Purpose: To report the ocular features of patients with PD who presented with visual complaints to a tertiary eye care center. **Methods:** This was a retrospective study carried out between January 2015 and March 2020 at the Neuro-Optometry clinic of a tertiary eye care center in Southern India. All PD patients with ocular complaints examined by the neuro-ophthalmologists were referred to Neuro-Optometry Clinic for detailed evaluation. Patients with other neurodegenerative disorders, brain injury, and other causes of vision loss or extraocular motility disorders were excluded. **Results:** A total of 43 patients (7 females, 36 males) between 50 and 86 years of age (mean: 70 ± 8.9 years) with a mean duration of PD of 4.5 ± 4.5 years were studied. Decreased vision associated with reading difficulty (40%) was common in PD patients. In terms of gaze restriction, vertical gaze involvement (35%) was more than horizontal involvement (7%). Convergence insufficiency (CI) was the most common binocular vision dysfunction (30%), followed by CI with oculomotor dysfunction (14%) and vertical gaze palsy (18%). Ground prisms were recommended for 26 patients (61%) and home vision therapy for 5 patients (12%) as corrective measures. **Conclusion:** Binocular vision dysfunction is highly prevalent among PD patients. This could potentially contribute to the reading difficulties and double vision encountered by these patients. Assessment of binocular vision and oculomotor parameters thus becomes important to understand and manage the reading difficulties in patients with PD.

**Key words:** Convergence dysfunction, Parkinson’s disease, reading dysfunction

Parkinson’s disease (PD) is a neurodegenerative disorder characterized by dopaminergic deficiency in the basal ganglia and can cause motor and nonmotor abnormalities involving eyes. It affects approximately 0.3% of the entire population in industrialized countries, with increasing prevalence with age. Compared to less than 0.3% in persons among 50–59 years, the prevalence increases to 1% in patients over 60 years of age. PD can cause motor and nonmotor dysfunction in the body, such as tremor, rigidity, akinesia, postural instability, cognitive impairment, and psychiatric disorders. Disturbances in oculomotor function, visual field loss, dry eye, decreased contrast sensitivity and color vision, visuospatial impairment, and visual hallucinations have been reported as the common ocular features. Convergence insufficiency (CI) affects almost 30% of the PD patients. PD patients may also experience binocular diplopia and reading difficulty. Compared to normal individuals, PD patients of similar age are found to have poorer vision-related quality of life. Although the mechanisms of many ocular manifestations are not fully understood, dopamine depletion in basal ganglia and retina are believed to be associated with decreased visual acuity, reduced contrast sensitivity, poor color discrimination, CI, and oculomotor dysfunction. Dopamine treatment has been shown to improve certain ocular functions, such as convergence ability. Optometric intervention depends on the understanding the etiology contributing to the visual symptoms, for example, diplopia due to CI can be treated with base-in prism or convergence training.

Very few studies have reported ocular features of PD pertinent to nonstrabismic binocular anomalies and reading dysfunctions. This study reports the ocular findings and optometric management for patients with PD in a tertiary eye care setup.

**Methods**

**Patients and procedures**

We retrospectively reviewed electronic medical records of PD patients who were referred to the Neuro-Optometry Clinic (NOC) between January 2015 and March 2020. Patients with PD had undergone detailed anterior and posterior segment evaluation by the neuro-ophthalmologists, before being referred to the NOC. This research was approved by the Institutional Review Board of Vision Research Foundation and adhered to the tenets of the Declarations of Helsinki.

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**Cite this article as:** Kwan SC, Atiya A, Hussaindeen JR, Praveen S, Ambika S. Ocular features of patients with Parkinson’s disease examined at a Neuro-Optometry Clinic in a tertiary eye care center. Indian J Ophthalmol 2022;70:958-61.
Demographic details, detailed history, ocular signs and symptoms, ocular deviation, visual acuity, diagnosis, and management aspects were extracted from the medical records. Patients with a history of head/ocular trauma, acquired brain injury due to road traffic accident and cerebral vascular accident, hyperthyroidism or other debilitating systemic diseases like malignancy, radiation therapy, neurological disorders, glaucoma, and retinal disorders were excluded. Mean distance best-corrected visual acuity (BCVA) was derived by converting the Snellen values to Log MAR visual acuity equivalent. Ocular deviation was measured by prism cover test, and ocular motility was carried out to evaluate the gaze limitation. A diagnosis of CI was made if near point of convergence (NPC) value was larger than 10 cm with or without oculomotor dysfunction. Saccade and pursuit scores evaluated using the Northeastern State University College of Optometry method was used to determine if they were lower than the age expected norms.[6] Color vision was assessed using Ishihara pseudoisochromatic plates. Reading speed was measured in words per minute (wpm) based on reading a simple paragraph in an English magazine for a minute. Developmental eye movement (DEM) ratio was calculated based on the time taken for the vertical and horizontal tasks on the DEM test.

