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Evaluation of Some Velar Functions before and after Surgical Treatment of Snoring

Key Words
Uvulopalatopharyngoplasty · Nasal air flow · Speech · Sleep apnea syndrome · Snoring

Abstract

The aim of this prospective study was to evaluate velar function before and after uvulopalatopharyngoplasty for isolated snoring and for sleep apnoea. It is based on the analysis of oral and nasal airflow during phonation by an EVA workstation of 24 patients before and after the surgical intervention. The results show (1) quantitative and qualitative airflow abnormalities before the operation, (2) an increase in the percentage of nasal airflow after the operation, and (3) a change in the airflow sequence, which is improved after the surgical procedure. In conclusion, this work confirms a modification of velar function after uvulopalatopharyngoplasty and raises the problem of contra-indications to this intervention.

Velumfunktion vor und nach chirurgischer Behandlung des Schnarchens

Das Ziel dieser prospektiven Studie war es, die Velumfunktion vor und nach Uvulopalatopharyngoplastik bei isoliertem Schnarchen und Schlafapnoe zu untersuchen. Als Grundlage diente die computergestützte Auswertung oraler und nasaler Luftströmungswerte während der Phonation vor und nach der Operation. Die Resultate zeigten 1. quantitative und qualitative Luftströmungsabnormalitäten vor der Operation, 2. eine Zunahme der prozentualen nasalen Luftströmung postoperativ und 3. einen veränderten zeitlichen Verlauf der Luftströmung, der sich nach der Operation normalisierte. Somit bestätigt diese Arbeit eine Modifikation der Velumfunktion, und es stellt sich die Frage nach den Kontraindikationen dieses Eingriffs.

Evaluation de la fonction velaire avant et après chirurgie du ronflement

Cette étude prospective a pour but d'évaluer la fonction vélaire avant et après uvulopalatopharyngoplastie pour ronflement simple ou syndrome d'apnées du sommeil. Elle repose sur l'analyse des débits d'air buccal et nasal en phonation par la station de travail EVA de 24 patients avant et après l'intervention chirurgicale. Les résultats mettent en évidence 1) des anomalies quantitatives et qualitatives des débits d'air avant l'opération, 2) une augmentation du pourcentage de débit d'air nasal après l'opération, 3) une modification de l'enchaînement des débits d'air en faveur d'une amélioration après le geste chirurgical. En conclusion, ce travail confirme une modification de la fonction vélaire après uvulopharyngopalatoplastie et pose le problème des contre-indications à cette intervention.

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Introduction

The use of uvulopalatopharyngoplasty (UPPP) procedures for isolated snoring or sleep apnoea syndrome (SAS) raises the problem of efficient velar function after partial resection of an a priori normal soft palate. Since the initial interventions, the absence of phonation alterations found at follow-up interviews have regularly been reported in the literature (excluding those abnormalities secondary to complications such as stenosis or velar insufficiency) [1–3]. Despite these results, a change in soft palate function in asymptomatic patients is not excluded. Objective acoustic studies show an increase in the frequency of the second formant [4–6], as well as a decrease in phonation time [4]. Objective aerodynamic studies are much less numerous [7, 8]. The work of Salas-Provance and Kuehn [7], carried out uniquely in the post-operative period, does not show any significant nasal or oral airflow abnormality, compared to a control population. Using an aerophonoscope II (a method allowing a semi-quantitative concomitant measure of nasal or oral airflow), Huet et al. [8] studied a population with isolated snoring operated with laser, and found no difference in the pre- and post-operative measures.

The aim of this study was to evaluate velar function before and after an UPPP for isolated snoring or SAS, using an aerodynamic method, simultaneously measuring nasal and oral airflow. With this method, the following post-operative parameters were explored: (1) the percentage of nasal airflow (NAF%) an increased percentage indicating a subclinical nasal passage of air; (2) the airflow curves, a modification of the curves signalling an alteration in the sequence of velar movements, and the population which may eventually be at risk for post-operative complications was sought.

