Nasopharyngoscopy in Palatopharyngeal Prosthetic Rehabilitation: A Preliminary Report

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Purpose: Prosthetic rehabilitation of speech disorders related to palatopharyngeal dysfunction is accomplished through separation of the oral and nasal cavities. The ability to achieve this separation is challenged when the disorder or defect involves the soft palate. Prosthetic rehabilitation of soft palate disorders and defects has traditionally relied on functional contouring of a prosthesis using functionally adapted impression materials. However, there are limitations to this process, particularly in its inability to visualize function as it relates to the prosthesis in a 3-dimensional space. The aim of this study was to address this limitation by describing outcomes related to the use of nasopharyngoscopy (NPS) for visualization of the velopharyngeal port during assessment and treatment of palatopharyngeal dysfunction. **Materials and Methods:** A retrospective analysis of speech data was conducted for 5 patients who were assessed before treatment, after prosthetic intervention using conventional functional impression techniques, and after prosthetic intervention using NPS. Nasalance and velopharyngeal orifice area outcome measurements were collected for each patient at clinically predetermined intervals. Perceptual assessment of speech samples was performed as well. **Results:** Improvements in speech function were observed for all patients after treatment with a prosthesis designed via a conventional functional impression technique; however, no patient showed normal values for nasalance or velopharyngeal orifice area. With the use of NPS to adjust the wax impression–derived prosthesis, both nasalance and velopharyngeal orifice area measurements for all patients were within normal limits. Similarly, perceptual judgment of speech found that normal resonance balance was obtained after use of NPS. **Conclusion:** The addition of NPS into prosthetic treatment for palatopharyngeal disorders shows promise for improved speech results. *Int J Prosthodont 2006;19:383–388.*

Speech affected by palatopharyngeal dysfunction can be functionally restored with intraoral prosthetic rehabilitation.[1] The value of palatomaxillary prostheses in restoring speech has been discussed in several reports.[1–6] In general, palatomaxillary prostheses restore the nasal-oral separation that is vital for normal speech resonance. While restoration of this separation is fairly straightforward for defects confined to the maxilla, it becomes more complicated for defects that involve the soft tissues of the palate or pharynx. This has been confirmed by 2 studies that measured functional outcomes in a series of patients treated prosthetically for palatopharyngeal disorders related to head and neck cancer.[1,3] Results from these 2 studies indicated that speech rehabilitation was compromised to a greater degree in individuals where the resection extended onto the soft palate compared to those where the resection was limited to the maxilla. More recently, this issue has been further complicated by the routine introduction of

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reconstruction of the soft palate and pharynx with microvascular free flaps. Thus, rehabilitation of soft palate disorders and defects presents the clinician with a challenging situation. Intuitively, this is not unexpected as the soft palate is a dynamic structure that moves in several different planes during normal function.

Researchers have debated which landmarks to use when determining a reference point for placement of the inferior border of a pharyngeal obturator.[7–12] Suggestions have been made regarding the optimal vertical height of a pharyngeal obturator,[7] as well as the optimal level of closure (ie, at the level of the palatal plane or the level of the anterior tubercle of C1).[7,13] However, research has shown that for connected speech, the height of the prosthesis has little influence on speech intelligibility.[3] In addition, the proportion of a pharyngeal obturator that contacts the posterior pharyngeal wall has been found to have no direct relation to functional speech results.[3] Therefore, it appears that previously described landmarks for obturator positioning may not be related to functional outcome. To overcome this quandary, the prosthodontist may rely on other factors to guide the process, such as the level of muscular activity in the pharynx.

