

CINEGRAPHIC OBSERVATIONS OF LARYNGEAL FUNCTION IN PARKINSON'S DISEASE.*†§

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ABSTRACT.

Thirty-two unselected male patients with Parkinson's disease were examined by telescopic cinelaryngoscopy. Correlation of vocal abnormality and general neurologic symptoms with the laryngoscopic examination leads to the conclusion that the phonatory abnormalities noted in Parkinson's disease are related to rigidity in the phonatory posture of the larynx. The described dysfunctions correlated with the symmetry of trunk and limb rigidity in 100% of the patients.

Parkinson's disease is a commonly occurring movement disorder which is associated with degenerative lesions of the extrapyramidal areas of the brain — in particular, the nigrostriatal neuronal system. The major symptoms of Parkinson's disease include slowed movement (bradykinesia), resting tremor, often of the classic pill-rolling type, rigidity, and poor control of coordinated movements such as walking. One patient has described the experience as having gone from "automatic to manual pilot." Symptoms range from mild to severe, and may be either unilateral, or bilateral. Usually one side of the body is affected to a greater degree than the other side. Early signs include abnormal gait, such as loss of normal arm swinging with walking, resting tremor, change in handwriting, and loss of facial expression. Speech is often affected in Parkinson's disease and vocal weakness may be an early symptom of the disease.

The speech abnormalities of patients with Parkinson's disease have been studied by many authors. Commonly used descriptions of voicing abnormalities in Parkinson's disease are listed in Table I.¹ In addition to voice quality, articulatory function and prosodic features are also frequently affected. Specifically, Parkinsonian speech is often characterized by imprecise consonants, short rushes of words, inappropriate silences and variable speaking rate.¹ These abnormalities are caused by a combination of defects in respiratory support, voice production, and articulatory movements.

Review of the literature reveals that a high percentage of patients with Parkinson's disease have vocal dysfunction. Logeman, Fisher, Boshes, and

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Blonski² studied over 200 unmedicated patients with Parkinson's disease whose deviant voice characteristics included breathiness, 15%; hoarseness, 45%; and roughness, 29%. These authors proposed that there is a progression of speech dysfunction in Parkinson's disease which begins with laryngeal abnormalities and progresses to lingual and labial neuromuscular defects. These observations of a very large series of patients added to substantial evidence that most patients with Parkinson's disease develop abnormal vocal function.

The pathophysiology of laryngeal function that is responsible for the phonatory abnormalities of Parkinson's disease has not been adequately described. The most frequently referenced description of the larynx, in a group of patients with Parkinson's disease, is a report by Cisler³ published in 1927. Cisler described "diminished" vocal cord movement in more than one half of his patients with post-encephalitic Parkinson's symptoms and observed that the vocal cords did not close completely. Schilling,⁴ in a 1925 report of Parkinson's disease patients, described vocal fold "rigor" with dominance of the adductors. On the other hand, Darly, Aronson, and Brown¹ stated that the laryngoscopic examination of the Parkinson's disease patient does not reveal any characteristic abnormalities. This conclusion was based on the series of Parkinson's disease patients studied at the Mayo Clinic and on the authors' extensive review of other available studies. Review of the large literature on speech and voice dysfunction in Parkinson's disease indeed yields relatively little detailed information about the laryngoscopic examination in this disorder. In an attempt to define more clearly the pathophysiology of vocal abnormalities in Parkinson's disease, telescopic cinelaryngoscopy was employed in a group of patients diagnosed to have Parkinson's disease.

METHODS.

Thirty-two unselected consecutive patients with confirmed diagnoses of idiopathic Parkinson's disease were referred from the Parkinson's Disease Study Group at the VA Medical Center, West Los Angeles. These patients were involved in long-term

TABLE I.
Voice Abnormalities in Parkinson's Disease.

Breathy voice quality	Reduced word stress
Monoloudness	Harsh vocal quality
Monopitch	Abnormally high pitch for age

double-blind drug efficacy studies involving Sinemet, a combination of Carbidopa and Levodopa. None of the patients had undergone neurosurgical procedures or had known central nervous system (CNS) disease other than Parkinson's disease. The patients ranged in age from 49-74 years, with a mean of 65 years. Duration of symptoms ranged from 1-16 years, with a mean of 13 years.

