Posturographic Markers for Early-Stage Parkinson's Disease in Elderly Patients Presenting with Dizziness: A Case Series in an ENT Clinic

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Objective: This study aimed to characterize the posturographic features of elderly patients newly diagnosed with early-stage Parkinson's disease (PD) who initially presented with dizziness.
Methods: Over a three-year period, 1,840 patients visited a dizziness-specialized otolaryngology clinic. Among them, four were newly diagnosed with early-stage PD. Posturographic data of these patients were analyzed.
Results: Common posturographic characteristics were observed, including elevated locus length per unit area (L/A), calculated by dividing the total locus length by the sway area, and increased sway frequencies in the 5–8 Hz range as seen in the power spectral analysis.
Conclusion: In line with previous findings, elevated L/A values and higher sway frequencies may be useful early indicators of PD.

Key words: Parkinson disease, center of pressure, spectral analysis, locus length per unit area, stabilometry

INTRODUCTION

Dizziness is a common complaint among patients with Parkinson's disease (PD), with a reported prevalence ranging from 48% to 68% [1], particularly among elderly patients visiting otolaryngology clinics.

In clinical practice, early PD may be misattributed to presbyvestibulopathy or other non-neurological causes that delay diagnosis and treatment. This challenge is compounded by the fact that many elderly individuals experience overlapping symptoms in multiple systems, including the visual, vestibular, and somatosensory pathways. Therefore, tools that can sensitively detect postural control abnormalities may provide important diagnostic clues.

Posturography is a widely used non-invasive method for objectively assessing postural stability. It measures parameters such as sway area, total path length of the center of pressure, Romberg quotient, and spectral components of body sway. Of particular interest is the locus length per unit area (L/A), which is calculated by dividing the total locus length by the sway area. It serves as a parameter that reflects fine motor adjustments involved in postural control [2]. L/A values tend to increase in PD patients with subtle tremor or rigidity [3], even when the overall sway area remains normal.

Most existing studies primarily focus on patients with moderate to advanced PD (Hoehn and Yahr stage ≥ 3), as postural imbalances typically emerge in the later stages. However, some studies have suggested that balance impairments are present in the early stages of PD and can be detected using posturography [4, 5]. Therefore, the primary aim of this study was to describe the posturographic characteristics of elderly patients newly diagnosed with PD who initially presented to an otolaryngology clinic with dizziness. In particular, we explored whether elevated L/A and higher peak bands in power spectral analysis could serve as useful indicators.

MATERIALS AND METHODS

This retrospective study analyzed the clinical data of 1,840 patients who visiting Goto otorhinolaryngology clinic, a dizziness-specialized otolaryngology clinic, over a three-year period beginning in April 2020. All clinical evaluations were conducted at the clinic and data analysis was performed at Tokai University School of Medicine.

Among all the patients, four elderly patients were newly diagnosed with PD by neurologists at referred hospital. All patients were physically dependent and could be classified as having Hoehn and Yahr stage less than 3, and none had commenced dopaminergic therapy at the time of evaluation.

As part of the routine diagnostic work-up for dizziness, all patients underwent computerized dynamic posturography using the GraviRecorder GW5000 or G5500 systems (Anima Co., Ltd., Tokyo, Japan) Fig. 1. The parameters measured included sway area (center of pressure, mm^2), total locus length (cm), locus L/A, Romberg quotient (ratio of closed eye to open eye sway), and power spectral analysis of anterior-posterior and medial-lateral body sway. The pattern of postural sway was assessed using XY trajectory plots and veloc-

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Fig. 1 Stabilimeter used for posturographic assessment.
https://anima.jp/products/gw5000

Table 1 Clinical and posturographic characteristics of four elderly patients with early-stage Parkinson's disease.

