Neurosurg Rev (2012) 35:369–379
DOI 10.1007/s10143-011-0365-y

ORIGINAL ARTICLE

Prognostic factors of visual field improvement after trans-sphenoidal approach for pituitary macroadenomas: review of the literature and analysis by quantitative method

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Received: 8 February 2011 / Revised: 13 June 2011 / Accepted: 4 September 2011 / Published online: 15 November 2011
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Abstract The objective of the study was to evaluate the preoperative visual field defect, the postoperative outcome and the possible prognostic factors in patients with pituitary macroadenoma, using a quantitative method (the mean deviation=MD), and to review the literature. A total of 73 patients, operated trough trans-sphenoidal approach, were selected, and data in single eyes were analysed by calculating the frequency and the degree of postoperative improvement (relative improvement). The visual field defect improved in 95.7% of eyes: The recovery was complete in 48.9% and partial in 46.8%. Multivariate logistic regression showed that factors, independently predictive for complete recovery, were as follows: low preoperative MD absolute value (p=0.008), low cranio-caudal diameter of tumour (p=0.02) and young age (p=0.0001). The mean relative improvement in visual field defect (dMD%) was correlated with the preoperative visual acuity (p=0.0001) and inversely related with the preoperative MD (p=0.007) and the age (p=0.017). The relative improvement was higher in tumours with a smaller cranio-caudal diameter (p=0.0185). In conclusion, using a quantitative method, we can measure the degree of the postoperative visual field defect improvement. Predictive factors for a complete recovery were good preoperative visual function, young age and low cranio-caudal tumour.

Keywords Pituitary adenomas · Visual improvement after trans-sphenoidal surgery · Visual field outcome · Visual outcome

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Introduction

Pituitary adenomas with suprasellar extension can produce visual impairment due to the compression of the optic chiasm. The visual field defect may be associated with visual acuity deterioration, colour perception decrease and optic disc atrophy.

The trans-sphenoidal surgery allows a safe decompression of the anterior visual pathways in the majority of patients, with a low complications rate [1, 17]. It is, at present, the choice treatment for pituitary adenomas, with exception for prolactinomas that can be treated with dopamine agonists as the first line therapy [22]. Several studies reported improvement in the visual function after trans-sphenoidal surgery for pituitary adenomas, ranging from 56% to 90%, but the need to consider many variables (the visual acuity and field, the monocular or binocular involvement and the difference on methods of evaluation) may explain why the results are heterogeneous [3, 4, 6, 7, 13, 14].

In our study, we analysed the visual parameters separately, distinguishing the two eyes in each patient.

Moreover, using a quantitative measure for the visual field defect, we calculated not only the frequency but also the degree of the postoperative improvement.

Methods

Patient selection

We reviewed the data of more than 2,000 consecutive patients operated for pituitary adenomas at the Department of Neurosurgery, San Raffaele Scientific Institute, between 1990 and 2009. The inclusion criteria for this study were as follows: (1) pituitary adenomas with suprasellar extension and preoperative visual field and/or visual acuity impairment due to the anterior optic pathways compression; (2) patients that underwent trans-sphenoidal selective adenomectomy for the first time at our department; (3) histological diagnosis of pituitary adenomas; (4) pre- and postoperative (at least 6 months after operation) complete ophthalmologic examination, performed by the same ophthalmologist (SB).

We selected 73 patients; the mean age was 52.2 years±1.25 (range, 16–81), and the median was 54 years. Twenty-eight patients were female (38.4%) and 45 were male (61.6%). The mean cranio-caudal diameter, on the preoperative magnetic resonance imaging (MRI), was 31.0 mm±0.7 (range, 16–53), and the median was 30 mm. The mean duration of preoperative symptoms was 9.0±0.8 months, and the median was 6 months (range from 0, in four patients with pituitary apoplexy, to 48 months). Sixty-three cases (86.3%) were non-functioning pituitary adenomas, whereas ten (13.7%) were secreting adenomas (four growth hormone-secreting and six prolactinomas non-responsive to medical therapy).

