

The effect of functional endoscopic sinus surgery on nasal resonance

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Abstract

Background and objective: Functional endoscopic sinus surgery (FESS) increases the nasal volume, and thereby it can alter the nasal resonance. The objectives were to measure the percentage of nasal resonance following FESS and compare it with healthy individuals with normal nasal findings.

Methods: The nasometric analysis of voice was done using n/p/m consonant sounds in 72 individuals with healthy post FESS cavities (group 1) and 72 healthy individuals with normal nasal findings without any nasal pathology (group 2). The scores of nasal resonances were expressed in percentages and were compared between the two groups. Both in group 1 and group 2, 32 (44.4%) were females, and 40(55.6%) were males. In group 1, 51 participants had bilateral FESS cavities, and 21 had unilateral FESS cavities. Kannada was the mother tongue in 30 (41.7%) participants in group 1 and 36 (50.0%) in group 2. Malayalam was the mother tongue in 42(58.3%) participants in group 1 and 36 (50.0%) in group 2.

Results: In both cases and control groups, more than 80% of the participants were showing less than 20% of nasal resonance. In group 1, the mean values of n/p/m sounds were 11.23%, 10.23% and 11.42% respectively, and in group 2 the mean values were 8.27%, 8.58% and 8.58% respectively. But the *P* value was not statistically significant. Individuals with unilateral FESS cavities had more nasal resonance values compared to bilateral FESS cavities. Similarly, Kannada speaking people had more values compared to Malayam speaking individua.

Conclusion: Changes in nasal resonance after FESS is minimal, and it is unnoticed. But it may affect the speech quality in professional voice users, depending on their language. Though the nasometer is considered as the most validated instrument to record nasal resonance, we feel that further standardization is needed to evaluate the nasalance.

KEYWORDS

Functional endoscopic sinus surgery, Nasal resonance, Nasometry

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INTRODUCTION

The most important factor for the determination of speech quality is nasal resonance. Any obstruction to nasal airways, such as nasal polyposis, septal deviation etc. may reduce nasality. Nasal and oral sounds measured as nasality which is calculated as nasal acoustic energy divided by nasal and oral acoustic energy.¹ Nasometry is an objective technique that measures the nasality of the speech. It is considered as the most valid instrument for the analysis of nasal resonance.² Nasometer consists of a simple headset with microphones placed on the top and bottom of a plate that collects energy from the oral cavity and nasal cavity separately and computes nasalance¹ and value is expressed in terms of percentage. Nasal resonance/nasality are usually measured for standardised (oral and nasal) sentences, sustained vowels (a/e/i/o/u) and sustained consonants (m/n). Following functional endoscopic sinus surgery (FESS), the volume of the nasal cavity increases, which causes hypernasalance.³ A significant increase in the nasalance scores in post FESS cases when preoperative scores are compared with post-operative scores.^{4,5} In the majority of studies, preoperative nasalance scores were compared with postoperative scores of the same patients. We feel that inflamed and oedematous mucosa in rhinosinusitis and nasal polyposis can substantially change the nasalance. This may be the reason for the significant difference in nasalance scores in the post FESS cases. Regional dialect and native language also influence the nasalance score.⁶ Considering these, we have compared the nasalance scores of healthy post FESS cases with nasalance of the individuals with the normal nasal airway. We could not find similar such studies in the English literature where nasalance of post FESS cases are compared with healthy individuals and also nasalance in different languages are compared in post FESS patients.

In this study, nasometric analysis of voice was done using VAGHMI- voice and speech system software in normal and post FESS participants, and the values were compared.

PATIENT AND METHODS

After ethical committee approval and informed consent, nasometric analysis of voice using n/p/m consonant sounds was done in 144 participants. Seventy-two participants with healthy FESS cavities who underwent FESS before six months or earlier were included in group 1 (cases), and 72 participants with normal diagnostic nasal endoscopy (DNE) findings without any nasal pathology were included in group 2 (controls). Out of 72 cases, 51 cases had bilateral FESS cavities, and 21 had unilateral FESS cavities. Nasal pathology like hypertrophied inferior turbinates, deviated nasal septum, concha bullosa, tumours of nose and paranasal sinuses (PNS), allergic rhinitis, obstructive lesions in the oral cavity and oropharynx and active upper respiratory tract infections were excluded in the study. Post FESS cases with recurrence of the diseases were excluded. Patients with cleft lip, cleft palate, uvulopharyngopalatoplasty in the past were also excluded. In group 1, participants ranged from 18 to 63 years with a

