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The evaluation of velopharyngeal function using flexible nasendoscopy

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Abstract

Nasendoscopy is an essential tool in assessing the dynamic function and structure of the velopharyngeal sphincter during speech and swallowing.

Flexible fibre-optic nasendoscopy has been used by the cleft palate team at Withington Hospital, Manchester since 1989. Seventy-six patients were referred between 1989 and 1994 for evaluation of velopharyngeal function during speech. Flexible nasendoscopic evaluation was attempted in 50 patients, and successfully carried out in 43 patients. The age range was four years to 77 years (mean 21 years). The patients were divided into two groups: Group 1 consisting of patients with cleft palate and Group 2 comprised of patients with non-overt cleft palate-related velopharyngeal dysfunction of various aetiologies; such as, submucous cleft, post-tonsillectomy, post-adenoidectomy, neurological and post-traumatic.

Based on the findings on nasendoscopy, videofluoroscopy and clinical speech/voice analysis the following treatment options were recommended: 17 (40 per cent) for pharyngoplasty, five (11 per cent) for revision pharyngoplasty, 15 (35 per cent) for speech therapy, four for an obturator and one for tonsillectomy. Two previously undetected submucous clefts were diagnosed.

Key words: Endoscopy; Nasopharynx

Introduction

The use of nasendoscopy in the diagnosis of velopharyngeal incompetence was first described by Pigott, 1969. A 3 mm rigid endoscope was used to visualize the velopharyngeal valve at rest, as well as during speech. The subsequent introduction of flexible fibreoptics into medicine (Sawashima and Hirose, 1968) revolutionized the evaluation and treatment of velopharyngeal dysfunction (Muntz, 1987; D'Antonio *et al.*, 1988; Witzel *et al.*, 1988). The flexible nasendoscope allows us to visualize the velopharyngeal valve from above, without disturbing the normal flow of speech production (Shprintzen, 1989). A further advantage is the visualization of the larynx: frequently, laryngeal pathology secondary to glottal re-inforcement of weak oral consonants occurs in patients with velopharyngeal insufficiency. Flexible nasendoscopy is nowadays an essential tool in the team assessment of speech and resonance disorders associated with velopharyngeal dysfunction.

Between 1989 and 1994 flexible nasendoscopy was carried out in 50 patients in South Manchester for evaluation of velopharyngeal function during speech. The results of the evaluation and the recommendations for management are discussed in this paper.

Patients and methods

Fifty patients were referred between 1989 and 1994 for flexible nasendoscopic evaluation of velopharyngeal dysfunction during speech.

The nasal cavity is sprayed with two per cent lignocaine or five per cent cocaine. The endoscope is introduced through the middle meatus to obtain a panoramic view of the velum as well as the posterior and lateral pharyngeal walls.

The procedure is explained to the patient. In case of a child he/she is allowed to hold the scope and view the video monitor. The patient is encouraged to view the entire procedure on the video monitor. On two occasions we allowed the child to pass the endoscope through his nasal cavity and gently guided it into position successfully.

When the endoscope is in the optimal position the speech therapist instructs the patient to carry out a wide variety of speech tasks and non-verbal activities such as blowing and swallowing. The speech tasks include the recital of oral consonants and vowel

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TABLE I
THE AETIOLOGY OF VELOPHARYNGEAL DYSFUNCTION

Group	Number of patients
Group 1 (n = 23)	
Post cleft palate repair	15
Post cleft palate repair and pharyngoplasty	8
Group 2 (n = 20)	
Submucous cleft palate (undiagnosed)	2
Repaired submucous cleft palate	2
Repaired submucous cleft palate and post-pharyngoplasty	1
Post-tonsilectomy	2
Post-adenoidectomy	2
Post-head injury	1
Idiopathic	5
Large lingual tonsils and velopharyngeal dysfunction	1
Velo-cardio-facial syndrome	1
Hypertrophied tonsils	1
Post-syphilitic	1
Paradoxical vocal fold syndrome	1

sounds alone, as well as in words and sentences. Other speech tasks include the nasal consonants 'm', 'n' and 'ng' which require a nasal airflow and therefore an open sphincter.