The patients were examined in conjunction with Parkinson's Clinic visits, or during hospitalization, so that accurate information was available on their neurological state at the time of laryngoscopy. In order to observe a full range of pathology, examinations were made at differing times of the day and were repeated as medication schedules were changed. Laryngoscopy was accomplished with 90° wide angle Ward-Berci laryngopharyngoscope with a documentation light sheath, and xenon light source. Cine documentation was made with a 16 mm Beaulieu camera via a 39 mm lens.

The patients' larynges were filmed during several tasks. These included: prolonged phonation of the vowel /i/ (ee); deep inspiration; normal respiration; highest and lowest pitch of /i/, at loud and soft intensity; and rapid repetition of /i/. The developed film was studied with an optical analyzer which has slow and steady stop-frame capability.

The patients' voices were rated clinically at the time of each examination on a 4-point scale of voice adequacy from normal to most pathological. Articulatory defects were most often described by the patients as slurring of words. Articulatory abnormalities, observed by patient, family, or examiner, were simply noted as present or absent. Information regarding handedness, side of body most affected by symptoms, and any changes of speech with medication changes was recorded. Patient history and examination data were maintained and updated for each visit. All examinations and ratings were done by one examiner (DGH).

The patients' films were identified by a log number and were analyzed without the clinical data, which were subsequently correlated with the film descriptions for each patient examination. A number of patients were evaluated with high quality sound recording equipment in a double wall sound-treated room, with simultaneous recording of photoglottography, and electroglottography. The data from these perceptual and quantitative analyses will be reported separately.

RESULTS.

Three patients had no complaint of any voicing difficulty; however, one of these subjects was judged to have voice abnormality. The speech of two patients was essentially unintelligible due to severe articulatory defects. The remaining patients complained of varying degrees of vocal weakness, and demonstrated a range of the previously described vocal abnormalities. Vocal quality was reported to have progressively deteriorated over several years. Vocal weakness was the first noticed symptom of Parkinson's disease in two patients. Articulatory abnormalities were noted to fluctuate in relation to medication schedules and amounts. In contrast, voicing was not observed to fluctuate noticeably by any of the patients. The degree of articulatory dysfunction did not correlate well with voice abnormality.



Fig. 1. A single frame of film from mid-phonation of the vowel /i/, produced by a 64-year-old male with Parkinson's disease of 15 years duration. The patient's phonation is weak, breathy, and of short duration.

Four patients were examined while experiencing withdrawal from medication as a therapeutic "drug holiday." It was thus possible to examine the larynx in these individuals while they were in an unmedicated state and as medication was reinstated to clinically optimal levels. While there often were changes in articulation, there were no observable changes in the characteristics of laryngeal appearance with medication changes in these, or any other patients in the study.

Abnormal phonatory posturing of the laryngeal structures was observed in all but two of the patients studied. These two individuals had no voice complaint and had normal voices. The defect in vocal cord posture which characterized the appearance of the larynx during phonation in the remaining patients, is pictured in Figure 1. This photograph is reproduced from a single frame, filmed during an attempt at prolonged phonation. The patient is 64 years of age and has had Parkinson's symptoms for 15 years. His voice was rated as most abnormal on the scale of voice adequacy, was breathy, monotonous, and had poor intensity. In addition he could sustain phonation for an abnormally short duration. The patient's neurological symptoms were relatively symmetrical in the trunk and limbs, and included tremor, rigidity, and bradykinesia. The vocal cords were obviously bowed in phonatory position. With the vocal processes tightly approximated, there was a significant, visible, glottic gap during phonation.

Varying degrees of similar vocal cord bowing were identified in the films of 30 of the 32 patients. On cine film, the bowed cords appeared to vibrate throughout a greater width than normal. Increasing amounts of visible glottic gap during phonation correlated with increased breathiness and poor intensity. Patients with increased glottic aperture during voice production had difficulty sustaining prolonged phonation.

Individual frames from cine film of soft, normal, and "loud" phonation by a 58-year-old patient are demonstrated in Figure 2. The patient has had Park-

