Int Ophthalmol (2019) 39:21–31
https://doi.org/10.1007/s10792-017-0778-x

ORIGINAL PAPER

Clinical characteristics and ophthalmologic findings of pituitary adenoma in Korean patients

Tae Gi Kim · Kyung Hyun Jin · Jaheon Kang

Received: 11 June 2017 / Accepted: 24 November 2017 / Published online: 22 December 2017

Abstract
Purpose To investigate the clinical characteristics of and ophthalmic findings in Korean patients diagnosed with a pituitary adenoma.
Methods The medical records of 534 patients diagnosed with a pituitary adenoma at Kyung Hee University Hospital between January 2007 and December 2016 were retrospectively reviewed.
Results Mean patient age was 47.9 ± 16.2 years. The most common symptoms at the time of presentation were headache (26.2%) and visual disturbance (12.4%). The referral rate to the ophthalmology department was 18.44% and patients most often presented to the neurosurgery department. Optic chiasm compression was identified in 23.4% of patients (54.4% of patients referred to ophthalmology, 15.0% of patients not referred to ophthalmology). Normal visual field (57%) was the most common visual field feature followed by bitemporal hemianopsia (17.8%). Optic chiasmal compression without visual field defects was found in 36.1% of patients. Tumor volume was positively correlated with visual field pattern standard deviation (PSD, $p = 0.020$) and best-corrected logMAR visual acuity ($p = 0.000$) and negatively associated with tumor volume and visual field mean deviation (MD, $p = 0.000$). Best-corrected visual acuity ($p = 0.000$), MD ($p = 0.001$), and PSD ($p = 0.028$) significantly improved after surgery.
Conclusions Pituitary adenoma patients do not always have ocular symptoms at their first presentation, even when optic chiasm compression and visual field deficits are present. Therefore, collaboration with an ophthalmologist is important when evaluating pituitary adenoma patients.

Keywords Pituitary adenoma · Visual field · Epidemiology

Introduction

The optic chiasm is the point at which optic nerves partially cross after passing through the optic foramen. Pressure on the optic chiasm by a pituitary tumor can cause bilateral visual disturbances, visual field deficits, and color vision disorders [1, 2]. Pituitary adenoma is the most common benign tumor of the central nervous system, accounting for 10–15% of all brain tumors, and is estimated (via autopsy) to occur in 20–25% of the general population [3, 4]. When a

T. G. Kim · J. Kang (✉)
Department of Ophthalmology, Kyung Hee University Hospital at Gangdong, Kyung Hee University, # 892, Dongnam-ro, Gangdong-gu, Seoul 05278, Republic of Korea
e-mail: kjh0614@khu.ac.kr

K. H. Jin
Department of Ophthalmology, Kyung Hee University Medical Center, Kyung Hee University, Seoul, Republic of Korea

growing tumor presses on the optic chiasm, decreased visual function can result. However, collaboration with multiple departments, including neurosurgery, neurology, ophthalmology, endocrinology, and internal medicine, is necessary when evaluating pituitary adenoma patients because symptoms are not limited to ocular problems. In 1978, Klaubet et al. [5] reported that the chief complaint in patients with pituitary adenoma is decreased visual function. However, with neuroimaging advances in the 1980s (e.g., brain magnetic resonance imaging [MRI] and computed tomography [CT]) and more accurate hormone detection tests, hormone-associated systemic symptoms have become the most common onset manifestations [6, 7].

Visual field defects and decreased vision occur in 9–32% and 4–16% of pituitary adenoma patients, respectively [8–10]. However, the actual incidence of these symptoms is likely higher because subtle changes in the visual field and vision are often difficult to identify subjectively. Klauber et al. [5] showed that 37% of patients with pituitary adenomas did not complain of visual field problems, but had defects identified by visual field testing. Given that quality of life decreases with disease progression, collaboration with ophthalmologists is important when evaluating pituitary adenoma patients. Unfortunately, few studies have examined ophthalmologic examinations and ophthalmology referral rates in pituitary adenoma patients diagnosed in other departments [11–13].

Therefore, the purpose of this study was to evaluate the clinical features of and ophthalmic findings in patients diagnosed with pituitary adenomas. These findings from various points of views are discussed.

Methods

The medical records of 534 consecutive patients diagnosed with pituitary adenomas between January 1, 2007 and December 31, 2016 at Kyung Hee University Hospital were retrospectively reviewed. For each patient, sex, age at diagnosis, chief complaint at presentation, features of brain MRI, and the department first visited were investigated. If ophthalmic examination was performed, visual acuity, intraocular pressure, and visual field findings (automated visual field test) were also included in analyses. All patients had undergone fundus photography and optical coherence tomography (OCT) to confirm the absence of disc abnormalities and exclude the possibility that visual field changes were caused by glaucoma. We also used these images to evaluate nasal and temporal optic disc atrophy and papilledema caused by optic chiasm compression associated with the pituitary adenoma. The chief complaint at presentation was based solely on patient-reported symptoms and did not consider ophthalmic testing results or systemic examination findings.

