The Taub Oral Panendoscope: A New Technique

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In order to advance the present body of knowledge of the multidimensional facets of the structures involved in speech production, it is necessary to provide a method for direct observation of the velopharyngeal and laryngeal areas during phonation. Our knowledge can be further enhanced by simultaneously recording the sights and sounds of phonation for later definitive analysis and interpretation in conjunction with, and in light of, other established methods.

We have designed an oral panendoscope that more than adequately provides for direct observation of velopharyngeal and laryngeal areas during phonation and facilitates the simultaneous audio-visual recording of the speech mechanism.

Conventional x-ray technique is of limited usefulness in studying velopharyngeal and laryngeal structures since only one plane, in two dimensions, can be viewed at a time. Even if structural relationships of such structures could be dynamically viewed in planes other than those obtained from lateral x-ray studies, the surface anatomy with all its subtle muscular movements and sphincter-like action would go unnoticed. Because of the inherent inability to record surface phenomena by x-ray methodology, gaps in our knowledge of the speech mechanism still exist.

Direct observation of the soft palate and posterior pharynx and their function were first reported in 1836, in which Hilton observed palatal activity in a patient who had a large defect of the face following spontaneous separation of a large, bony tumor (*1*). Similar observations have been made of the soft palate and pharynx, at rest and during speech. While such cases are interesting, they contribute little to our understanding of speech pathology because of the general condition of the patient and the severity of the anatomical and physiological distortion.

Various optical instruments have been employed for the visual examination of cavities of the body, but these possess numerous drawbacks and disadvantages, particularly when applied to the direct visual observation and photography of the velopharyngeal and laryngeal areas during phonation. The conventional endoscopes are generally awkward devices of lim-

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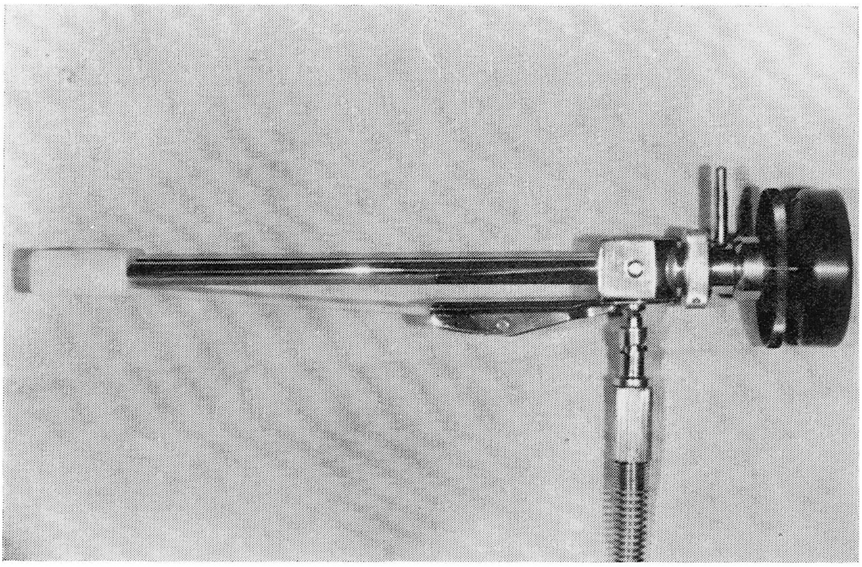

FIGURE 1. The Taub oral panendoscope provides a tool and method for simultaneous visual observation and audio-visual recording of the operation of the speech mechanism during the production of speech sounds in normal and abnormal subjects. The image at the distal end, where the rotating lens is located, is transmitted through objective, achromatic, and ocular lenses to the eyepiece-in normal position, not upside-down. The effect is as though the viewer's eye were actually in the mouth. Magnification is up to 8 times with unity at 7 cm. Field of vision is a 50° cone area. The lens may be rotated 180°, for observation of both the nasopharyngeal and laryngeal areas. Illumination is sufficient for color motion photography.

ited application and scope, of limited and inadequate illumination, and of little adaptability and flexibility. They are difficult to manipulate and maneuver and leave much to be desired.

Recent technical advances have been made in the field of tubular optics and telescopes. An improved endoscopic instrument for culdoscopy and color motion picture photography was developed by Clyman in 1963 (*2*). Optical and illumination systems employed in these instruments have been so much perfected as to enable the eye of the examiner to detect irregularities up to 0.001 inch. In 1962, the author of this paper (then a resident in Plastic Surgery at Kings County Hospital) independently conceived of and subsequently brought the oral panendoscope to its present stage of development. The purpose of this paper is to describe the instrument and to demonstrate ways in which it can be used for the investigation of the velopharyngeal port.

Description

The oral panendoscope (Figure 1) is an integrally illuminated tubular optical device which, by means of a newly-designed lens system,[1] increases

[1] National Electric Instrument Division, Englehard Hanovia Inc., Elmhurst, N. Y.

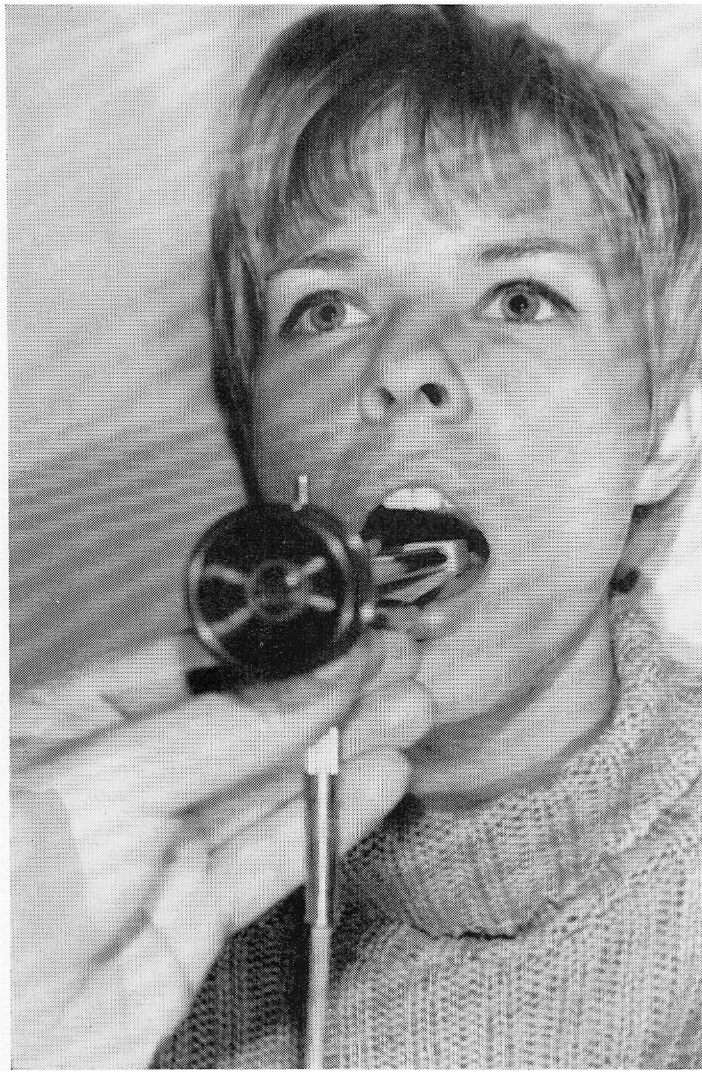

FIGURE 2. Illustration of the use of the oral panendoscope. The mouth may be closed with the instrument inside, providing visual observation during phonation.

