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A comparison of active anterior rhinomanometry and nasometry in the objective assessment of nasal obstruction

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SUMMARY

Nasometry is an objective technique that was originally devised for assessing nasality of speech. It is based on a comparison of the acoustic output from the nose and the mouth for a given spoken word or phrase. Subjects with nasal obstruction tend to have "hyponasal" speech and this study compares the standard technique of active anterior rhinomanometry with nasometry in the objective assessment of nasal obstruction. There was a significant association between the Total Nasal Resistance (TNR) and the nasality measurements using nasophonemically enhanced test phrases in 15 adult subjects. This test has obvious advantages over rhinomanometry which can be difficult, time consuming and unreliable particularly in the younger and severely congested patient.

INTRODUCTION

The method of choice for objectively assessing nasal obstruction is undoubtedly by rhinomanometry. Most workers following the guidelines set down by a recent International Committee Report (Clement, 1984) now use the active anterior technique particularly if the area of interest lies within the nasal cavity rather than the nasopharynx. The other forms of rhinomanometry, however, attract considerable interest and their relative advantages and disadvantages continue to be debated (Jones et al., 1987). One of the main problems with the measurement of nasal resistance to airflow is the need for the experience and adequate time to determine it accurately. In addition, the technique involves the fitting of a cannula to the patient and the use of a face mask which some patients, particularly children, find unpleasant. In order to obtain reproducible results the investigator must expect a high degree of cooperation from the subject which is not always forthcoming. There are other reasons why rhinomanometry has not achieved universal acceptance amongst otorhinolaryngologists at least in the United Kingdom and these have been outlined by Broms (1982).

Nasality represents a subjective impression of the contribution of resonance within the post-nasal space, sinuses and nasal cavities to the subject's speaking voice. Patients with compromized nasal airways with otherwise normal palatal function have a "flat" sounding or hyponasal voice which changes little when the nostrils are occluded. Phrases which contain nasal cosonants, in particular *n*, *m*, and *ng*, highlight this difference best and test phrases such as "bananas", and "my name means money" spoken before and during occlusion of the nostrils enable the listener to build up a subjective impression of nasality.

One of the major problems of using nasality to assess nasal obstruction in those with normal palatal function is that it is a subjective parameter which is perceived differently and is a skill that is dependent on tonal acuity and experience (Maw et al., 1981). There have been several attempts to objectively measure nasality and so increase measures of agreement. In the past various manometric devices (Hess and McDonald, 1960) and methods using mirrors have been proposed (Moser, 1942). There are four main techniques in use today and these are spectrography in which the frequency spectrum of the speech is determined (Kytta, 1976), palatopharyngeal pressure/flow analysis (Warren and Dubois, 1964), piezo electric accelerometry (Horii and Lang, 1981) and determination of the oral and nasal acoustic ratio across a specified frequency range (Fletcher, 1970).

The oral and nasal acoustic ratio (TONAR) was first devised as a quick non-invasive method of determining objectively the nasality, or "Nasalance" of speech (Fletcher, 1970). Although previous studies had examined this aspect of speech analysis (Shelton et al., 1967), Fletcher's comprehensive work has determined the data processing criteria for maximum reliability and developed the concept into a commercial production instrument known as the Nasometer® (Kay Elemetrics Corporation, Pine Brook, NJ, U.S.A.). The vast majority of clinical work with this machine has to date been performed on patients with cleft palate or other maxillofacial defects leading to hypernasality of speech. This study was performed to investigate the use of this apparatus in objectively assessing nasal obstruction from the hyponasality of speech that it produces by comparing it with active anterior rhinomanometry.

MATERIALS AND METHOD

1. Subjects

Fifteen healthy adult volunteer subjects (nine male, six female) were instructed to perform the tests described below. There were no features of palatopharyngeal dysfunction and examination of this region revealed no abnormality. To obviate the effects of the nasal cycle both rhinomanometry and nasometry were performed at the same sessions, within a time interval of 30 minutes and in random order. Subjects were chosen with varying degrees of nasal obstruction and were studied without the use of topical vasoconstriction.