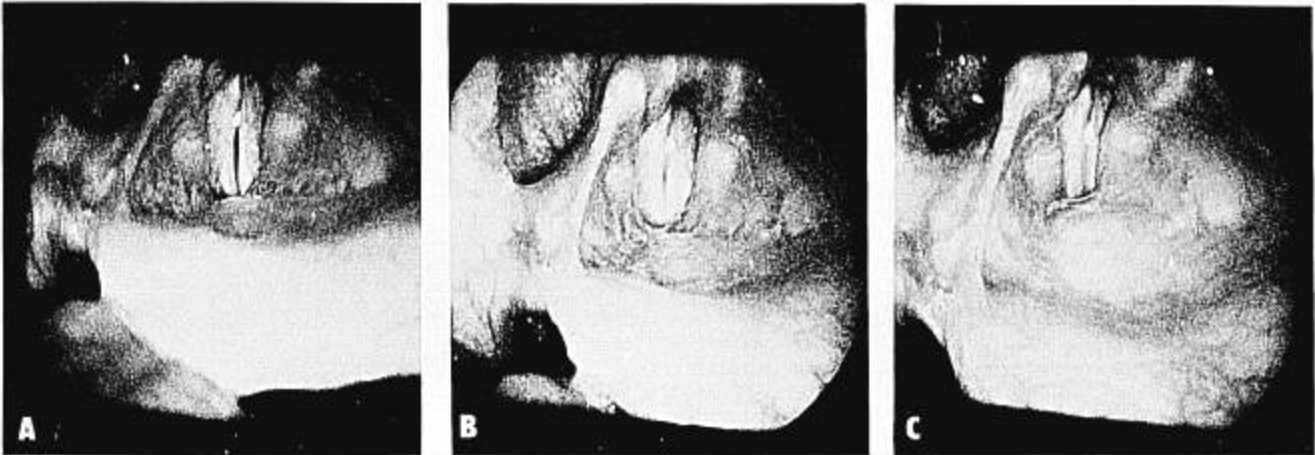


Fig. 2. Individual frames from cine film during soft (A), normal (B), and "loud" (C) phonation of the vowel /i/ produced by a 58-year-old male. Parkinson's disease symptoms were limited to the left side of the body. The patient's normal speaking voice was on several examinations rated as normal, but he complained of vocal weakness at the end of the day.

inson's disease for 9 years. He is a busy executive who relies on the use of his voice. He frequently notes weakness of his voice at the end of the day. His Parkinson's symptoms are confined to a mild tremor of his left arm, which is controlled by medication, and occasional episodes of sudden immobilizing rigidity of the left side of his body. He has slight abnormality of gait. At the time of examination, his voice was rated as normal. Slow and stop frame analysis demonstrated that there was visible bowing of the vocal cord edges, more prominent on the right side, even though there was apparent effective vocal cord closure. Close inspection revealed that closure of the cords was accomplished because the left vocal process moved under the right vocal process as the arytenoid cartilages were brought medially. With increased intensity of phonation (Fig. 2-C), this crossing of the vocal processes became more exaggerated. The right cord appeared to be more bowed and was slightly shorter from anterior commissure to vocal process. In addition, the ven-

tricular fold on the left side was more contracted, and this contraction became quite pronounced with the highest intensity phonation. Sometimes, there was a perceptible shift of the posterior larynx to the right as this patient phonated.

In addition to bowing of the vocal cords, this basic asymmetry of the laryngeal structures was seen in varying degrees in a majority of the patients studied. Crossing of the vocal processes is presented in consecutive frames in Figure 3. This patient's primary complaints were of left sided tremor and rigidity of the trunk and limbs. His voice was breathy and of poor intensity. The left cord was longer than the right. There was asymmetry of the position of the arytenoid and corniculate cartilages, with the upper cartilage on the right positioned more medial and anterior than on the left. On cine film, the left vocal process appeared to cross posterior to the right vocal process.

