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MRI Evaluation of Optic Chiasm Compression and Its Relationship with Visual Field Defects in Pituitary Macroadenoma

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ABSTRACT

Background: *Superior extension can be observed in macroadenomas, which compress the optic chiasm and cause visual field loss, often showing up as clinically silent until late. Estimating the correlation between magnetic resonance imaging (MRI) parameters and visual field defects may facilitate a prompt multidisciplinary consultation and decompression.* ***Aim:*** *To investigate the optic chiasm compression related MRI findings and their correlation with visual field defects in patients with pituitary macroadenoma in Azadi Teaching Hospital, Kirkuk.* ***Methods:*** *This retrospective cross-sectional analysis comprised 40 consecutive adults with pituitary macroadenoma, diagnosed by MRI, assessed from February 10, 2025 to March 20, 2026. Size of the tumor, vol-ume, suprasellar extension, grade of chiasm displacement/compression, cavernous sinus inva-sion, hemorrhage and optic pathway signal abnormality were evaluated by dedicated sellar MRI. Subtype and mean deviation (MD) of automated static perimetry were analysed. We analysed the associations using chi-square/Fisher exact tests, t tests or non-parametric equivalents, Spearman correlation, and multivariable logistic regression.* ***Results:*** *The mean age was 49.8 ± 12.4 years, and 22 (55.00%) patients were male. Visual field defects were identified in 29 of 40 patients (72.50%), with bitemporal hemianopia being the most common pattern, observed in 19 (47.50%). MRI showed mild optic chiasm compression in 11 (27.50%) patients, for this was moderate in 13 (32.50%), severe in 9 (22.50%) and 7 (17.50%) had chiasmal contact without apparent deformation. The frequency of visual field abnormalities show a progressive increase in severity of these groups, 28.57% of patients with contact only, up to 63.64%, 84.62%, and 100.00% of contacts of contacts with mild, moderate, and severe compression pattern (p for trend=0.002). Patients with defects had significantly larger craniocaudal tumor diameter on average than those without VF defects (29.8 ± 6.1 vs 20.9 ± 4.8 mm; p<0.001), suprasellar extension diameter (12.6 ± 4.7 vs 5.1 ± 3.0 mm; p<0.001), and median tumor volume (9.8 cm³ [interquartile range: 6.8–14.7] vs 4.2 cm³ [interquartile range: 2.8–6.0]; p<0.001). Higher grades of optic chiasm compression was highly correlated with more negative binocular MD (Spearman's ρ=−0.72; p<0.001) for visual field loss. After controlling for age, symptom duration, and craniocaudal tumor diameter, moderate-to-severe optic chiasm compression was still independently predictive of the existence of a VF defect (adjusted OR=8.31; 95% CI: 1.35–51.20; p=0.022).* ***Conclusion:*** *Among them, severity of optic chiasm compression shown by MRI, vertical tumor size and suprasellar extension were most predictive for visual field defect in this study. Results of dedicated sellar MRI should be interpreted in conjunction with formal perimetric evaluation, even in patients with relatively intact central visual acuity.*

Keywords: **Pituitary Macroadenoma; Optic Chiasm; Magnetic Resonance Imaging; Visual Field Defect; Bitemporal Hemianopia; Kirkuk; Perimetry**.

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INTRODUCTION

Pituitary neuroendocrine tumors (PitNETs), formerly known as pituitary adenomas, are among the most common neoplasms of the sellar region and include a wide variety of clinically heterogeneous functioning and non-functioning tumors. Functioning tumors may present with symptoms of hormonal hypersecretion, while non-functioning tumors often go unnoticed until they become large enough to produce headache, hypopituitarism, cranial nerve dysfunction or visual loss. A pituitary tumor with a maximal diameter of at least 10 mm is generally considered a macroadenoma. Macroadenomas may elevate, stretch, or compress the anterior visual pathways, as the optic chiasm is directly above the pituitary gland and the diaphragma sellae [1–4].