mean age of 40.5 years. In group 2, participants ranged from 18 to 72 years with a mean age of 45.0 years. The maximum number of participants was in the range of 31-40 (30.6%) and 41-50 years (30.6%). Both in group 1 and group 2, 32 (44.4%) were females, and 40 (55.6%) were males. Kannada was the mother tongue in 30 (41.7%) participants in group 1 and 36 (50%) participants in group 2. Malayalam was the mother tongue in 42 (58.3%) participants in group 1 and 36 (50.0%) in group 2. All the participants underwent diagnostic nasal endoscopy after a detailed clinical examination. Nasometric analysis of voice for n/p/m consonants sounds using VAGHMI version 8.1 system and speech systems- Bangalore. Voice analysis was carried out prior to diagnostic nasal endoscopy to prevent the decongestant effect of adrenaline as it can alter the nasalance value. Subjects were made to sit comfortably and instructed to produce two trials of sustained consonants/n/p/m/for a minimum of 5 seconds at comfortable phonation. The two microphones of nasometer measure the nasal and oral sound intensities separately and then compute the nasalance. Nasalance was recorded using VAGHMI software. Nasalance is the ratio of acoustic energy output from the nasal and oral cavity of the speaker; it is calculated using the formula given below

$$\text{Nasalance} = \frac{\text{nasal acoustic energy}}{\text{nasal} + \text{oral acoustic energy}} \times 100\%$$

RESULTS

For/n/p/m sounds, the majority of the participants (more than 80%) were showing less than 20% of nasalance scores in both the groups (Table 1).

The mean value for/n/sound in group 1 (cases) was 11.23 with a standard deviation of 17.60 and the median value was 2.45, whereas in group 2 (controls), the mean value was 8.27 with a Standard deviation of 11.25 and the median value 2.00. The *P*-value was 0.792, which was not statistically significant. The mean value for 'm' sound in group 1 was 11.42 with a standard deviation of 16.62, and the median value was 3.25, whereas in group 2, the mean value was 8.58 with a standard deviation of 0.90 and the median value was 2.20. The *P*-value was 0.670, which was not statistically significant. For/p/sound in group 1, the mean value was 10.23 with a standard deviation of 14.19, and the median value was 3.35. In group 2, the mean value was 8.58, with a Standard deviation of 10.38, and the median value was 2.85. The *P*-value was 0.746, which was non- significant (Table 2).

The mean values of nasal resonance for n/p/m sounds in Kannada speaking cases were 14.33%, 10.49%, and 13.45%, respectively, whereas in Kannada speaking, controls were 8.61%, 8.48%, and 8.53%, respectively. The mean values of nasal resonance for n/p/m sounds in Malayalam speaking cases were 9.01%, 10.04% and 9.97%, respectively, whereas, in controls, it was 7.94%, 8.68% and 8.64%, respectively. Again 'P' value was not statistically significant.

TABLE 1 Distribution of nasalance scores for/n/p/m/sounds in controls and cases

Group		N Sound		P Sound		M Sound	
		n	Percentage	n	Percentage	n	Percentage
Cases	<20%	60	83.33	61	84.72	59	81.94
	20%–30%	1	1.39	1	1.39	2	2.78
	>30%–40%	1	1.39	3	4.17	2	2.78
	>40%–50%	4	5.56	7	9.72	4	5.56
	>50%–60%	5	6.94	0	0	5	6.94
	>60%	1	1.39	0	0	0	0
Controls	<20%	60	83.33	64	88.8	61	84.72
	20%–30%	5	6.94	2	2.78	6	8.33
	>30%–40%	6	8.33	5	6.94	4	5.56
	>40%–50%	1	1.39	1	1.39	1	1.39
	>50%–60%	0	0	0	0	0	0
	>60%	0	0	0	0	0	0

TABLE 2 Nasal resonance percentage in cases and controls for n/p/m sounds

Item	Group	n	Mean	Std. Deviation	Median	Mann whitney test 'P' value
N Sound	Cases	72	11.23	17.60	2.45	0.792
	Controls	72	8.27	11.25	2.00	
P Sound	Cases	72	10.30	14.19	3.35	0.746
	Controls	72	8.58	10.38	2.85	
M Sound	Cases	72	11.42	16.62	3.25	0.670
	Controls	72	8.58	10.90	2.20	

*P value- Not significant

Out of the 72 participants in group 1, 51 participants had bilateral healthy FESS cavities, and 21 participants had unilateral healthy FESS cavity. The mean value of the nasal resonance for n/p/m sounds in participants who had bilateral healthy FESS cavities were 10.81%, 9.15% and 10.61%, whereas the mean value of the nasal resonance for the sound n/p/m who had unilateral healthy FESS cavities were 12.23%, 12.84%, and 13.38%. The mean value of the unilateral FESS cavities, when compared with Bilateral FESS cavities and controls, the 'P' value, was not significant (Table 3).