the light transmission from the objective prism to the viewer and camera at the proximal end. A high-intensity incandescent lamp adjacent to the objective lens illuminates the target surfaces at proper levels of light as required for direct observation, motion picture, and still photography. An eyepiece is provided with a glare shield for clinical use and a threaded adapter for camera mounting. Light intensity is controlled by a variable output transformer which operates from a standard 110 V 60 cycle ac power source. A nylon removable tongue depressor functions as a heat shield to protect exposed tissue from contact with the lamp bulb. The

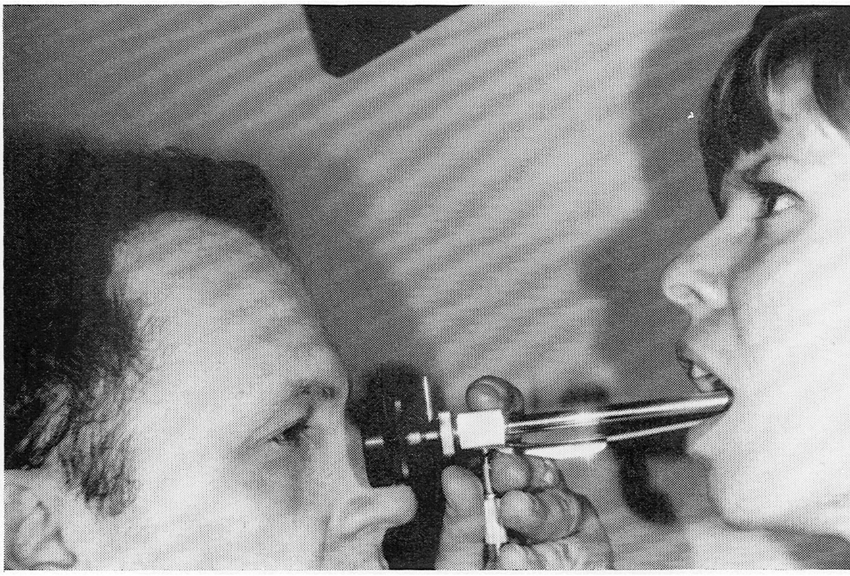

FIGURE 3. With the subject seated, the instrument is inserted into the oral cavity with the objective lens up, and is manipulated for viewing the posterior pharynx and nasopharynx. The muscular activity of the palatopharyngeal sphincter mechanism is clearly observed while patient recites various combinations of vowel-consonant-vowel sounds. The lens is rotated 180° for viewing the larynx during the production of various vowel sounds in natural, falsetto and singing voice.

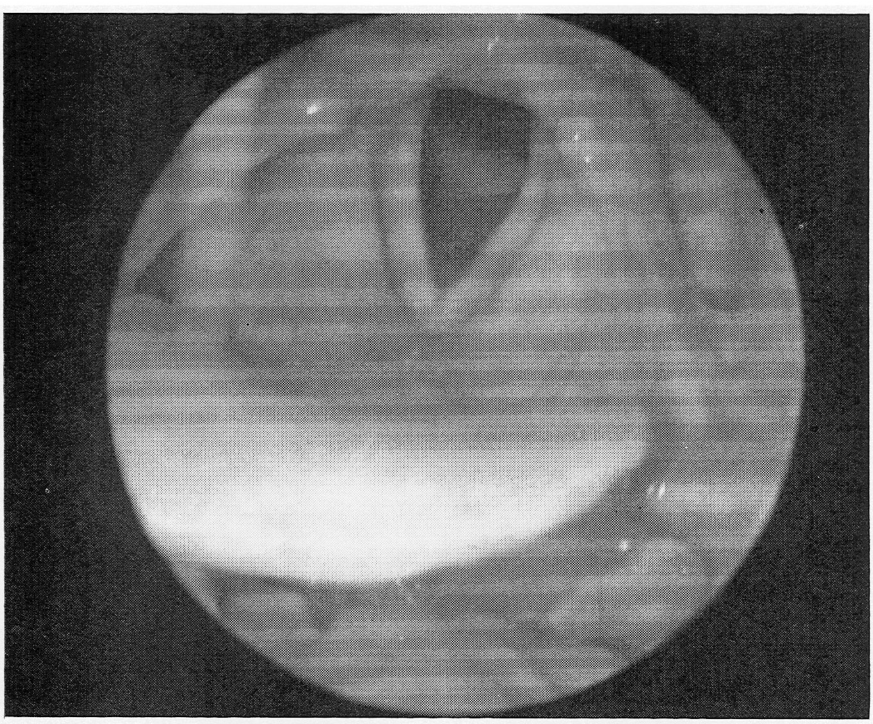

FIGURE 4. Direct view of the larynx with the panendoscope.

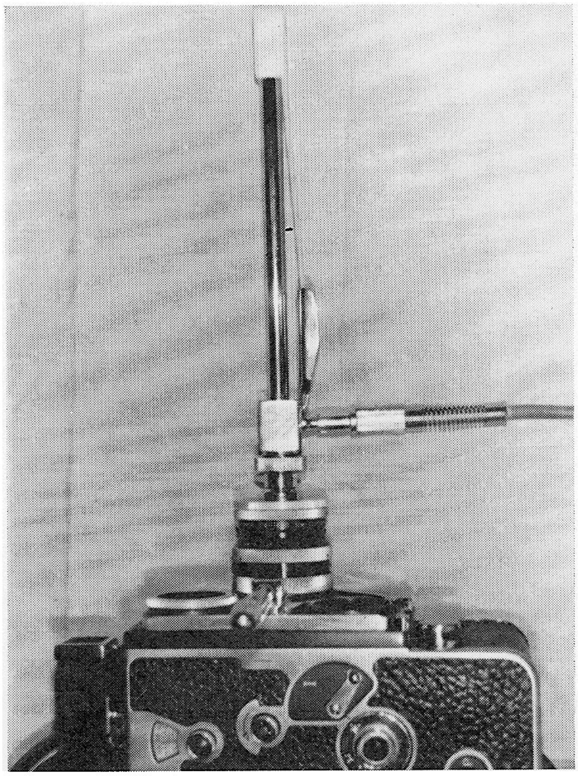

FIGURE 5. For motion photography, either an 8 mm or 16 mm single lens reflex camera may be attached to the instrument for recording in color at 24 frames per second, using high speed film.

tongue blade is smaller than a conventional wooden tongue blade and may be fixed to the body of the instrument in such a manner as to minimize sound distortion during phonation. Magnification is inversely proportional to the distance from the objective lens to the target, being approximately 8 times at the objective lens and approximately life size at 7 cm from the objective lens (the depth of the larynx). The image received at the distal end is bright, undistorted, and in focus throughout the distances involved. When the instrument is used clinically, it does not have to be refocused during use. However, when the panendoscope is attached to a camera lens, the camera lens has to be focused for varying distances (to be described later). The field of vision is a 50° cone area having its apex near the surface of the objective lens. The axis of vision is at right angles to the instrument tube axis.