Statistical analysis
One sample Kolmogorov–Smirnov normality test was used to test for the normality of the data. Descriptive analysis was used to calculate proportions.

Results
Forty-three patients including 36 men and 7 women with a mean age of 70 ± 8.9 years were included in the study. The mean duration period of PD in these patients was 4.5 ± 4.5 years. The median interquartile range distance best-corrected visual acuity was 0.10 (0.00–0.18) log MAR for the right eye (range: 0.00–0.60 log MAR) and 0.00 (0.00–0.10) log MAR for the left eye (range: 0.00–0.48 log MAR), respectively. The major visual complaints included decreased vision associated with reading difficulty (40%; 17 of 43), decreased vision with double vision (16%; 7 of 43), only double vision (21%; 9 of 43), and restrictive ocular movements (12%; 5 of 43). Twenty-seven of the 43 study patients (63%) had gaze limitation, of which 9 had both vertical and horizontal gaze restriction, 15 had bilateral gaze restriction involving only vertical gaze, and 3 had horizontal gaze restriction. Convergence anomaly was found in 21 patients, out of which 13 had CI, 6 had CI combined with oculomotor dysfunction, and 2 had intermittent divergence squint – CI type. Receded NPC and reduced near positive fusional vergence amplitudes among patients with PD are depicted in Figs. 1 and 2, respectively. The mean ± SD horizontal ocular deviation (in Prism Diopters) at distance was 2.9 exo ± 7.4 (range: 14 exo to 25 exo) and at near was 9.4 exo ± 7.3 (range: 4 exo to 25 exo). The mean ± SD vertical deviation (in Prism Diopters) at distance was 0.1 right hyperphoria ± 3.9 (range: 1 R/L to 4 L/R) and at near was 5.0 right hyperphoria ± 9.5 (range: 1 R/L to 3 L/R). Reading speed could be assessed only in 17 patients whose mean (SD) reading speed was 86.6 ± 40 wpm. The ocular findings of PD patients are tabulated in Table 1. Ground prisms were recommended for 26 patients (61%) followed by home vision therapy for 5 patients (12%) for diplopia and reading difficulty.

Discussion
Asthenopia is the commonest visual complaint reported in patients with PD. Repka et al.[6] reported asthenopia was present in almost 43.6% of patients aged 45–80 years compared to 5.1% in age-matched controls. In the study by Repka et al.,[6] 23% of patients expressed difficulty while reading, compared to 26.7% in the study done by Biousse et al.[7] which also reported reading difficulty among 9.7% in age-matched controls. Our results showed that almost 40% (17 of 43) of PD patients encountered reading problems, higher than earlier studies.

Repka et al.[6] and Biousse et al.[7] reported 10% (3 of 30) and 7.7% (3 of 39) of diplopia occurrence among patients with PD compared to 37% in our study, higher than previous studies.[6,7] Our data showed that 97.6% (42 of 43) of patients with PD expressed at least one visual complaint that can potentially benefit from optometric management, such as reading difficulty, decreased vision, and double vision. The higher occurrence of reading difficulty and diplopia in our study indicates the need for a comprehensive binocular vision assessment in patients with PD.

BCVA has been found to be affected in PD, and the difference could range between 0.05 and 0.15 Log MAR compared to age-matched controls.[6,8] The mean unilateral BCVA of 0.09 log MAR in our PD patients was comparable to previous studies.[6,8] Factors that have been proposed to contribute to poorer acuity included decreased dopamine level, cortical dysfunction, and debilitated physical state in patients with PD.[6] The severity of PD rather than its duration has also been found to related to the extent of acuity reduction.[6]