Techniques for the prosthetic rehabilitation of soft palate disorders and defects have been described and generally include a process in which functional contouring of a prosthesis using functionally adapted impression materials is achieved via muscular activity in the velopharynx during speech, swallowing, and a series of head movements.[7,13,14] Thus, instead of relying on bony landmarks, the prosthodontist is able to interpolate function based on markings in the impression material. However, this presents the prosthodontist with another challenge because of the difficulty in establishing a common pattern of muscle activity both within and across individuals. Research has shown that velopharyngeal muscular activity is variable within individuals, with different patterns of closure exhibited during different functions. For example, it has been shown that velopharyngeal closure will vary based on the phonetic context of speech, such that sounds requiring high intraoral pressure are associated with greater muscular contraction than low-pressure sounds.[15,16] Further, the relative contributions of velopharyngeal muscles during speech, including the superior pharyngeal constrictor, have been found to be inconsistent both within and across subjects.[17] Finally, the use of a landmark such as Passavant's ridge to position a velopharyngeal prosthesis is unreliable, as this ridge occurs in few normal speakers and only in a portion of disordered speakers.[18–20] More importantly, when Passavant's ridge does occur, it may appear in a region that is higher or lower than the functional muscular level.[21] Thus, an impression made using this muscular prominence as a landmark may be misleading in some cases.

The idea of finding a common muscular activity pattern that could be applied across individuals would also be flawed because variability in velopharyngeal function has been shown. For example, men display different patterns of velopharyngeal closure than women during speech.[15,16] Further, general patterns of velopharyngeal closure are variable across individuals. For example, some individuals display circular patterns of closure, while others display a coronal pattern of closure.[22] Thus, the use of a muscular landmark or assumed general pattern of activity across individuals will not facilitate the construction of a prosthesis when using impression-recording techniques. However, the positioning of a prosthesis to take advantage of residual functional muscular activity in the velopharynx is intuitively strategic and should be exploited. This requires visualization of the nasopharynx, which is best achieved with the addition of nasopharyngoscopy (NPS) to the conventional prosthetic treatment protocol.

The conventional process of constructing a prosthesis with functionally adapted impression materials involves interaction between the patient, prosthodontist, and speech pathologist. Prosthetic treatment of patients may include the use of aeromechanical and acoustic speech assessment techniques to assess the adequacy of prosthetic intervention. While these techniques aid in the construction of a pharyngeal prosthesis and are essential in quantifying the changes imposed on the speech system by such a prosthesis, they do not guide the prosthodontist in how to physically alter the prosthesis to achieve an optimal result. Thus, a challenge remains because the diagnosis, impression recording of the pharyngeal space, and insertion of the prosthesis are conducted without direct visualization of the dynamic structures of the pharyngeal surface anatomy. To circumvent these challenges, the authors have added the use of NPS to the conventional technique to visualize the palatopharyngeal port during assessment and treatment.

The use of a flexible fiber-optic nasendoscope in the treatment of palatopharyngeal defects is considered essential for several reasons: *(1)* it provides direct visualization of the pharynx and the associated residual functional muscular activity, which is important for diagnosis and treatment of the palatopharyngeal disorder; *(2)* it allows the clinician to monitor treatment outcomes over time; *(3)* it enhances team communication by clearly detailing the challenges for rehabilitation of each patient; *(4)* it is an excellent patient education tool that helps patients understand the physiology of and challenges posed by their condition; and *(5)* it is hypothesized that the use of NPS allows prosthetic treatment to be designed to match diagnostic findings in palatopharyngeal prosthetic care. The present study attempts to address this latter statement.

Materials and Methods

The authors reviewed the charts for patients who were identified as having begun palatopharyngeal prosthetic care for velopharyngeal dysfunction between June 2003 and July 2005. Fifteen patients were identified for potential inclusion in this study. Of those patients, 5 who had speech assessments before prosthetic intervention, after prosthetic intervention using conventional functional impression techniques, and after prosthetic intervention with the use of NPS were included in this study. Of the excluded 10 patients, 3 did not proceed with prosthetic care after assessment with NPS, 4 were assessed with NPS and were waiting for prosthetic treatment, and 3 received prosthetic treatment using NPS from the initial stage of prosthesis construction.

The 5 patients studied included 2 individuals who were treated for oropharyngeal cancer via surgical resection and microvascular reconstruction followed by radiation therapy. Radiotherapy had been completed 1 year prior to prosthetic intervention. Velopharyngeal insufficiency resulted after radiotherapy. The third patient was treated for carcinoma of the soft palate through complete resection of the soft palate. This patient did not receive radiotherapy. The fourth patient was treated for maxillary carcinoma with a fibular flap reconstruction, which resulted in anterior displacement of the soft palate. The fifth patient presented with velopharyngeal dysfunction of unknown etiology. All but one patient were dentate. The age of the patients ranged from 8 to 58 years.