Patient	1	Agee matched	2	Agee matched	3	Agee matched	4	Agee matched
	76F	avarage	74F	avarage	73M	avarage	81F	avarage
DHI	20		44		50		24	
Pt Hx	Suddern HL		Suddern HL		none		Suddern HL	
Initial Dx	Vestibular dysfunction		Vestibular dysfunction		PPPD		Vestibular dysfunction	
Area CoP EO/EC (cm2)①	1.87/3.60	(4.85/6.31)	1.57/2.70	(4.26/5.55)	1.48/1.07	(4.55/6.56)	2.69/6.86	(5.53/7.19)
LNG EO/ EC(cm) ②	103.69/155.58	(108.42/137.55)	95.83/120.70	(96.99/125.10)	60.84/71.13	(109.60/164.89)	99.43/190.36	(121.57/151.96)
L/A EO/EC (1/cm)	55.30/43.22	(24.88/25.99)		(25.50/26.63)	41.20/66.08	(27.76/29.43)	36.96/27.75	(24.13//25.21)
ML sway EO/EC (cm)	0.42/0.80	(0.35/0.24)	0.75/0.80	(0.26/0.20)	-0.58/-0.22	(0.07/0.42)	2.4/2.33	(0.44/0.28)
AP sway EO-EC (cm)	2.36/2.76	(-0.25/-0.14)	0.03/0.52	(-0.28/-0.11)	-1.04	(-0.72/-0.27)	1.26	(-0.23/-0.20)
Power Spector Peak band	AP 6Hz		ML7-8Hz		ML6-7Hz		ML5-6Hz	
Romberg	1.92	-1.31	1.73	-1.32	0.73	(-1.46)	2.55	-1.29

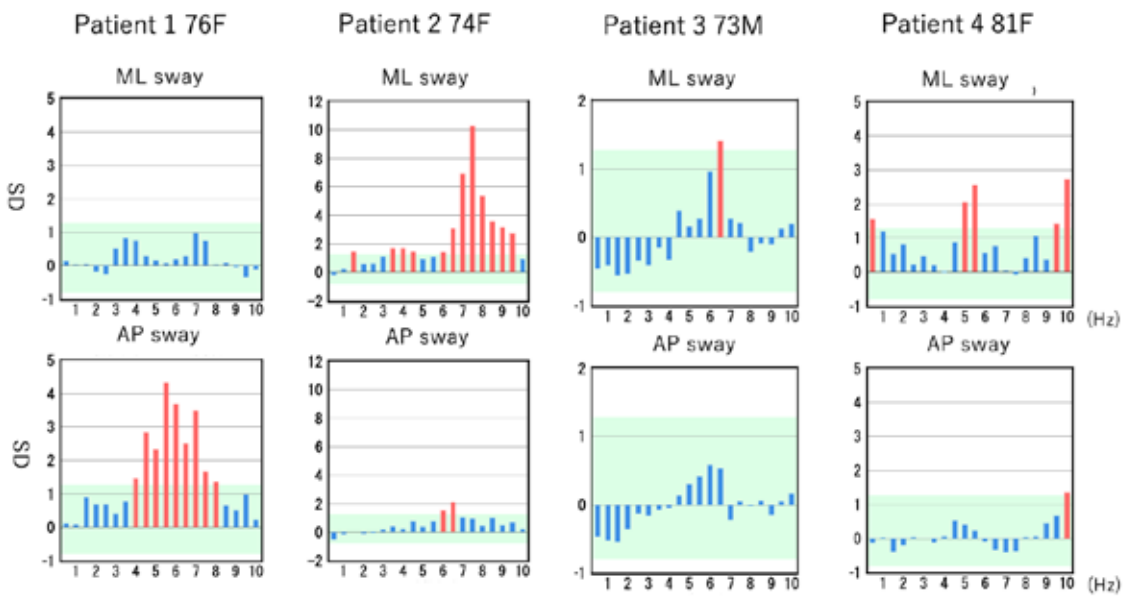

Fig. 2 Power Spectral Analysis: In the medio-lateral and anterior-posterior directions during eye closure, all patients exhibited prominent frequency peaks in the highfrequency range (2–10 Hz).

ity vector diagrams, which showed a consistent sway direction. When the velocity vector was predominantly greater in the anteroposterior direction, the pattern was classified as "anteroposterior type," and when greater in the mediolateral direction, it was classified as "mediolateral type." Furthermore, cases with a kurtosis value of 3 or higher were defined as "centripetal type," while those with a kurtosis value of 3 or lower were defined as "diffuse type." [6].