Patients with PD have larger exodeviations compared to age-matched controls, especially at near. An earlier study by Almer et al.[9] reported a significant horizontal deviation in patients with PD compared to controls at distance (1.5 exo ± 2.5 vs 0.8 exo ± 3.0) and near (6.0 exo ± 7.7 vs 1.2 exo ± 3.5). Another study by Repka et al.[6] also found the PD group to have higher mean exo values than controls at distance (1 exo vs 0.1 exo) and near (6 exo vs 2.5 exo). We found 2.9 exo ± 7.4 at distance and 9.4 exo ± 7.3 at near among our patients with PD, consistent with previous literature.[6,8]

In terms of gaze limitation, impairment in vertical gaze is the most common. A mean upward gaze deficiency of -0.4 was reported among a group of patients with PD compared to -0.1 in the controls of similar age, where -4 indicated total restriction to 0 indicating no restriction.[6] Another study by Corin et al.[10] found that among the 70 PD patients in the study, 74.3% showed abnormality in up gaze followed by 71.4% in down gaze, 55.7% in right gaze, and 54.3% in left gaze. Our data showed that 35% of patients had restrictive eye movement in vertical gaze followed by combination of limitation of gazes among 21%. In our study, all patients had bilateral gaze limitation. Basal ganglia dysfunction and diffuse lesions in the brainstem have been proposed to cause the vertical gaze defect, especially in upward direction.[11]

Oculomotor dysfunction is one of the key ocular manifestations in patients with PD, and it affects as much as 75% of the patients with PD.[11] Such dysfunction can be in the form of compromised saccadic eye movement, head moving ahead of the eyes, or absence of gaze in at least one
Our study found that 79% (34 of 43) of the patients with PD had at least one of the components of oculomotor dysfunction, which was consistent with a previous study. Earlier studies have also reported that patients with PD showed slower response in initiating horizontal saccades, lower maximal saccadic velocity, and impaired turning performing associated with saccade dysfunction.

Weakness of convergence is another feature among patients with PD. A mean value of 15 cm in NPC among patients with PD was recorded compared to 9 cm in the controls. A more recent study by Nowacka et al. even showed a higher proportion of 24.5% of patients with PD had receded NPC (48 of 196), while only 9.7% (19 of 196) of the controls had such deficits when a cutoff point of 10 cm was applied. Our results showed that 30% (13 patients) of the patients with PD had CI and 14% (6 patients) had CI combined with oculomotor dysfunction. In addition, NPC was immeasurable among 17 subjects due to poor or grossly reduced convergence. Despite a

Table 1: Ocular findings in patients with Parkinson’s disease

| Parameters                                      | Results                                                                                                                                 |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Gaze limitation (n=43)                          | Patients with gaze limitation: 27 patients Limitation in both vertical and horizontal gazes: 9 patients Limitation in vertical gaze: 15 patients Limitation in horizontal gaze: 3 patients |
| Binocular vision dysfunctions (n=27)            | Convergence insufficiency: 13 patients Convergence insufficiency combined with oculomotor dysfunction: 6 patients Intermittent divergent squint: Convergence insufficiency type: 2 patients |
| Color discrimination issues (n=28)              | (i) Correct reading in all the Ishihara color plates in both eyes: 24 patients (ii) Unable to correctly identify all Ishihara color plates in both eyes: 2 patients (iii) Unable to correctly identify all Ishihara color plates in right eye only: 2 patients |
| Reading speed (measured using English text) (n=17) | Mean±SD: 86.6±40 wpm Median: 93 wpm Range: 26-170 wpm                                                                                     |
| Developmental eye movement test (DEM) ratio (n=6) | Mean±SD: 1.18±0.40 Median: 1.22 Range: 0.46-1.67                                                                                         |

Figure 1: Receded near point of convergence in Parkinson’s disease

Figure 2: Reduced near positive fusional vergence amplitudes in Parkinson’s disease
larger proportion (15 patients) of vertical gaze limitation in this study, convergence dysfunction was also commonly present.

Insufficient dopamine in the basal ganglia and extramural pathology have been proposed to lead to such deficits.[6] Besides prescribing base-in prism, vision therapy may help in certain patients with PD. However, all these treatments are primarily dependent on the chief visual complaints of the patient, the visual demands, and most importantly the stability of the disease in itself. Recently, two successful cases of applying vision therapy to improve the signs and symptoms of PD patients with CI have been reported by Kergoit et al.[14]