Materials and Methods

This prospective study, begun in August 1994, analysed an acoustic and aerodynamic recording of a sentence, spoken by the patient on the day prior to, as well as 2 months after surgery. The intervention was always carried out at our ENT Department by the same surgeon. Surgery consisted of a resection of the membranous soft palate, including the uvula muscle, sometimes associated with a tonsillectomy, depending on the patient's anatomy. An enlargement plasty was realized in patients with SAS, which consisted of a partial sectioning of the posterior pillars (with the palatopharyngeal muscles), as well as the suspension of the posterior pillar mucosa by suturing it to a notch created in the mucosa of the anterior pillars (repecting the glossostaphylin muscles).

Population

Twenty-four patients were recorded. Ten patients presented with isolated snoring, and 14 patients with SAS. This population was exclusively male, with a mean age of 46 years, the range being 27–70 years.

Material

This study was carried out using an EVA station (Evaluation Vocale Assistée, SOREMED, fig. 1). Two types of sensors were used. The first were airflow sensors (heat pneumotachographs), one oral and one nasal. At the oral site, flow was captured by a mask; at the nasal site, by two plugs, each placed in the nasal vestibule.

The second was an acoustic sensor. The sound was captured either by a microphone (AKG C409), placed within the mask (simultaneously recording the acoustic and the aerodynamic signal), or by an external microphone (AKG C525), thus avoiding any distortion caused by the mask. These sensors were linked to a measuring and a signal treatment apparatus. Data treatment was computerized (PC 486 DX33). Two programs, proposed by EVA (fig. 2), were used for this study. The 'acoustic analysis' program used a sonogram with an instantaneous spectrum. The 'velar leakage' program allowed: (1) to measure nasal and oral airflow, during both inspiration and expiration, and to calculate in percentages the nasal air volume/total expiration air volume ratio, using sentences containing occlusive and constrictive consonants, thus quantifying nasal leakage during phonation; (2) to visualize expired nasal and oral airflow curves during articulation, and to study their sequence, as a mirror image relative to the time axis. A vocal tape recording of the same sentence was realized systematically.

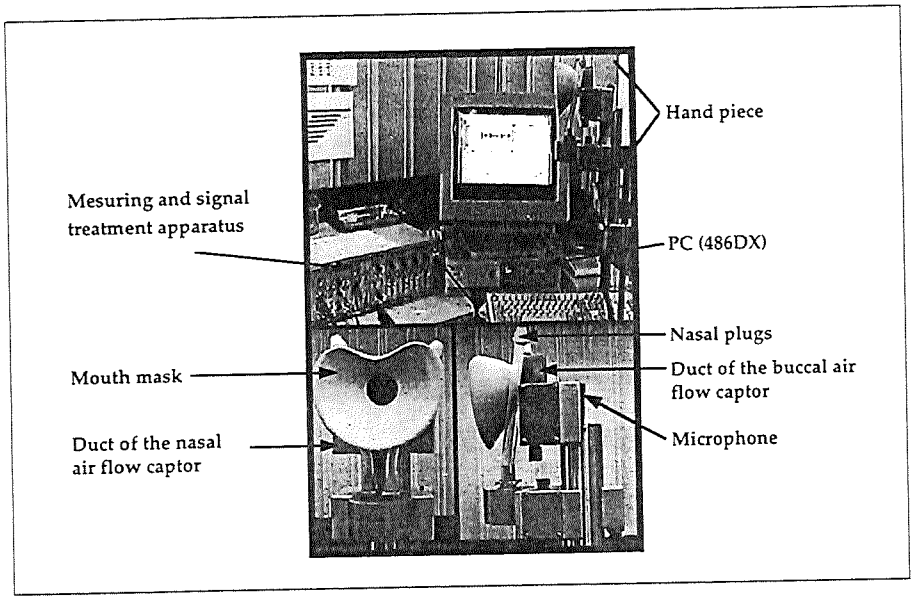

Fig. 1. NAF% and pre-operative speech emission duration.