The NPS procedure was accomplished using a 3-mm flexible fiber-optic Pentax endoscope attached to the KayPENTAX Digital Swallowing Workstation for digital recording of all scoping procedures. Before NPS, a cotton pledget soaked in an equal solution of topical anesthetic (4% lidocaine hydrochloric acid, Xylocaine, AstraZeneca Canada) and nasal decongestant (1% phenylephrine HCl, Neo-Synephrine, Sanofi-Aventis) was inserted with bayonet forceps into the nasal passage that was more patent upon visual inspection. The pledget remained in the passage for 5 minutes before removal. The scope was inserted through the middle nasal meatus until the velopharyngeal port was in full view. With the pharyngeal prosthesis inserted, the structures were observed during rest, speech, and swallowing. Patency of the velopharyngeal airway for nasal breathing with the prosthesis was observed at rest. Speech samples specifically designed to stress the velopharyngeal mechanism were used to assess the adequacy of the prosthesis in occluding the velopharyngeal opening. Alterations to the prosthesis were made based on the results of the NPS.

All patients included in this study were treated and assessed by the same clinicians at each time period. Nasalance (Nasometer II, Model 6400, KayPENTAX) and velopharyngeal orifice area (PERCI-SARS, Microtronics) outcomes were chosen as indicators because of their sensitivity to dysfunction of the velopharyngeal system.[1,23] Methods for obtaining nasalance and velopharyngeal orifice area measurements were as described previously.[1] As part of routine clinical treatment, both measurements were obtained before any prosthetic intervention, within 2 weeks of delivery of a definitive prosthesis using conventional functional impression techniques, and within 2 weeks of delivery of the prosthesis constructed with the use of NPS.

In addition to the instrumental measurements, speech samples were digitally recorded at the 3 assessment times. Using these speech samples, perceptual judgments of resonance were made by 2 independent speech-language pathologists, each with more than 20 years of experience in the area of voice and resonance disorders. The speech recordings consisted of standard phrases being spoken by the patients. The 2 listeners were given 2 listening tasks: a within-subject paired-comparison task and a Likert scale rating task. In the paired-comparison task, the response protocol consisted of a forced-choice task in which 2 speech samples from the same patient were played through headphones, and the listener rated the second sample relative to the first based on perceived hypernasality. The following paired comparisons were made: preprosthetic vs prosthesis with no NPS, preprosthetic vs prosthesis with NPS, and prosthesis with no NPS vs prosthesis with NPS. The presentation of the components of the pairs was completely counterbalanced to avoid any order effects. In addition, each condition was compared with itself. Finally, a random selection of 20% of the paired samples was replayed. The Likert scale rating task consisted of 6 speech samples from each speaker (2 samples from each assessment time), presented in random order. The listeners were asked to rate each sample on a 7-point scale from severely hyponasal to severely hypernasal. The listening experts were blind to the number of speakers and the treatment conditions.

Results

Patient characteristics and speech results are listed in Table 1. Speech results can be viewed in Figs 1 to 3. Preprosthetic instrumental speech results indicated that all patients were in need of intervention for velopharyngeal dysfunction. Before intervention with NPS, the patients used conventionally designed prostheses for periods of time ranging from 1 month to just over 1 year. Improvements in speech function as

Table 1 Patient Characteristics and Speech Results

	Nasometer results (% nasalance)*			PERCI results (VPO area in mm^2)†		
Sex	Preprosthetic	Prosthesis without NPS	Prosthesis with NPS	Preprosthetic	Prosthesis without NPS	Prosthesis with NPS
M	54.0	20.0	8.0	80.0	12.0	2.8
F	66.0	40.0	17.0	47.0	0.1	0.3
F	58.0	14.0	4.0	80.0	14.9	0.5
F	61.0	49.0	18.0	0.4	0.8	0.6
M	47.0	31.0	14.0	80.0	80.0	1.7
Mean	57.2	31.0	12.3	57.5	21.6	1.2

VPO = velopharyngeal orifice.
*Normal mean range[25,26] = 9.4%–13.7% (mean SD = 4.4).
†Normal mean range[25,26] = 0.0–5.0 mm^2.

