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The effects of functional endoscopic sinus surgery and the extent of pathology on speech outcome after surgery

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Abstract: **Objective**: This study aimed to determine both the task of nasal and paranasal sinuses pathologies on the nasal attitude of speech and the impacts of functional endoscopic sinus surgery (FESS) on speech construction and acuity. **Background**: The role of endoscopic functional sinus surgery in improving speech quality is controversial. **Methods**: It is a prospective study that was conducted on 30 patients with chronic rhinosinusitis and nasal polyposis at Otorhinolaryngology Department in Menoufia University Hospital in period between January 2017 and November 2017; 18 males with mean age of 33 yrs. and 12 females with mean age of 31 yrs. Speech assessment was done for all patients before and at least one month after surgery. All patients fulfilled full history, local nasal examination, clinical examination by CT scan to paranasal sinuses, and assessed objectively of nasalized and non-nasalized speech samples using nasameter in addition to auditory perceptual assessment that was conducted by trained phoniatrician. The patients were listed for undergoing endoscopic sinonasal surgery due to chronic inflammatory nasal obstruction. **Results**: Nasal obstruction and speech hyponasality due to chronic rhinosinusitis and nasal polyposis were objectively improved after FESS evident by measuring the nasalance percentage of the mean nasal sentence by nasometer especially in patients with severe nasal and maxillary sinus pathologies with highly significant relation between results recorded before and after surgery. Also, there is significant relation between pre and post-operative nasometric results as regard nasal pressure, nasal flow, nasal sound pressure level/ oral sound pressure intensity. **Conclusion**: FESS results in significant improvement of the degree of hyponasality and speech quality. These findings are affected greatly with the extent of the pathology. FESS significantly affects speech production and perception so, it must be taken in consideration specially when dealing with professional voice user to inform them about these changes. It is observed that patients with nasal cavity and maxillary sinus severe pathologies are the most affected by FES with measurable significant improvement in post-operative speech quality.

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Key words: Sinus surgery, Nasometer, Hyponasality, Speech outcome.

1. Introduction

Speech is produced by modifying the vibrating column of air from the larynx. The larynx produces the vowel sounds and the pitch of the speech. High frequency sounds, the consonants, are added by the pharynx, tongue, lips, and teeth. The nose and paranasal sinuses added quality to this by allowing some air to escape through them [1].

The speech resonates through the nose, the mouth and paranasal sinuses; escaping of small volume of air from the nose subsequently rhinolalia clausa (closed nasality) or what is called hyponasality results, if too much then rhinolalia aperta (open nasality) or hypernasality ensures [2]. The term hyponasal speech may be found in individuals suffering from obstruction in the nose like, nasal polyps, septal deviation and choanal atresia, which leads to narrowing in the nasal airways [3].

The nasometer is an apparatus in the form of microcomputer based device that computes on acoustic extent depending on the ratio of sound intensities originating from oral and nasal cavities in phonation. nasometer is used for measuring of nasalance, where this is parameter of nasality which can be affected by nasal obstruction. The nasalance score is zero with complete nasal obstruction while it is 100% with bilabial nasal consonant /m/ for example [4].

Most surgeries used for treating of chronic inflammation in the sinuses (chronic sinusitis) are aimed to facilitate aeration of the paranasal sinuses. This goal is typically can performed by the subtraction of obstructing soft tissues and bone with increasing in the drainage of sinus ostia. Such alterations in the relationship between different structures in the nose may leading to induce differences in the surface area of the sinonasal air passages and the degree of resistance to air current. The modification of airway passages may be responsible for inducing of an alterations in the resonance distinctiveness and apparent quality of nasally created sound; bilabial /m/, alveolar /n/, and velar /ŋ/ [5,6].

Many studies [5,7,8] reported that patients after endoscopic sinus surgery experienced perceptual changes in their speech and voice. The relation between nasality after FESS is a matter of controversy and hasn't received enough attention by researchers.

This work aimed to determine both the task of paranasal and nasal sinuses pathologies on the nasal attitude of speech and the effects of endoscopic sinus surgery on speech quality for pre-surgical counseling of subjects regarding predictable alterations in speech eminence after operation in the sinus.

2. Patients and methods:

This prospective study was performed on 30 patients; 18 males with age range of 25-41 years (mean age is 33 yrs.) and 12 females with age range of 17-45 years (mean age is 31 yrs.) with chronic rhinosinusitis or nasal polyposis during the period from January 2017 to November 2017.