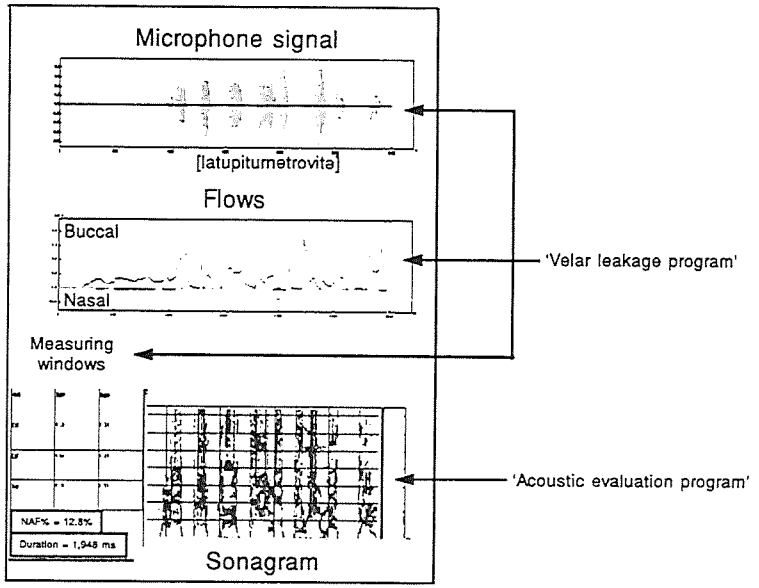

Fig. 2. Study of the sentence [latupiturnətrovitə] by the EVA programs.

Protocol (fig. 2)

The sentence used was 'La toupie tourne trop vite' [latupiturnətrovitə]. Identification of the phonemes is accomplished using a microphone signal (velar leakage program), as well as a large-band sonographic analysis (acoustic analysis program). The parameters obtained for this study, for the whole sentence, [tupi] and [turn], were: NAF%, which corresponds to the expired nasal airflow divided by the total expired airflow multiplied by 100, and the duration of the selected vocal segment.

Only NAF% was obtained for the phonemes of the word [tupi]. The NAF% quantified the amplitude of nasal leakage. Its qualitative aspect was appreciated by localizing the leak in the sentence. The absence of leakage was considered normal, except for [n]. A localized leak for certain phonemes, as well as diffuse leak, were thus observed.

The movement sequence was studied by the aspect of the oral airflow curve during [tupi] and the aspect of the nasal airflow curve during [turn]. The different aspects observed are shown in figure 3. These parameters were obtained the evening before the intervention, and at 2 months after. At 2 months, the patients were equally questioned to ascertain any observed change in their form of speaking.

Methodology

The data obtained was studied for the totality of the population (inter-individual analysis) and individually (intra-individual analysis). Inter-individual analysis comprises the description of the population before the intervention, then the comparison of the parameters after the intervention. Intra-individual analysis studies the parameters before and after the intervention for the same patient in order to determine the evolution of the air leak, as well as the sequence modification.

Statistical analysis was realized using the DM90 program (ADIMEP Toulouse). The tests used were most often non-parametric, due to the limited number of subjects and to the wide coefficient variation. For the cohort series, this was the Wilcoxon t test or the couple method, and for the non-cohort series, the Mann-Whitney U test or mean comparison was used.

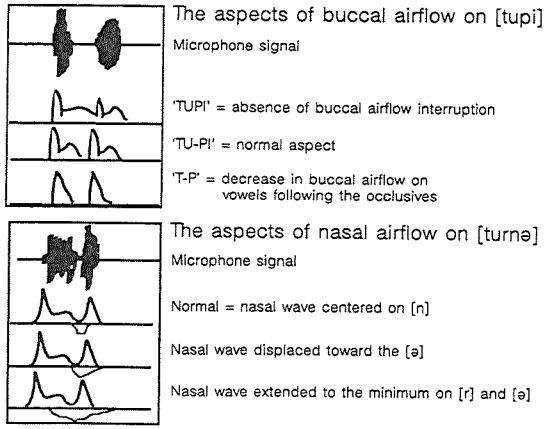

Fig. 3. The different aspects of the flow curves.