Tumor location was categorized as intrasellar or suprasellar extension, and tumor-associated optic chiasm compression was categorized as present or absent based on brain MRI findings. Brain MRI was also used to determine whether chiasm compression included optic chiasm contact with or abutment to the tumor. Tumor horizontal and vertical dimensions were measured in the axial plane and tumor height was measured in the coronal plane. Tumor volume was calculated as the product of the height, horizontal length, and vertical length. The department of the first visit was defined as the department in which the patient first presented for symptoms associated with pituitary adenoma. The presence and type of surgical treatment was determined by examining the medical records in each patient. Pituitary adenoma function was characterized as functional or non-functional based on the combined pituitary stimulation test results.

Ophthalmic examination included measurement of best corrected visual acuity (BCVA) and intraocular pressure. Patients with a prior history of intraocular surgery or ocular disease known to affect visual field testing were excluded. The BCVA was measured in both eyes using a logarithm of the minimum angle of resolution (logMAR) chart. The mean value of both eyes was used in analyses. The visual field test was performed using the automated Humphrey® Visual Field Analyzer II (Carl Zeiss Meditec, Inc., Dublin, CA, USA) using the Central 24-2 Swedish interactive threshold algorithm (SITA). The visual field test was conducted on the right eye first, followed by the left, after refractive error correction. Patients who had more than 20% fixation losses or more than 33% false positive or false negative responses were excluded from analyses.

Visual field defects were classified using the Grey scale for visual field tests. Mean values between the right and left eyes were calculated and used in analyses for mean deviation (MD) and pattern standard deviation (PSD). Visual field defects were classified into ten types, with other types classified as "atypical" (Fig. 1).

All statistical analyses were performed using SPSS statistical software (version 18.0, SPSS, Inc., Chicago, IL, USA). Pituitary adenoma patients were divided into two groups according to the presence or absence of optic chiasm compression, as identified by brain MRI imaging. Differences between groups in MD, PSD, and BCVA were compared using independent sample t-tests. Correlations between visual acuity and tumor volume, MD, and PSD were analyzed using Pearson's correlation tests. Pre- and post-operative values of MD, PSD, and BCVA were compared using paired sample *t*-tests. Statistical significance was defined as $p < 0.05$.

Table 1 Distribution of age and sex in patients with pituitary adenoma

Age (years)	No. of patients (%)		
	Male	Female	Total
< 10	0	0	0 (0.0)
11–20	10	17	27 (5.1)
21–30	21	44	65 (12.2)
31–40	29	57	86 (16.1)
41–50	37	91	128 (24.0)
51–60	38	57	95 (17.8)
61–70	38	47	85 (15.9)
71–80	17	25	42 (4.9)
> 80	5	1	6 (1.1)
Total	195 (36.5)	339 (63.5)	534 (100)
Mean age	49.9	46.6	47.9

Results

This study included 534 patients (195 male, 399 female) with a mean age of 47.9 ± 16.2 years (range 10–86 years) at the time of diagnosis. The relative proportion of females was highest for patients 50–59 years old (male:female = 37:91), with the proportion of males gradually increasing after the age of 60 (Table 1). In total, 114 of 534 patients (21.3%) visited the ophthalmology department. Patients who did not visit the ophthalmology department had a mean age of 47.4 ± 16 years at the first visit. Patients who did visit the ophthalmology department had a mean age of 49.5 ± 17 years at the first visit. Examination of age distribution revealed that patients over 50 years of age had a higher frequency of visiting the ophthalmology department (Fig. 2). Mean tumor volume was 8.4 ± 10.9 cm^3.

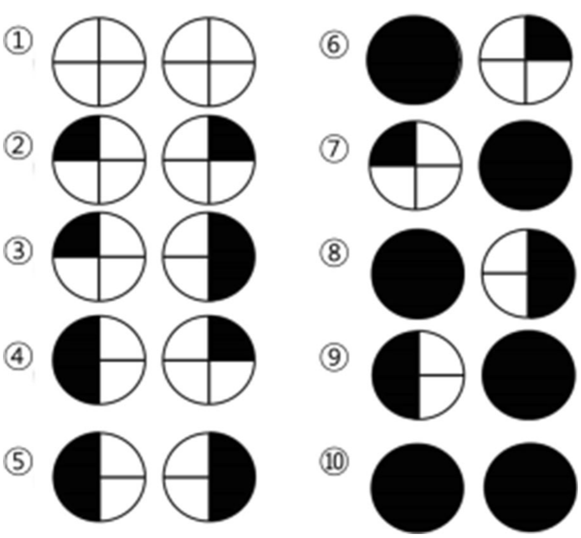

Fig. 1 Types of visual field defects according to visual field patterns

Symptoms at presentation

The most common symptoms at presentation were headache (26.2%), galactorrhea and amenorrhea (17.0%), acromegaly (13.7%), and decreased vision (12.4%). In patients who visited the ophthalmology