The sublabial trans-sphenoidal microsurgical approach, as previously described, was performed by the senior authors (PM and MG) in all patients, achieving complete decompression of anterior optic pathways [17]. Postoperative follow-up was assessed every 6 months, by MRI and ophthalmologic and endocrinologic evaluations. In 48 cases (65.8%), the MRI or hormonal data showed a radical surgery (see Figs. 1 and 2); in 25 cases (34.2%), a small tumour remnant in the cavernous sinus remained, which did not lead to compression of anterior visual pathways. The mean postoperative follow-up was 27.0±2.3 months (range, 6–120), and the median was 17 months. No major complications occurred early or late after surgery, as intrasellar blood collection or optic nerve and chiasm herniation into the empty sella.

To analyse possible prognostic factors for postoperative recovery, we measured the cranio-caudal diameter, which extend from the sellar floor (lower limit) to the cranial pituitary adenoma margin, as an estimate of the tumour size and the sovrasellar extension, and we considered three different cohorts of patients: (1) age over or under 50 years, (2) tumour cranio-caudal diameter superior or inferior to 30 mm and (3) time interval between symptoms onset and surgery superior or inferior to 12 months.

Ophthalmologic evaluation

All patients underwent the ophthalmologic evaluation 1 week before operation and 6 months later. When after this interval, we performed postoperative visits every 6 months; we considered the last one. Four items were evaluated: (1) computerised perimetry, (2) visual acuity, (3) colour vision and (4) fundus oculi.

The visual field was assessed using a Humphrey field analyser (central 30–2 threshold test; Humphrey Instruments, London, UK), an automated test providing a qualitative topographic representation (greyscale), a quantitative measure (decibels) of the central and peripheral retinal light sensitivity threshold and, finally, a statistical analysis such as the mean deviation (MD). MD is the mean of all deviations between the sensitivity threshold of each retinal point and the normal expected value found in healthy people. Therefore, MD indicates how much the visual field strays from the normal one. In patients with normal vision MD is approximately 0, whereas a negative number indicates a visual field defect (see Figs. 3, 4 and 5).

The visual acuity, with the best correction for refractive disease, was assessed using standardised optotypes and measured with the Snellen decimal conversion, ranging from 0 for no light perception to 1 for normal vision. The light perception, the hand motion at 50 cm from the eye, the finger count at 50 cm from the eye were assimilated to 0.01; the value 0.05 corresponded to 20/400 or 1/20.

The colour perception was tested with pseudoisochromatic plates, Ishihara colour plates, and the data were classified as normal or abnormal. Abnormality was assessed when acquired red/green dyschromatopsia, associated with optic compressive neuropathy, was evident.

The optic disc was examined trough the ophthalmoscope: The presence of optic disc pallor was recorded both in case of temporal pallor or papillary atrophy.

The data obtained from the 73 selected patients were analysed considering 146 eyes separately. Exclusion criteria were (1) eyes showing normal findings (six cases) and (2) eyes affected by other pathologies besides the chiasm compression, as glaucoma (one case); hence, our analysis was based on 139 eyes.

The postoperative visual field and acuity outcomes were evaluated as improved, worsen or unchanged. The improvement was classified in: (1) complete recovery, if the normality was achieved; (2) partial recovery, if there was a decreasing variation ≥1 dB of MD absolute value or an increasing variation ≥0.1 U of visual acuity. The value of