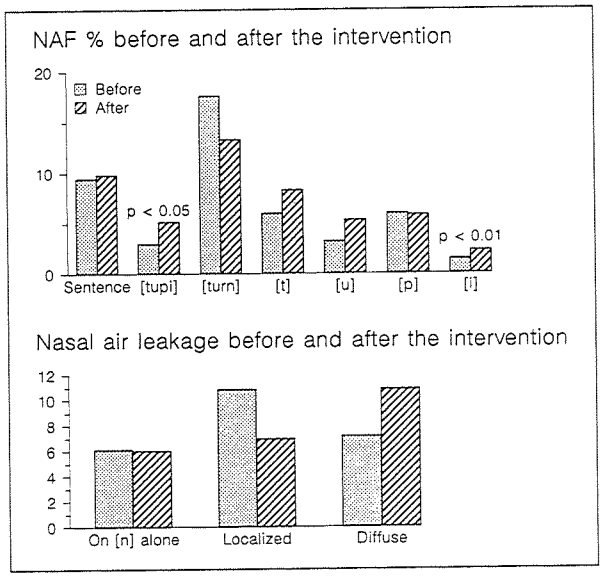

Fig. 4. Inter-individual analysis: nasal air leakage.

Table 1. Percentage of nasal air flow and pre-operative speech emission duration

	NAF, %		Duration, ms	
	mean	SD	mean	SD
Sentence	9.2	8.4	1,432	406
[tupi]	2.7	2	315	147
[turn]	17.6	15.8	261	70
[t]	5.7	4.2		
[u]	3	2.1		
[p]	5.8	5.3		
[i]	1.2	1.2		

Results

Inter-Individual Analysis

Pre-Operative Population. The mean NAF% (2.7%) remained within normal limits (inferior to 5%) [9] for the word [tupi], which contains exclusively oral phonemes. Two patients, however, had a NAF% greater than 5% with this word pre-operatively. The separate study of the phonemes showed that the NAF% is relatively large for occlusive consonants and for [u]. For the entire sentence and for the word [turn], which contain nasal consonants, their interpretation offers no quantitative information as to the pre-operative nasal leakage, but allows to verify the absence of closed nasality. Air leakage was localized in 11 cases, and diffuse in 7 cases. Thus, abnormal nasal air leakage, by amplitude and by localization, was observed before the intervention, which predominated with the consonants. Moreover, a decrease in the oral airflow wave was noted on the vowels following occlusive consonants in 10 cases. The nasal airflow curve of the nasal consonant [n] extended to the [r] and the [ə] in 3 cases. This was simply adjusted laterally on the [ə] in 9 cases. These results suggest the presence of pre-operative sequence abnormalities. No statistical relationship was shown between the presence of these abnormalities and the patient ages or their pathologies.

Post-Operative Comparison. After the intervention, a statistically significant increase in the percentage of nasal airflow for [tupi] ($p < 0.05$) and for [i] ($p < 0.01$) was observed. The localization of the leak tended to become diffuse (fig. 4). The duration of the sentence decreased (fig. 5). This decrease was statistically significant for [tupi] ($p < 0.01$). Concerning the sequence, a normalization of the oral airflow aspect for [tupi] was observed (fig. 5). The nasal airflow wave tended to become recentered for [n] in the word [turn], with disappearance of the extended aspect (fig. 5). A correlation was looked for between the post-operative nasal air leak localization and the pre-operative parameters. A statistically significant relationship was found between the presence of a leak and an elevated percentage of a pre-operative nasal airflow for [tupi] and for [i] ($p < 0.01$). The post-operative percentage of nasal airflow for [tupi] was inversely correlated ($r = 0.539$) to the pre-operative duration ($p < 0.01$). Thus, an impairment tended to occur in patients who presented with no pre-operative abnormality.