Individual frames from soft, normal, and loud

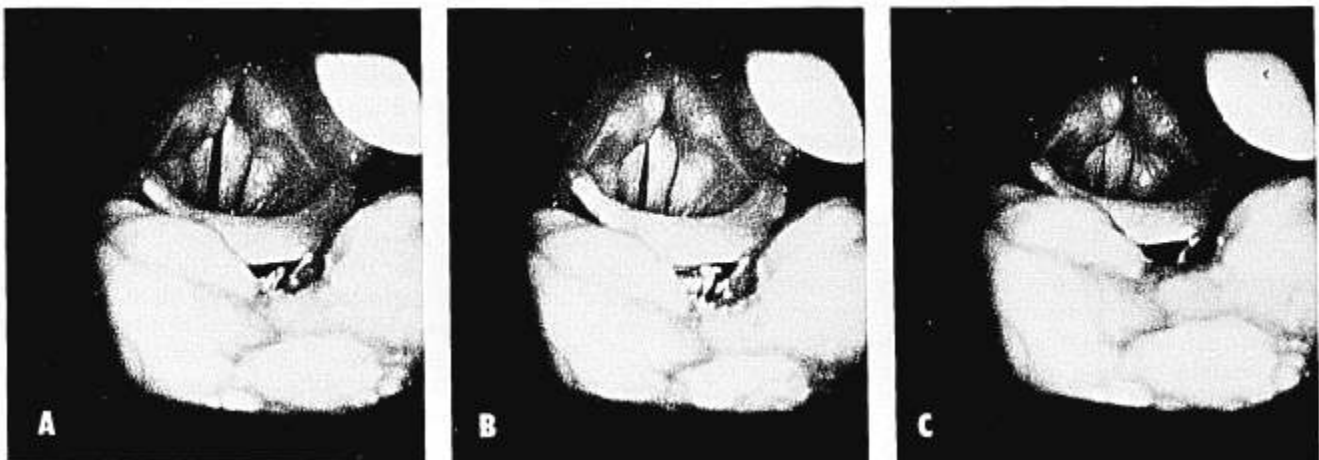


Fig. 3. Consecutive frames from cine films as the vocal cords progressively adduct in a patient with left sided Parkinson's disease symptoms.

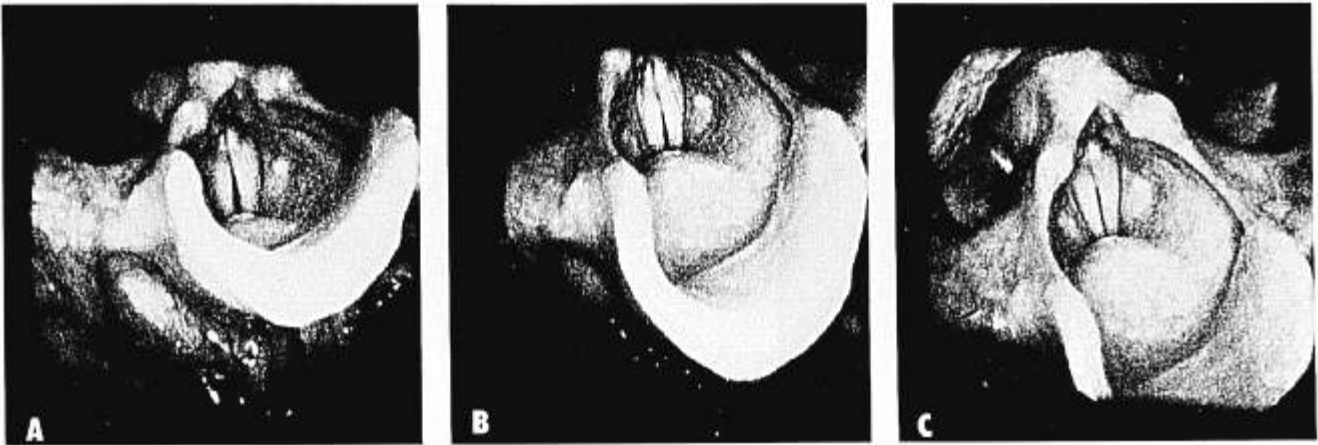


Fig. 4. Individual frames from soft (A), normal (B), and "loud" (C) phonation of the vowel /i/ produced by a 65-year-old male with Parkinson's disease. The patient's voice was breathy and weak. Limb and trunk muscles were affected by Parkinsonian symptoms in a symmetrical pattern; however, onset of symptoms was first noted on the left side.

phonation of the vowel /i/ by a 65-year-old male are shown in Figure 4. The patient has rigidity of both sides of his body, but symptoms were greater on the left. Film from soft phonation demonstrates that the vocal processes are hyperadducted (Fig. 4-A). As the patient attempted to increase intensity, pictured in Figure 4-B, the larynx rolled forward, and the left vocal process pushed against the right. The apex of the left arytenoid and corniculate cartilage were more posterior and more lateral than those on the right. The left ventricular fold appeared to be more contracted. Comparable positions of phonatory posture are seen in Figures 5 and 6.

Similar asymmetry was identified in 26 of the 32 patients. On repeated examinations, the described relationships of the cords were consistent for each patient. The side on which the vocal process was more posterior, with the apex of the arytenoid more posterior and lateral, and the ventricular fold more contracted, correlated in 100% of the 26 patients with the side of the body most affected by symptoms of Parkinson's disease. The phonatory posture of those patients who were rated as having better voices demonstrated overclosure of the vocal processes and/or contraction of the ventricular folds. In this position of phonation, overlapping of the vocal processes places the posterior portion of the upper vocal cord on top of the lower cord. This appears to have the effect of limiting the vibration of the posterior cord and of narrowing or closing the glottic gap during phonation.