PROCEDURE FOR EXAMINATION. The combination heat shield and tongue depressor is fitted to the instrument. Before inserting the instrument into the oral cavity, the light should be turned on and kept at a clinical level intensity for one minute so that the heat from the lamp will prevent the objective lens from fogging. With the patient seated, the tongue depressor

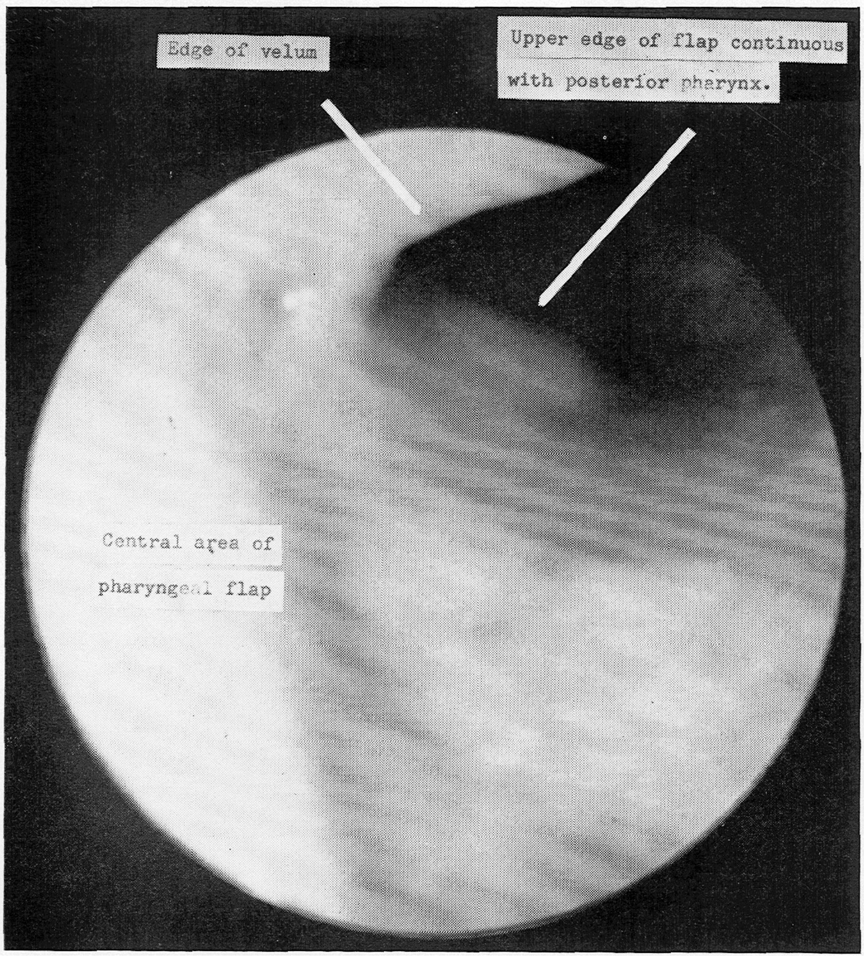

FIGURE 6. Upward view showing pharyngeal flap and left aperture during normal respiration.

member is placed on top of the tongue and the instrument gently inserted as closely as possible to the posterior pharynx, care being taken to avoid pressure or contact with the soft palate, particularly the glosso-palatine folds, since these areas are sensitive to touch. The uvula should rest on the top surface of the tongue blade proximal to the apertures for viewing and illumination (Figure 2).

The examiner does not look through the telescope as it is being introduced, but rather observes the oral cavity as the instrument is guided into place (Figure 3). Once the instrument is in the proper position for viewing, the patient may be asked to close his lips around the oral panendoscope and to phonate various combinations of vowel-consonant-vowel sounds such as *aba, mama, oh boy, papa, apa,* et cetera. The clarity of these

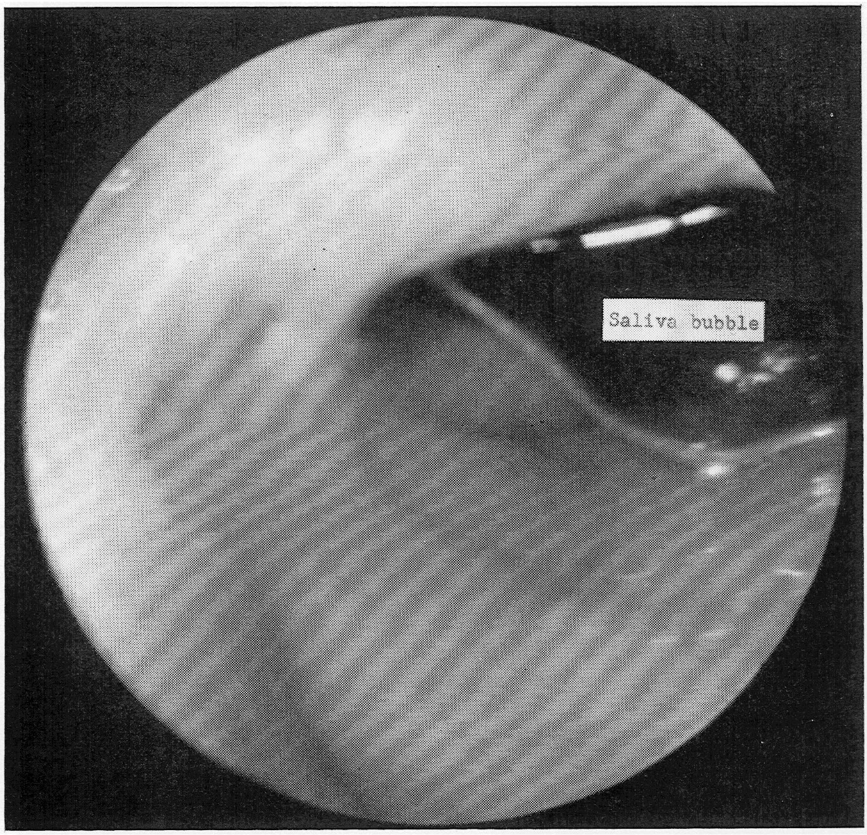

FIGURE 7. Upward view showing bubble of saliva filling left aperture. Presence of saliva seems to play a role in effecting degree of nasality.

sounds may be greatly enhanced by wrapping adhesive tape around the tongue blade and metal tubes, approximately 3½ inches away from the proximal end of the tongue blade, so that the lips may close snugly around the instrument (over the taped area) without permitting any escape of air between the blade and metal tubes.

If the patient has a marked gag reflex and therefore finds it difficult to tolerate the instrument in areas such as the glosso-palatine arches and the soft palate, these areas may be sprayed with a topical anesthetic such as Cetacaine, or a 1% solution of Pontocaine. Once the area is sprayed, it is suggested that a period of one or two minutes elapse before re-inserting the oral panendoscope.

With the objective lens in the superior position, while the patient is phonating various vowel-consonant-vowel sounds, varying degrees of velopharyngeal closure may be observed. The area of vision includes movements of the posterior pharyngeal wall, including the formation of Passavant's pad and the mesial movement of the palatopharyngeus muscles.