Ethical consideration:

An informed consent using appropriate language was taken before starting the study. It included Study title, Performance sites, Purpose of the study, Study procedures, Benefits, Risks, Right to refuse and Signature.

The patients were selected according to the following criteria: free from other ear and throat problems, free from any speech disorders and did not undergo any previous nasal surgery to ensure that any alterations caused by surgery would be observed to its maximum extent. Patients were classified into two groups according to severity of pathology based on radiological evaluation; group A (15 patients) with mild to moderate pathology and group B (15 patients) with severe pathology. Exclusion criteria included: (1) Patients with major septal deviation, (2) Patients with uncontrolled hypertension, (3) patients with motor speech disorders, and (4) patients with history of any kind of palatal problems.

All patients were subjected to: *History taking;* the present and the past history of each patient were recorded with special stress on the following questions: duration of nasal obstruction, any precipitating event, whether the condition is continuous or intermittent and whether it is unilateral or bilateral. *Nasal examination;* this included the external appearance of the nose, anterior rhinoscopy was done using light source and nasal speculum, and nasal endoscopy was done to augment the previous measures. *Instrumental assessment*; radiological assessment including computerized coronal and axial tomography with or without contrast and objective analysis of speech samples through using nasometer. *Subjective assessment of speech:* this was done through listening to speech samples of patients pre and post-operatively. This type of assessment is called auditory perceptual assessment (APA).

Speech sample:

The test words are designed to place the nasal consonants in different phonologic environments for APA and nasometric analysis. For this study we used: /mama/ for the bilabial nasal consonant, /banana/ for the alveolar nasal consonant, and /maŋga/ for the velar nasal consonant. In addition to standard Arabic nasal sentence /mama betnaym manal/ and oral sentence /kamal labes kaki/.

Speech assessment was performed one week pre-operatively and at least one month post-operatively through:

(A) APA:

Subjective evaluation of patients' speech in free conversation including speech sample to detected hyponasality, hypernasality, the degree of nasality, consonant imprecision, faulty compensatory mechanisms (glottal articulation and pharyngalization of fricatives), facial grimace, the overall intelligibility of speech, and impacts on patients' life. Audible nasal air emission, overall intelegability of speech and impacts on patients' life; all these parameters are graded on 4-point scale [0=normal and 3= severe affection].

(B) Nasometry:

Nasalance is assessed using Nasometer (Model 6400-2; Kay Elemetrics Corp., Lincoln Park, N.J.). The voice recording instrument has a pair of microphones; one on either side of a sound separator that rested against the upper lip of the patient. Each microphone concerned with measuring nasal and oral sound intensities separately that computed the nasalance in percentage. Nasalance score refers to the ratio of nasal to oral plus nasal acoustic energy. The value can vary from 0% (no sound from nose) as in oral consonants to 100% (all the sound from nose) as in nasal consonants.

Surgical procedure:

All patients were subjected to FESS under general anesthesia with endotracheal intubation through the mouth and using topical epinephrine 1:1000-impregnated pledgets placed in the middle meatus and parallel to the inferior turbinate, one per side. Then the axilla of the middle turbinate anteriorly and the areas of the basal lamella and sphenopalatine branch area posteriorly were injected with 2 ml (1 ml in each side) of 1% lidocaine with 1:100,000 epinephrine. The endoscopic surgery was performed depending on the affected sinuses evaluated during pre-operative CT scan. The surgical procedures were performed according to the guidelines described by Messerklinger and Stammberger [9]. This procedure was performed as indicated with a combination of powered and manual instruments. Finger cot merocels were placed within the middle meatus and silactic stents were fashioned for use in the frontal sinuses as needed. Certain medications such as aspirin, non-steroidal anti-inflammatory drugs and anticoagulant medications were stopped prior to surgery and for a similar period after the surgery.

Statistics:

Data was collected throughout history, basic clinical examination, radiological, nasometric assessment, and APA and outcome measures collected, tabulated and analyzed using Microsoft Excel Software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0, IBM Corp. Released 2011. Armonk, NY, USA). Comparison between pre-operative and late post-operative speech evaluations was performed. Quantitative data was presented as mean and standard deviation (SD) and values compared used paired t-test [10]. $P < 0.05$ was considered as significant and $P < 0.001$ as highly significant. Qualitative data was presented as numbers and corresponding percentages.