2. Nasometry
The Nasometer was interfaced to an IBM personal computer equipped with floppy disc drives to facilitate data collection and analysis. Calibration was carried out according to the manufacturer's instructions before the commencement of the data collection session and in each case the same technician set up and operated the machine. The computer processes digitally converted analogue data before displaying an average Nasalance score for a particular word, phrase or speech passage. Figure 1 shows the head set in position with the acoustic separator plate held perpendicular to the plane of the face between the nose and mouth. Affixed to this are the two microphones each of which converts the acoustic output from the nose or mouth into an analogue signal. The Nasalance score is derived essentially from the ratio of nasal and oral acoustic outputs expressed as a percentage across a narrow frequency band centered at 500 Hz (Fletcher, 1976). The instrument is so arranged that the outputs from each microphone and the derived Nasalance scores can be displayed on the screen against time.

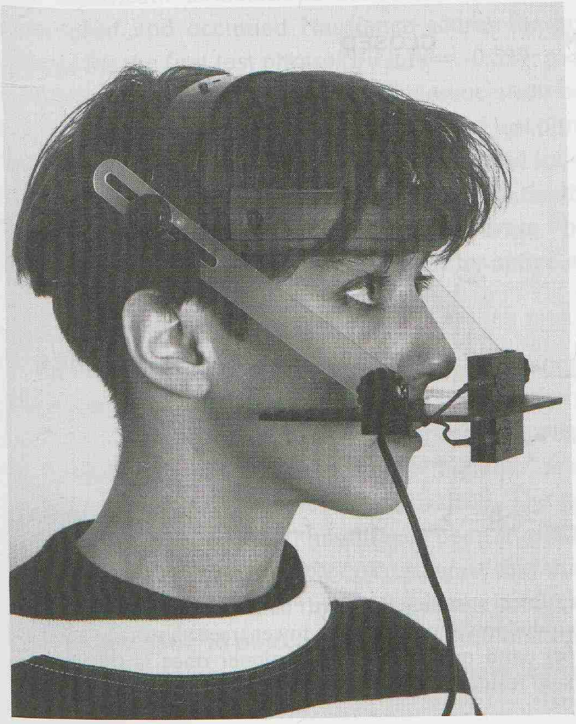

Figure 1.
The Nasometer head set in position showing acoustic separator plate on which are mounted the oral and nasal microphones.

An example of the Nasometer display is shown in Figure 2. This consists of a time history plot of the word "bananas" repeated in alternation with the nostrils open and then occluded. The outputs from the mouth and nasal microphones are seen in the lower half with the nasal trace falling considerably when the nostrils were closed. The upper trace represents the derived Nasalance, and is derived from the ratio of the nasal and oral outputs at a given time. In the same way this also fell sharply once the nose was occluded. The scores with the nostrils occluded tended to vary the most and this may have been due to inconsistent placement of the nasal clip, although care was taken to reduce this source of error to a minimum. Nasalance measurements were made in the above subjects before or after rhinomanometry. Each person was asked to repeat the nasophonemically enhanced test phrases (1) "bananas" ten times and (2) "my name means money" five times once with the nasal apertures open and then with the nostrils occluded using a proprietary swimmers' nose clip. The differences in the unoccluded and occluded scores were determined on the basis of a previous study in which this was shown to be a reproducible way of expressing the objective correlate of nasality (Parker et al., 1989).