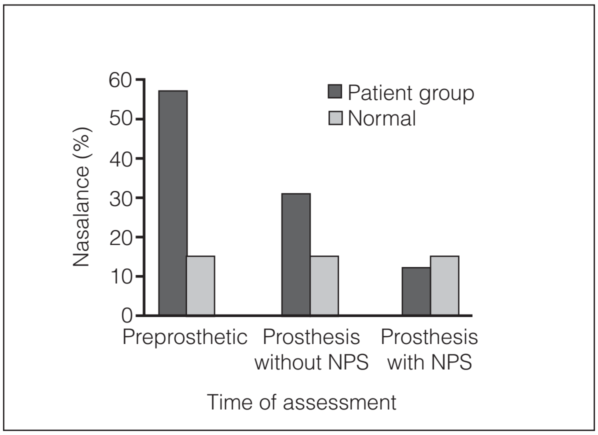

Fig 1 Nasometer results compared to reference data[24] for normal speakers.

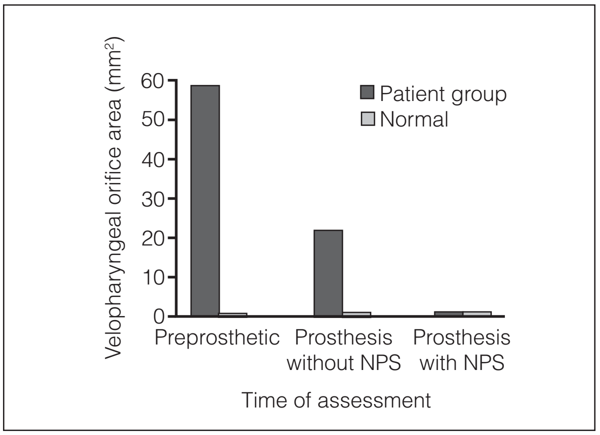

Fig 2 PERCI results compared to reference data[25] for normal speakers.

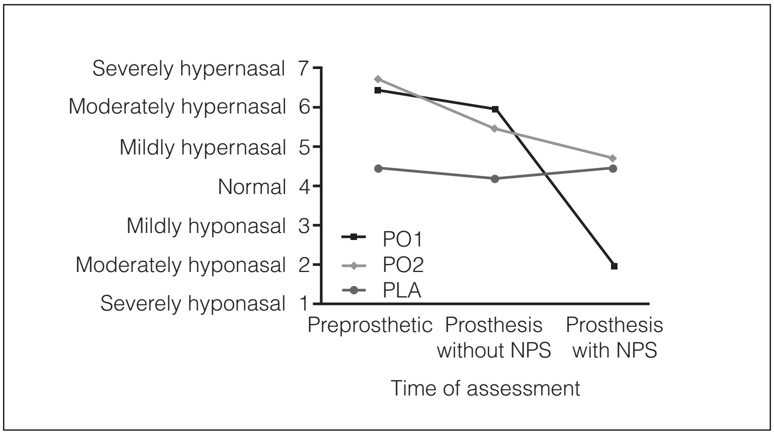

Fig 3 Mean perceptual ratings of nasality for each speaker. PO = pharyngeal obturator; PLA = palatal lift appliance.

measured through the Nasometer and PERCI systems were observed for all patients after treatment with a conventionally designed prosthesis. However, these improvements were limited in that no patient showed what would be considered normal speech results as measured by either the Nasometer or PERCI systems. One of the 5 patients approximated normal nasalance, but did not achieve a normal velopharyngeal orifice area. Two of the 5 patients approximated normal velopharyngeal orifice areas, but did not achieve normal nasal resonance. The remaining 2 patients did not approximate normal values for either nasalance or velopharyngeal orifice area. After the addition of NPS into prosthetic treatment, speech results for all patients were within normal limits as assessed through the Nasometer and PERCI systems.

