ORIGINAL ARTICLE

Changes in Visual Function over Time in Koreans with Non-arteritic Anterior Ischaemic Optic Neuropathy

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ABSTRACT

Non-arteritic anterior ischaemic optic neuropathy (NAION) causes severe visual loss in elderly patients. However, there are not much data of clinical course of NAION in Asian patients. To evaluate changes in visual acuity and visual field defects associated with non-arteritic anterior ischaemic optic neuropathy (NAION) among Korean patients, the medical records of 50 eyes from 43 patients with NAION patients seen from 1989 to 2011 were reviewed. A significant change in visual acuity was defined as a three-line change in Snellen acuity. Visual field defects were evaluated with Goldmann perimetry. Changes in the visual field were evaluated using the grid method. Thirty-eight percent of eyes showed improvement, 54% showed no change, and 8% showed deterioration of visual acuity at the last follow-up. Thirty-four percent of eyes showed improvement, 54% showed no change, and 12% showed deterioration of the visual field at the last follow-up. Most improvement in visual acuity occurred during the first month after the initial visit and in visual field between the first and third months of follow-up. The prognosis of visual acuity in association with NAION was worse in Korean patients as compared with Western studies. However, improved prognosis of visual field defects might come from the use of different methods for evaluation of the visual field.

Keywords: Ischaemic optic neuropathy, visual acuity, visual fields

INTRODUCTION

Non-arteritic anterior ischaemic optic neuropathy (NAION) is one of the major causes of severe visual impairment. It is characterized by the sudden onset of visual field loss with or without decreased visual acuity. The pathogenesis is not yet fully understood but is thought to result from acute ischaemia of the optic nerve head, which is supplied by the posterior ciliary artery.¹ NAION was thought to occur in the patients older than 50 years; the mean annual incidence rate was estimated to range from 2.3 to 10.2 per 100,000 among those older than 50 years old.^{2,3} However, in recent studies of NAION that included large numbers of patients, 11–23% of NAION patients were under 45 or 50 years old.^{4,5}

The characteristics of visual field defects and visual loss in NAION were evaluated retrospectively in several reports.^{6–12} The Ischemic Optic Neuropathy Decompression Trial (IONDT), a multicentre research group that evaluated the efficacy of optic nerve decompression after NAION was developed,¹³ prospectively demonstrated the pattern of visual field defect and the change in severity using automated perimetry.¹⁴ Another large prospective study that also evaluated visual field defect pattern and visual acuity was performed by Hayreh and Zimmerman. They used Goldmann perimetry because automated perimetry did not exist at the beginning of the study.¹⁵ Most subjects in the study were white. However, those studies had different definitions of subjective changes in visual field defects. In this study, we evaluate

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changes in visual acuity and visual field defects using Goldmann perimetry among Korean people using more objective definitions. We also analysed the changes in visual acuity and visual field defects during the early period after onset of the disease, reported the results of long-term follow-up, and compared these with the results from previous studies.

MATERIALS AND METHODS

Patient Selection and Examination

Detailed medical records for patients diagnosed with NAION at Seoul National University Hospital from 1989 to 2009 were reviewed retrospectively. Inclusion criteria for the diagnosis of NAION were as follows¹⁶: (1) a history of sudden visual loss and an absence of other ocular and neurologic diseases that might influence or explain the patient's visual symptoms; (2) initial examination should be performed within 1 month after symptoms developed; (3) optic disc oedema at onset that was documented by an experienced ophthalmologist; (4) spontaneous resolution of optic disc oedema (usually observed within 2 to 3 months); (5) optic disc-related visual field defects in the eye; (6) no neurologic or ocular disorder that could be responsible for optic disc oedema or visual impairment; and (7) visual field examination using the Goldmann perimeter was obtained at the initial visit during the acute phase of disease and at the 6-month follow-up. We excluded patients who underwent any surgical intervention or had any other retinal or optic nerve disease that can induce visual acuity or visual field changes. Patients who had any other systemic disease that may influence optic disc shape were also excluded.

Visual Acuity and Visual Field Evaluation

Best-corrected visual acuity was obtained with the Snellen visual acuity chart. Vision below 20/200 was classified as follows: 20/400, finger counting (FC), hand motion (HM), perception of light, and no perception of light. We compared initial visual acuity at onset to visual acuity at 1 month, 3 months, 6 months, 1 year, and 2 years after the initial examination. If there was more than a 3-line or 3-step improvement or worsening in visual acuity, this difference was considered to be significant and was classified as "improved" or "worsened", respectively. Less pronounced changes in visual acuity were classified as "no change".