Results

Nasendoscopy was successfully carried out in 42 patients on the first attempt and one on the second attempt. The age range was four to 77 years with a mean of 21 years (Figure 9).

The patients were divided into two groups based on the aetiology of the dysfunction. Group 1 consisting of those with a cleft palate and Group 2 consisting of those with non-overt cleft palate and velopharyngeal dysfunction of various other aetiologies (Table I).

The Plastic surgeon, Speech Therapist and the Otolaryngologist then jointly analyze this information with the videofluoroscopic pictures, the clinical speech/voice analysis, and computer measurements of the nasal air flow and recommended the following treatment options: (1) speech therapy (2) pharyngeal flap surgery and speech therapy (3) revision of pharyngeal flap and speech therapy (4) speech prosthesis and speech therapy. The results of the evaluation and treatment recommendations are listed in Table II.

Of the 23 patients in Group 1 (those with a cleft palate, all of whom had the palate repaired in infancy) eight had subsequent pharyngeal flap or pharyngoplasty. Endoscopy was performed on all 23 patients to investigate suspected velopharyngeal dysfunction. Based on the endoscopy, videofluoroscopy and speech/voice analysis nine patients were recommended for pharyngoplasty, nine for speech therapy, one for an obturator and four for revision pharyngoplasty.

In Group 2 (n = 20), there were two each in the post-tonsillectomy and post-adenoidectomy categories. All four patients were recommended for pharyngoplasty. Two undiagnosed submucous cleft palate were diagnosed using the endoscope and one was repaired, and the other managed with speech therapy. Three other repaired submucous clefts were endoscoped: one was recommended for pharyngeal flap surgery, another for revision of the pharyngeal flap and the third for speech therapy. One post-head injury patient was seen and managed with an obturator. Five were placed in the idiopathic category, two of them were recommended for pharyngeal flap surgery and two for speech therapy and the third for a palatal training appliance. One patient with velo-cardio-facial syndrome with hypernasal speech was recommended for pharyngoplasty and one patient was recommended for tonsillectomy for hypernasality. One patient with post-syphilitic scarring of the palate was recommended for speech therapist assessment.

The speech outcomes of the surgery/prosthesis and speech therapy are shown in Table III.

TABLE II
THE TREATMENT RECOMMENDATIONS

Aetiology of velopharyngeal dysfunction	Pharyngoplasty and speech therapy	Revision pharyngoplasty and speech therapy	Speech therapy	Obturator	Diagnosis and other treatment
Post cleft palate repair (15)	9		5	1	
Post cleft palate repair and pharyngoplasty (8)		4	4		
Submucous cleft palate (undiagnosed)					2 (diagnosed)
Repaired submucous cleft (2)	1		1		
Repaired submucous cleft and post-pharyngoplasty (1)		1			
Post-tonsillectomy (2)	2				
Post-adenoidectomy (2)	2				
Post-head injury (1)				1	
Idiopathic (5)	2		2	1	
Large lingual tonsils and VPI (1)			1		
Velo-cardio-facial syndome (1)	1				
Hypertrophied tonsils (1)					Tonsillectomy
Post-syphilitic (1)			1		
Paradoxical vocal fold syndrome (1)			1		

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TABLE III
SPEECH RESULTS N = 38

Degree of hypernasal resonance	Pre-intervention	Post-intervention
Severe	14	2
Moderate	13	0
Mild	11	12
Normal	0	24

Discussion

The velopharyngeal (VP) valve was first studied in patients with defects of maxilla. The nasendoscopic appearance of the VP valve was first described by Pigott in 1969. Further studies of the VP function were carried out by Shprintzen *et al.*, 1974 using multi-videofluoroscopy.

Pigott in his pioneering work, compared the nasal surface of the velum in 25 patients with cleft palate with 25 normal subjects using a rigid nasendoscope. He observed that there was a central bulge on the soft palate during speech tasks and attributed it to the musculus uvulae. This central bulge was found to be absent diagnostically, in cleft palate patients (Pigott, 1969).