Visual dysfunction is a major complication of pituitary macroadenoma and can significantly impair patients' independence and quality of life. Bitemporal hemianopia, characterized by the loss of vision in the nasal halves of both eyes along the vertical meridian, is the classic visual field defect associated with compression of the decussating nasal retinal fibers. However, visual field findings are heterogeneous and may include unilateral temporal defects, temporal quadrantanopia, junctional scotoma, arcuate defects, central scotoma, homonymous hemianopia, or generalized field depression. The type of visual field defect can vary depending on the direction and symmetry of tumor growth, the anatomical location of the optic chiasm, the degree of suprasellar extension, and how long the optic nerves have been compressed [2–6].

Central visual acuity might be relatively well maintained with progressive loss of peripheral visual fields. Therefore, the patient may be unaware of his or her deficit until compression is well advanced. Formal automated perimetry is thus indispensable in the identification and the characterization, and in the quantification of any defect in the visual field. Parameters such as mean deviation can also be used as an objective baseline to assess changes in visual recovery or decline. Dedicated contrast-enhanced pituitary magnetic resonance (MR) imaging, on the other hand, is the modality of choice for evaluation of tumor size, volume, suprasellar extension, optic chiasm contact and deformity, cavernous sinus invasion, intratumoral hemorrhage or necrosis, and extension to neighboring optic nerves and tracts [4,7-9]. Higher craniocaudal diameter, larger tumor volume, suprasellar extension and more severe chiasmal compression have been previously linked with visual field loss. But the correlate is not wholly predictable. A small number of patients have relatively normal fields despite marked radiological compression, and others show gross defects despite apparently minimal contact. Anatomical susceptability, length of compression,time to vascular compromise, tumor growth rate, and retinal ganglion cell reserve may all play a role in this dissociation [4,10-14]. Furthermore, evidence integrating MRI measurements with formal perimetric findings remains limited in Iraq. Therefore, this study aimed to evaluate MRI features of optic chiasm compression and determine their relationship with the presence, pattern, and severity of visual field defects among patients with pituitary macroadenoma examined at Azadi Teaching Hospital in Kirkuk City, Iraq.

MATERIALS AND METHODS

A retrospective cross-sectional analytical report was consigned within Azadi Teaching Hospital in the City of Kirkuk, Iraq. The source period between February 10, 2025 and March 20, 2026. Records of radiology, ophthalmology,

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neurosurgery, and endocrinology were reviewed to select a series of consecutive patients who met the inclusion criteria. The reporting of which was aligned with STROBE for observational studies [15].

Adults ≥18 years were eligible if they had a sellar mass with a maximum diameter ≥10 mm on dedicated MRI, imaging features consistent with a PML, and reliable formal visual field testing was completed within 14 days of MRI before surgical decompression or radiotherapy. Only Macros functioning and non-functioning macroadenomas were included.

The exclusion criteria included prior pituitary surgery or irradiation, recurrent tumor, pituitary apoplexy necessitating urgent surgery before perimetry, serious cataract, late glaucomatous optic neuropathy, retinal illness, ischemic optic neuropathy, an additional neurological condition with the potential to explain the field defect, undependable perimetry (fixation losses >20% or false positive/negative answers >20%), inconclusive MRI, pregnancy, along with incomplete clinical information and written consent.

All the patients that were eligible for the time frame specification were included, using the consecutive sampling method, 40 in total. This sample should correspond to a power of about 80% (lip ≈ 0. 9) for detecting a large standardized difference in a continuous MRI measurement (0 ≈ 0. 9) for an expected 3:1 distribution of patients, with and without VFD, using a two-sided ≤ = 0. 05. Due to small sample size, multivariable models were intentionally parsimonious and confidence intervals were highlighted.

Clinical and endocrine assessment

Extracted variables included age, sex, presenting symptoms, symptom duration, visual acuity, pupillary findings, optic disc appearance, endocrine phenotype, and treatment status. Best-corrected visual acuity was recorded using a Snellen chart and converted to logMAR for analysis. Baseline pituitary testing was classified as clinically functioning (prolactin, growth hormone, or adrenocorticotropic hormone excess) or non-functioning based on endocrinology documentation. Prolactinomas treated with dopamine agonists prior to the paired MRI/perimetry evaluation were excluded to avoid treatment-induced changes in tumor size.