We used Goldmann perimetry to evaluate the whole visual field. All visual field examinations were performed by an experienced technician. Initial

visual fields were compared to those obtained 1 month, 3 months, 6 months, 1 year, and 2 years after the initial examination.

The pattern of visual field defects was classified as 13 patterns that were a simplified categorization of the 22 patterns that were used previously to analyse the pattern of visual field defects.¹⁶ We used the grid method to calculate changes in visual field defects.¹⁷ With this method, the visual field is divided into 100 units: each unit has a different size and distribution to reflect its functional value. Significant change in the peripheral visual field defect was defined as "improved" or "worsened" when over 20% of the initial visual field units were expanded or constricted, respectively. Any other minor change was defined as "no change".

Statistical Methods

We used SPSS software version 17.0 (SPSS, Inc., Chicago, Illinois, USA) for statistical analysis. All tests were two-tailed, and significance was set at 0.05. We compared visual acuity and visual field defect status with those of the previous visit. The significance of change during follow-up was analysed by paired-samples *t* test. Final visual acuity and visual field were compared with those of initial visit, 1 month, 3 months, 6 months, 1 year, and 2 years after the initial examination.

RESULTS

Fifty eyes from 43 patients satisfied all the inclusion criteria for this study. Mean age at diagnosis was 58.8 years, and the mean follow-up period was 36.0 months. Among the 9 patients who had bilateral disease, only one eye from each of 2 patients was included because the excluded eye had old NAION but the related data were not available (Table 1).

TABLE 1 Demographic characteristics of the patients with non-arteritic optic neuropathy.

Demographic variable	Total
Eyes/patients	50/43
Male/Female	25/18
Right eye/Left eye	27/23
Bilateral involvement	9 patients
Age at initial visit (range)	58.84 years (33–80)
Initial visit after first symptom (range)	14.9 days (1–30)
Follow-up period (range)	36.0 months (6–206)
Diabetes mellitus	10 (19.2%)
Hypertension	23 (44.2%)

Visual Acuity

The distribution of visual acuity at each follow-up period from the initial visit to the last follow-up is shown in Table 2. Twenty-eight eyes (56%) of NAION patients had visual acuity lower than 20/200, and 10 eyes (20%) of the eyes had visual acuity of 20/40 or better at the initial visit. Six eyes (12%) had visual acuity of 20/20 at the initial visit. In one eye, visual acuity declined to HM at the 1-month follow-up and FC at the 3-month follow-up, then showed no change after 1 year; other eyes maintained their 20/20 vision. At the last follow-up, 20 eyes (40%) had vision less than 20/200 and 15 eyes (30%) had vision of 20/40 or better. The change in visual acuity during the follow-up is displayed in Figure 1. Fifteen eyes (30%) showed improved vision at the 6-month follow-up. In total, 19 eyes (38%) experienced improved vision at the last follow-up. During the first month after the initial visit, 10 eyes (31%) experienced improved vision; the ratio declined to less than 10% after that period. Although 3 eyes (27%) showed improvement after more than 1 year from the initial visit, because the total number of eyes during that period was too low ($n = 11$), we could not interpret the data as having significant meaning. Visual acuity of each visit was compared with that of last follow-up. There was significant difference

between initial visit and last follow-up ($p = 0.020$, paired-samples t test), although no significant difference with last follow-up after 1 month. Therefore, we concluded that significant change of visual acuity occurred during first month after initial visit.

Visual Field

The initial pattern of visual field defects is shown in Table 3. The most common pattern was superior altitudinal defect (11 eyes, 22%), followed by inferior altitudinal defect (10 eyes, 20%) and inferior nasal defect (8 eyes, 16%) patterns. These three patterns constituted approximately 60% of all defect patterns in this study. The most evident improvement of visual field was shown during the period ranging from the 1- to 3-month follow-up visits (Figure 2). From the initial visit to the 1-month follow-up, 4 eyes (15%) showed improvement and 4 eyes (15%) showed deteriorated visual field. From 1-month to 3-month follow-up, 11 eyes (33%) showed improvement, but no eye showed a deterioration in terms of visual field. However, there was no significant difference of visual field area in each visit with last follow-up ($p > 0.05$, paired-samples t test). At the 6-month follow-up, 16 eyes (32%) showed visual field improvement after

TABLE 2 The distribution of visual acuity of non-arteritic ischaemic optic neuropathy during the follow-up.