Croft *et al.* in 1981 described various patterns of velopharyngeal valving in normal and cleft palate subjects. The valving patterns were classified as coronal, saggital, circular and circular with passavants ridge, based on the relative contribution of the velum, lateral and posterior pharyngeal walls. The movements of these structures have also been rated numerically on a 5-point scale (D'Antonio *et al.*, 1988) with five representing maximum movement of the velum to the posterior pharyngeal wall and lateral walls to the midline. We do not use either system of classification at present, although we provide a descriptive analysis of the relative contributions of the velum, posterior and lateral pharyngeal walls to the velopharyngeal closure. The consistency of the closure and symmetry are also described. All these factors influence the management decisions.

The flexible fiberoptic nasendoscopy is invaluable in assessing the dynamic function and the structure of the velopharyngeal area as part of the team assessment of the speech and resonance disorders and swallowing, especially nasal regurgitation. It allows visualization of the nasal cavity, choana, adenoid pad, Eustachian tube, velum, the lateral and posterior pharyngeal walls and vocal folds.

Proper anaesthesia and placement of the endoscope are essential (Muntz, 1992). Cocaine, two per cent, or a mixture of 0.25 per cent oxymetazoline and two per cent lignocaine, and lignocaine, two per cent can all be used as a topical anaesthetic. It can be applied on a cottonoid pledglet or sprayed on the mucosa. We use lignocaine, two per cent spray or cocaine five per cent. The disadvantages of xylocaine are the stinging sensation, the bad taste and the lack of vasoconstriction. Cocaine has the dual action of vasoconstriction and anaesthesia and is better tolerated, but careful attention should be given to the dosage due to the adverse reactions associated with it.

Navigation of flexible nasendoscopy in patients with cleft palate and lips can be difficult due to significant nasal deformities. So it is essential to assess the nasal cavities prior to endoscopy preferably with a Thudichum speculum. It is important to pass the endoscope through the middle meatus and as high as possible into the choana to view the velum, lateral and posterior pharyngeal walls together D'Antonio *et al.*, 1986; Muntz, 1992). Traversing the inferior meatus contributes to the greatest distortion and may preclude visualization of velopharyngeal closure (Muntz, 1992).

The speech tasks are so designed as to study the dynamic articulatory actions of the velopharynx. It should place minimal and maximal demands on the velopharyngeal mechanisms during speech (D'Antonio *et al.*, 1986). Mild dysfunction is best observed under conditions of increased demand. A brief speech therapy session may also help to differentiate learned behaviour from true velopharyngeal incompetence.

When the endoscope is in position the following points are noted:

Static anatomy of the nasopharynx and velopharyngeal portal:

(1) size of the adenoid pad relative to the size of the nasopharynx;
(2) size and shape of the Eustachian tube;
(3) morphology of the soft palate;
(4) state of the mucous membrane and evidence of any scarring;
(5) any aberrant vessels noted – this is particularly important in cases of velocardiofacial syndrome.

Dynamic anatomy of the nasopharynx:

(1) The relative contribution of the adenoid and the tonsils to the velopharyngeal dysfunction;
(2) the relative contribution of the velum, posterior and lateral pharyngeal walls to the valving pattern;
(3) the consistency and symmetry of the valving pattern;
(4) the change, if any, with biofeed back therapy;
(5) examination of the vocal folds.

Patients with palatal incompetence often develop laryngeal pathology as a result of maladaptive glottal substitutions for oral consonants so it is essential to examine the vocal folds as part of the nasendoscopic assessment.

Flexible nasendoscopy for evaluation of velopharyngeal function during speech is still underutilized especially in the paediatric age group. The

TABLE IV
SUCCESS AND FAILURE RATES WITH FLEXIBLE NASENDOSCOPY

Age range	Success rates	Failure rates
4–8 years	9 (56%)	7 (44%)
8–12 years	7 (100%)	none
12–16 years	8 (100%)	none
16+ years	19 (100%)	none