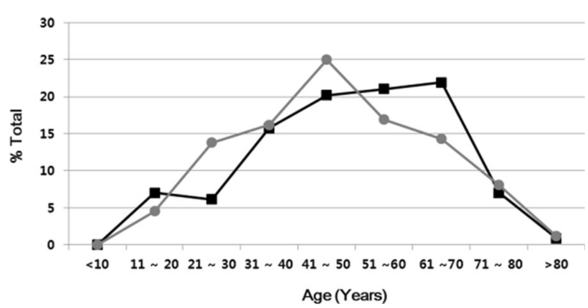

Fig. 2 Age at diagnosis in patients who were referred to the ophthalmology department (filled square, $n = 114$) and who were not referred to the ophthalmology department (filled circle, $n = 420$)

department, the most common initial presenting symptoms were headache (30.7%), decreased vision (23.7%), and acromegaly (13.2%, Table 2). Of the 114 patients who visited the ophthalmology department, 19 visited the ophthalmology department first and 16 of these patients (84.2%) presented with decreased vision.

Department of initial diagnosis

Initial pituitary tumor diagnoses were most often made in the departments of neurosurgery (51.7%) and internal medicine (36.1%). Only 19 patients (3.6%) were diagnosed in the ophthalmology department. The overall referral rate to the ophthalmology department was 18.4%, with 95 of 515 patients referred. Patients were most commonly referred to ophthalmology by neurosurgery (56 patients [58.9%]), internal medicine (21 patients [22.1%]), and neurology (14 patients [14.7%], Table 3).

Pituitary adenoma classifications

The majority of patients had intrasellar extension of the tumor mass on brain MRI (362 patients [67.8%]), with only about one-third of patients having suprasellar extension. However, 67 patients (58.8%) in the group that visited the ophthalmology department had suprasellar extension. In the ophthalmology referral group (114 patients), 54.4% of patients had evidence of optic chiasm compression on brain MRI. In the ophthalmology non-referral group, 15% of the patients had optic chiasm compression (Table 4).

Visual field testing results

A total of 107 patients had reliable visual field testing results. Of these, 61 patients (57%) had normal visual fields and 19 patients (17.8%) had typical bitemporal hemianopsia (Table 5). Of the 46 patients who had visual field defects, 19 patients (41.3%) did not complain of decreased vision or visual disturbances. The proportion of patients with optic chiasm compression increased with increasing visual field defect severity. Additionally, optic chiasm compression was found in 36.1% of patients with no visual field defects (Table 5). Mean MD and PSD were -10.90 and 5.25 dB, respectively, in the optic chiasm compression group and -5.20 and 3.79 dB, respectively, in the non-compression group. Visual field defects were more severe in the optic chiasm compression group, in which MD was significantly decreased than in the non-compression group ($p = 0.021$). Mean logMAR BCVA was 0.44 ± 0.53 in the optic chiasm

Table 2 Presenting clinical features of pituitary adenoma by referral group

Features	Ophthalmology referred group	Non-ophthalmology referred group	Total (%)
Headache	35	105	140 (26.2)
Galactorrhea + Amenorrhea	8	83	91 (17.0)
Acromegalic features	15	58	73 (13.7)
Decreased vision	27	39	66 (12.4)
Dizziness	7	20	27 (5.1)
No symptom	7	17	24 (4.5)
Neurologic symptom	3	20	23 (4.3)
Fatigue, generalized weakness	5	8	13 (2.4)
Facial palsy	1	12	13 (2.4)
Nausea, vomiting, syncope	2	9	11 (2.1)
Headache + decreased vision	–	9	9 (1.7)
Polydipsia	1	5	6 (1.1)
Visual field defect	1	2	3 (0.6)
Arthralgia	–	1	1 (0.2)
Other	2	32	34 (6.4)
Total	114	420	534 (100)

Table 3 Distribution of initial diagnostic sources by referral group and tumor type

Diagnostic source	Ophthalmology referred group	Non-ophthalmology referred group	Nonfunctioning	Functioning	Total (%)
Neurosurgery	56	221	187	89	276 (51.7)
Internalist/ Endocrinologist	21	174	90	103	193 (36.1)
Neurologist	14	20	30	3	33 (6.2)
Ophthalmologist	19	–	16	3	19 (3.6)
Pediatrics	1	1	1	1	2 (0.4)
Gynecologist	2	1	–	3	3 (0.6)
Other	1	7	5	3	8 (1.5)
Total	114	420	330	204	534 (100)

Table 4 Radiological findings between ophthalmology and non-ophthalmology referred groups

MRI findings	Ophthalmology referred group (%)	Non-ophthalmology referred group (%)	Total (%)
Optic chiasm compression			
Present	62 (54.4)	63 (15.0)	125 (23.4)
Absent	52 (45.6)	357 (85.0)	409 (76.6)
Tumor extension			
Suprasellar	67 (58.8)	105 (25)	172 (67.8)
Intrasellar	47 (41.2)	315 (75)	362 (32.2)
Total	114 (100)	420 (100)	534 (100)