Visual acuity	Initial visit (%)	Follow-up					
		1 month (%)	3 months (%)	6 months (%)	1 year (%)	2 years (%)	Final (%)
<0.1	28 (56)	14 (44)	12 (50)	19 (38)	14 (54)	7 (41)	20 (40)
≥ 0.1 and <0.5	12 (24)	9 (28)	8 (33)	16 (32)	8 (31)	6 (35)	15 (30)
≥ 0.5	10 (20)	9 (28)	4 (17)	15 (30)	4 (15)	4 (24)	15 (30)
Total	50	32	24	50	26	17	50

FIGURE 1 The change in visual acuity during the follow-up. Most Improvement of visual acuity occurred during the first month after the initial visit.

initial visit. However, 6 eyes (12%) experienced a deterioration in the visual field during the 6-month follow-up. The proportion was almost the same until the last follow-up. At the last follow-up, the eyes with frequent patterns (superior altitudinal, inferior altitudinal, and inferior nasal field defect patterns) showed visual field improvement in 64%, 30%, and 37% of cases, respectively. However, there was no significant difference in the degree of improvement between those groups ($p = 0.270$, Pearson chi-square test).

DISCUSSION

Visual acuity and visual field defects showed improvement in approximately 30% of eyes and

TABLE 3 The distribution and change in visual field defect patterns of non-arteritic ischaemic optic neuropathy during the follow-up.

Pattern of visual field defect	Eyes (%)	Change in visual field		
		Worse (%)	Same (%)	Improved (%)
Inferior altitudinal	10 (20)	1 (10)	6 (60)	3 (30)
Inferior nasal	8 (16)	1 (13)	4 (50)	3 (37)
Inferior temporal	1 (2)	0 (0)	1 (100)	0 (0)
Superior altitudinal	11 (22)	0 (0)	4 (36)	7 (64)
Superior nasal	1 (2)	1 (100)	0 (0)	0 (0)
Superior temporal	1 (2)	1 (100)	0 (0)	0 (0)
Nasal hemifield	1 (2)	0 (0)	1 (100)	0 (0)
Temporal hemifield	1 (2)	0 (0)	1 (100)	0 (0)
Central island	4 (8)	0 (0)	4 (100)	0 (0)
Ceco-central scotoma	3 (6)	0 (0)	1 (33)	2 (67)
Peripheral constriction	3 (6)	0 (0)	2 (67)	1 (33)
Total defect	5 (10)	2 (40)	2 (40)	1 (20)
Normal	1 (2)	0 (0)	1 (100)	0 (0)
Total	50 (100)	6 (12)	27 (54)	17 (34)

deterioration in approximately 10% of eyes. In visual acuity, both improvement and deterioration showed the biggest change during the first month after the initial presentation. The initial visual field defect was most likely to improve between the 1-month and 3-month follow-up visits. Worsening of the initial visual field defect occurred throughout the follow-up period. There were some differences in the visual acuity changes between this study and the results of IONDT¹⁸ and Hayreh and Zimmerman¹⁵ (Table 4). The eyes in this study had worse initial visual acuity than the previous studies. Hayreh and Zimmerman reported that among the eyes presented within 2 weeks after the onset of symptoms, 49% had visual acuity of 20/30 or better and 23% had visual acuity of 20/200 or worse. However, 20% had visual acuity of 20/40 or better and 56% had visual acuity of 20/200 or worse in this study. We could not compare visual acuity with IONDT results directly because such patients were enrolled only when initial visual acuity was 20/64 or worse. Fewer patients demonstrated improved visual acuity during the early period of follow-up. One possibility for the discrepancies between the studies might derive from racial differences. In IONDT, 95% of study subjects were white.¹⁹ However, all subjects in this study were Asian. It is well known that white people have a higher incidence of NAION than other racial groups.^{2,4,5} However, there was no confirmed relationship between race and the prognosis of visual acuity in NAION until now. Another possible reason for these discrepancies is that the systemic condition of NAION in patients may affect the prognosis. There are well-known risk factors for the incidence of NAION, such as arterial hypertension, nocturnal arterial hypotension, diabetes mellitus, ischaemic heart disease, hyperlipidaemia, atherosclerosis, and arteriosclerosis.^{11,20–23} However, there were no reliable

FIGURE 2 The change in visual field defects. Most Improvement of visual field defect occurred between the first and third months of follow-up.

TABLE 4 Comparison of visual acuity change in non-arteritic ischaemic optic neuropathy with ischaemic optic neuropathy decompression trial (IONDT)¹⁸ and study of Hayreh and Zimmerman¹⁵.