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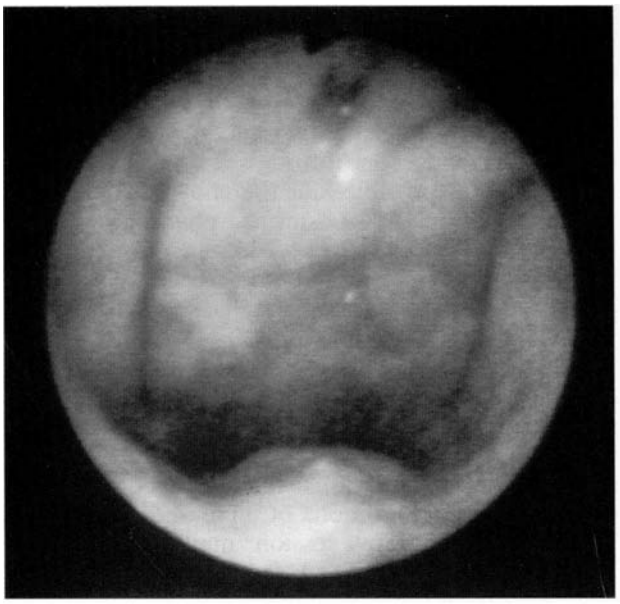


FIG. 1
Endoscopic view of a normal velopharyngeal sphincter at rest showing the convex bulge of the musculus uvulae.

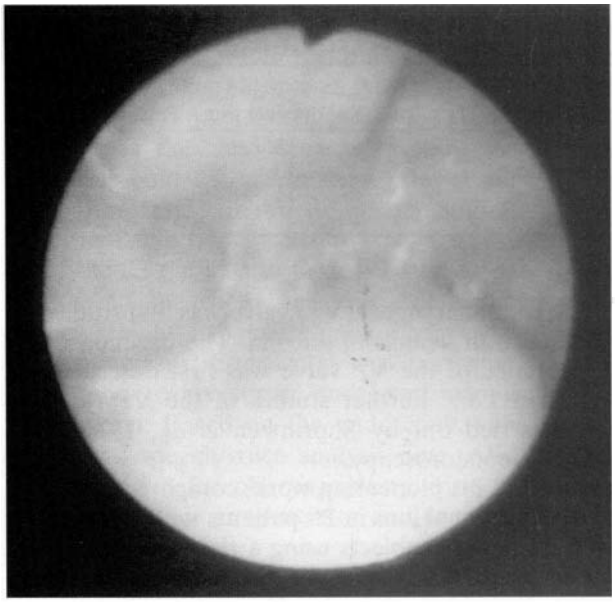
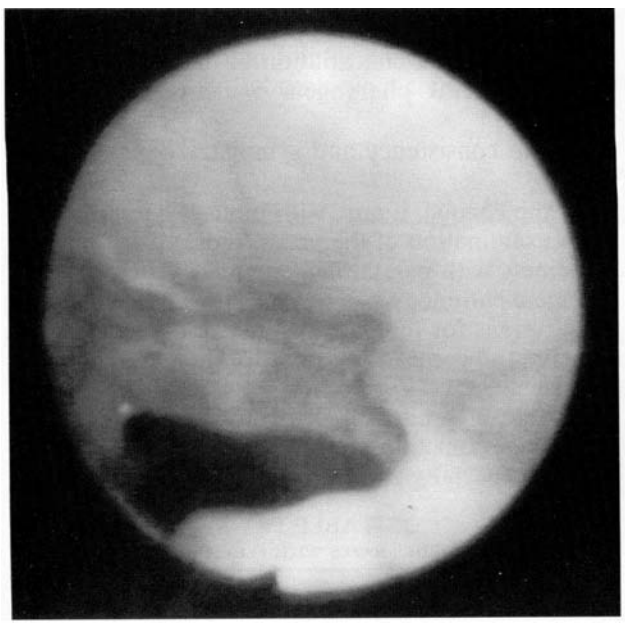