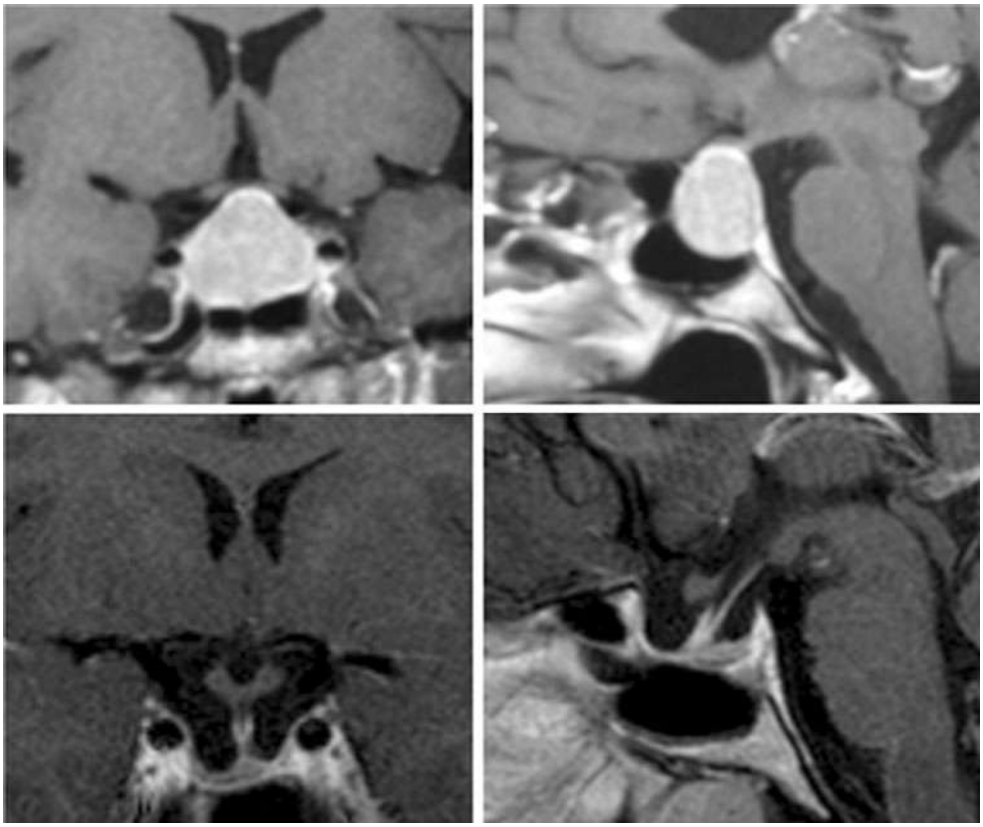

Fig. 1 *Top* Coronal and sagittal T1-weighted contrast-enhanced MRI in a 53-year-old man with non-functioning pituitary macroadenomas. Before surgery, bitemporal hemianopsia (see Fig. 3) and hypopituitarysm were present. *Bottom* Coronal and sagittal T1-weighted contrast-enhanced MRI performed in the same patients 6 months after trans-sphenoidal surgery. The tumour was radically removed and the anterior optic pathways decompressed: the visual field, hypothyroidism and hypoadrenalism recovered, whereas hypogonadism persisted after surgery

1 dB was chosen because, at a preliminary analysis of visual field based on greyscale, the difference from postoperative and preoperative MD in unchanged eyes was in mean 0.5±0.3 dB (range, 1–0.3).