Study	Number of eyes	Follow-up period	Change of visual acuity at 6 months			Change of visual acuity at 12 months			Change of visual acuity at 24 months		
			Improved (%)	No change (%)	Worsened (%)	Improved (%)	No change (%)	Worsened (%)	Improved (%)	No change (%)	Worsened (%)
IONDT ¹⁸	258	24 months	43	42	15	41	43	16	31	47	22
Hayreh and Zimmerman ¹⁵	386	24 months	41	40	19	42	42	16	37	45	18
This study	50	24 months	30	62	8	31	58	11	38	54	8

data as to whether systemic risk factors influence the prognosis in NAION. Unfortunately, this study is retrospective in design, so there is a lack of detailed information about systemic diseases other than arterial hypertension (44%) and diabetes mellitus (19%). Therefore, we could not compare those systemic risk factors directly with the results from previous studies.

The initial visual field remained stable in 56%, improved in 32%, and worsened in 12% of patients during the 6 months of follow-up. These values were 54%, 34%, and 12%, respectively, at the last follow-up. There were no significant changes after 6 months of follow-up. More eyes in this study showed improvements and fewer eyes showed no change in initial visual field when compared with previous studies (Table 5). In the IONDT,¹⁴ which involved the use of automated perimetry, classification of visual field defect patterns was simplified because follow-up examination was mainly focused on the improvement or worsening of the initial visual field at the time of disease onset. The authors divided areas where visual field defects occurred into superior, inferior, and central areas. Central field area defects were also subdivided into central or paracentral defects. In IONDT, the number of eyes that showed superior, inferior, and central area visual field defects was evenly distributed at the initial visit. At the 12-month follow-up, a significant pattern shift toward improvement was observed only in the central visual field. Therefore, the authors concluded that improved visual acuity was correlated to improvement of the central visual field. Hayreh and Zimmerman used different methods to identify changes in the visual field defect.¹⁵ The authors and other ophthalmologists evaluated changes in the visual field subjectively. They concluded that the central visual field remained stable in 68%, improved in 16%, and worsened in 16% of patients. With respect to the peripheral field, visual field defects did not change in 65%, improved in 17%, and worsened in 18% during the 24-month follow-up period. The authors also reported that visual acuity and visual fields were stable more than 6 months after the initial visit. Different prognoses for visual field defects may derive from the varying approaches used to measure the initial visual field. Hayreh and Zimmerman¹⁵ measured the change in visual field subjectively, but we used the grid method, an objective method, for area calculation. There were some changes in the peripheral visual field that were not considered significant by Hayreh and Zimmerman but were considered significant in this study after area calculations. Furthermore, the two studies may differ in the prognosis for visual field defects in NAION, as we mentioned earlier in our description of visual acuity changes.

There are some limitations to this study. The first is the relatively small sample size. Because our hospital is tertiary referral centre, there was possibility of

TABLE 5 Comparison of visual field change in non-arteritic ischaemic optic neuropathy with ischaemic optic neuropathy decompression trial (IONDT)¹⁴ and study of Hayreh and Zimmerman¹⁵.

Study	Number of eyes	Follow-up period	Perimetry	Definition of change	Visual field location	Improved (%)	No change (%)	Worsened (%)
IONDT ¹⁴	245	12 months	Automated perimetry	Pattern shift	Central	7	86	7
					Superior	20	75	5
					Inferior	24	71	5
Hayreh and Zimmerman ¹⁵	386	24 months	Goldmann perimetry	Subjective grading by clinicians	Central	16	68	16
					Peripheral	17	65	18
					Total	34	54	12
This study	50	24 months	Goldmann perimetry	Grid method				

retention bias that patients of very good or very poor condition would not come and were lost during follow-up period. Therefore, there is some weakness in the statistical power of result comparisons. The second is the retrospective design of this study. We did not have detailed medical records about systemic conditions, and the follow-up interval was not the same for each patient. Therefore, different prognoses from the other studies could not be compared with respect to systemic risk factors, and some data from each follow-up examination were missing. Finally, we could not evaluate central visual field in as much detail as reported by the IONDT. The central visual field is thought to be directly correlated with visual acuity. However, it is difficult to measure fine changes in central visual field acuity with Goldmann perimetry.

In conclusion, this study provides further information related to NAION. As far as we know, this is the first study that evaluate long-term clinical course of NAION among pure Asian patients. Specifically, we describe the significant changes in visual acuity that occurred during the first month after the initial visit and the changes in visual field that occurred between 1 month and 3 months after the initial visit. We also determined that the prognosis of visual acuity was slightly worse than in Western studies, whereas the prognosis for visual field was slightly improved, although there was some disparity related to the evaluation of significant changes in the visual field. However, further studies are required to identify a direct relationship between disease prognosis and race and for the evaluation of common objective methods, especially Goldmann perimetry for the assessment of significant changes in the visual field.

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