NASAL AIRFLOW MEASURES PRE- AND POST- TONSILLECTOMY

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ABSTRACT - There is little known about the role of tonsils in speech. In particular, the effect that removal of the tonsils has on the speech mechanism has not been investigated. The present study investigated the effect of tonsillectomy on the ratio of nasal to oral airflow as an indirect measure of velopharyngeal function in a group of children (N = 23) age range 7 - 14 years compared with a control group (N = 33) children age range 8 - 14 years. The results indicated that tonsillectomy does have a significant effect by increasing nasal airflow in proportion to oral airflow in nasal consonant environments. These changes in the balance of nasal to oral airflow in the tonsillectomy group, however, were not detected by experienced judges of nasality.

INTRODUCTION

Tonsillectomy and adenoidectomy are the most common paediatric surgical procedures performed (Andreassen, Leeper & MacRae, 1991; Bluestone, 1992). While the effect of adenoidectomy and adenotonsillectomy on nasality have been investigated extensively, there is little known about the effects of tonsillectomy on nasality. The obstructive nature of tonsillar hypertrophy (enlargement) prior to surgery is well documented, but the consequent effect on resonance and velopharyngeal closure remains relatively unexplored (Kummer et al, 1993). The lack of research in this area may be due to the commonly held belief that tonsils play no role, or at best, a minimal role in speech (Finkelstein, Nachmani & Ophir, 1994). The generation of speech is basically an aerodynamic process. Because the velopharyngeal port is one of the most important valves that directs the airflow during the production of speech, measurement of volume velocity of airflow across the port is a useful indicator of velopharyngeal function (Kuehn, 1982; Yorkston et al, 1988). For this reason, nasal airflow has been widely used in the assessment of VPI for research purposes (Thompson & Hixon, 1979; Dalston, Warren & Smith, 1990; Andreassen, Smith & Guyette, 1992).

METHOD

Subjects

Twenty three children who had undergone tonsillectomy at least 3 months prior to the assessment date (tonsil group), and 33 children who had not undergone tonsillectomy (control group) participated in this study. Control subjects were selected to match the age range and gender of the experimental group. Table 1. displays the experimental and control group characteristics, including mean age and the percentage of females and males for each group.

Group	No. subjects	Female	Male	Mean age
Tonsillectomy	23	15 (65%)	8 (35%)	11.1
Control	33	23 (70%)	10 (30%)	11.2

Table 1. Group characteristics of both experimental and control group

INSTRUMENTATION

Three parameters of speech production were recorded simultaneously: 1. Volume velocity of airflow from the nose (henceforth nasal airflow), 2. Volume velocity of airflow from the mouth (henceforth oral airflow), 3. Sound pressure level at the mouth (henceforth the speech signal). A small microphone was attached to the oral compartment of the mask in order to ensure a standard distance from microphone to the mouth, and to allow the simultaneous recording of the speech signal. Nasal and oral airflow were measured with a custom designed pneumotachograph. The edges of the Downs CPAP mask were fitted with an air-filled plastic diaphragm that accomplished three purposes; firstly, it provided a soft, comfortable surface in direct contact with the skin; secondly, the soft edges of the mask did not place excessive pressure on the normal mechanical movements of the face and jaw; and thirdly, the diaphragm fitted closely to the contours of the face, decreasing the risk of air escaping from the nasal and oral chambers. The mask was divided into two chambers by a rubber insert designed to fit the contours of the upper lip and prevent leakage from one chamber to another. A flowhead was connected to each of the nasal and oral chambers of the mask. The differential pressure across a mesh diaphragm in the flow head was measured by two variable reluctance differential pressure transducers (Celesco LCVR) with a range of 0-1.3 cmH_2O for nasal flow and 0 - 2.5 cmH_2O for oral flow. The transducers and connections to the carrier-demodulator unit, analog-digital signal conversion unit and Macintosh Powerbook computer are illustrated in Figure 1.

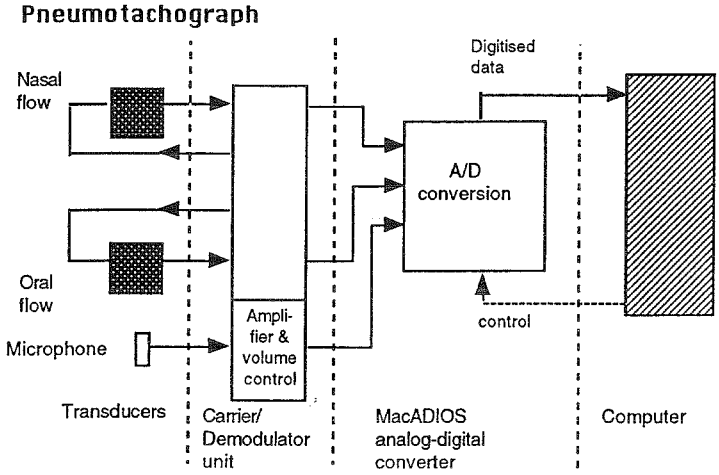

Figure 1 Simplified block diagram of the pneumotachograph system - transducers through the demodulation of the signal, A/D conversion and presentation of waveforms on computer screen.

The transducers converted changes in the pressure differential across the flow head to frequency modulations of a fixed frequency carrier signal. The signal was demodulated, producing a linear variation of voltage with pressure. The voltage signal was digitised by a MacADIOS 8 ain analog-to-digital converter connected to a Macintosh Powerbook 180c. Converted data were displayed graphically using a custom

designed instrument within the Soundscope/16 signal processing package, designed to allow the simultaneous viewing of the selected speech signal, nasal, and oral airflow. A Macintosh Powerbook was used during the recording of data as it enabled the equipment to be transportable.