Even after post-hoc power analysis, we could not find any significant difference between unilateral, bilateral FESS cavities, and control for n/p/m sounds.

DISCUSSION

The characteristics of voice are dependent on vocal cords, vocal tract, lungs, and chest. Nasal and oral cavity, paranasal sinuses, pharynx and larynx act as resonators for sound production. Any abnormality or

alteration in the function of these structures can lead to a change in voice.⁷ The patency and volume of the nasal cavity affect the characteristics of the voice.⁸ Nasal resonance is essential in many professionals like singers. The quality of the voice depends on the singer's ability to develop and use the resonators successfully.

The sound produced by the larynx reaches the palatopharyngeal area, and this is directed towards the nasal and oral cavity separately to produce nasal and oral sounds.⁹

Nasal resonance is divided into two types; hypernasality and hyponasality. Hypo nasal speech may be due to obstruction in the nasal cavity due to conditions like septal deviation, choanal atresia, nasal polyps. In contrast, causes for hypernasality are velopharyngeal insufficiency and cleft palate.¹⁰ Nasalance scores less than 20% doesn't indicate hypernasality. Scores between 20%-30% probably indicate hypernasality; scores above 30% are abnormal.¹¹

Several quantitative methods have been proposed to measure the nasal resonance, for example, the Oro-nasal system, nasal view and Oral-nasal coupling index.¹² The need for a reliable, objective measure, along with good validity was largely met with Nasometer.

TABLE 3 Nasalance mean value comparison between FESS cases and controls.

Fess Cavity						
Variable	FESS Cavity	No	Mean	SD	Median	P value
N sound	Bilateral	51	10.81	17.79	2.20	0.426
	Unilateral	21	12.23	17.51	3.90	
	Control	72	8.27	11.25	2.00	
P sound	Bilateral	51	9.15	12.97	2.90	0.524
	Unilateral	21	12.84	16.86	4.60	
	Control	72	8.58	10.38	2.85	
M sound	Bilateral	51	10.61	16.43	2.90	0.553
	Unilateral	21	13.38	17.32	6.30	
	Control	72	8.58	10.90	2.20	

FESS increases the volume of the nasal cavity. De Paula SR et al.⁴ did a study on volume assessment on the FESS cavity using rhinometry. After FESS, the volume of the nasal cavity was increased to 45,16 cm³ from 38,69 cm³.

Nasal surgeries like FESS, septoplasty, and turbinoplasty, can alter the nasal scores in the immediate post operative period, when performed alone or in combination (FESS combined with septoplasty).^{4,5,7,9,12-15}

However, with time, the nasal resonance recovers and gets back to normal. The increase in the nasal resonance immediately after surgery may be due to the crust formation and oedema. The crust may reduce the mucosal vibration and decrease the energy dampening leading to an increase in energy transfer to the nasal cavity. However, with the time crusting decreases, the sinus and nasal cavity heals. The mucosal vibration and dampening function may gradually normalize.

We have compared the nasalance scores of healthy FESS cavities with normal individuals, unlike in other studies where comparison was made between pre- versus post-surgery in the same patient.^{4,5} Preexisting mucosal oedema and inflammation in sinonasal diseases can affect the nasalance. It is compromised in rhinosinusitis and nasal polyposis patients compared to normal individuals. This may be the reason for the significant difference in nasalance scores in these studies. The nasal resonance in healthy control has high variations, which overshadows post-FESS resonance changes, by the high normative standard deviation. Probably these are the reason for no significant differences in nasalance between controls and post-FESS cases in this study.

Nasalance scores and nasal volumes are less in patients who underwent FESS for nasal polyps than those who underwent FESS for other than nasal polyps.⁵ Nasal polyps are known for recurrence, and in the majority of the cases, mucosal oedema persists even after the surgery. This may be the reason for the decrease in nasalance scores and nasal volume in post FESS cavities done for nasal polyps. High nasalance score in unilateral cases probably due to the indications for unilateral FESS. Usual indications for unilateral FESS are chronic rhinosinusitis, fungal sinusitis, etc., and complete recovery

is possible after surgery. While the most common indication for bilateral FESS is nasal polyposis in our center, which is known for recurrence. This may be why low nasalance value in bilateral FESS compared to unilateral FESS cases in this study.