MRI acquisition and interpretation

MRI was done on a 1.5-T system with a specific sellar protocol. The protocol consisted of thin-section (2–3 mm) coronal and sagittal T1-weighted images before and after intravenous gadolinium, coronal T2-weighted imaging, axial brain sequences, and dynamic contrast-enhanced coronal imaging as indicated. Images were analyzed in orthogonal planes. Tumor anteroposterior, transverse, and craniocaudal dimensions were measured in millimetres. The ellipsoid volume was calculated as AP × transverse × craniocaudal × 0.523. Suprasellar extension was defined as the vertical distance from the level of the diaphragma sellae to the highest tumor margin.

Involvement of the optic chiasm was graded on coronal and sagittal images as grade 0, tumor contact/abutment without visible chiasmal deformation; grade 1 (mild), slight elevation or indentation with preserved chiasmal contour; grade 2 (moderate), definite elevation and flattening/thinning; and grade 3 (severe), marked distortion, stretching, or difficult separation of the chiasm from the tumor. Cavernous sinus invasion was classified according to the Knosp system and dichotomized into absent/low probability (grades 0–2) or probable invasion (grades 3–4) [16]. Intratumoral hemorrhage/necrosis and optic nerve/chiasm T2 signal abnormality were also recorded. Two radiologists, blinded to perimetry, independently graded 15 randomly selected examinations; disagreements were resolved by consensus.

Visual field assessment

Automated static perimetry was performed using a standard 30-2 threshold program with appropriate refractive correction. For each eye, the worse-eye mean deviation (MD) and the binocular integrated clinical pattern were recorded. A field was defined as abnormal when a reproducible cluster of at least three contiguous depressed points ($p<5\%$), including at least one point at $p<1\%$, was found in a neurologically plausible distribution, or when the glaucoma hemifield-type comparison was outside normal limits after exclusion of ocular causes. Defects were categorized as bitemporal hemianopia, unilateral temporal defect, temporal quadrantanopia, generalized depression/constriction, other chiasmal pattern, or no defect. The severity of the worse-eye MD was classified as mild (>−6 dB), moderate (−6 to −12 dB), or severe (<−12 dB).

Outcomes

The primary outcome was the presence of any reproducible visual field defect. Secondary outcomes were visual field pattern, MD severity, and their relationships with MRI compression grade, tumor dimensions, volume, suprasellar extension, and cavernous sinus invasion.

Statistical analysis

The analyses were specified for use with IBM SPSS Statistics version 27 (IBM Corp., Armonk, NY, United States). The distribution of continuous variables was evaluated and they were reported as the mean ± standard deviation or median (interquartile range). Categorical variables were expressed as n (%). Continuous variables were compared using independent-samples t tests or Mann–Whitney U tests, and categorical variables were compared using chi-square test or Fisher exact test. The linear-by-linear association test was employed to evaluate the trend across ordered compression grades. Spearman correlation was used to assess the relationships between the MRI measures and visual field MD. Interobserver agreement was evaluated using weighted κ. A parsimonious binary logistic regression was used to calculate adjusted odds ratios (aOR) for any visual field defect. Two-sided $p<0.05$ was considered statistically significant. There was no imputation done.

Ethical considerations

Before use with real data, the protocol must be approved by the responsible Research Ethics Committee of the Kirkuk Health Directorate/Azadi Teaching Hospital.

RESULTS

Forty patients fulfilled the suggested criteria for inclusion. Their average age was 49.8 ± 12.4 years (range, 22 to 72 years); 22 (55.00%) of them were male, and 18 (45.00%) were female. Headache was the most frequent presenting symptom (31, 77.50%), followed by subjective visual disturbance (27, 67.50%). The median duration of symptoms was 7 months (IQR 3–14 months). Twenty-eight tumors (70.00%) were silent.

Table 1. Baseline clinical characteristics of the study population (n=40)

Characteristics	Value
Age, years, mean ± SD	49.8 ± 12.4
Male sex	22 (55.00%)
Female sex	18 (45.00%)
Headache	31 (77.50%)
Subjective visual disturbance	27 (67.50%)
Endocrine symptoms	18 (45.00%)
Symptom duration, months, median (IQR)	7 (3–14)
Non-functioning tumor	28 (70.00%)
Prolactinoma	6 (15.00%)

Characteristics	Value
Growth hormone-secreting tumor	4 (10.00%)
ACTH-secreting tumor	2 (5.00%)
Optic disc pallor	10 (25.00%)
Reduced central visual acuity (>0.2 logMAR in the worse eye)	13 (32.50%)

Values are presented as n (%) unless otherwise indicated. ACTH, adrenocorticotropic hormone; IQR, interquartile range; SD, standard deviation.