Table 5 Optic chiasm compression ratio by VF defect type

VF defect type	No. of patient	Optic chiasm compression	
		Present	Absent
1	61 (57.0)	22 (36.1)	39 (63.9)
2	5 (4.7)	3 (60.0)	2 (40.0)
3, 4	7 (6.5)	6 (85.7)	1 (14.3)
5	19 (17.8)	16 (84.2)	3 (15.8)
6, 7	1 (0.9)	1 (100.0)	0 (0.0)
8, 9	6 (5.6)	5 (83.3)	1 (16.7)
10	4 (3.7)	4 (100.0)	0 (0.0)
Atypical	4 (3.7)	1 (25.0)	3 (75.0)
Total	107	58	49

compression group and 0.24 ± 0.32 in the non-compression group, but this differences was not statistically significant ($p = 0.061$, Table 6). The MD decreased (Pearson correlation coefficient $= -0.483$, $p < 0.001$), PSD increased (Pearson correlation coefficient $= 0.414$, $p < 0.001$), and BCVA worsened (Pearson correlation coefficient $= 0.330$, $p = 0.020$) as tumor volume increased (Fig. 3).

Optic disc abnormalities

The ophthalmology referral group included 114 patients. Ten of these patients (8.7%) had nasal or temporal sector optic disc atrophy on OCT examination, with all 10 patients having optic chiasm compression visible on MRI. No patient had papilledema.

Functional status of pituitary adenomas

Patients with non-functional pituitary adenomas had a mean age of 52.1 ± 16.4 years at the time of diagnosis and patients with functional pituitary adenomas had a mean age of 41.2 ± 16.1 years at the time of

Table 6 Comparison of BCVA, MD and PSD between optic chiasmal compression and non-compression groups

	Optic chiasm compression		*p* value*
	Present	Absent	
BCVA (logMAR)	0.44 ± 0.53	0.24 ± 0.32	0.061
MD (dB)	− 10.90 ± 9.47	− 5.20 ± 4.98	0.012
PSD (dB)	5.25 ± 3.99	3.79 ± 2.98	0.204

MD mean deviation, *PSD* pattern standard deviation, *BCVA* best corrected visual acuity

*p value by independent t test

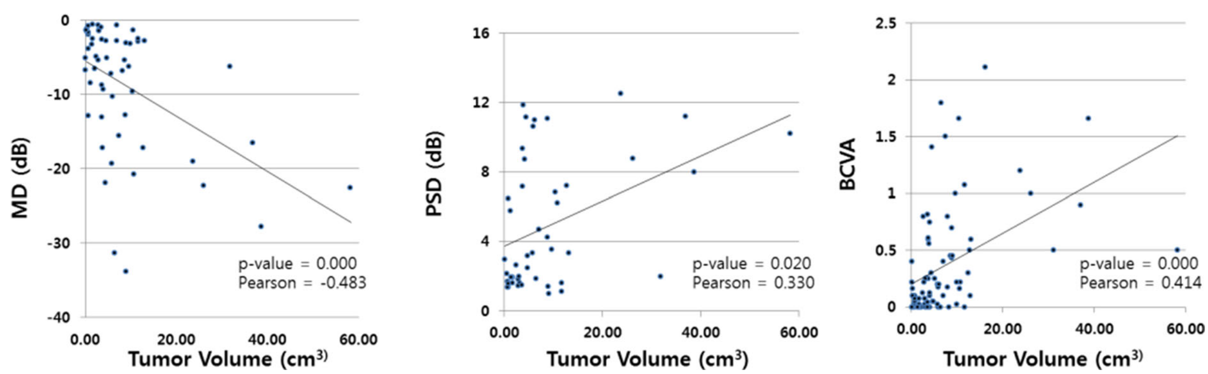

Fig. 3 Relationship between tumor volume and MD, PSD and BCVA. Tumor volume correlates with MD (Pearson = − 0.483, $p = 0.00$), PSD (Pearson = 0.330, $p = 0.02$), and BCVA (Pearson = 0.414, $p < 0.00$) significantly. MD = mean deviation; PSD = pattern standard deviation; BCVA = best corrected visual acuity

diagnosis (Table 7). The most common chief complaint in the non-functional adenoma group was headache (128 patients [39.1%]) and decreased vision (62 patients [19%]). In the functional adenoma group, 91 patients (43.5%) had a chief complaint of galactorrhea and amenorrhea and 4 patients (1.9%) had a chief complaint of decreased vision. The proportion of patients with decreased vision caused by optic chiasm compression was higher in the non-functional group than in the functional group (Table 7). Additionally, a larger proportion of patients visited the ophthalmology department in the non-functional group (23.6%) than in the functional group (17.6%). Visual field changes were found in 54.4% of non-functional adenoma patients, but in only 20.5% of functional adenoma patients (Table 8).