At the anterior commissure, the vocal cords are at the same level. Thus, in these patients there was a point at which the vocal cords came together most firmly, and posterior to which they were crossed. In most patients who demonstrated over-closure of the vocal processes, there was some evidence of epithelial damage at this point. This ranged from a persistent mucous string or collection of whitish material, at the point of crossing (Figs. 1, 2, and 6), to ac-

tual nodules. In patients with greater asymmetry of body symptoms and of laryngeal posture, the cord on the most involved side consistently closed under the cord of the less involved side of the body. In patients who had more symmetrical symptom involvement, the vocal processes came together at nearly the same level (Figs. 1 and 4).

Five of the 32 patients demonstrated an extreme degree of supraglottic contraction in their "normal" mode of phonation. A frame from midphonation of /i/, demonstrates the typical phonatory posture of one of these patients in Figure 7. The appearance is similar to that seen in spastic dysphonia; however, stop-frame cine examination reveals that there is underlying bowing of the vocal cords. In contrast to dysphonia plicae ventricularis, the ventricular folds are not brought together as vibratory components, but rather appear to squeeze the mid-portion of the vocal cords together. One might expect that the voice of this patient would be strained. However, when phonating with this position of laryngeal



Fig. 5. Mid-phonation position of the vocal cords of a 60-year-old male with Parkinson's disease. The patient's other symptoms involved rigidity and tremor of the left arm.



Fig. 6. An individual frame from phonation by a 72-year-old male with Parkinsonian symptoms of both sides of the body. Rigidity was greater on the left side of the body. The asymmetry of the pyriform fossae may be caused by the rotation of the thyroid cartilage that is associated with greater rigidity of the left cricothyroid muscle. Similar asymmetry of the pyriform fossae was seen frequently in the patients studied.

structures, his voice sounds quite normal. The patients who demonstrated this contraction of the supraglottic musculature all had more symmetrical tremor and rigidity of the trunk and limbs. There was no relationship of handedness to the symmetry of impairment.

Tremor of the vocal tract structures was frequently observed. This varied from examination to examination and correlated with general neurologic symptoms. Most commonly, tremor involved the tongue and strap muscles. Tremor of the supraglottic muscles was seen in the films of 10 patients. During relaxed breathing, 4 patients showed tremulous movement of the arytenoids. Voice tremor was perceived only in those patients who had visible movement of the head that did not stop during phonation.

Patients were followed for periods that ranged from 6 months to 4 years. During these periods there was no discernable change in the cine documented characteristics of the laryngeal examination for a given patient. The phonatory pattern and typical laryngeal posture remained similar over time. In contrast, some patients experienced significant fluctuations in articulatory defects and in other disease symptoms. These were often associated with changes in medication dosage and schedule.

DISCUSSION.

Abnormalities in the phonatory posture of the laryngeal structures were observed in all of the patients studied who had voice complaints. These abnormalities resulted in bowed cords and an abnormally large glottic aperture during phonation. Patients who had asymmetry of limb and trunk muscular dysfunction demonstrated corresponding asymmetry of laryngeal phonatory position. Closure of the vocal cords was more effective in patients who had Parkinsonian symptoms confined to one side of the body. In these patients, the laryngeal posture in

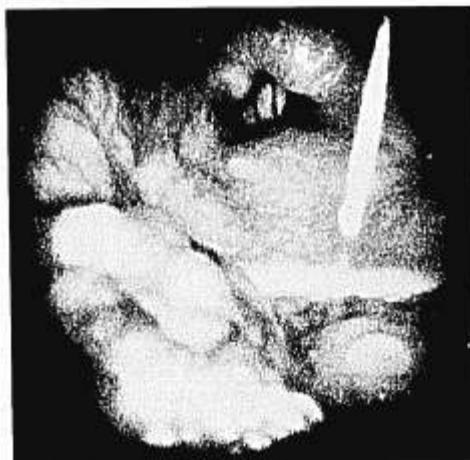


Fig. 7. Contraction of the supraglottic musculature in a patient who demonstrated relatively symmetrical body symptoms of Parkinson's disease. The voice of this patient was rated as normal at the time of this examination.

phonation included crossing of the vocal processes, so that hyperadduction of the arytenoids resulted in narrowing of the glottic aperture and reduction of the amount of vocal cord involved in vibration.