3. Results:

The study included thirty Egyptian patients; 12 females (40%) and 18 males (60%), the ages were 17-45 years (mean age at the time of surgery =31 years). Upon reviewing APA results, 10 out of 15 patients (66.7%) from group A presented with hyponasal speech, whereas, 5 patients were normal in speech of the same group. After one month post-operatively, only two patients (13.37%) had hyponasality while the remaining patients (86.7%) showed normal speech. These results showed highly significant relation when compared with pre-operative results (the mean value of nasalance in patients with mild to moderate chronic inflammatory nasal obstruction before surgery was significantly lower than the mean value after surgery, $P < 0.05$). Upon reviewing APA results from group B, we revealed that 13 out of 15 patients (86.7%) presented with hyponasal speech pre-operatively. These results changes to 4 patients (26.7%) presented with hyponasality of low grade and 3 patients (20%) with hypernasality one month post-operatively of highly significant relation when comparing pre-operative with post-operative results (Table. 1).

Table (1): Results of APA pre-operative and post-operative for both groups.

	Group A		**Group B**	
	Pre operative	**1mon post operative**	**Pre operative**	**1mon post operative**
	N (%)	N (%)	N (%)	N (%)
Hyponasal	10 (66.7%)	2 (13.3%)	13 (86.7%)	4 (26.7%)
Hypernasal	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (20%)
Normal	5 (33.3%)	13 (86.7%)	2 (13.3%)	8 (53.3%)
P-value	0.001**		0.04*	

* = significant - ** = highly significant

Table (2): Comparison of the nasalance score of oral sentences (%) in patients pre- and post-operatively according to the extent of pathology.

	pre-operative		**post-operative**		**P value**
	Mean ± SD	**Range**	**Mean ± SD**	**Range**	
Group A (n = 15)	11±4	9-13	13±3	6-17	0.1
Group B (n = 15)	7±5	5-13	19±4	13-21	0.009*
Paired t-test	1.65		7.05		

* = significant

None of patients had unintelligible speech, audible nasal air emission, facial grimace, or faulty compensatory mechanisms pre- or post-operative. Only 2 patients from group B showed post-operative imprecision of consonants and 2 patients had impacts on their lives post-operatively compared with 5 patients pre-operatively (from the same group) with non-significant relation.

As regard the nasalance; In group (A), before operation, the average level of nasalance in subjects was 11±4 (mean ± SD) for oral sentence and 43.83 % with a range of 37.89 % to 50.33% for nasal sentence (taking in consideration that nasalance score of nasal sentence in normal individuals for nasal sentence is 54.7 ± 5.8 %) [4], but this increased to 13±3 for oral sentence and 54.94% with a range of 38.12% to 65.57% for nasal sentence after surgery. The mean values of nasalance score for nasal sentence post-operation were elevated significantly as matched with that before operation (P< 0.05). Upon the changes of nasalance in group B, the mean value of nasalance was 7±5 for oral sentence and 40.45 % with a range of 29.43 % to 46.69% for nasal sentence before surgery that increased to 19± 4 and 61.75% with a range of 48.33% to 78.11% respectively post-operation. The nasalance values were elevated significantly for oral sentence and highly significant increased (P< 0.05) for nasal surgery after surgery (P=0.001) (Table 2 and 3). These results revealed that the severer the pathology, the better the speech quality would be expected following sinus surgery when comparing pre-operative to post-operative measures.

Table (3): Comparison of the nasalance score of nasal sentences (%) in patients pre- and post-operatively according to the extent of pathology.

	Pre-operative		Post-operative		P value
	Mean±SD	Range	Mean±SD	Range	
Group A (n = 15)	43.83±2.22	37.89 – 50.33	54.94 ± 1.69	38.12 – 65.57	0.006*
Group B (n = 15)	40.45±2.80	29.43 – 46.69	61.75 ± 1.78	48.33 – 78.11	0.001**
Paired t-test	3.26		2.11		

* = significant - ** = highly significant

4. Discussion:

Supraglottic airspace resonators are very important for normal speech production and perception, even though there is great debate regarding the actual involvement of both paranasal sinuses and nasal cavity on quality of speech [11]. Assessment of nasality is made subjectively by the speech pathologists' perceptions through APA. However, it isn't an accurate measure. Therefore, attempts to find an objective measure to evaluate nasality is a work of researchers [12].