Figure 3 shows the perceptual results for nasality ratings by the independent speech-language pathologists. Two patients were missing speech recordings from 1 of the 3 assessment times and so were not included in the perceptual study. Two of the 3 patients included in the perceptual study had a pharyngeal obturator, and 1 had a palatal lift appliance. When presented with the speakers using a pharyngeal obturator, the listeners rated the nonobturated condition as more hypernasal than either obturated condition 100% of the time. The listeners rated the conventional obturator condition as more hypernasal than the NPS-modified obturator 88% of the time. For both patients with a pharyngeal obturator, results of the Likert scale revealed that ratings of hypernasality decreased after revision of their obturators using NPS. One patient approached normal and the other went from moderately hypernasal to moderately hyponasal. There was relatively little change in the perception of the patient with the palatal lift appliance across treatment conditions.

Discussion

The results of this study suggest that the addition of NPS into prosthetic treatment for palatopharyngeal disorders shows promise for improved speech results for some patients. Reference data suggest that normal nasalance values for individuals between the ages of 8 and 85 should range between 9.4% and 13.7% (SD = 4.4%),[26] and that nasalance scores above 26% are associated with perceptual judgments of clinically significant hypernasality.[27] Table 1 shows that nasalance scores in 3 out of 5 patients were above this limit when speaking with a prosthesis designed without NPS. After adjustment of the prostheses with NPS, all patients fell below the cutoff associated with perceptual judgments of hypernasality. Regarding aeromechanical assessment, normal velopharyngeal orifice area values range between 0 and 5 mm^2.[25] Velopharyngeal orifice areas between 10 and 20 mm^2 result in air pressure and flow patterns associated with velopharyngeal impairments that can lead to judgments of hypernasal speech.[28,29] Table 1 shows that 3 of the 5 patients were within this abnormal range before revision of their prosthesis with NPS. After adjustment of the prostheses with NPS, all patients demonstrated velopharyngeal orifice areas within a normal range.

The perceptual results suggest that experienced listeners could perceive a change in nasality that reflected the findings from the instrumental measurements for the patients with a pharyngeal obturator. This same correlation was not found in the patient with a palatal lift appliance. Interestingly, the patient with the palatal lift appliance was judged to have very mild hypernasality before any prosthetic intervention, even though instrumental measurements reflected substantially abnormal values. This patient's velopharyngeal dysfunction was congenital in nature and did not stem from an acquired event. Theoretically, this patient may have developed some compensatory articulation strategies throughout speech development that decreased the perception of hypernasality for listeners. This patient reported that speaking without the palatal lift appliance became more difficult as the day went on, reflecting the burden that velopharyngeal dysfunction places on the speech system. The primary benefit of the prosthesis in this case may have been the prevention of such fatigue.

Traditional techniques for constructing a pharyngeal prosthesis involve the use of both static and functional impression techniques. The literature describes a wide variety of techniques, materials, and anatomic locations for pharyngeal prosthesis care. The outcomes of treatment are rarely reported in an objective manner and usually rely on the clinician's perception. NPS provides visualization of the nasopharynx so that appropriate treatment decisions can be made for a specific patient, as opposed to the traditional out-of-field-of-vision approach, which relies on the notion that one anatomic landmark will be appropriate for all. Moreover, the availability of technology to assess speech through acoustic and aeromechanical measures allows for objective measurement to be coupled with clinicians' perception. It is advocated that NPS should become an element in the routine clinical armamentarium of the prosthodontist. Further, prosthodontists involved in treatments influencing resonance should make routine use of acoustic and aeromechanical measurements of speech throughout the stages of care required to construct a pharyngeal prosthesis.

There are limitations of the present study that must be addressed. First, it should be acknowledged that the number of patients studied is small, requiring that conclusions be made with caution. Another potential limitation is that the patient population presented with heterogeneous etiologies of velopharyngeal dysfunction. While this may be viewed as a limitation, the results of this study suggest that NPS technology was useful in treatment of several different etiologies. Thus, in future studies with larger patient populations, the relative benefit of NPS across etiologies can be explored. Finally, the retrospective nature of the data compilation is a limitation. To overcome this limitation, future studies are required to prospectively assess the use of this technology in a randomized group design in which outcomes of the conventional technique are directly compared to outcomes obtained with the NPS technique. It will also be important to address the economic value of this technology. Therefore, in addition to patient function, the impact of this technology on clinical time and resources should be described.

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