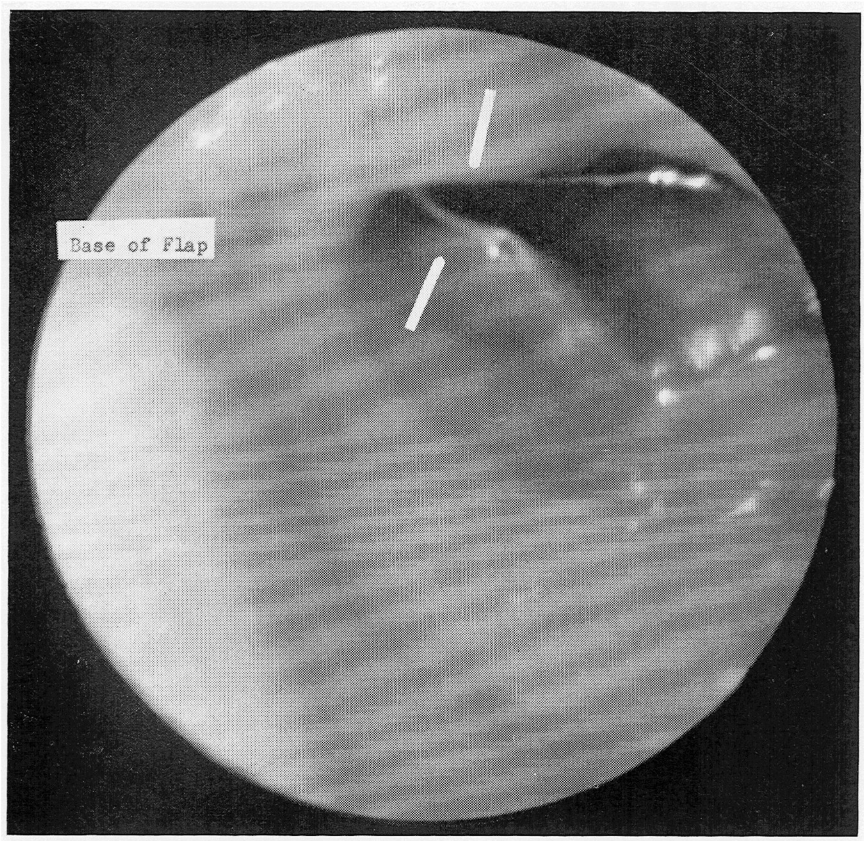

FIGURE 8. Looking upwards into left aperture during phonation of vowel sound *ah*. Note that saliva bubble is still present. Lateral pharyngeal musculature has moved mesially and anteriorly narrowing aperture. Arrows indicate that near the base attachment of the flap there is closer approximation of the velum to the posterior pharynx due to anterior movement of the latter.

The entire width of the posterior-superior aspect of the soft palate may be clearly observed in its upward excursion to the epipharynx during velopharyngeal closure. The torus and opening of the Eustachian tubes, and the posterior edge of the nasal septum are clearly visible. Sight-sound-motion relationships in normal and abnormal subjects are clearly discernible and relatable.

The optical tube may be rotated 180 degrees for viewing the larynx during the production of various vowel sounds in natural, falsetto, and singing voice (Figure 4). The entire laryngeal mechanism and surrounding structures, including the true and false vocal chords, epiglottis, anterior commissure, aryepiglottic folds, arytenoid cartilages and piriform fossa, are brightly illuminated and clearly visible at approximately or slightly greater than life size. An area of approximately 2 cm in size of the tracheal lumen is visible.

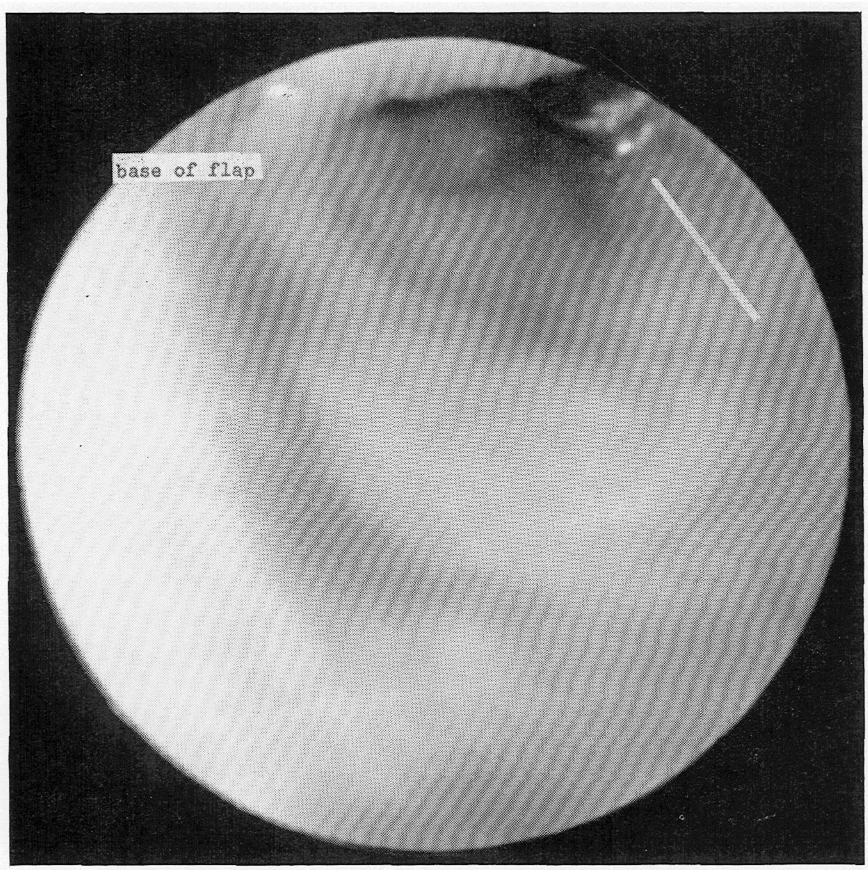

FIGURE 9. This photograph was taken during the phonation of *bah*. Note bubble of saliva occluding lateral aspect of aperture.

The telescope is rotatable completely around the instrument and can be situated in either an *up* or *down* position (in intermediate positions, vision will be obliterated by the white heat shield). Any further manipulation that may be necessary to enhance the examination is accomplished by maneuvering the entire instrument and not just the telescope tube.

The oral panendoscope is fitted with a special lamp designed for use up to six volts for diagnostic procedures and capable of operation at higher voltages for short periods during cinema photography and still photography. A variable output transformer will provide the lamp with an adjustable voltage as well as the proper overvoltage required for photography.

The instrument may be properly sterilized by ethylene oxide, or by any cold sterilization procedure used for standard endoscopic instruments (such as Zephiran, 1:750 dilution). The instrument should not be autoclaved, cleansed with alcohol, corrosive solutions, or carbolic acid.

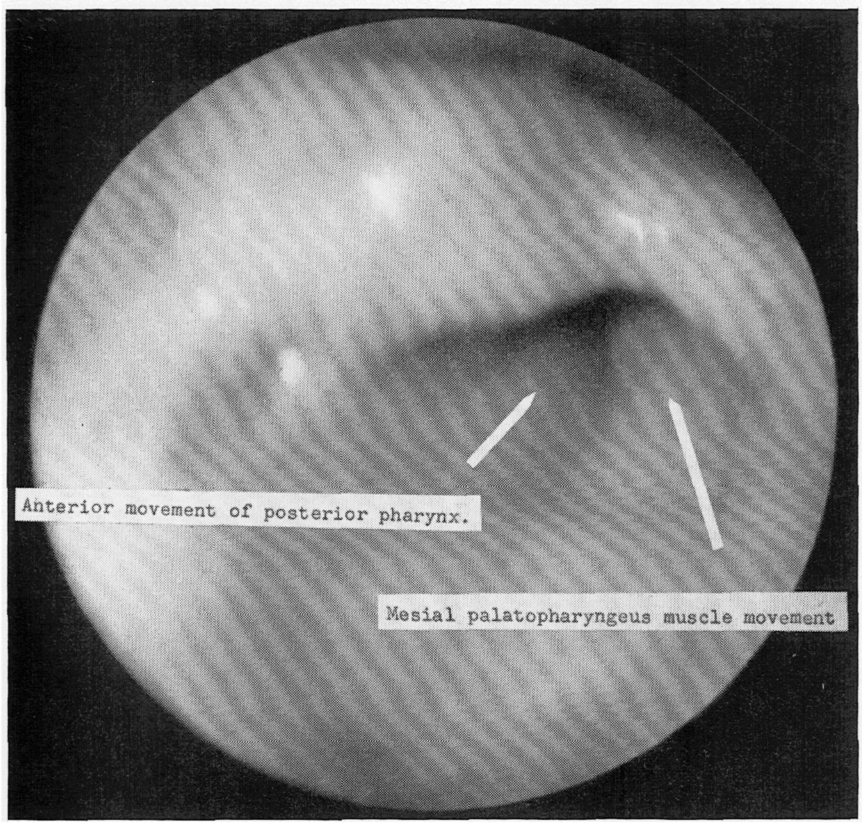

FIGURE 10. Complete closure obtained during 'gagging'.