Speech tasks

The same speech tasks were used for both aerodynamic and perceptual measures, and consisted of 20 words contained in carrier phrases, and four sentences. These 24 speech items were randomised in their presentation order and read by the subjects 3 times. An average measurement was obtained for the 3 repetitions of each speech item.

The speech items can be divided into four broad articulatory categories:-

Nasals		Non nasals	
long	hamper	beat	vase
din	sinker	board	cars
meat	winter	dart	feet
map	hotmilk	cord	seat
bumper	banter		
oatmeal	dancer		

Nasal sentences	Oral sentences
Mamma makes jam	Bobby buys a puppy
Man in the moon	Sit by the sea

RESULTS

Results of the aerodynamic measures were analysed in terms of mean ratio flow (nasal flow/oral flow) values. These represented normalised values, which are expected to be reasonably stable, as variaions will be reflected in both nasal and oral flow measures. Absolute nasal and oral airflow values are more sensitive to variations, such as intensity of productions, by one individual, or between subjects. A significant difference was found for the nasal context ($U = 241$, $p < .05$), with the mean ratio flow values being significantly higher for the tonsillectomy group than the control group. Results of the Mann-Whitney U-test for the nasal and non nasal speech variables are displayed in table 2.

context	tonsil grou	control	Mann-Whitney	2-tailed p
nasal	0.64 (.31)	0.47 (.15)	241	< .05
non nasal	0.02 (.03)	0.02 (.03)	344	not sig. (0.55)

Table 2. Mean and standard deviation ratio flow values of the tonsillectomy and control groups, in the nasal and non nasal speech tasks

An error bar which displays the 95% confidence intervals for the tonsillectomy and control groups according to nasal and non nasal word context is displayed in figure 2.

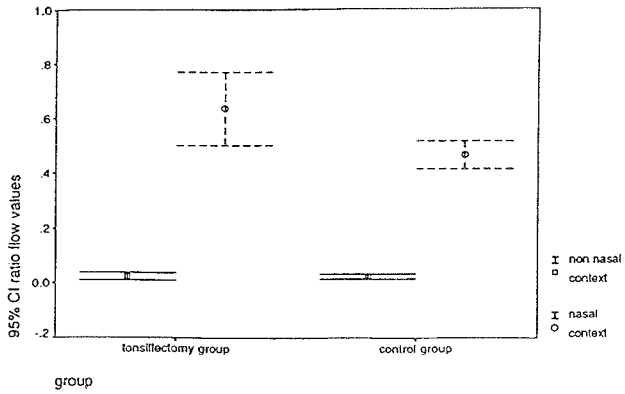

Figure 2. Comparison of ratio flow values in a nasal and non nasal contexts

DISCUSSION

This study has shown that subtle differences are present in the velopharyngeal movements of the tonsillectomy group when compared to the group of matched controls. Children who had undergone tonsillectomy were found to have increased nasal airflow in a nasal word environment, although there were no differences between the two groups in a non nasal word environment. Ratio flow values for the tonsillectomy and control groups were comparable for words and sentences that contained all oral consonants. These findings indicate that the tonsillectomy group were able to achieve adequate velopharyngeal closure during the production of fully oral utterances, and in this way, did not differ from the control group. Ratio flow values for the tonsillectomy group were found to be significantly higher than those for the control group in contexts that contained a nasal consonant. The increased nasal flow for the tonsillectomy group may be indicative of a slowness, or sluggishness of velopharyngeal movement, evidenced when the velum is required to move between an open and closed position in the presence of nasal consonants.

The findings of this study suggest that further investigation of nasality changes after tonsillectomy surgery is needed to determine the clinical significance of these changes. To what extent do these changes affect listeners' perceptions of the nasal balance of the speakers, and for how long do such changes in nasal airflow persist post-surgery?

REFERENCES

Andreassen, M.L., Leeper, H.A., & MacRae, D.L. (1991). Changes in vocal resonance and nasalization following adenoidectomy in normal children: preliminary findings. *The Journal of Otolaryngology*, *20*, 23 - 242.

Andreassen, M.L., Smith, B.E., & Guyette, T.W. (1992). Pressure-Flow measurements for selected oral and nasal sound segments produced by normal adults. *Cleft Palate-Craniofacial Journal*, *29*, 1- 9.

Bluestone, C.D. (1992). Current indications for tonsillectomy and adenoidectomy. *Ann Otol Rhinol Laryngol, 101*, 58 - 64.

Dalston, R.M., Warren, D.W., & Smith, L.R. (1990). The aerodynamic characteristic of speech produced by normal speakers and cleft palate speakers with adequate velopharyngeal function. *Cleft Palate-Craniofacial Journal, 27*, 393 - 399.

Finkelstein, Y., Nachmani, A., & Ophir, D. (1994). The functional role of tonsils in speech. *Arch Otolaryngol Head Neck Surg, 120*, 846 - 851.

Kummer, A.W., Billmire, D.A., & Myer, C.M. (1993). Hypertrophic tonsils: the effect on resonance and velopharyngeal closure. *Plastic and Reconstructive surgery, 91*, 608 - 611.

Kuehn, D.P. (1982). Assessment of resonance disorders. In N. Lass, L. McReynolds, J. Northern & D. Yoder (Eds.), *Speech, language and hearing: Vol. 111. Pathologies of speech and language* (pp. 499 - 525). Philadelphia: WB Saunders.

Thompson, A.E., & Hixon, T.J. (1979). Nasal airflow during normal speech production. *Cleft Palate Journal, 16*, 412 - 420.

Yorkston, K.M., Beukelman, D.R., & Bell, K.R. (1988). *Clinical management of dysarthric speakers*. Austin: Pro. Ed.