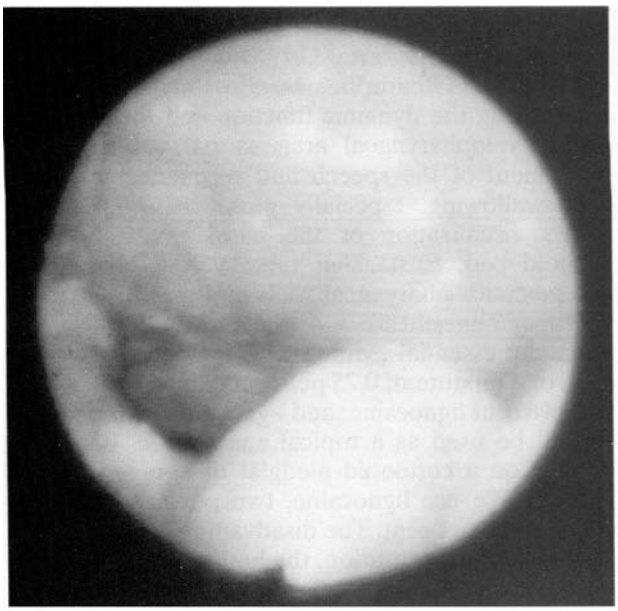
FIG. 2
Normal velopharyngeal sphincter closure during speech.

procedure has a compliance rate of over 90 per cent in children of four to six and 100 per cent in children over six years old (Shprintzen, 1989). We carried out the nasendoscopy successfully in 86 per cent of patients. All the failures were in the age group of four to six years (Table IV). We have since improved our compliance rate to approximately 98 per cent for children aged over three years, using a 3 mm endoscope and a different topical anaesthetic.

In normal subjects, the velum and lateral and posterior pharyngeal walls may all contribute to the closure of the velopharyngeal sphincter. Figures 1 and 2 show an open sphincter in a normal subject and the closure with speech tasks. Note the presence of a mid-line bulge at the six o'clock position, due to the musculus uvulae. This convex bulge is absent in the repaired cleft palate as well as in the submucous cleft palate (Croft *et al.*, 1978). Figures 3 and 4 respectively, show the sphincter at rest and during speech tasks in a subject with an inadequately repaired palate. Note the absence of the musculus uvulae bulge.

In the occult submucous cleft palate, the musculus uvulae is absent. Kaplan (1975) was the first to coin the term occult submucous cleft palate. He observed that subtle changes in the musculature of the palate may lead to velopharyngeal dysfunction and hyper-





FIGS. 3 and 4
Shows the sphincter at rest and during speech in an individual with inadequately repaired cleft palate. There is incomplete closure during speech.

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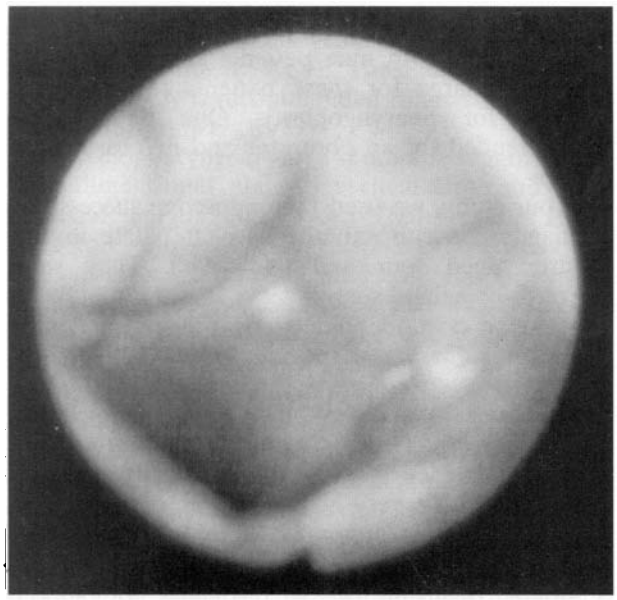
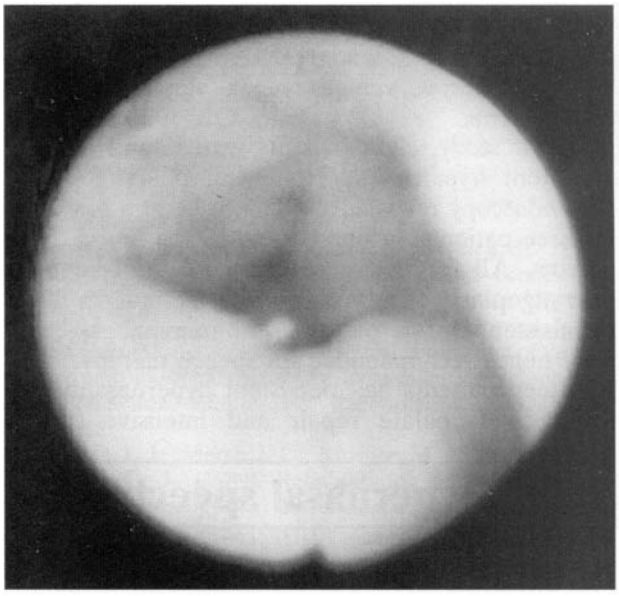