There are an urgent requirement for perfect determination tools, especially in estimation of the impacts of the nasal surgeries, prosthetic fitting, and maxillofacial surgeries. For direct objective assessment of nasality we need measuring and comparing pressure levels of sounds emitted from mouth and nose. Nasometer apparatus generally is used for determination of nasalance and is affected by any obstruction in the nasal air passages [4].

The current work was done to shed a spot of light on the role of functional endoscopic sinus surgery on speech quality. According to tension, thickness and length adjustments of the vocal folds, There are many factors affecting the tone quality formed by normal vibrating vocal folds, where it can differ in incidence, intensity, duration, or quality. When the velum is low it leaves the entrance to the nasal cavities open. The addition of the nasal branches to the vocal tract creates a larger and longer resonator. In customary speech, nasality is attributed to nasalization and is a linguistic sort that can be appropriate to consonants or vowels in a definite language. The most important physical difference in assessing the level of nasality in normal speech is the closing and opening of a velopharyngeal passageway among nasal and oral vocal tracts [13].

The term FESS was formerly coined by to give an interest to the probable for reestablishing mucosal recovery and sinus drainage [14]. The goal of practical endoscopic sinus operation should be to open affected or infected sinuses at the normal ostium and, when it is possible, to remove totally the fundamental bony partitions in area as neighboring to chronic sinusitis. Simultaneously, an integral mucosa coated the nasal cavity should be present in the region of skull base, the frontal recess, and the medial orbital wall [15].

The score of nasalance is dependant mainly on phonetic contents of speech. The total sound force in

normal subjects in a typical Korean nasal sentence was nearly reached 54.7%, while in English nasal sentence was averaged 61.06 % as shown by Dr. Larry Adams (University of Alabama at Birmingham, 1989). In the current investigation, the values of the nasalance score were lower than normal values before the surgery especially in severe pathologies that had changed post-operatively to nearly normal values with mild to moderate increase in about 20% of cases (Table. 1) with highly significant relation when comparing pre-operative with post-operative values. This results show that nasal airway obstruction due to either chronic rhinosinusitis or nasal polyposis especially in severe pathologies cause significant hyponasality pre-operative as evident by nasalance score, but there are other factors that influence nasalance such as the functional and anatomical status of the velopharynx which can direct various sounds to either nose or mouth rather than phonetic content of the speech sample (high posterior posture of the tongue associated with marked velopharyngeal deficiency).

In our study we find significant matching between findings revealed by APA and measures nasometric nasalance scores, but it couldn't be relied upon.

The current research matches with Chen and colleagues who postulate that sinus surgery results in measurable effects in the produced acoustic signals and the perceived nasality of a patient's speech [7]. The study agreed with Hosemann and colleagues who support the finding of consistent alterations in the acoustic properties of individuals' phonemes after surgical intervention in the paranasal sinuses [16]. Hong and colleagues also had the same findings with additional minimal spectrographic supportive data [4]. This study disagreed with Michael and colleagues who conclude that patients undergoing sinus surgery did not exhibit subjective changes in resonance postoperatively. Aside from difference in harmonic to noise ratio for the nasal sentence, objective microacoustics remain unchanged [17]. This may be explained as they relied in their study on acoustic analysis of voice that is unnecessarily changed in patients of nasal obstruction (the change of voice is of less extent than change of speech sounds' energy) rather than analysis of vowels which are not nasalized sounds in some languages (some languages have not nasal vowels) and use of continuous nasal consonants of low intensity for voice analysis. The same observed in Hong and colleagues study [4] that could not measure neither the first nor the second nasal formants in some patients because they caused by the lower level of sound intensity with non-significant relation of some parameters in the time the nasalance values were significant.

Conclusion:

We conclude that chronic rhinosinusitis and nasal polyposis cause hyponasality especially in those with severe pathology as evident by nasometer, and this hyponasality eliminate to match the range of nasality of normal subjects after at least one month after functional endoscopic sinus surgery with some cases of hypernasality that explained by the changes in the shape and diameter of the resonating vocal tract after removal of severe pathology. This expected to be temporary for long term evaluation. These changes are affected by the severity of pathology (more improvement in patients with severe pathology than in patients with mild to moderate pathology). Nasometer is a good objective indicator of the changes of speech after surgery in case of using proper speech sample in assessment. Surgeons should inform their patients with severe pathology about the possibility of post-operative hypernasality especially if they are professional voice users.