Intra-Individual Analysis (fig. 6)

After the intervention, no patient noted any voice change. Eighteen patients did note a temporary difficulty in pronouncing [r] or [g]. Half of them believe to have adapted to a dif-

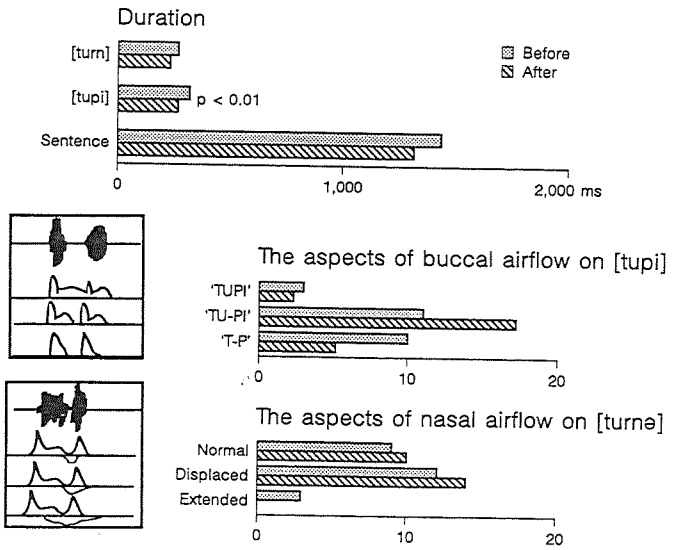

Fig. 5. Inter-individual analysis: phonation duration and flow curve aspects.

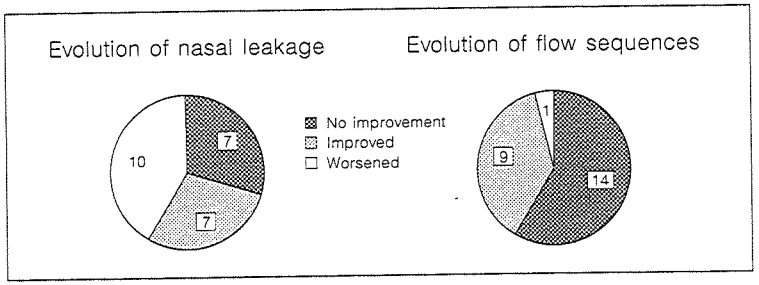

Fig. 6. Intra-individual analysis.

ferent manner of pronouncing the phoneme. The nasal leak improved (decrease in a localized or diffuse leak) in 7 cases and worsened (increase in the percentage and/or diffusion of nasal airflow) in 10 cases. The sequence was less frequently modified, with a tendency towards improvement in 9 cases, and worsening in only 1 case.

A correlation was looked for between the evolution of the nasal air leak and the pre-operative parameters. A statistically significant relationship was found between the improvement of the leak and an elevated pre-operative percentage of nasal airflow for [toupi], [u] and [i] ($p < 0.01$). Worsening of a nasal leak was more frequent when the pre-operative nasal leak was localized (8 of 10 cases), and in patients presenting with SAS (8 of 10 cases). As above, improvement seemed to occur in the pre-operatively abnormal population, and deterioration occurred more frequently in the normal population.

Discussion

This study has revealed, in seeking to show a modification of velar function after UPPP, the presence of abnormalities in the population of patients presenting with isolated snoring and SAS. This observation has already been reported by Monoson and Fox [10] in a subjective speech study using a jury of listeners in a SAS population. This study compared 13 patients with SAS with 13 controls and found a statistically significantly increased frequency of speech articulation and resonance abnormalities in SAS patients (9 SAS vs. only 2 controls). Huet et al. [8] equally observed 2 cases of pre-operative velar function abnormalities out of 25 patients with isolated snoring. One of these presented with moderate subclinical open nasality due to which the intervention was contra-indicated. The other patient presented with closed nasality secondary to pharyngeal obstruction of velar origin. Our study's findings confirm these notions: (1) a nasal air leak was observed in 18 patients; (2) airflow sequence abnormalities were observed in 13 patients, and (3) a greater frequency of abnormalities was seen in patients presenting with SAS, although the difference was not statistically significant. These results suggest that pre-operative sequence abnormalities of velar movement may be shown to be related to the usual morphodynamic abnormalities seen in these patients (long and hypotonic soft palates). They need to be compared, however, to a control 'non-snoring' population.