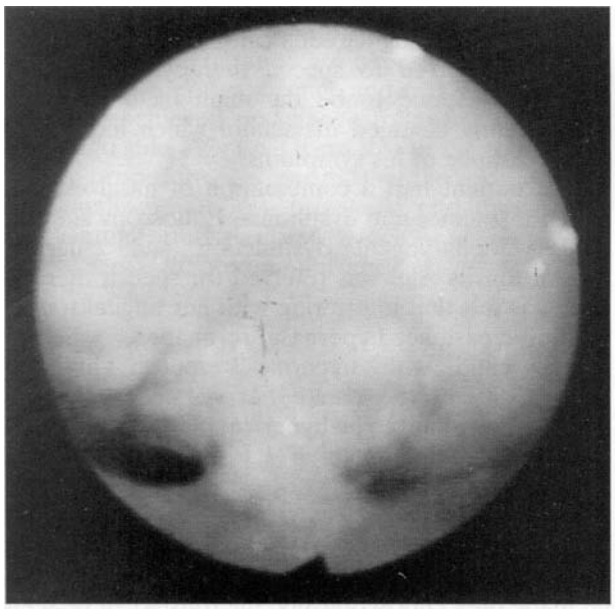


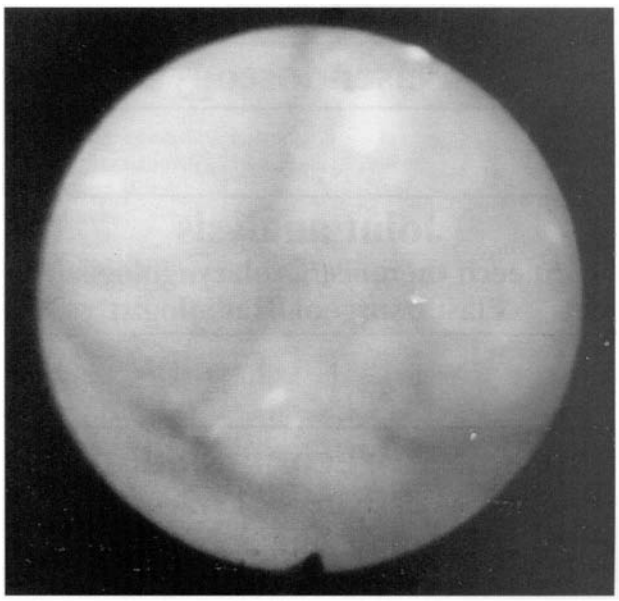
FIGS. 5 and 6

Occult submucous cleft palate: At rest the midline convex bulge of the soft palate is absent. During attempts at closure a depression on the superior surface of the soft palate appears diagnostic of this condition.

nasality. Shprintzen *et al.* (1976) evaluating 150 patients with hypernasal speech with multi-view videofluoroscopy, found that 19 patients had good velopharyngeal closure on lateral views but had central gaps on other views. Oral examination and palpation was normal in all these patients. Croft *et al.* (1978) investigating these patients with flexible nasendoscopy found that the superior surface of the soft palate at rest appears flattened and during speech tasks a characteristic depression appears on the superior surface of the soft palate. This is the classical finding in occult submucosal cleft palate. The diagnosis is based on videofluoroscopic and nasendoscopic appearance. Figures 5 and 6 show the nasendoscopic appearance of an occult submucous cleft palate. At rest the convex mid-line bulge of the soft palate is absent (Figure 5) and the superior surface of the soft palate appears to be flattened. During speech tasks, as the velopharyngeal sphincter attempts to close, a classical depression appears on the superior surface of the soft palate (Figure 6). This is diagnostic of the occult submucous cleft palate.