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Conflicts of interest:

No conflicts of interest declared.

The Statement of Ethics:

The study protocol was approved by the Research Ethics committee of Menoufia University.

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Ethical consideration:

An informed consent using appropriate language was taken before starting our study. It included Study title, Performance sites, Purpose of the study, Study procedures, Benefits, Risks, Right to refuse and Signature.

References:

1. Arends N, Povel DJ, Os EV, Speth L. Predicting voice quality of deaf speakers on the basis of glottal characteristics. Journal of Speech, Language, and Hearing Research. 1990 Mar;33(1):116-22.
2. Bell-Berti F. Velopharyngeal Function: A Spatial–Temporal Model. In Speech and language 1980 Jan 1 (Vol. 4, pp. 291-316). Elsevier.
3. Jiang RS, Huang HT. Changes in nasal resonance after functional endoscopic sinus surgery.

American journal of rhinology. 2006 Jul;20(4):432-7.
4. Hong KH, Kwon SH, Jung SS. The assessment of nasality with a nasometer and sound spectrography in patients with nasal polyposis. Otolaryngology--Head and Neck Surgery. 1997 Oct;117(4):343-8.
5. Ladefoged P, Maddieson I. The sounds of the world's languages. Oxford: Blackwell; 1996 Feb 5. P.102 ISBN 978-0-631-19815-4.
6. Arai T. The Replication of Chiba and Kajiyama's Mechanical Models of the Human Vocal Cavity (< Feature Articles> Sixtieth Anniversary of the Publication of the Vowel, Its Nature and Structure by Chiba and Kajiyama). Journal of the Phonetic Society of Japan, (2001)5(2), 31-38.
7. Chen MY, Metson R. Effects of sinus surgery on speech. Archives of Otolaryngology–Head & Neck Surgery. 1997 Aug 1;123(8):845-52.
8. Hosemann W, Göde U, Dunker JE, Eysholdt U. Influence of endoscopic sinus surgery on voice quality. European archives of oto-rhino-laryngology. 1998 Dec 1;255(10):499-503.
9. Stammberger H and Posawetz W Functional endoscopic sinus surgery- concept, indication and results of the Messerklinger technique. Eur Arch Oto-Laryngology. 1990;247(2):63-76.
10. David HA, Gunnink JL. The paired t test under artificial pairing. The American Statistician. 1997 Feb 1;51(1):9-12.
11. Soneghet R, Santos RP, Behlau M, Habermann W, Friedrich G, Stammberger H. Nasalance changes after functional endoscopic sinus surgery. Journal of Voice. 2002 Sep 1;16(3):392-7.
12. Jiang RS, Huang HT. Changes in nasal resonance after functional endoscopic sinus surgery. American journal of rhinology. 2006 Jul;20(4):432-7.
13. Shriberg LD, Austin D, Lewis BA, McSweeny JL and Wilson DL. The Speech Disorders Classification System (SDCS) extensions and lifespan reference data. Journal of Speech, Language, and Hearing Research. (1997): 40(4), 723-740.
14. Kennedy DW, Zinreich SJ, Rosenbaum AE and Johns ME. Functional endoscopic sinus surgery: theory and diagnostic evaluation. Archives of Otolaryngology. (1985): 111(9), 576-582.
15. Wigand ME, Iro H and Birkholz T. Endoscopic surgery of the paranasal sinuses and anterior skull base. (1990) G. Thieme Verlag.
16. Hosemann W. Die endonasale Chirurgie der Nasennebenhöhlen—Konzepte, Techniken, Ergebnisse, Komplikationen, Revisionseingriffe. In Teil I: Referate Aktuelle Rhinologie.—Forschung und Klinik. (1996) (pp. 155-269). Springer, Berlin, Heidelberg.
17. Brandt MG, Rotenberg BW, Moore CC, Bornbaum CC, Dzioba A, Glicksman JT and Doyle PC. Impact of nasal surgery on speech resonance. Annals of Otology, Rhinology & Laryngology, (2014)123(8), 564-570.

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