There is no standard method to evaluate nasal resonance and record the nasalance. Evaluation of nasal resonance is mainly perceptive, and it is state of the art. Instrumental evaluation cannot be replaced by perceptual evaluation. As there is no standardised method to record the nasalance, people have used vowels, nasal and oral consonants, oral and nasal sentences, etc. We feel that significant differences in nasalance in different studies, probably due to this reason.

Regional dialect and native language influence the nasalance score. Nasalance scores of people from the Mid-Atlantic dialectal region are high compared to those from Southern and Mid- Western dialectal region.⁶ Similarly, Canadian French nasalance is lower compared to English talkers. Among the Indian language, nasalance score was studied in children for the Marathi language by Nandakumar A, 2002. The sample size was too small in his study ($n = 9$). According to him, nasalance scores of Marathi speaking kids were similar to American English speaking children.¹⁶

In our study nasalance score was slightly higher in Kannada speaking participants compared to Malayalam speaking participants, but it was not statistically significant

CONCLUSION

It is difficult to measure the quality of voice and nasalance, which is more perceptive than the objective. FESS can alter the nasal resonance since these changes are minimal; the change in the quality of voice is insignificant. Language dialect too plays a role in nasal resonance. Though nasometer is considered as the most reliable and validated instrument to record nasal resonance, we feel that further standardization is needed to evaluate the nasalance.

REFERENCES

1. Ronald E. *Measurement of nasal airway//Scott-Brown. Scott-Brown's otorhinolaryngology, head and neck surgery*. 7th ed. London: Hachette Livre; 2008:1375-1376.
2. Bae Y, Kuehn DP, Ha S. Validity of the nasometer measuring the temporal characteristics of nasalization. *Cleft Palate Craniofac J*. 2007;44:506-517.
3. de Paula Santos R, Habermann W, Hofmann T, Stammberger H. Pre and post functional endoscopic sinus surgery nasal cavity volume assessment by acoustic rhinometry. *Braz J Otorhinolaryngol*. 2006;72:549-553.
4. Soneghet R, Santos RP, Behlau M, Habermann W, Friedrich G, Stammberger H. Nasalance changes after functional endoscopic sinus surgery. *J Voice*. 2002;16:392-397.
5. Jiang RS, Huang HT. Changes in nasal resonance after functional endoscopic sinus surgery. *Am J Rhinol*. 2006;20:432-437.
6. Mayo CM, Mayo R. Normative nasalance values across languages. *ECHO*. 2011;6:22-32.
7. Kim SD, Park HJ, Kim GH, Wang SG, Roh HJ, Cho KS. Changes and recovery of voice quality after sinonasal surgery. *Eur Arch Otorhinolaryngol*. 2015;272:2853-2859.
8. Birkent H, Erol U, Ciyiltepe M, Eadie TL, Durmaz A, Tosun F. Relationship between nasal cavity volume changes and nasalance. *J Laryngol Otol*. 2009;123:407-411.
9. Kim YH, Lee SH, Park CW, Cho JH. Nasalance change after sinonasal surgery: analysis of voice after septoturbino-plasty and endoscopic sinus surgery. *Am J Rhinol Allergy*. 2013;27:67-70.
10. Sataloff RT, Heman-Ackah YD, Hawkshaw MJ. Clinical anatomy and physiology of the voice. *Otolaryngol Clin North Am*. 2007;40:909-929v.
11. Kummer AW. *Cleft palate and craniofacial anomalies: effects on speech and resonance*. 2nd ed. New York, NY: Clifton Park; 2008. <https://trove.nla.gov.au/version/44701730>
12. Bressmann T. Comparison of nasalance scores obtained with the nasometer, the nasalview, and the oronasal system. *Cleft Palate Craniofac J*. 2005;42:423-433.
13. Amer HS, Elaassar AS, Anany AM, Quriba AS. Nasalance changes following various endonasal surgeries. *Int Arch Otorhinolaryngol*. 2017;21:110-114.
14. Ozbal Koc EA, Koc B, Ercan I, Kocak I, Tadihan E, Turgut S. Effects of septoplasty on speech and voice. *J Voice*. 2014;28:393.e11-15.
15. Yeğin Y, Çelik M, Şimşek BM, et al. Assessment of effects of septoplasty on acoustic parameters of voice: a prospective clinical study. *Turk Arch Otorhinolaryngol*. 2016;54:146-149.
16. Nandurkar A. Nasalance measures in Marathi consonant-vowel-consonant syllables with pressure consonants produced by children with and without cleft lip and palate. *Cleft Palate Craniofac J*. 2002;39:59-65.

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