Photographic Use

For photography, the oral panendoscope is provided with an eyepiece having a screw thread to fit a #5 camera adapter ring (Figure 5) which, in turn, may be adapted by step-up or step-down rings to attach to any camera lens. It is preferred that a single lens reflex camera be used, since this permits viewing through the 'taking' lens which is attached to the panendoscope. In this manner, the operator may observe what he is photographing. If the ground glass (fresnel) in the viewfinder can be replaced with a clear glass, clarity of the image and the ability to focus sharply will be enhanced.

For still color transparencies, high speed EHB Ektachrome film is recommended. Any 35 mm single lens reflex camera may be used. When using 35 mm film, the 'taking' lens may vary from 50 mm to 105 mm, depending upon the size of the image desired. The 105 mm lens magnifies the image to fill the entire area of a 35 mm film frame. The image with a 50 mm lens will be smaller but brighter because of the reduced magnification. When using any reflex camera, the 'taking' lens is generally focused be-

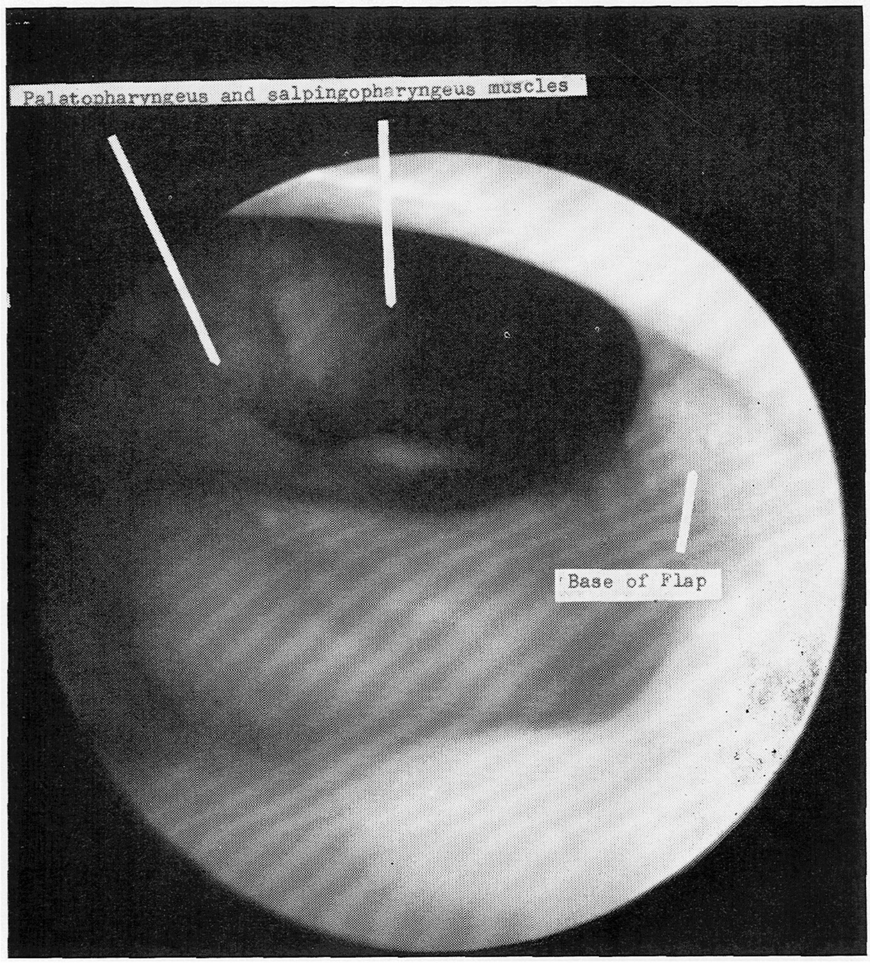

FIGURE 11. Looking up into right aperture; Estimated size 10 mm x 4 mm. Closure was not achieved during phonation although the aperture narrowed to approximately 6 mm x 3 mm during plosive sounds. Residual nasality persisted.

tween one foot and infinity with the F stop wide open. A light controller transformer has been designed for synchronizing overvoltage of the lamp bulb with the camera shutter. This synchronous flash control is monitored through a flash cord which may be attached to the 'X' outlet of any single lens reflex camera. Shutter speeds for color film may range from 1/4 to 1/15 of a second, or more, depending upon the distance of the area being photographed and the condition of the lamp. Should faster speeds be desired for still color photography, EHB Ektachrome film may be developed at higher ASA ratings, such as 250, if custom processed.

For black and white photography, faster shutter speeds may be obtained with the use of Tri-X, ASA 400, by developing in acufine and by boosting

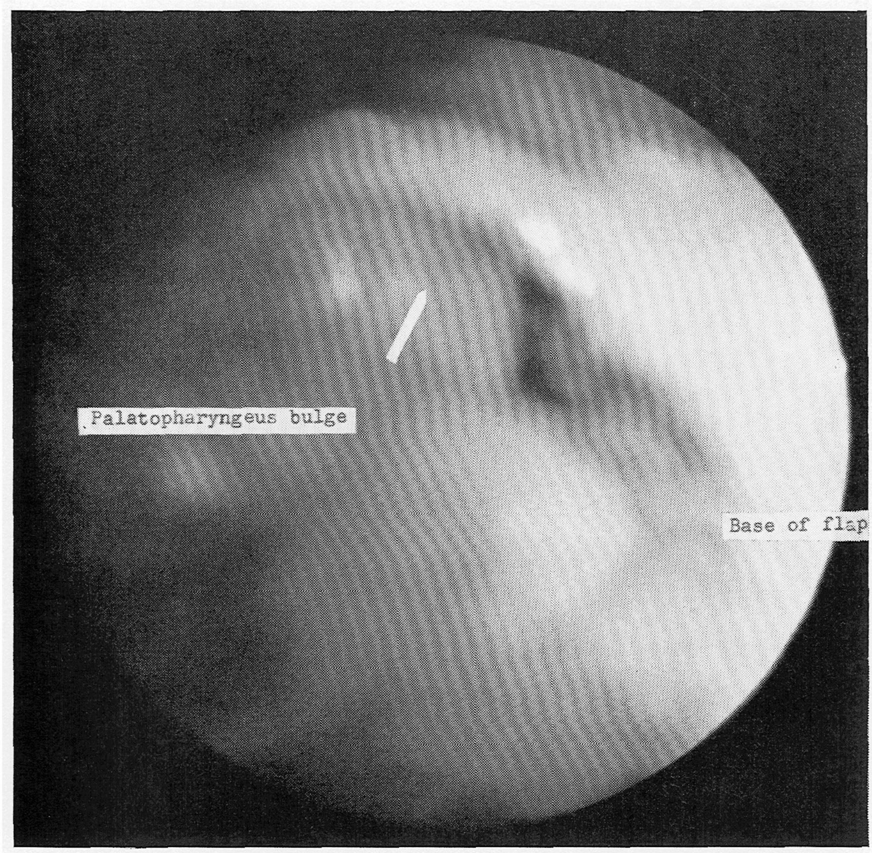

FIGURE 12. View again of right aperture. Complete closure obtained during 'gagging'. Note extreme mesial and anterior movement of lateral and posterior pharyngeal musculature.