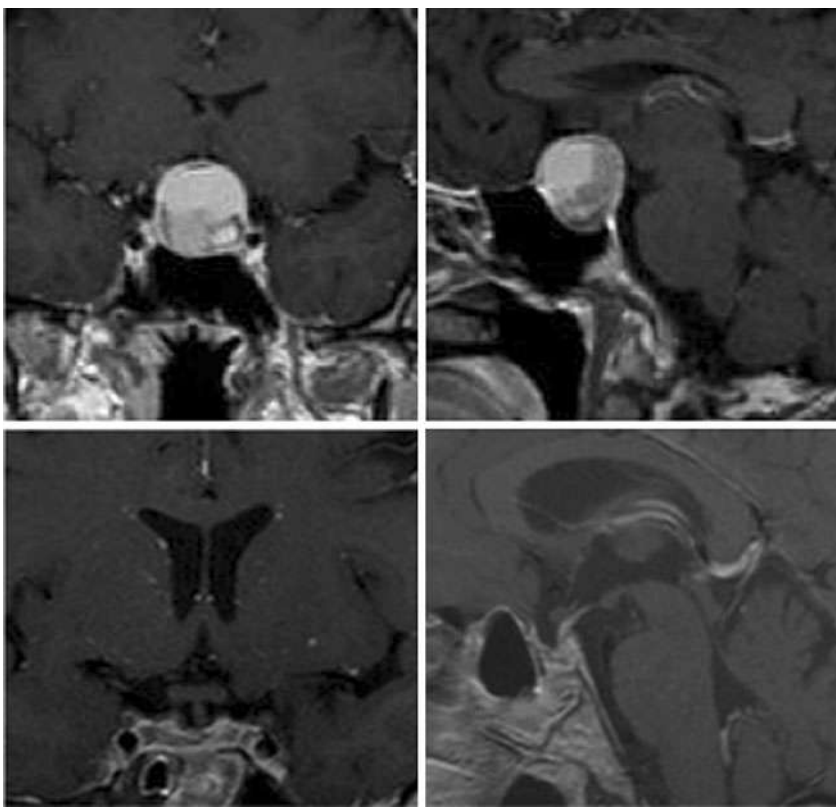

Fig. 2 *Top* Coronal and sagittal T1-weighted contrast-enhanced MRI T1 in a 64 year-old man with apoplexy of non-functioning pituitary macroadenomas. The diagnosis was made after sudden onset of headache and visual field defect (bitemporal hemianopsia, see Fig. 4). *Bottom* Coronal and sagittal T1-weighted contrast-enhanced MRI performed in the same patients 6 months after trans-sphenoidal surgery. The tumour was radically removed and the visual field defect recovered after surgery