Each posturography session consisted of 60-second trials with eyes open and closed, conducted in a double-leg stance barefoot on a solid platform. Two of the four patients also underwent video head impulse testing using ICS Impulse (Otometrics, Denmark), and vestibular-evoked myogenic potentials were recorded with surface electrodes to evaluate otolith function. Clinical data including medical history, dizziness handicap inventory scores, and initial diagnoses were obtained from electronic medical records.

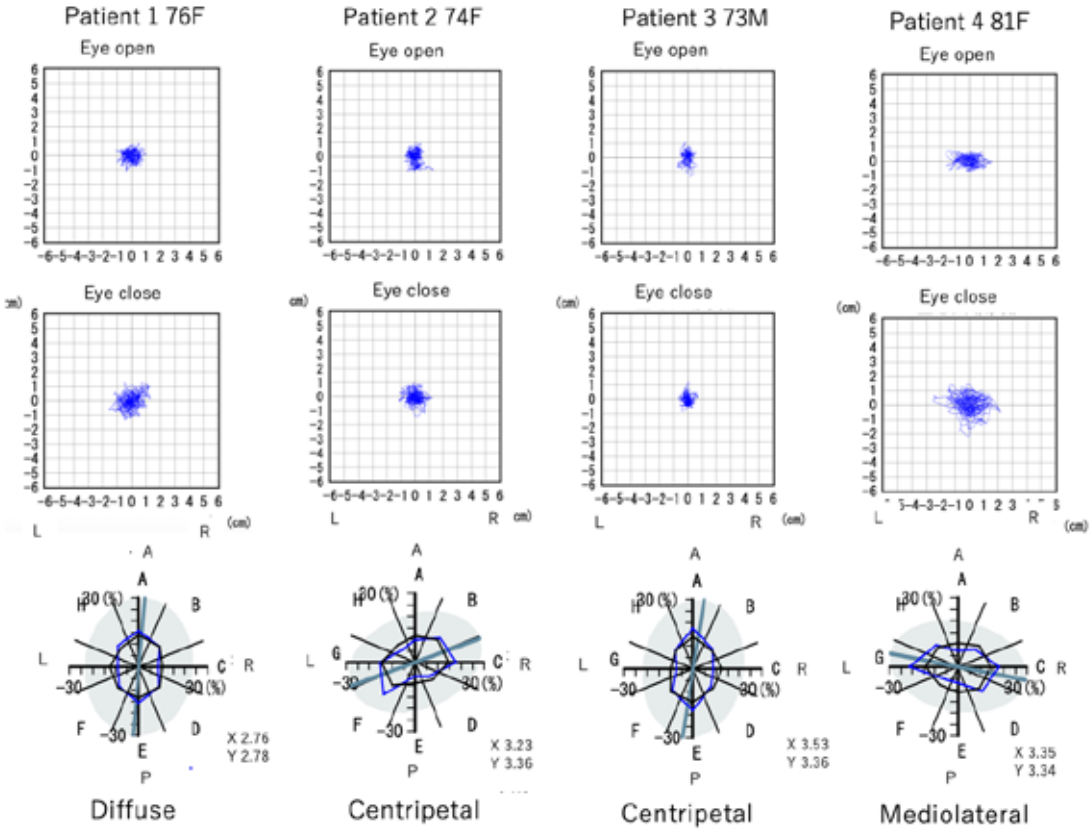

Fig. 3 Postural sway pattern using XY trajectory plots and velocity vector diagrams. Patient 1: XY trajectory seems centripetal, but XY kurtosis is less than 3; therefore, it is classified as the diffuse type. Patient 2 and 3: XY trajectory seems centripetal and kurtosis value is higher than 3–defined as "centripetal type." Patient 4: velocity vector is predominantly greater in the mediolateral direction, and thus classified as "mediolateral type." [9].

RESULTS

The study cohort consisted of three female and one male patient aged between 73 and 81 years (mean age: 76.3 years). All patients presented with dizziness as the chief complaint and were initially diagnosed with peripheral vestibular conditions. These diagnoses were made by an experienced dizziness specialist at the clinic. Specifically, two patients were diagnosed with one-sided vestibular dysfunction following sudden sensorineural hearing loss, one with persistent postural-perceptual dizziness (PPPD) and one with suspected vestibular neuritis. Neurological features suggestive of PD, including bradykinesia, hand tremors, and dysarthria, were either absent or overlooked during the initial otolaryngological evaluation (Table 1).