ASA ratings to 1200. Excellent black and white and color prints, 8″ by 10″ in diameter, have been made of the larynx and nasopharynx from negatives 33 mm in diameter, taken with a 2¼ by 2¼ single lens reflex camera through a 135 mm lens. The color slides obtained with this technique are of exceptional quality and permit excellent projection and reproduction.

For color motion picture photography, audio-visual recording of the speech mechanism during the production of speech sounds may be accomplished as follows. By using the Beaulieu 16 mm reflex and the Nagra ¼″ Magnetic Tape Recorder, synchronized sound may be recorded with the motion picture camera driven by a synchronous motor. The synchronous signal for camera speed is integrated into the system (generated by the Nagra main power supply). For synchronizing sound and the event of velopharyngeal closure, the use of the standard 'clap-board' technique is time-consuming and costly of lamp-life because the panendoscope has to be re-introduced and positioned in the oral cavity after synchroni-

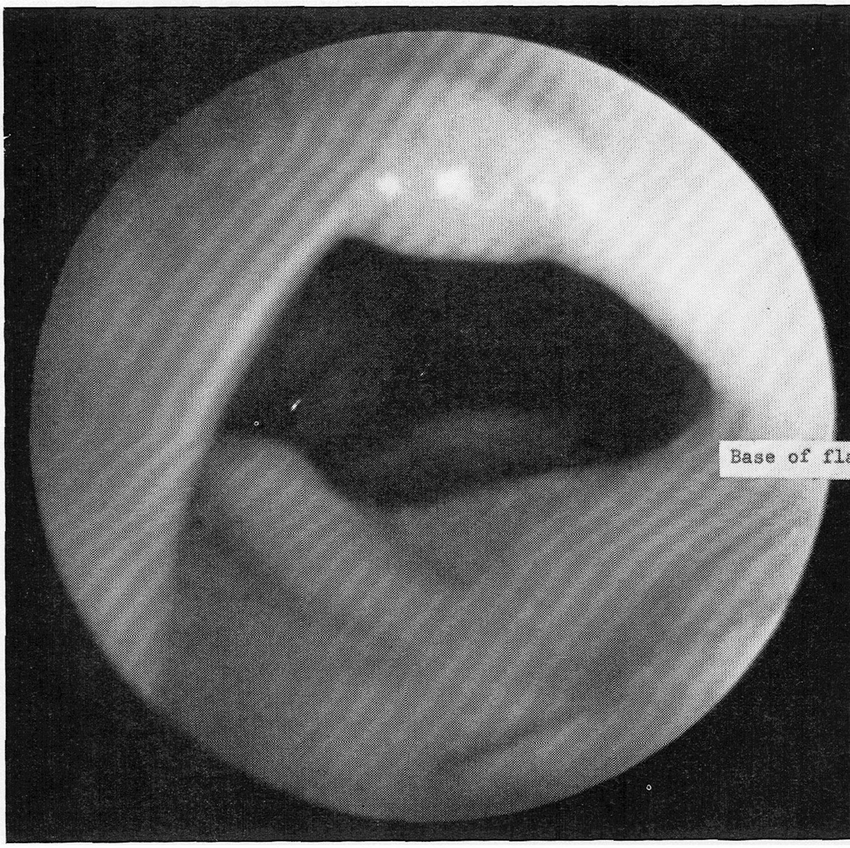

FIGURE 13. An 18-year-old female with a pharyngeal flap and excellent speech result. View of right aperture during normal respiration.

zation has been established. It is recommended instead that the overvoltage flash controller be synchronized with a high frequency sound blip which is fed directly into the recording system. In this manner, the instrument may be positioned for proper observation of the velopharyngeal closure at low levels of light intensity and then, once in position, overvolted to brighter illumination with the foot pedal control which simultaneously activates the sound blip. During film synchronization editing, it will be easy to match up the increase in light intensity on individual frames with the blip on the sound track. Sound speeds are taken at 24 fps, using ER Ektachrome 16 mm or 25 mm standard C mount type. The 25 mm lens will produce a larger image, filling up most of the 16 mm frame. A special adapter for standard 'C' mount lenses (for 16 mm cameras) can be obtained from the manufacturer.

For motion picture photography, the Beaulieu camera R16E is recommended. The larger Arriflex may also be used. Both cameras deliver 100% of the light to the film, since the reflex viewing system is an alternate one.

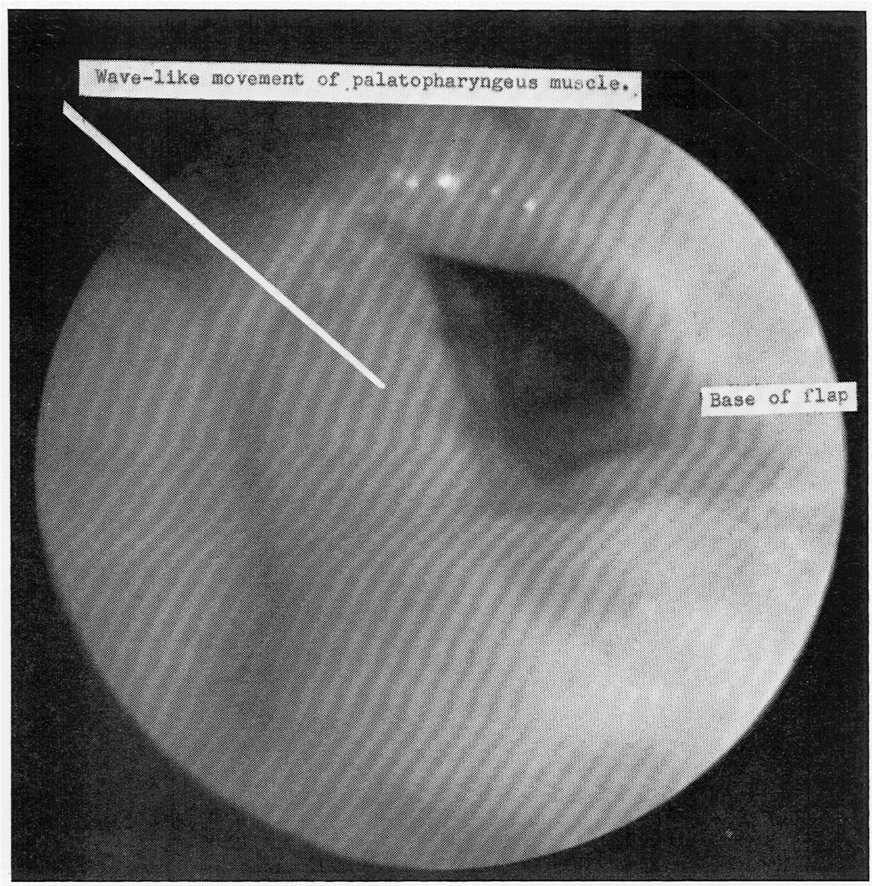

FIGURE 14. Right aperture during phonation of *aba*. Note wave-like movement of palatopharyngeus muscle across the space in the coronal plane. During phonation of *ah,* as shown above, a small opening remained apparently necessary for normal nasal resonance. A greater degree of closure was obtained for plosive sounds.