Treatment modality and surgical outcome

A total of 315 patients received medical or surgical treatment, with the majority of patients undergoing transsphenoidal surgery (173 patients [54.9%], Table 9). The proportion of patients with a non-functional adenoma was higher in surgically treated patients than in medically treated patients (Table 9). Mean tumor volume was greatest in the transcranial surgery group (19.52 ± 15.44 cm^3) and lowest in the medical treatment group (1.00 ± 15.02 cm^3). Ninety-one of 114 patients who visited the ophthalmology department underwent treatment. Of these 91 patients, 59 (64.8%) underwent transsphenoidal surgery, a rate that was higher than in the overall study population (54.9%, Table 9). Forty-seven patients who underwent surgical treatment had ophthalmic manifestations of a pituitary tumor before and after surgery. However, MD ($p = 0.001$), PSD ($p = 0.028$), and BCVA ($p = 0.000$) all significantly improved following surgery (Table 10).

Discussion

Pituitary adenoma is a noncancerous tumor that accounts for 10–15% of all intracranial neoplasms

Table 7 Clinical features of pituitary adenoma by tumor type

Features	Nonfunctioning	Functioning			Total (%)
		Acromegaly	Prolactinoma	Other	
Mean age ± SD	52.1 ± 16	45.2 ± 16	37.6 ± 16	40.9 ± 16	47.9 ± 16
Sex ratio (M/F)	141:186	42:50	4:101	8:2	195:339
Presenting symptom					
Headache	128	4	6	2	140 (26.2)
Galactorrhea + Amenorrhea	–	–	91	–	91 (17.0)
Acromegalic features	–	73	–	–	73 (13.7)
Decreased vision	62	2	2	–	66 (12.4)
Dizziness	24	1	2	–	27 (5.1)
No symptom	21	3	–	–	24 (4.5)
Neurologic symptom	21	2	–	–	23 (4.3)
Fatigue, generalized weakness	12	–	1	–	13 (2.4)
Facial palsy	12	1	–	–	13 (2.4)
Nausea, vomiting, syncope	10	1	–	–	11 (2.1)
Headache + decreased VA	8	1	–	–	9 (1.7)
Polydipsia	–	–	–	6	6 (1.1)
Visual field defect	3	–	–	–	3 (0.6)
Arthralgia	–	1	–	–	1 (0.2)
Other	29	3	2	–	34 (6.4)
Total	330	92	104	8	534 (100)

Table 8 Differences between nonfunctional and functional adenoma groups

	Nonfunctioning (%)	Functioning (%)	Total
Ophthalmology referred group	78 (23.6)	36 (17.6)	114
Non-ophthalmology referred group	251 (76.4)	168 (82.4)	420
Visual field defect			
Present	37 (54.4)	8 (20.5)	45
Absent	31 (45.6)	31 (79.5)	62

Table 9 Therapeutic modalities used to patient

Type of treatment	Ophthalmology referred group	Non-ophthalmology referred group	Functioning	Non-functioning	Tumor volume ± SD (cm^3)	Total
Medication	8 (8.8)	38 (17.0)	39 (84.8)	7 (15.2)	1.00 ± 15.02	46
GKRS	15 (16.5)	65 (29.0)	36 (45)	44 (55.0)	4.73 ± 15.27	80
TSA	59 (64.8)	114 (50.9)	66 (38.2)	107 (61.8)	10.64 ± 15.11	173
TCA	9 (9.9)	7 (3.1)	0 (0)	16 (100)	19.52 ± 15.40	16
Total	91 (100)	224	141	174	8.18 ± 14.97	315

GKRS gamma knife radiosurgery, *TSA* transsphenoidal approach, *TCA* transcranial approach

and 50–80% of all pituitary tumors. Although the estimated prevalence rate in the general population is approximately 20–25%, only one-third of these are clinically reported [3, 4]. Pituitary adenomas are

Table 10 Comparison of visual function before and after surgery

	Before surgery	After surgery	*p* value*
BCVA (logMAR)	0.41 ± 0.46	0.18 ± 0.22	0.000
MD (dB)	− 10.63 ± 9.13	− 6.99 ± 6.43	0.001
PSD (dB)	5.89 ± 4.06	4.34 ± 3.31	0.028

MD mean deviation, *PSD* pattern standard deviation, *BCVA* best corrected visual acuity

**p* value by paired *t* test

classified by size and function. Adenomas that are larger than 10 mm in size are categorized as macroadenomas and adenomas that are smaller than 10 mm in size are categorized as microadenomas. The functional and non-functional adenoma classifications are based upon endocrine activity, as determined by pituitary tissue hormone secretion. Adenoma-related hormone secretions cause equal physiologic conditions and galactorrhea, amenorrhea, acromegaly, and Cushing's disease often result. Small, nonfunctional adenomas are often incidentally detected, but most functional tumors are diagnosed based on hormonal symptoms. Fast-growing, non-functional adenomas are often diagnosed because of visual field changes caused by the intracranial mass [4].