The dizziness handicap inventory scores ranged from 20 (mild handicap) to 50 (severe handicap), indicating variable perceived dizziness-related impairments. Posturography revealed sway area values between 1.48 and 2.69 mm^2, and total locus lengths ranging from 60.8 to 103.7 cm with eyes open and 71.1 to 190.3 cm with eyes closed. The L/A values, calculated by dividing the locus length by the sway area, were markedly elevated in all cases, ranging from 36.96 to 61.19 with eyes open, greater than two standard deviation above the age-matched normative values [7] of approximately 24–27.

Power spectral analysis revealed dominant frequency peaks in the 4–10 Hz range in the anterior-posterior and medial-lateral directions (Fig. 2). The Romberg quotient ranged from 0.73 to 2.55, with one patient exceeding the expected value (> 2). Sway patterns in these patients were classified as centripetal type in two patients and mediolateral and diffuse types in one patient (Fig. 3). In the two patients who underwent video head impulse testing (vHIT) and vestibular-evoked myogenic potential (VEMP) testing, a unilateral increase in gain accompanied by catch-up saccades was observed, suggesting the presence of peripheral vestibular dysfunction.

DISCUSSION

Our findings suggest that an elevated L/A ratio and high-frequency components of body sway may represent early posturographic markers of PD. All four patients in our series exhibited L/A values exceeding the normative ranges by at least two standard deviations, despite having sway areas and total path lengths within normal limits. This finding supports previous reports suggesting that the L/A ratio is a sensitive parameter for detecting abnormal postural control, potentially reflecting subclinical tremors or rigidity.

Power spectrum analysis revealed dominant frequencies in the range of 5–8 Hz, consistent with reports that high-frequency sway was characteristic of early PD as a result of tremors in the lower extremities [8, 9]. Sway frequencies tended to be higher in patients with cerebellar dysfunction than in those with vestibular dysfunction (< 1 Hz) [10].

A key clinical implication of our findings is that posturographic abnormalities may precede overt clin-

ical signs [11, 12] of PD, particularly when traditional neurological symptoms are minimal or absent. In ENT clinics, where dizziness is a frequent complaint, awareness of such postural signatures can prompt timely referral to the neurology department.

A comparison with other common causes of dizziness, such as persistent postural-perceptual dizziness or chronic vestibulopathy, is essential. Unlike PD, these conditions may show increased sway area or directional instability but typically do not demonstrate elevated L/A or high-frequency oscillations. Thus, integrating posturography into the diagnostic pathway for dizziness may enhance the early detection and diagnostic precision.

However, further validation through prospective studies with larger cohorts and healthy controls is required. Future research should also explore the role of combining posturography with wearable sensors or machine learning models to improve early diagnostic accuracy.

CONCLUSION

Posturography alone is insufficient to differentiate early-stage PD from age-related vestibular dysfunction, particularly in elderly patients. However, certain posturographic parameters, such as increased L/A and higher peak frequency bands in power spectrum analysis, may serve as early indicators of PD. These findings may aid in identifying early PD, particularly in ENT clinical settings, potentially facilitating timely and appropriate referral to neurologists. Future studies with larger cohorts and rigorous application of MDS criteria, as well as inclusion of patients with atypical parkinsonian syndromes, are warranted to validate and expand upon our findings.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this study.

AUTHOR CONTRIBUTIONS

Ai Yamamoto: Conceptualization, Investigation, Data curation, Formal analysis, Visualization, Writing-original draft.

Fumiyuki Goto: Supervision, Methodology, Writing-review and editing, Project administration.

Hiroaki Iijima: Writing-review and editing.

Shoji Kaneda: Data collection, Clinical evaluation.

Koichiro Wasano, Kenji Okami: Supervision, Resources.

All authors reviewed and approved the final manuscript.

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Ethics approval: Tokai University School of Medicine approved the study protocol.

The requirement for informed consent was waived because of the retrospective design of the study.

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