The post-operative alterations induced by the resection of the soft palate remain controversial. Subjective studies [3] do not show any voice alterations, but suggest the possibility of articulation difficulties, more or less temporary, for the phonemes having a velar articulation support. Our study confirms these findings: 18 patients noted difficulties for [r] or [g]. This is usually transitory, reflecting either a recuperation or an adaptation by the patient.

As for the acoustic findings, studies by Murry and Bone [4], Rihkanen and Soini [5], and Nakaï [6] have shown changes of the first and second formants, which vary as a function of the phonemes. These were interpreted by a Japanese team [6] as an adaptation to the change in volume and form of the pharyngeal cavity. For Rihkanen and Soini [5], these changes tend to regress as the post-operative delay increases. Fiz et al. [11] compared vocalization in 18 men with obstructive SAS syndrome and 10 normal men as control group. The harmonic characteristics (maximum frequency, mean frequency and number of harmonics) of vowels [i] and [e] were significantly different in these two populations. The absence of homogeneity of these results may be related to the language differences between these authors, as well as to the fact that acoustic analysis is not easily interpretable in velopharyngeal dysfunction [12].

Regarding the aerodynamic findings, the work of Salas-Provance and Kuehn [7], comparing, in the post-operative period, a population of snorers with a control population, found no statistically significant abnormalities. This result is not surprising, given that the changes remain subclinical, except for complications. Moreover, it does not eliminate a modification in the operated group in the absence of a pre-operative comparison. The study of Huet et al. [8] shows no change of airflow before or after the intervention. But as opposed to our series, the population studied was comprised exclusively of isolated snorers, the surgical technique (laser) was different, and a semi-quantitative analysis was used.

Using quantitative data, our study found a statistically significant increase in the percentage of nasal airflow 2 months after the intervention. The shortening of the soft palate using the classic UPPP technique leads to a subclinical nasal air leakage. This is associated with a change in the sequence of airflow. This change corresponds most often to an improvement, which may explain why the air leak remains asymptomatic. This improvement is equally reflected by a decrease in the duration of the vocal emission, a decrease already reported by Murry and Bone [4]. This phenomenon may be related to an improvement of velar dynamics: a shorter and more tense soft palate, after a post-operative delay, would be more easily mobile.

The correlations shown between the post-operative changes and the pre-operative characteristics of this series tend to define a population of patients at risk after UPPP. Contrary to the fears of Huet et al. [8], which led them to contra-indicate a patient presenting preoperatively with subclinical open nasality, the population presenting with pre-operative abnormalities tends to be improved by the intervention. It is, in fact, the normal population which is at risk of a deterioration. Patients presenting with SAS fall most often into the first group. A real population at risk, therefore, does not seem to exist, and according to our results, subclinical open nasality does not constitute an operative contra-indication.

The variability of results gleaned from the literature may be due to several factors. The language problem is in the forefront, reflecting the phonetic variations of the authors' language. This difficulty is apparent with English, which contains no nasal vowels [13, 14].

The absence of precise information in articles which target the vocal problem concerning the surgical technique and the percentage of SAS patients in the population studied renders any comparison of results difficult. Finally, the influence of a post-operative delay is of equal importance. The study of Salas-Provance and Kuehn [7] shows that a delay of 6 months is optimal in order to appreciate the definitive modifications secondary to the intervention.

Conclusion

UPPP induces alterations of the soft palate. Surgery seems to favour nasal air leakage, which is counterbalanced by an improvement of its dynamics. This change occurs in a population whose velar function seems abnormal before the intervention. These results should incite further studies of velar function in patients presenting with SAS and isolated snoring before therapy.

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