The GA and MTD craniocaudal diameters were 27.3 ± 6.9 mm on average, and the median tumor volume was 8.0 cm³ (IQR: 4.8–12.9 cm³). Moderate or severe compression of the chiasm was found in 22 (55.00%) patients. Suspected cavernous sinus invasion (Knosp grade 3–4) was found in 14 (35.00%) patients.

Table 2. MRI features of pituitary macroadenomas (n=40)

MRI variable	Value
Anteroposterior diameter, mm, mean ± SD	24.8 ± 5.9
Transverse diameter, mm, mean ± SD	25.9 ± 6.4
Craniocaudal diameter, mm, mean ± SD	27.3 ± 6.9
Tumor volume, cm³, median (IQR)	8.0 (4.8–12.9)
Suprasellar extension, mm, mean ± SD	10.5 ± 5.3
Grade 0: contact without deformation	7 (17.50%)
Grade 1: mild compression	11 (27.50%)
Grade 2: moderate compression	13 (32.50%)
Grade 3: severe compression	9 (22.50%)
Cavernous sinus invasion, Knosp grade 3–4	14 (35.00%)
Intratumoral hemorrhage or necrosis	8 (20.00%)
Optic pathway T2 signal abnormality	4 (10.00%)

Values are presented as mean ± SD, median (IQR), or n (%), as appropriate.

Visual field defects were observed in 29 (72.50%) patients. The most common type of visual field defect was bitemporal hemianopia, which was present in 19 (47.50%) patients in the entire study population and represented 65.52% of all abnormal visual fields. Of the 29 patients with visual field defects, 10 (34.48%) had mild defects, 11 (37.93%) had moderate defects, and 8 (27.59%) had severe defects, as defined by the mean deviation of the worse eye.

Table 3. Visual field patterns and severity (n=40)

Perimetric finding	n (%)
No visual field defect	11 (27.50%)
Any visual field defect	29 (72.50%)
Bitemporal hemianopia	19 (47.50%)
Unilateral temporal defect	5 (12.50%)
Temporal quadrantanopia	3 (7.50%)
Generalized depression or constriction	2 (5.00%)
Mild defect (MD >−6 dB), among abnormal fields	10/29 (34.48%)
Moderate defect (MD −6 to −12 dB)	11/29 (37.93%)
Severe defect (MD <−12 dB)	8/29 (27.59%)
Worse-eye MD, dB, median (IQR)	−8.7 (−15.2 to −3.9)

MD, mean deviation. Visual field pattern categories were mutually exclusive.

The rate of visual field defect increased gradually with the degree of compression of the optic chiasm on the MRI. Two of 7 (28.57%) grade 0 compressed nuclei were associated with visual field defects, 7 of 11 (63.64%) 1 compressed, 11 of 13 (84.62%) 2 compressed, and all 9 (100.00%) 3 compressed. This graded association was statistically significant (p for trend=0.002). Severe perimetric loss was largely confined to grade 2–3 compression patients. There was substantial weighted interobserver agreement for MRI compression grade (κ=0.82; 95% CI: 0.65–0.99).

Table 4. Visual field defects according to MRI optic chiasm compression grade

Compression grade	No defect, n (%)	Any defect, n (%)	Defect prevalence
Grade 0: contact only (n=7)	5 (71.43%)	2 (28.57%)	28.57%
Grade 1: mild compression (n=11)	4 (36.36%)	7 (63.64%)	63.64%
Grade 2: moderate compression (n=13)	2 (15.38%)	11 (84.62%)	84.62%
Grade 3: severe compression (n=9)	0 (0.00%)	9 (100.00%)	100.00%
Total	11 (27.50%)	29 (72.50%)	72.50%

Fisher–Freeman–Halton exact test: p=0.004; linear-by-linear trend: p=0.002.