Such is not the case with the 16 mm Bolex reflex, where the reflex viewing system is a split-image type resulting in some loss of light to the film. The Bolex camera may be used, but the results with the Beaulieu will probably be better.

All motion pictures should be taken with the camera tripod-mounted, although, if the operator finds it necessary, the camera may be hand-held. Patients should be coached on the intraoral acceptance of the panendoscope and instructed about the proper technique of phonation.

For 8 mm color motion picture photography, the Camex reflex is recommended, using KRII type A color film. The panendoscope may also be attached to an Orthicon television camera for teaching and research purposes.

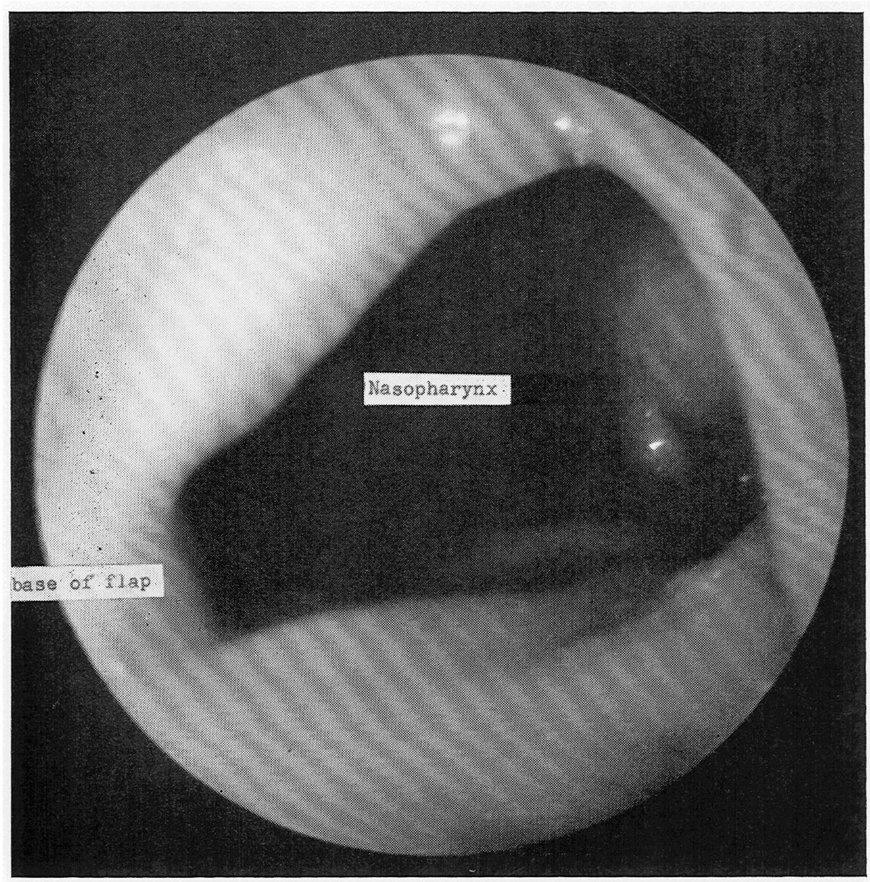

FIGURE 15. Left aperture of an 18-year-old female with pharyngeal flap and excellent speech. Photograph taken during normal respiration.

Case Reports

I. A sound color movie of an 18-year-old female with an excellent speech result following a pharyngeal flap procedure (*3*) appears to validate the hypothesis of Spriestersbach and Morris that the flap may function as an immobile living obturator. The film shows that velopharyngeal closure is achieved by the mesial movements of the palatopharyngeus muscles against the relatively immobile flap structure.

II. Motion picture studies of an 8-year-old male with a complete cleft of the hard and soft palate revealed no posterior wall movement and little or no movement of the palatopharyngeus muscles during phonation. Following a pharyngeal flap procedure an excellent speech result was obtained. Here, again, the flap appeared to function as an immobile obturator. There was marked mesial movement of the lateral pharyngeal musculature. Since these muscles are normally intrinsic to the velum, the fulcrum of their maximum excursion is dependent upon a midline velar structure. The intact velum completes this sphincter of the posterior and lateral pharynx, serving as an anchor against which the palatopharyngeus muscles can pull, thereby

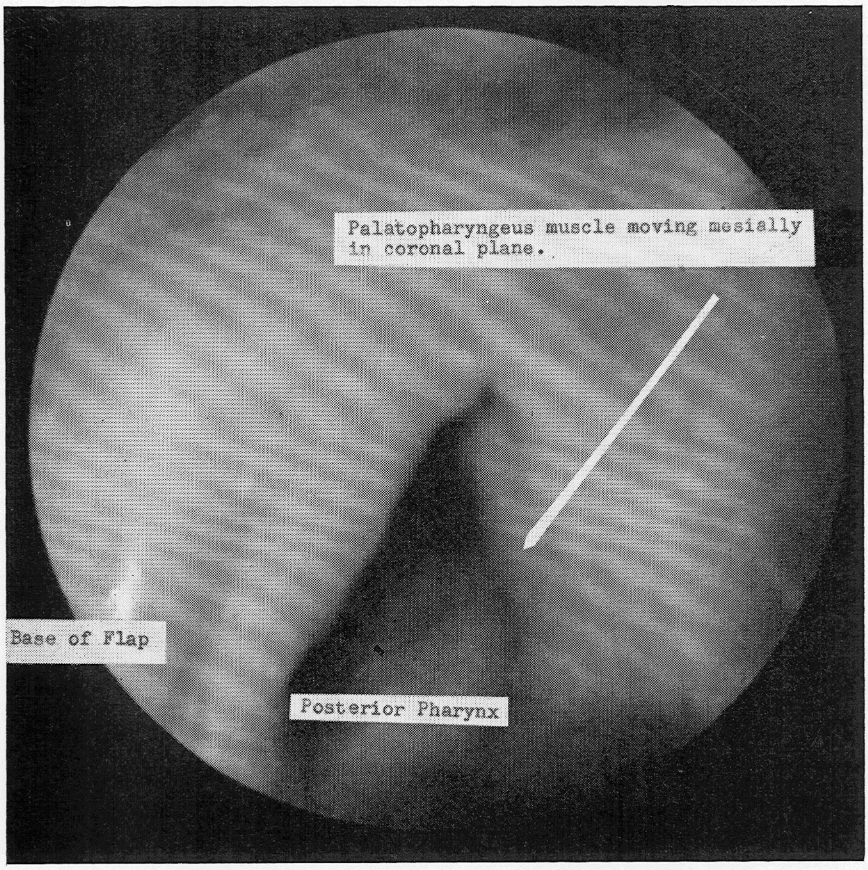

FIGURE 16. Left aperture during phonation of *ah* in *abah*. Note opening still remaining during the vowel sound.

achieving maximal mesial movement. With the palate widely split such movement is impossible. The pharyngeal flap divides the posterior pharynx into a hemi-sphincter and is the keystone for this lateral and posterior wall movement.