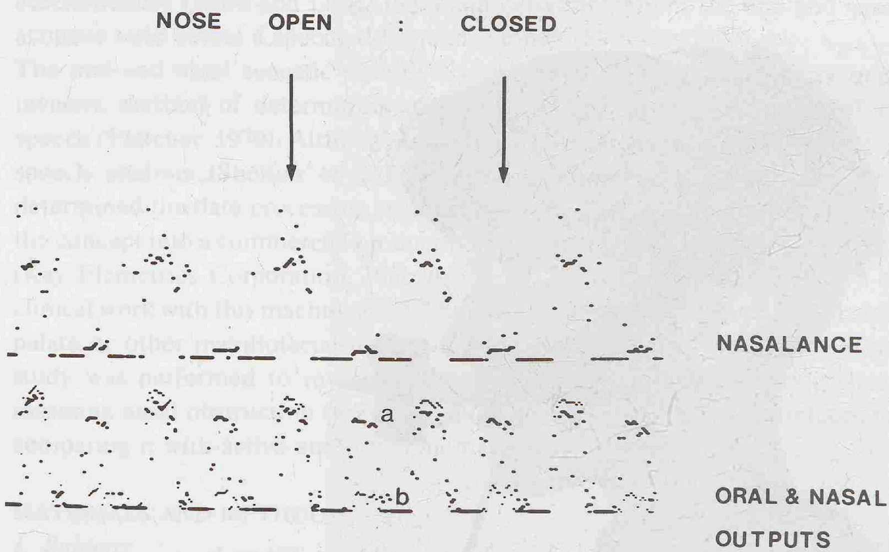

Figure 2. Time history plot of a subject speaking the word "bananas" repeatedly with the nostrils unoccluded and then occluded in alternation. The lower trace shows the acoustic outputs from the (a) oral and (b) nasal microphones. The upper trace is the derived Nasalance. Note that nasal occlusion results in a fall in output from the nasal microphone, and with it the Nasalance score.

3. Rhinomanometry

Active anterior rhinomanometry was performed in accordance with the international recommendations discussed earlier using a calibrated Mercury Electronics NR3 machine interfaced to a small microcomputer. Total Nasal Resistance (TNR) values were calculated from the means of four determinations taken in both inspiration and expiration at the recommended pressure gradient of 150 Pa. The technique used a well fitting face mask and pressure cannula along the lines described by Solow and Greve (1980). In each case the measurements were recorded by the same technician.

RESULTS

The Total Nasal Resistance determinations were between 0.21 and 1.05 Pa.S/cc, with a median value of 0.37 Pa.S/cc. Nasalance scores were calculated as the difference between the unoccluded and occluded Nasalance values for a given test phrase and subject. These were between 5.9 and 20.1% with a median value of 12.5% for test phrase 1 and 4.7 and 20.0%, with a median value of 9.7% for the second test phrase. Since bivariate normal distribution of the data could not be assumed, the measures of association between the resistance and nasometric determinations were investigated using Spearman's Rank Correlation test. There were significant associations between the TNR and the differences in the unoccluded and occluded Nasalance scores for both test phrases. This was greatest for the first test phrase (First $rs=-0.529$; $p<0.025$: Second $rs=-0.482$; $p<0.05$) and is shown in Table 1. The association between the TNR and unoccluded Nasalance scores per se for the second test phrase was significant at the 5% level ($rs=-0.49$; $p<0.05$) but not for the second ($rs=-0.431$; $p>0.05$). It would thus appear that in evaluating nasal obstruction the difference in the unoccluded and occluded Nasalance scores for the phrase "bananas" provides the best agreement with the TNR as determined by active anterior rhinomanometry.

DISCUSSION

There is good agreement between the TNR as determined by active anterior rhinomanometry and the Nasalance scores of the two test phrases used. It is apparent that the relationship described is strongest when the unoccluded-occluded difference for the test phrase "bananas" is used. As the nasal resistance increases the Nasalance score tends to drop. The general reliability and reproducibility of the Nasometer has already been studied in our laboratory and found to be good (Parker et al., 1989). We suggest that this apparatus will prove more advantageous than direct rhinomanometry to the busy otorhinolaryngologist when called upon to objectively assess nasal obstruction. It is certainly popular with the patients, particularly children where it may have a role to play in the selection for adenoidectomy.

Table 1. Measures of association between TNR and Nasalance scores.

TNR/Pa.S./cc	Nasalance score (%) unoccluded-occluded	
	phrase 1	phrase 2
0.84	18.7	20.0
0.23	20.1	14.4
0.46	10.4	8.5
0.30	11.8	13.9
0.35	12.7	8.4
0.48	6.4	10.1
0.55	8.7	4.9
1.05	8.0	7.6
0.63	14.7	8.6
0.27	12.5	9.8
0.37	8.3	6.9
0.92	5.9	4.7
0.31	19.4	12.5
0.21	16.9	12.8
0.22	14.6	9.7
test Spearman's coefficient (rs) significance		
TNR and phrase 1 (diff)	−0.529	$p < 0.025$
TNR and phrase 2 (diff)	−0.482	$p < 0.05$

What is particularly attractive about this technique is that unlike rhinomanometry no pressure cannulae or occlusive face masks are required and it does not rely upon a co-ordinated breathing cycle other than that involved in producing normal speech. These problems are in our experience crucial limiting factors in obtaining reliable and reproducible results from rhinomanometry especially in the younger patient. In addition nasometric analysis provides meaningful results in patients with total nasal obstruction. Further prospective studies are needed to define the place of the Nasometer within the discipline of scientific and clinical rhinology.

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