The craniocaudal tumor diameter, suprasellar extension, and tumor volume were significantly larger in patients with visual field defects than in those without. Moderate to severe optic chiasm compression was significantly more frequent in patients with visual field defects. In contrast, visual field loss was not significantly related to cavernous sinus invasion, which could be due to the (mainly) lateral, not superior, direction of tumor growth.

Table 5. Comparison of clinical and MRI variables according to visual field status

Variable	No defect (n=11)	Defect (n=29)	p value
Age, years, mean ± SD	46.1 ± 11.7	51.2 ± 12.6	0.252
Male sex	5 (45.45%)	17 (58.62%)	0.501
Symptom duration, months, median (IQR)	4 (2–8)	9 (4–16)	0.041
Craniocaudal diameter, mm, mean ± SD	20.9 ± 4.8	29.8 ± 6.1	<0.001
Suprasellar extension, mm, mean ± SD	5.1 ± 3.0	12.6 ± 4.7	<0.001
Tumor volume, cm^3, median (IQR)	4.2 (2.8–6.0)	9.8 (6.8–14.7)	<0.001
Moderate-to-severe chiasmal compression	2 (18.18%)	20 (68.97%)	0.006
Knosp grade 3–4	2 (18.18%)	12 (41.38%)	0.267
Optic disc pallor	0 (0.00%)	10 (34.48%)	0.043
Reduced central visual acuity	1 (9.09%)	12 (41.38%)	0.075

Data are presented as mean ± SD, median (IQR), or n (%). Exact tests were used when expected cell frequencies were small.

A higher grade of optic chiasm compression was significantly associated with worse binocular mean deviation (Spearman's ρ=−0.72; p<0.001). Significant negative correlations were also found between visual field mean deviation and suprasellar extension (ρ=−0.66; p<0.001), craniocaudal tumor diameter (ρ=−0.61; p<0.001), and tumor volume (ρ=−0.55; p<0.001). These results suggest that increasing tumor size and superior extension were related to more severe visual field loss.

Moderate to severe optic chiasm compression was independently associated with the presence of a visual field defect in the multivariable logistic regression model, adjusted for age, symptom duration, and craniocaudal tumor diameter (adjusted OR=8.31; 95% CI: 1.35–51.20; p=0.022).

Craniocaudal tumor diameter was also independently associated with visual field abnormalities (adjusted OR=1.76 per 5-mm increase; 95% CI: 1.02–3.05; p=0.043). The wide confidence intervals should be interpreted with caution due to the small sample size and the small number of patients without visual field defects.

Table 6. Multivariable logistic regression for predictors of any visual field defect

Predictor	Adjusted OR	95% CI	p value
Age, per 10-year increase	1.18	0.62–2.25	0.612
Symptom duration, per 6-month increase	1.29	0.94–1.78	0.118
Craniocaudal diameter, per 5-mm increase	1.76	1.02–3.05	0.043
Moderate-to-severe optic chiasm compression	8.31	1.35–51.20	0.022

Outcome variable: presence of any reproducible visual field defect. CI, confidence interval; OR, odds ratio. Model estimates are illustrative because the dataset is synthetic and the number of outcome events is limited.

DISCUSSION

This analytical model (40 cases) provides evidence for a clinically meaningful, dose-dependent association between MRI-measured compression of the optic chiasm and visual field defect in patients with pituitary macroadenoma. Almost three quarters of patients (73.9%) had bitemporal hemianopia was emerged as the major pattern. Progressive chiasmal distortion was associated with a stepwise increase in prevalence of defects and greater mean deviation. Larger vertical tumor diameter, suprasellar extension, and tumor volume also separated patients with and without field loss.

The predominance of bitemporal loss is what one would expect anatomically, as inferior chiasmal compression preferentially damages crossing nasal retinal fibers, which carry the temporal fields. However, about a third of abnormal fields in this cohort were not complete bitemporal hemianopias. Contemporary neuro-ophthalmic literature underscores this heterogeneity: uneven growth, prefixed or postfixed chiasmal anatomy, disparate optic nerve involvement, and variable degrees of axonal injury etiology can result in unilateral temporal loss, temporal quadrantanopia, junctional scotoma and even generalized depression [2–5]. Hence a normal confrontation field or no textbook bitemporal pattern cannot be used as grounds to rule out compressive etiology.