The most common symptoms that pituitary adenoma patients presented with were headache (26.2%), galactorrhea and amenorrhea (17.0%), acromegaly (13.7%), and decreased vision (12.4%). These findings are consistent with previous studies and suggest that the incidence of decreased visual function has declined in pituitary adenoma patients [6, 7]. However, when visual changes and disturbances are subtle, patients may not recognize them. Some studies have even reported that 37% of patients with pituitary adenomas do not have visual field defects. However, collaboration with ophthalmologists is still important when evaluating these patients [4]. In the current study, 41.3% of patients with an abnormal visual field did not complain of decreased vision or visual disturbances. Only 18.4% of all included patients were referred to the ophthalmology department after visiting another department, but 54.4% of patients had optic chiasm compression. As a result, 15.0% of patients with optic chiasm compression were not referred to ophthalmology. Therefore, even when ocular symptoms are not a chief complaint, patients with or suspect for pituitary adenomas should visit an ophthalmologist.

Pituitary adenomas are benign masses that do not directly invade tissue. These tumors can present with decreases in visual function, including visual disturbances, visual field deficits, and color vision disorders. Vision changes generally result from compression by non-functional pituitary adenomas. It has been reported that decreased visual function is observed in 17% of patients with symptoms [14]. Khalid et al. [15] reported that 69% of patients with pituitary macroadenoma have optic nerve compression. In our study, 12.4% of patients had decreased visual function and 23.4% of patients had chiasm compression. However, optic nerve compression was present in 54.4% of patients who visited the ophthalmology department. This finding indicates that a decrease in visual function caused by optic nerve compression was the most common reason for visiting the ophthalmology department.

Compression of the optic chiasm may result in visual field changes and visual disturbances by blocking axonal conduction, blocking anterograde and retrograde axoplasmic flow, and/or disturbing nerve conduction (via the resulting demyelination) [16]. Bitemporal hemianopsia occurs when a pituitary adenoma anatomically invades the optic chiasm. The nasal half of macular fibers cross the midline in the chiasm. This is particularly prominent in inferonasal fibers, which briefly loop back into the contralateral temporal optic nerve sheath 1–2 mm before forming the optic tract. This loop is called Willebrand's Knee [17]. When the optic chiasm is compressed, fibers that cross the midline are more susceptible to damage from higher pressures. Non-crossing fibers run parallel to each other, which allows for a more even dispersion of the increased force [18]. Therefore, the crossed nasal macular fibers are more easily damaged and bilateral hemianopsia develops when chiasm compression occurs. In support of this, numerous studies have shown that larger adenomas cause more severe optic chiasm compression and result in more extreme visual field and vision changes [19, 20].

The incidence of visual field defects associated with pituitary adenomas varies, but has been reported to be 37–96% [21–24]. Pituitary adenoma patients most commonly have bitemporal hemianopia and quadrantanopia, although various other visual field defects have been observed. The current study found that most patients had a normal visual field (57.0%), but that 17.8% of patients had bitemporal hemianopsia. Therefore, visual field defects may develop relatively late in the disease process, after anatomic changes (e.g., optic nerve compression) have developed. In support of this theory, we found a higher incidence of optic chiasm compression in patients with larger visual field defects (Table 5). Correlation analyses revealed that pituitary adenoma volume was negatively correlated with MD ($r = -0.483$, $p < 0.001$) and positively correlated with PSD ($r = 0.414, p < 0.001$). The logMAR visual acuity was also significantly and positively correlated with adenoma volume ($r = 0.414, p < 0.001$; Fig. 3). This result is not surprising, given that larger adenomas are more likely to compress the optic chiasm. The visual field MD was significantly lower in patients with chiasm compression than in patients without chiasm compression, but logMAR BCVA was not significantly different between the two groups. Therefore, visual field testing is more sensitive than visual acuity testing to changes associated with chiasm compression. Visual field MD may be a good indicator for the condition (Table 6, Fig. 3).

Patients with functional pituitary adenomas were diagnosed at a younger age than patients with non-functional tumors, particularly patients with prolactin-producing pituitary adenomas, who were youngest at the time of diagnosis (Table 7). Patients with non-functional pituitary adenomas often have non-specific symptoms and it takes time to observe the mass effect caused by tumor growth. Therefore, these patients are generally older at the time of diagnosis than patients with functional pituitary adenomas. In particular, early diagnosis of a functional adenoma can be made when hormone-related symptoms (e.g., galactorrhea, amenorrhea, and facial changes) are present. The symptoms generally occur before headache onset and visual field and vision decreases. In contrast, symptoms associated with non-functional adenomas only occur after the mass has grown large enough to cause compression symptoms. Thus, a visual field deficit commonly presents in patients with non-functional pituitary adenomas. Brada et al. [25] reported that a decreased visual field is present in 44.7% of patients with functional adenomas and 73% of patients with non-functional adenomas. Halle et al. [26] reported that 8 of 10 non-functional adenoma patients presented with a chief complaint of eye problems. Our study shows that a decreased visual field was present in 17.6% of patients with functional adenomas and 54.4% of patients with non-functional adenomas. Furthermore, 16 of 19 patients (84.2%) who visited the ophthalmology department first had non-functional adenomas. Therefore, results from the current and prior studies suggest ocular problems are most often associated with non-functional adenomas.