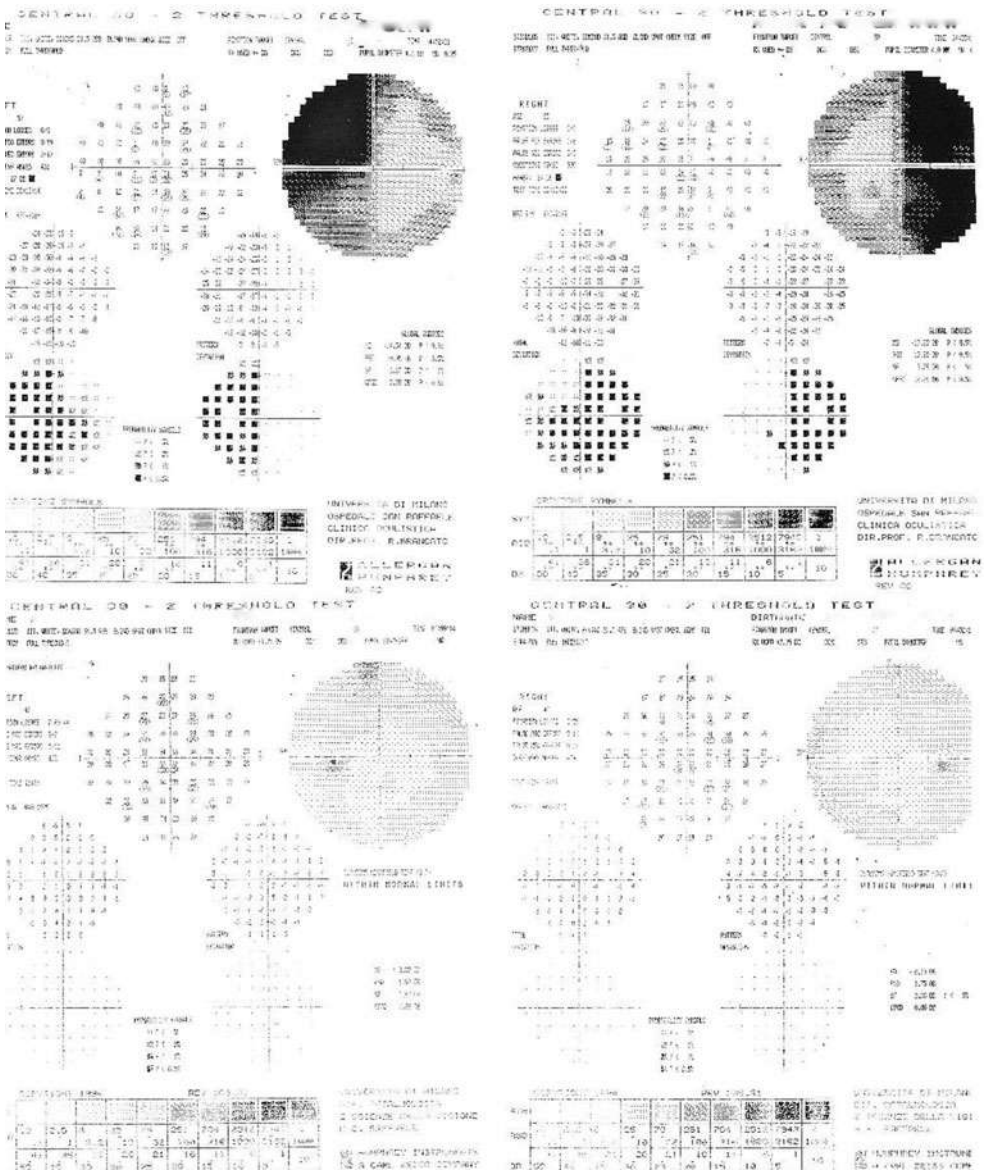

Fig. 3 *Top* Computed perimetry acquired by the Humphrey field analyser before surgery in the patient with pituitary macroadenoma reported in Fig. 1. The qualitative data are topographically represented with the greyscale: *dark tones* are assigned to the less sensitive areas, and *increasingly clear tones* are assigned to the more sensitive areas. *MD* indicates the mean deviation; in patients with normal vision, MD is approximately 0, whereas a negative number indicates a visual field defect. The Humphrey field analyser records also the fixation losses (perception of light stimulus in correspondence of the blind spot, previously identified by the system), the false positive errors (the system emits a noise but not the light stimulus) and the false negative errors (the system emits a supraliminal stimulus, which should be seen by the patient); the test is defined reliable when any one of the three controlling trials was <20% [11, 21]. The preoperative perimetry shows a bitemporal hemianopsia: on the left eye, the MD is −14.54, and on the right eye, the MD is – 17.93 dB. *Bottom* Computed perimetry acquired by Humphrey field analyser on same patient 6 months after surgery. The postoperative perimetry shows a normal visual field; on the left eye, the MD is −0.30 and the postoperative relative improvement of visual field (dMD%), calculated with the formula (postoperative MD−preoperative MD)/preoperative MD× 100, is 97.9%. On the right eye, the MD is −0.29; the dMD% is 98.4%

Finally, we calculated the relative improvement of the visual field defect (dMD%) using the following formula (see Figs. 3, 4 and 5):

$$\text{dMD \%} = \frac{(\text{Postoperative MD} - \text{preoperative MD}) \times 100}{\text{Preoperative MD}}$$

Statistical analysis

Continuous data were expressed as mean±SE and median. Nominal variables were compared with use of chi-square test. Non-parametric test were used for data with abnormal distribution, suggested by Kolmogorov–Smirnov normality