The average reading speed of patients in this study with PD was 86.6 ± 40 wpm, as tested in 17 subjects consistent with literature that showed about 50% slower reading speed in PD compared to age, gender, and language-matched control.[15] Other factors that may affect reading speed in patients with PD were found to be reduced visual acuity and contrast sensitivity.[16] In our study, all patients with PD achieved binocular near visual acuity of N6. Since contrast threshold was not measured this remains unknown. Onset of PD was found to be rare before 50 years of age and increase of incidence was seen after 60 years of age.[3] In our study, the mean age of onset of PD (SD) was 65 (10) years of age. A study reported the disease duration to range between 2 and 20 years that correlates with this study where the duration ranged between 6 months and 20 years.[17]

Limitations to our study include the absence of the control group to allow for comparison. Certain information, such as the severity of PD and quantitative recording of certain binocular vision data, were not available due to the retrospective nature of our study. The future scope of the study would be to follow-up these patients to assess the compliance and usefulness of the prism prescription. It is also important to understand the changes in binocular vision parameters with the disease progression.

Conclusion
To conclude, binocular vision dysfunctions are highly prevalent in patients with PD. Clinicians should be aware of the common ocular symptoms such as reading difficulties and double vision in patients with PD. Comprehensive evaluation of the binocular vision status is important to understand and address the visual complaints in PD, especially as the disease progresses.

Acknowledgements
The authors would like to thank Dr. Shikha Bassi R, Dr. Durga Priyadarshini, Dr. Vidhya Dharani M, and Dr. Padma Lakshmi K for their clinical support.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest
There are no conflicts of interest.

References
1. Bodis-Wollner I. Retinopathy in Parkinson disease. J Neural Transm (Vienna) 2009;116:1493-501.
2. Ekker MS, Janssen S, Seppi K, Poewe W, de Vries NM, Theelen T, et al. Ocular and visual disorders in Parkinson’s disease: Common but frequently overlooked. Parkinsonism Relat Disord 2017;40:1-10.
3. de Lau LM, Bretelet MM. Epidemiology of Parkinson’s disease. Lancet Neurol 2006;5:525-35.
4. Tanner CM, Goldman SM. Epidemiology of Parkinson’s disease. Neurol Clin 1996;14:317-35.
5. Jankovic J. Parkinson’s disease: Clinical features and diagnosis. J Neurol Neurosurg Psychiatry 2008;79:368-76.
6. Repka MX, Claro MC, Lopue DN, Reich SG. Ocular motility in Parkinson’s disease. J Pediatr Ophthalmol Strabismus 1996;33:144-7.
7. Biousse V, Skibell BC, Watts RL, Lopue DN, Drews-Botsch C, Newman NJ. Ophthalmologic features of Parkinson’s disease. Neurology 2004;62:177-80.
8. Almer Z, Klein KS, Marsh L, Gerstenhaber M, Repka MX. Ocular motor and sensory function in Parkinson’s disease. Ophthalmology 2012;119:178-82.
9. Maples WC, Aitchley J, Flickin T. Northeastern state university college of optometry’s oculomotor norms. J Behav Optom 1992;3:143-50.
10. Nowacka B, Lubinski W, Honczarenko K, Potemkowski A, Safranow K. Ophthalmological features of Parkinson disease. Med Sci Monit 2014;20:2243-9.
11. Corin MS, Elizan TS, Bender MB. Oculomotor function in patients with Parkinson’s disease. J Neurol Sci 1972;15:251-65.
12. Shibasaki H, Tsuji S, Kuroiwa Y. Oculomotor abnormalities in Parkinson’s disease. Arch Neurol 1979;36:360-4.
13. Lohnes CA, Earhart GM. Saccadic eye movements are related to turning performance in Parkinson disease. J Parkinsons Dis 2011;1:109-18.
14. Kergoat H, Law C, Chiqui E, Kergoat MJ, Leclerc BS, Panisset M, et al. Orthoptic treatment of convergence insufficiency in Parkinson’s disease: A case series. Gerontol Geriatr Med 2017;3:2333721417703735. doi: 10.1177/2333721417703735.
15. Yu CY, Lee T, Shariati MA, Santini V, Poston K, Liao YJ. Abnormal eye movement behavior during reading in Parkinson’s disease. Parkinsonism Relat Disord 2016;32:130-2.
16. Moes E, Lombardi KM. The relationship between contrast sensitivity, gait, and reading speed in Parkinson's disease. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn 2009;16:121-32.
17. Brabo NC, Minett TS, Ortiz KZ. Fluency in Parkinson’s disease: Disease duration, cognitive status and age. Arq Neuropsiquiatr 2014;72:349-55.