Increased contraction of the supraglottic musculature was also frequently observed. In patients who had asymmetrical laryngeal dysfunction, this was particularly evident. A few patients demonstrated often remarkable contraction of the supraglottic larynx during their usual phonation. This appeared to result in a "squeezing" of the glottis and was also associated with more normal, less breathy voicing.

These findings must be interpreted in light of available information on the effects of Parkinson's disease on muscular control. Relatively few electromyographic studies of the speech organs in Parkinson's disease have been reported. However, recordings of articulatory musculature have demonstrated that there is significantly increased resting and background tone in lip muscles, and that the degree of this abnormal resting activity correlated with the body side most affected by general rigidity and other symptoms.⁵ This study by Leanderson and colleagues demonstrated a loss of normal reciprocal function between antagonistic muscle groups. It has been known for some time that impairment of reciprocal control in antagonistic muscle groups is one of the most characteristic signs of motor dysfunction in Parkinson's disease.⁶ Abnormally increased resting and background activity have also been noted in field recordings from the region of the interarytenoid muscles and of the posterior cricoarytenoid muscles in patients with Parkinson's disease who had vocal dysfunction.⁷

The interactive coordination of the laryngeal musculature in the control of phonatory posture is not completely understood. The muscles which have at-

tachments to the arytenoid cartilage are the posterior and lateral cricoarytenoid muscles, the thyroarytenoid muscles, including vocalis fibers and aryepiglottic fibers, and the interarytenoid muscles, both rectus and oblique portions. These muscles presumably act in a coordinated manner to maintain a given arytenoid position. The position of the vocal process then depends on the relative strength of the combined muscular actions. This necessarily must involve fine motor control of antagonistic muscle groups in normal function, which apparently breaks down in Parkinson's disease.

Cricothyroid muscle function also can affect glottal configuration. Bilateral contraction of the cricothyroid muscles acts to tense the vocal cords by lengthening the distance from the posterior cricoid to anterior commissure, via rotation and anterior motion of the thyroid cartilage. The effect of greater cricothyroid muscle contraction on one side than the other can be observed in patients with known isolated superior laryngeal nerve paralysis.⁸ In this condition, cine photography demonstrates that the paralyzed side shows a more lax, often bowed vocal cord, which is shorter than on the normal side, and the vocal process is usually positioned at a higher level than on the normal side. A similar configuration is seen in Parkinsonian patients whose trunks and limbs are affected to a greater degree on one side; however, it is the cord on the less affected side that has this appearance. Presumably, such an effect could result from abnormally increased tone and contraction on the more affected side, giving the appearance of relative paresis on the more normal side.

Dysfunction of the vocalis muscle fibers in these patients may also contribute to the abnormal cord configuration. The appearance of the vocal cords is not typical of that of the paralysis seen after recurrent laryngeal nerve section. The cords are, on close inspection, firm and rather solid appearing even though they are bowed.

Photographic study indicates evidence of increased contraction in the adductors. There is increased contraction of the thyroarytenoid and ventricular fibers. Furthermore, there is evidence of asymmetrical contraction of the cricothyroid musculature, especially in patients who have greater Parkinson's symptoms on one side of the body than the other. The strong association of these observations with other evidence of involvement by Parkinson's disease leads to the conclusion that the observed abnormalities in the phonatory posture of the patients

studied are related to abnormal rigidity in the musculature of the larynx. Electromyographic studies of the individual muscles of the larynx, combined with information about the phonatory posture of the laryngeal structures, would provide a greater understanding of the motor control of phonation in patients with Parkinson's disease and might also contribute valuable information on the functional interaction of these muscles in the maintenance of normal laryngeal function.

SUMMARY.

Abnormalities in the phonatory posture of laryngeal structures were observed in patients who demonstrated voicing abnormalities that are associated with Parkinson's disease. The abnormalities appear to be related to rigidity of the muscles of the larynx and the effects of the increased muscular activity correlate well with the symmetry of Parkinsonian symptoms in the trunk and limb muscles. Perceived phonatory abnormality may not accurately predict the presence, absence, or degree of laryngeal pathophysiology in patients with Parkinson's disease or with other neuromuscular abnormalities. Quantitative measures, such as electromyography, glottography, and acoustic analysis, in conjunction with documented laryngoscopy are likely to result in better definition of the phonatory abnormalities which result from Parkinson's disease.

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