.9.

BTT in smokers and nonsmokers with allergic rhinitis

Among the smokers majority had severe hyposmia (40%). 10% of the patients had anosmia. Only 5% of the smokers were normosmic. Among nonsmokers majority were normosomic (50%). The rest had mild to moderate hyposmia.

The BTT score of smokers and non smokers within each subgroup of allergic rhinitis was compared. The BTT score in moderate severe persistent allergic rhinitis with history of smoking was 6.86 and was 10.94 in nonsmokers. This mean difference was found to be significant (p=0.003). In the other subgroups this mean difference was not significant.

CONCLUSION

In the current study we found that nasal functions were significantly impaired in smokers with allergic rhinitis. MCC as measured with saccharine transit time was significantly prolonged in smokers as compared to non smokers with allergic rhinitis. The difference in STT values among smokers and nonsmokers was significant in patients with moderate severe persistent allergic rhinitis. Olfactory threshold scores measured as Butanol threshold test scores were significantly lower in smokers when compared to non smokers with allergic rhinitis. Amongst the subgroups of allergic rhinitis olfactory threshold was more decreased with the severity of allergic rhinitis. The MCC and olfactory threshold scores were found to have a good correlation with the number of pack years in smokers.

The derangement in nasal functions in smokers with allergic rhinitis is an interesting finding which indicates that smoking leads to worsening of symptoms in allergic rhinitis. Though this may not have any immediate applicability to treatment if this condition, it helps in understanding the nature of disease progression. Further evaluation with a larger population is required to validate these results.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Bousquet PJ, Bousquet-Rouanet L, Co Minh HB, Urbinelli R, Allaert FA, Demoly P. ARIA classification of Allergic Rhinitis severity in clinical practice in france. Int Arch Allergy Immunol. 2007;143:163-9.
2. Cohen NA, Zhang S, Sharp DB, Tamashiro E, Chen B, Sorscher EJ, et al. Cigarette smoke condensate inhibits transepithelial chloride transport and ciliary beat frequency. Laryngoscope. 2009;119(11):2269-74.
3. Stanley PJ, Wilson R, Greenstone MA, MacWilliam L, Cole PJ. Effect of cigarette smoking on nasal mucociliary clearance and ciliary beat frequency. Thorax. 1986;41:519-23.
4. Baena-Cagnani, Gómez RM, Baena-Cagnani R, Canonica GW, The impact of environmental tobacco smoke and active tobacco smoking on the development and outcomes of asthma and rhinitis. Current Opinion Allergy Clin Immunol. 2009;9(2):136-40.
5. Topp R, Thefeld W, Wichmann HE, Heinrich J. The effect of Environmental tobacco smoke(ETS) exposure at home or at work on Allergic Sensitization and Allergic Rhinitis in adults. Indoor Air. 2005;15(4):222-7.
6. Doty RL. Clinical Studies of Olfaction. Chem Senses. 2005;30(1):207–9.
7. Croy I, Lange K, Krone F, Negoias S, Seo HS, Hummel T. Comparison between Odor Thresholds for Phenyl Ethyl Alcohol and Butanol. Chem Senses. 2009;34:523–7.