Figures 7 and 8 respectively, show the sphincter at rest and during speech with a flap pharyngoplasty in position. It can be seen that the flap takes part in adequate closure of the sphincter. Nasendoscopy is helpful in determining the width and the level of the pharyngoplasty, thus enabling accurate recommendations for revision of the surgery in cases of





FIGS. 7 and 8

Post-pharyngoplasty: Shows the sphincter at rest and during speech with a pharyngeal flap *in situ.*

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persisting hypernasality. It can also help to determine the type of secondary surgical procedure most likely to improve velopharyngeal closure in individual patients.

In our study, eight patients were found to have persistent hypernasality following pharyngoplasty. Nasendoscopy revealed the flap to be at a low level in three patients; in one patient it was found to be narrow. All four were recommended for revision pharyngoplasty. The others were found to have inconsistent closure patterns with minimal gaps, and were hence recommended for speech therapy.

Fifteen patients had persistent hypernasality following cleft palate repair and intensive speech therapy. Nasendoscopy revealed inadequate closure of the sphincter in nine patients and the gap was sufficiently large for these patients to be recommended for pharyngoplasty. One patient was recommended for an obturator and five for speech therapy.

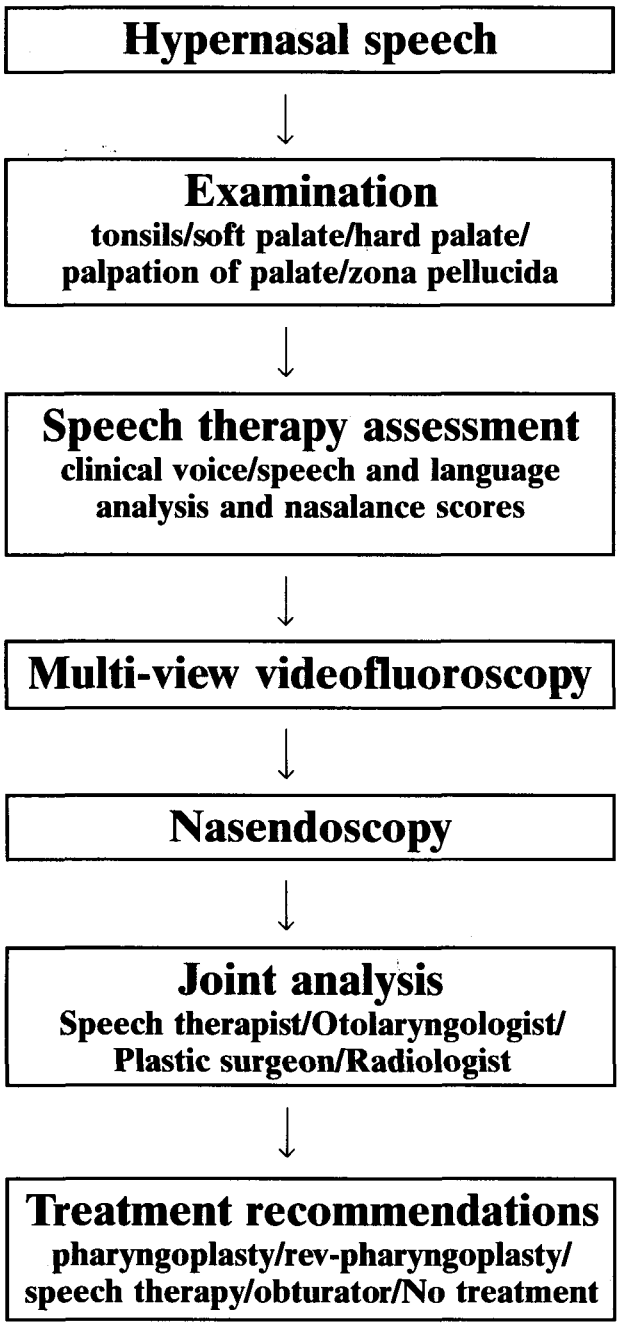

FIG. 9
Recommended management plan for children with abnormal nasal resonance.

In our study, we used the endoscope successfully to diagnose occult submucous cleft palate in two children aged four and five years. They were referred for palatal surgery.