Optic disc atrophy was observed in 8.7% of our pituitary adenoma patients who visited the ophthalmology department. Chronic tumor compression can lead to optic atrophy, which occurs in a characteristic "bow tie" pattern. This atrophy consists of nasal or temporal optic atrophy and has been reported in 34–50% of pituitary adenoma patients [27]. The nasal and temporal optic disc may be atrophic when medial compression of the chiasm or posterior optic nerve occurs. In the current study, optic disc atrophy was observed less frequently than in previous studies. However, our study utilized more advanced diagnostic techniques than previous studies, which were conducted before the year 2000 when relatively few diagnostic techniques existed.

Various pituitary adenoma treatment options are available, including surgical resection, hormone suppression (with medication), and radiation therapy. Common surgical resection methods include the transsphenoidal and transcranial approaches. The transsphenoidal approach is an endoscopic procedure and is used in most cases. Transcranial surgery may be considered when an endoscopic approach is complicated by large amounts of residual adenoma. Lastly, the sphenoidal approach can be used, but is often hindered by rhinostenosis and/or sphenoiditis. The transsphenoidal approach was the most common surgical resection performed in the current study (173 patients). The proportion of patients undergoing surgical treatment was higher in patients who visited the ophthalmology department (74.7%) than in patients who did not (54.0%). Additionally, patients who underwent surgical treatment had a higher incidence of non-functional adenoma than patients who underwent medical treatment. This finding likely resulted from a greater mass effect of non-functional adenomas, which makes patients more likely to undergo surgical treatment.

Visual field MD and PSD and BCVA all significantly improved with surgery. These findings are in agreement with a study by Moon et al. [13]. A pituitary adenoma causes nerve damage because optic chiasm compression results in axonotmesis, in which axons and their myelin sheath are damaged. However, the surrounding connective tissue (e.g., Schwann cells, endoneurium, perineurium, and epineurium) remains intact. Therefore, once the cause of axonotmesis has been removed, the axon will regenerate along its original path and a complete recovery can be expected [16, 28, 29]. In rare cases, a pituitary adenoma will also result in papilledema because of increased intracranial pressure (ICP). In these cases, visual acuity improvements after surgery may result from papilledema resolution via ICP reduction. An increase in ICP may occur because of tumor expansion or foramen of Monro compression. If tumor growth is asymmetric, papilledema may occur due to Foster–Kennedy syndrome. No patient in the current study had evidence of papilledema on fundus photographs or OCT images. Therefore, the visual acuity improvements observed after surgery were likely due to partial or total resolution of axonotmesis via optic chiasm compression alleviation. In agreement, approximately 90% of patients have improved vision following successful removal of a pituitary adenoma and the amount of improvement is associated with symptom duration [13]. Therefore, early diagnosis and treatment are important in cases of pituitary adenoma [30].

The current study examined ophthalmic conditions in pituitary adenoma patients. More specifically, we reviewed adenoma location and size, symptom presentation, and treatment in patients that had and had not visited our institution's ophthalmology department. In the group who visited ophthalmology, tumor size and visual field changes were correlated. Additionally, functional adenomas were diagnosed earlier than non-functional adenomas because of hormone-related symptoms associated with functional tumors. Unfortunately, early detection of non-functional adenomas is difficult because symptoms are nonspecific and take time to manifest. Recent advances in diagnostic techniques have made ocular symptoms less likely to appear in patients with pituitary adenoma. In patients with a nonfunctional adenoma, vision decreases and visual field deficits may be the only presenting signs when systemic symptoms are absent.

In conclusion, most pituitary adenoma patients have a normal visual field, even when optic chiasm compression is present. Our study shows that 36.1% of patients with optic chiasm compression had a normal visual field. However, visual field testing should be performed because visual field deficits and defects may be present, even in patients who do not complain of visual problems. This emphasizes the difficulty in diagnosing pituitary adenomas with subjective symptoms. Larger pituitary adenomas were associated with more severe visual field defects, highlighting the importance of early diagnosis. Therefore, we emphasize the importance of consulting an ophthalmologist when diagnosing patients with a pituitary adenoma.

Compliance with ethical standards

Conflict of interest No conflicting relationship exists for any author.