8. Wanner A, Salathe M, O'Riordan TG. Mucociliary clearance in the airways. Am J Respir Crit Care Med. 1996;154:1868-902.
9. Isik AC, Yardimci S, Guven C, Avunduk MC, Civelek S. Morphologic alteration induced by short-term smoke exposure in rats. ORL J Otorhinolaryngol Relat Spec. 2007;69:13-7.
10. Wyatt TA, Gentry-Nielsen MJ., Pavlik JA, Sisson JH. Desensitization of PKA-stimulated ciliary beat frequency in an ethanol-fed rat model of cigarette smoke exposure. Alcohol Clin Exp Res. 2004;28:1998-2004.
11. Gudis DA, Noam A. Cohen, Cilia Dysfunction. Otolaryngologic Clin N Am. 2010;43(3):461-72.
12. Gensch E, Gallup M, Sucher A, Li D, Gebremichael A, Lemjabbar H. Tobacco smoke control of mucin production in lung cells requires oxygen radicals AP-1 and JNK. J Biol Chem. 2004;279:39085-93.
13. Takeyama K, Jung B, Shim J.J, Burgel PR, Dao-Pick T, Ueki IF. Activation of epidermal growth factor receptors is responsible for mucin synthesis induced by cigarette smoke. Am J Physiol Lung Cell Mol Physiol. 2001;280:L165-72.
14. Kreindler JL, Jackson AD, Kemp PA, Bridges RJ, Danahay H. Inhibition of chloride secretion in human bronchial epithelial cells by cigarette smoke extract. Am J Physiol Lung Cell Mol Physiol 2005;288:894-902.
15. Leopold PL, O'Mahony MJ, Lian XJ, Tilley AE, Harvey B-G, Crystal RG. Smoking Is Associated with Shortened Airway Cilia. PLoS ONE. 2009;4(12):e8157.
16. Andersen I, Lundqvist G, Jensen PL, Philipson K, Procter DF. Nasal clearance in monozygotic twin. Am Rev Respir Dis. 1974;110:301-5.
17. Rutland J, Cole PJ. Non-invasive sampling of nasal cilia for measurement of beat frequency and study of ultrastructure. Lancet. 1980;2:564-5.
18. Sakakura Y, Sasaki Y, Togo Y, Wagner HN, Hornick RB, Schwartz AR, et al. Mucociliary Function during Experimentally Induced Rhinovirus Infection in Man. Ann Otol Rhinol Laryngol. 1973;82(2):203–11.
19. Quinlan MF, Salman SD, Swiet DL. Measurement of mucociliary function in man. Am Rev Respir Dis. 1969;99:13-23.
20. Mehra YN, Mann SBS, Mehra S, Verma A, Mittal A. Cryosurgery in Vasomotor rhinitis:An analysis of 156 patients. Indian J Otolaryngol. 1990;42:95-8.
21. Yadav J, Ranga RK, Singh J, Gathwala G. Nasal mucociliary clearance in healthy children in a tropical country. Int J Paed Otorhinolaryngol. 2001;57:21-4.
22. Mahakit P, Pumhirun P. A Preliminary Study of Nasal Mucociliary Clearance in Smokers, Sinusitis and Allergic Rhinitis Patients. Asian Pacific J Allergy Immunol. 1995;13:119-21.
23. Sun SS, Hsieh JF, Tsai SC, Ho YJ, Kao CH. Evaluation of nasal mucociliary clearance function in allergic rhinitis patients with technetium 99M-labelled macroaggregated albumin rhinoscintigraphy. Ann Otol Rhinol Laryngol 2002;111(1):77-9.
24. Proenca M, Fagundes Xavier R. Immediate and short term effects of smoking on nasal muco-ciliary clearance in smokers. Revista Portuguesa de Pneumologia. 2011;17(4):172-6.
25. Stanley PJ, Wilson R, Greenstone MA, MacWilliam L, Cole PJ. Effect of cigarette smoking on nasal mucociliary clearance and ciliary beat frequency. Thorax. 1986;41:519-23.
26. Mortensen J, Lange P, Jorgen N, Groth S. Lung mucociliary clearance. Eur J Nucl Med. 1994;21:953-61.
27. Ho JC, Chan KN, Hu WH. The effect of aging on nasal mucociliary clearance, beat frequency, and ultrastructure of respiratory cilia. Am J Respir Cit Care Med. 2001;163:983–8.
28. Puchell E, Aug F, Pham QT, Bertrand A. Comprasion of methods for measuring nasal mucociliary clearance in man. Acta Otolaryngol. 1981;91:297–303.
29. Kalogjera L, Dzepina D. Management of Smell Dysfunction Curr Allergy Asthma Rep. 2012;12:154–62.
30. Cowart BJ, Flynn-Rodden K, McGeady SJ, Lowry LD. Hyposmia in allergic rhinitis. J Allergy Clin Immunol. 1993;91:747–51.

Cite this article as: Bhaskara PC, Ross A, Gupta N. Impact of active smoking on nasal functions in patients with allergic rhinitis. Int J Otorhinolaryngol Head Neck Surg 2019;5:644-9.