Both the post-adenoidectomy patients had adenoidectomy for 'nasal speech' and both needed a pharyngoplasty to improve their speech. Both these children were later diagnosed as having velo-cardio-facial syndrome. This is a syndrome where there is a very high incidence of velar abnormalities and is associated with a very high incidence of middle-ear effusion. Adenoidectomy in these patients usually leads to disastrous consequence for speech. If there is doubt regarding nasal resonance or speech competency and, even if the oral cavity examination and palpation is normal, a cautious approach is needed. Ideally, a nasendoscopic examination should be carried out to rule out occult submucous cleft. If facilities and personnel are available a lateral videofluoroscopic view during speech tasks gives useful additional information regarding the length and movement of the palate and tongue function. Ideally, both should be carried out. Videofluoroscopy, including a Towne's view of the sphincter is also essential for any patient who cannot tolerate endoscopy. The recommended management plan for a child with abnormal nasal resonance is shown in the flow chart.

The post-tonsillectomy patients (n = 2) had extensive damage to the pillars with scarring of the soft palate and needed pharyngoplasty to improve their speech. A child with history of dysphonia and episodic stridor was endoscoped and the patient developed stridor during the procedure, the folds were found to adduct resulting in the stridor. He was diagnosed as having paradoxical vocal fold syndrome and was referred to speech therapy. Bullying at school was found to be the main factor. He has subsequently changed his school which has led to disappearance of his symptoms.

One patient had a combination of nasal escape, mixed resonance and dysphonia. Endoscopy showed mild velopharyngeal dysfunction and enlarged lingual tonsils. She was referred for speech therapy as it was felt that interfering with her lingual tonsils might increase her hypernasal resonance.

One child with hypernasal speech, had no abnormality of the palate but on endoscopy the tonsils were found to be hypertrophied and tethering the palate and impeding its movement. He is awaiting tonsillectomy.

Hypertrophied tonsils can interfere with elevation of the lateral aspects of the velum, lateral pharyngeal walls or both (Shprintzen, 1989). The diagnosis can be made only endoscopically, the tonsils can be seen in the pharyngeal airway, and during phonation the velum may contact the posterior pharyngeal wall

centrally, but some air leaks around its lateral aspects (Shprintzen, 1989). Tonsillectomy without adenoidectomy is recommended followed by speech therapy (Shprintzen, 1989).

The velopharyngeal valve should be regarded as a three-dimensional tube with vertical depth and cross-sectional length and width (Shprintzen, 1989). Therefore, the velum, lateral pharyngeal walls and the posterior pharyngeal wall interact at various points along the vertical depth; and this is responsible for limiting the use of endoscopy as the only tool for the assessment of velopharyngeal function. A lateral videofluoroscopic examination is also important to obtain a complete picture.

Limitations of the nasendoscopic examination should be borne in mind while making management decisions. It should always be analysed with the videofluoroscopic, clinical speech analysis data and objective nasal/oral airflow measurements. The examination relies on the examiner for interpretation of the results so it is very subjective. A study on inter- and intra-rater reliability of nasendoscopy (D'Antonio *et al.*, 1989), suggests that experienced clinicians working together as a group can make highly consistent judgements concerning velopharyngeal structure and function during speech from the video tapes. So the Otolaryngologist, the Plastic surgeon and the Speech and Language therapist all contribute to making the treatment recommendations. Video documentation allows re-evaluation of the produced speech sample in a team setting (Muntz, 1992). It also help in assessing the effectiveness of speech therapy, speech prosthesis and surgery.

In summary, 18 patients were spared from unnecessary surgery; 23 patients had appropriate surgery of varying types based on an objective assessment of the structure and function of the velopharyngeal sphincter. Two previously undiagnosed occult submucous cleft palates were diagnosed. Twenty-four patients (63 per cent) achieved normal resonance, 12 (32 per cent) patients moved from severe/moderate hypernasal resonance to mild hypernasal resonance and two patients (five per cent) achieved no change following the intervention (Table IV). Five were lost in the follow-up.

This procedure, by permitting the planning of individualized, surgical, prosthetic and therapeutic intervention offers the best chance of achieving the goal of satisfactory communication.

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