References

1. Laws ER Jr, Trautmann JC, Hollenhorst RW Jr (1977) Transsphenoidal decompression of the optic nerve and chiasm: visual results in 62 patients. J Neurosurg 46:717–722
2. Gnanalingham KK, Bhattacharjee S, Pennington R, Ng J, Mendoza N (2005) The time course of visual field recovery following transphenoidal surgery for pituitary adenomas: predictive factors for a good outcome. J Neurol Neurosurg Psychiatry 76:415–419
3. Blamires TL, Reeves BC (1996) Vision defects in patients with peri-chiasmal lesions. Optom Vis Sci 73:572–578
4. Asa SL, Ezzat S (2009) The pathogenesis of pituitary tumors. Annu Rev Pathol 4:97–126
5. Klauber A, Rasmussen P, Lindholm J (1978) Pituitary adenoma and visual function. The prognostic value of clinical, ophthalmological and neuroradiologic findings in 51 patients subjected to operation. Acta Ophthalmol 56:252–263
6. Trevino R (1995) Chiasmal syndrome. J Am Optom Assoc 66:559–575
7. Drange MR, Fram NR, Herman-Bonert V, Melmed S (2000) Pituitary tumor registry: a novel clinical resource. J Clin Endocrinol Metab 85:168–174

8. Hollenhorst RW, Younge BR (1973) Ocular manifestations produced by adenomas of the pituitary gland: analysis of 1000 cases. In: Kohler PO, Ross GT (eds) Diagnosis and treatment of pituitary tumors. Excerpta Medica, Amsterdam, pp 53–59
9. Ebersold MJ, Quast LM, Laws ER Jr, Scheithauer B, Randall RV (1986) Long-term results in transsphenoidal removal of nonfunctioning pituitary adenomas. J Neurosurg 64:713–719
10. Anderson D, Faber P, Marcovitz S, Hardy J, Lorenzetti D (1983) Pituitary tumors and the ophthalmologist. Ophthalmology 90:1265–1270
11. Kim MS, Jin KH, Kim JM (1990) A clinical study of ocular symptoms in brain tumors. J Korean Ophthalmol Soc 31:971–977
12. Kang SM, Kim JH, Cheong JH (2005) Relationship between location and size of pituitary adenoma and visual field change. J Korean Ophthalmol Soc 46:1690–1696
13. Moon CH, Hwang SC, Park TK (2011) Postoperative visual field outcomes in patients showing visual field defects due to pituitary adenoma. J Korean Ophthalmol Soc 52:726–733
14. Wray SH (1977) Neuro-ophthalmologic manifestations of pituitary and parasellar lesions. Clin Neurosurg 24:86–117
15. Khalid F, Anjum R, Tayyaba G (2010) Pituitary adenomas; demographic, visual, and neuro-rdiological patterns. Professional Med J 17:623–627
16. Kerrison JB, Lynn MJ, Baer CA, Newman SA, Biousse V, Newman NJ (2000) Stages of improvement in visual fields after pituitary tumor resection. Am J Ophthalmol 130:813–820
17. Muñoz-Negrete FJ, Rebolleda G (2002) Automated perimetry and neuroophthalmology. Topographic correlation. Arch Soc Esp Oftalmol 77:413–428
18. Kosmorsky GS, Dupps WJ Jr, Drake RL (2008) Nonuniform pressure generation in the optic chiasm may explain bitemporal hemianopsia. Ophthalmology 115:560–565
19. Lee JP, Park IW, Chung YS (2011) The volume of tumor mass and visual field defect in patients with pituitary macroadenoma. Korean J Ophthalmol 25:37–41
20. Thomas R, Shenoy K, Seshadri MS, Muliyil J, Rao A, Paul P (2002) Visual field defects in non-functioning pituitary adenomas. Indian J Ophthalmol 50:127–130
21. Ramamurthy G (1986) Experience with large pituitary adenomas in India. Neurol India 34:195–201
22. Natchiar G (1986) Neuroophthalmic considerations in pituitary tumours. Neurol India 34:165–170
23. Kaur A, Banerji D, Kumar D, Sharma K (1995) Visual status in suprasellar pituitary tumours. Indian J Ophthalmol 43:131–134
24. Poon A, McNeill P, Harper A (1995) Pattern of visual field loss associated with pituitary macroadenomas. Aust N Z J Ophthalmol 23:107–111
25. Brada M, Rajan B, Traish D, Ashley S, Holmes-Sellors PJ, Nussey S et al (1993) The long-term efficacy of conservative surgery and radiotherapy in the control of pituitary adenomas. Clin Endocrinol 38:571–578
26. Halle AA, Drewry RD, Robertson JT (1983) Ocular manifestations of pituitary adenomas. South Med J 76:732–735
27. Herse P (2014) Pituitary macroadenoma: a case report and review. Clin Exp Optom 97:125–132
28. Feinsod M, Selhorst JB, Hoyt WF, Wilson CB (1976) Monitoring optic nerve function during craniotomy. J Neurosurg 44:29–31
29. Donoff RB (1995) Nerve regeneration: basic and applied aspects. Crit Rev Oral Biol Med 6:18–24
30. Powell M (1995) Recovery of vision following transsphenoidal surgery for pituitary adenomas. Br J Neurosurg 9:367–373