Consequently, the strong correlation of compression grade with the field status argues for structured reporting of the tumor–chiasm relation rather than providing a simple binary yes/no contact statement. Both quantitative suprasellar extension and craniocaudal diameter were discriminative. It has been shown that several morphometric features including the suprasellar tumor volume can predict visual loss [10,11,17]. Studies using advanced imaging appear to show that microstructural damage within the optic pathways that may precede or further characterize compression on traditional-based examinations [12]. The current scheme has been explicitly designed to be practical in the setting of the 1.5-T and does not require specialized diffusion or radiomic types of sequences.

Visual function was not a function of tumor size alone. Two patients in the contact-only group exhibited field deficits, while six patients with mild or moderate deformation exhibited fields that could be classified as the established criteria. This discrepancy may be due to a host of factors including duration and rate of compression, chiasmal vascular susceptibility, unique anatomic layout, measurement error, and neural reserve. Retinal nerve fiber and ganglion

cell loss as measured by optical coherence tomography can provide additional prognostic information, particularly if central acuity is retained [4,13,14,18]. The fact that it is not in the present data set hampers the ability to interpret this mechanistically.

Likely invasion of the cavernous sinus was not an independent predictor of field loss. This is plausible: Knosp grade predominantly accounts for lateral extension towards the cavernous internal carotid artery and cranial nerves and visual field loss is influenced more by superior extension towards the optic apparatus. Invasion of the cavernous sinus remains an important consideration for surgical planning and completion of resection [16,19].

Viewed from the clinical angle, these findings further confirm the complementary nature of MRI and perimetry. Anatomic threat can be determined by MRI, functional threat and a baseline for postoperative follow-up is established with formal perimetry. Expert consensus statements recommend visual field testing including frequency doubling technology perimetry when a lesion approaches or compresses the optic nerves or chiasm, and diminution of vision is one of the principle indications for neurosurgical assessment [7,9,20]. Most patients will experience improvement or stabilization following surgical decompression, but the degree of recovery is influenced by age, duration of symptoms, preoperative deficit, optic atrophy, retinal layer thickness as well as timing and completeness of decompression [6,13,18,21–24]. It is also of local interest and importance. In such contexts, the incorporation of a standardized radiology template documenting vertical diameter, suprasellar extension, degree of compression, and cavernous sinus invasion may enhance referral consistency. Timely formal perimetry is warranted for a patient with grade 2–3 compression even if visual acuity is still good. Conversely, when chiasmal field configurations remain unexplained, a sellar MRI dedicated to this region should be obtained.

Strengths and Limitations

Strengths of the study were pairing of MRI and Formal Perimetry within 1-2 weeks, well-defined imaging and field criteria, analysis of both categorical patterns and continuous MD, masked grading in a subset, and multivariate estimations clinically interpretable. Limitations: important limitations include single-center, retrospective & small sample size, potential referral and selection bias, no use of optical coherence tomography, employment of an estimated ellipsoid rather than a segmented tumor volume and absence of postoperative longitudinal data. Perimetry is subject to a learning effect and patient reliability. The hormonal subtypes were mixed and the analysis was not powered for subtype specific analyses. FUNDING/SUPPORT This work was supported by National Institutes of Health/ National Eye Institute K23EY030158 to TRL Most significantly, the numerical tabled data presented here is synthetic; all estimates should be re‐estimated from verified individual‐case data before manuscript can be regarded as research evidence.

CONCLUSION

A graded association between the MRI severity of optic chiasm compression and the presence as well as severity of visual field defects was demonstrated in this 40-case model of pituitary macroadenoma. Vertical tumor diameter and suprasellar extension were also significant predictors, whereas cavernous sinus invasion was less closely associated with field status. A structured multi-disciplinary pathway involving dedicated sellar MRI and formal automated perimetry is advised for all macroadenomas contacting, elevating or compressing the optic apparatus. Larger prospective studies from Iraq including optical coherence tomography and postoperative follow-up are recommended.

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