III. In a 35-year-old female with a pharyngeal flap, in whom there was marked nasality, examination with the panendoscope revealed a large right aperture, approximately 10 mm in width, and a smaller aperture on the left measuring 7 mm. During phonation, the right lateral pharyngeal musculature did not approximate the base of the flap. Better closure was obtained on the left. However, during gagging, complete closure of both apertures was obtained because of the exaggerated movements of the palatopharyngeus muscles in combination with anterior movement of the posterior pharynx. This clearly demonstrates that gagging is no criteria for assessing velopharyngeal closure during phonation. The patient's speech improved noticeably when a bubble of saliva completely occluded the right aperture.

IV. In an 8-year-old girl with good speech following a pharyngeal flap procedure, denasality was a common occurrence. Examination with the panendoscope revealed that the pharyngeal flap was asymmetrically attached to the posterior pharynx with almost complete stenosis of the left

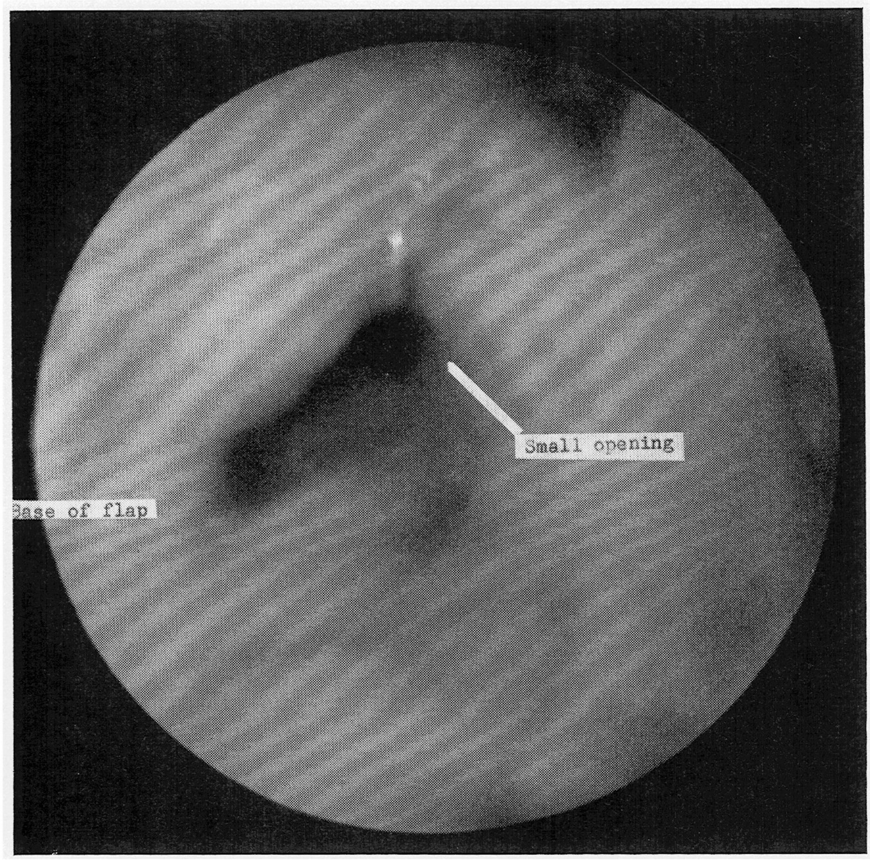

FIGURE 17. Left aperture during phonation of plosive component of *abah*. Note tighter closure but with small opening still present. Complete closure does not appear to be necessary for plosive sounds during normal speech at conversational speech levels.

lateral aperture and a 7 mm opening on the right. On this side, the velum was approximately 2 mm away from the posterior pharynx along its free vertical edge. There was no activity noted in the posterior pharynx during phonation and minimal movement of the lateral musculature. It was apparent that the right lateral aperture was adequate for good speech. However, when she accumulated a moderate amount of nasal secretion, the opening became occluded, resulting in marked denasality. It is clearly evident that varying amounts of nasopharyngeal mucus and/or saliva play a role in the production of normal speech and can effectively alter the degree of nasality in normal subjects and in patients with velopharyngeal incompetence.

Several general comments can be made. On studies which have been performed, complete closure of the lateral apertures during the phonation of the vowel sound *ah* did not occur in pharyngeal flap patients with excellent speech quality. During those vowels, the apertures remained open

2 to 3 mm or more. More complete closure occurred during the plosive sounds.

Motion picture studies have tended to support the frequent impression that Passavant's pad appears during speech primarily in individuals where there is some chance to achieve closure by such movement. Passavant's pad was observed in normal patients, but not in several patients with unmanaged clefts. It would appear that Passavant's pad is part of a ring-like contracting mechanism (sphincter) which is dependent for its anterior movement upon muscular continuity with the posterior-superior aspect of the soft palate.

It has been observed that velopharyngeal closure is not complete centrally in normal subjects during phonation of vowel sounds. A small opening was always noted in the mid-upper pharynx opposite the velum, which permitted air to escape into the nasal cavity, probably essential for a normal degree of nasal resonance. However, during the plosive sounds this central gap was closed.

Changes in voice tonality appear to be related to wing-like movements of the vertical dimension of the outer third of the velum towards or away from the superior pharyngeal wall. (Observation of this phenomena on color film with synchronous sound recordings has an almost esthetic quality.) This type of velar movement, which is impossible to see on x-ray film, alters the size of the epi-pharynx, thereby effecting changes in resonance and tonality. Further investigative work of this and the phenomena of delay velar movement following production of various speech sounds is in process.

Presented in Figures 6 through 17 are photographs taken with the panendoscope for the purpose of demonstrating structural relationships in patients who have had a pharyngeal flap.

In conclusion, it is hoped that with the use of the oral panendoscope a wide range of dynamic structural and anatomical defects heretofore unobservable may be studied and recorded. It is anticipated that pharyngeal flaps and other procedures for the correction of palatal incompetence can be designed and tailored to the individual patient's needs. (Color motion pictures of pre and post-operative pharyngoplasties using injectable teflon were demonstrated by the Cleft Palate Research Center of the University of Pittsburgh, at the American Cleft Palate Association Meeting in 1966.) If muscular activity is observed to be lacking or asymmetrical in the lateral pharyngeal area, then a suitable flap can be designed for maximum usage. The appearance of the posterior pharynx and nasopharynx varies from individual to individual as does the activity of its intrinsic musculature. Velopharyngeal closure is the adequate balance of the dynamic action of all of these structures. Direct observation of the individual components is essential for understanding the mechanism and planning for proper surgical correction.

Summary

The Taub oral panendoscope, designed by the author, creates the opportunity for improved diagnosis, treatment, and research by providing a tool and method for simultaneous visual observation and audio-visual recording of the operation of the speech mechanism during the production of speech sounds in normal and abnormal subjects. Direct clinical or photographic laryngoscopy without alteration or distortion of the natural position of the larynx is greatly facilitated.

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Acknowledgements: Cooperation of the National Electric Instrument Division, Englehard Hanovia, Inc., in the development and construction of the oral panendoscope is acknowledged. The author also wishes to thank Mr. Elliot Eckhaus for his photographic work, and to express his appreciation for the initial encouragement and support given to him by Dr. Bertram E. Bromberg and Dr. Richard H. Walden during the early phase of the development of the oral panendoscope.

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