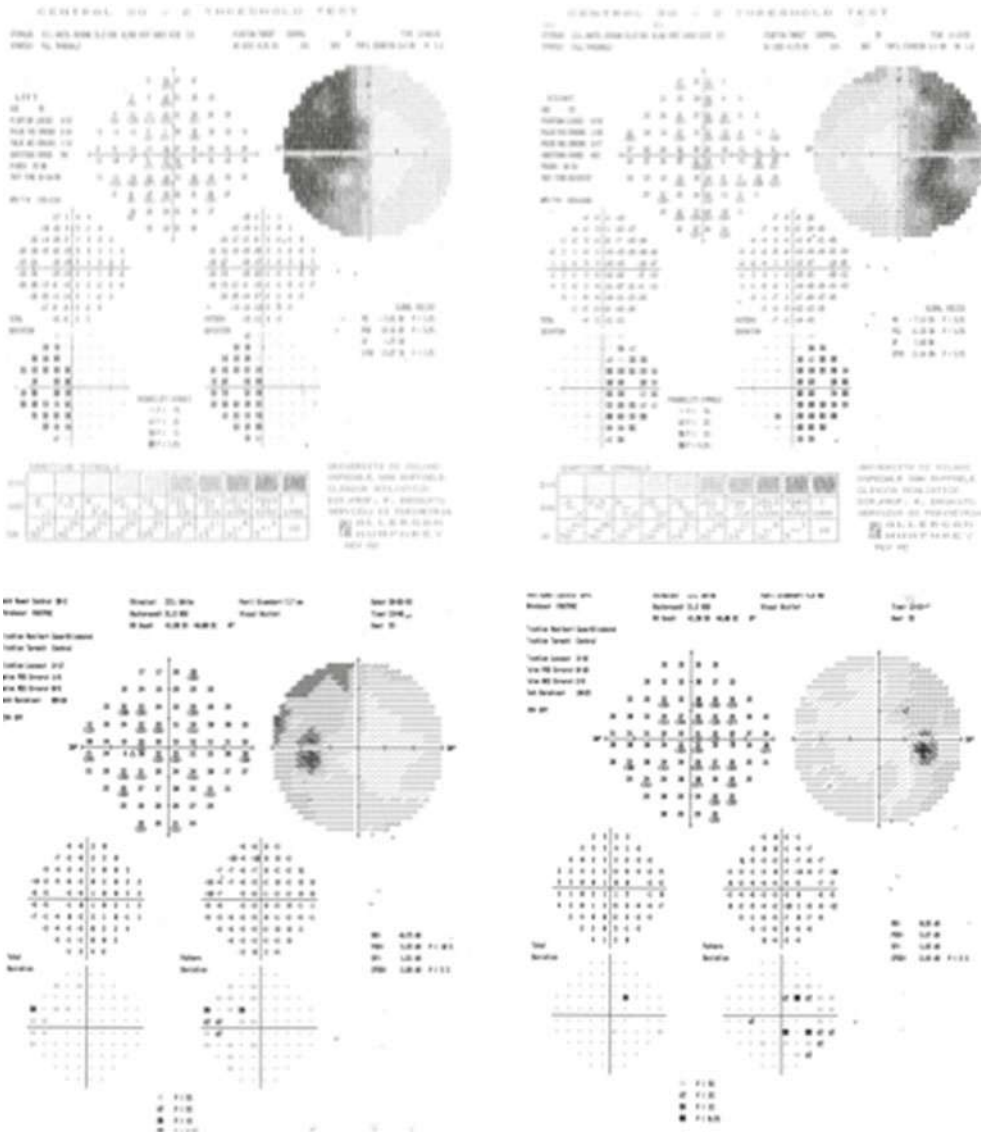

Fig. 4 *Top* Computed perimetry acquired by Humphrey field analyser before surgery in the patient with pituitary apoplexy reported in Fig. 2. The preoperative perimetry shows an incomplete bitemporal hemianopsia: on the left eye, the MD is −7.81, and on the right eye, the MD is −7.13 dB. *Bottom* Computed perimetry acquired by Humphrey field analyser on same patient 6 months after surgery. The postoperative perimetry shows a recovery of preoperative defect: on the left eye, the MD is 0.75, and the dMD% is 90.4%. On the right eye, MD is −0.85, and the dMD% is 88.1%.

test: For two independent samples, the Mann–Whitney *U* test was used. The Spearmen's correlation coefficient was used to analyse relation between two continuous variables. Multivariate logistic regression was used to compare which variable independently was a positive or negative predictive factor of postoperative improvement. A $p<0.05$ was considered to indicate statistical significance. All calculations were performed using the statistical package Stat View 5.0 (Abacus Concepts, SAS Institute Inc., Cary, NC, USA).

Results

Table 1 reports preoperative and postoperative data in 73 patients. Our selected population included four patients with apoplectic presentation of pituitary adenoma. In all four cases, the visual field only was impaired; the defect was in three patients monolateral (loss of vision in the temporal sector; MD=−5, −6.53 and −7.82, respectively) and bilateral in only one patients (bitemporal incomplete hemianopsia; MD=−7.81 on the left eye and −7.13 in the right eye). The recovery was complete in all four cases.

Among 139 eyes, all with preoperative abnormal perimetry, the preoperative mean MD was −11.9±0.6 dB (range, –31.9 to −1.6), and the median MD was −11 dB. Preoperative visual acuity compromise was present in 75 eyes (53.9%), with the mean of 0.7±0.03 (range, 0–1) and the median of 0.9. The colour perception was impaired in 49 eyes (41.2%, data obtained in 119 eyes). The optic disc was pale in 43 cases (34.4%, data obtained in 125 eyes). The MD preoperative value was inversely correlated with the visual acuity (Spearman's correlation coefficient, $p=0.0001$). Moreover, the preoperative MD absolute value was worse in the eyes with

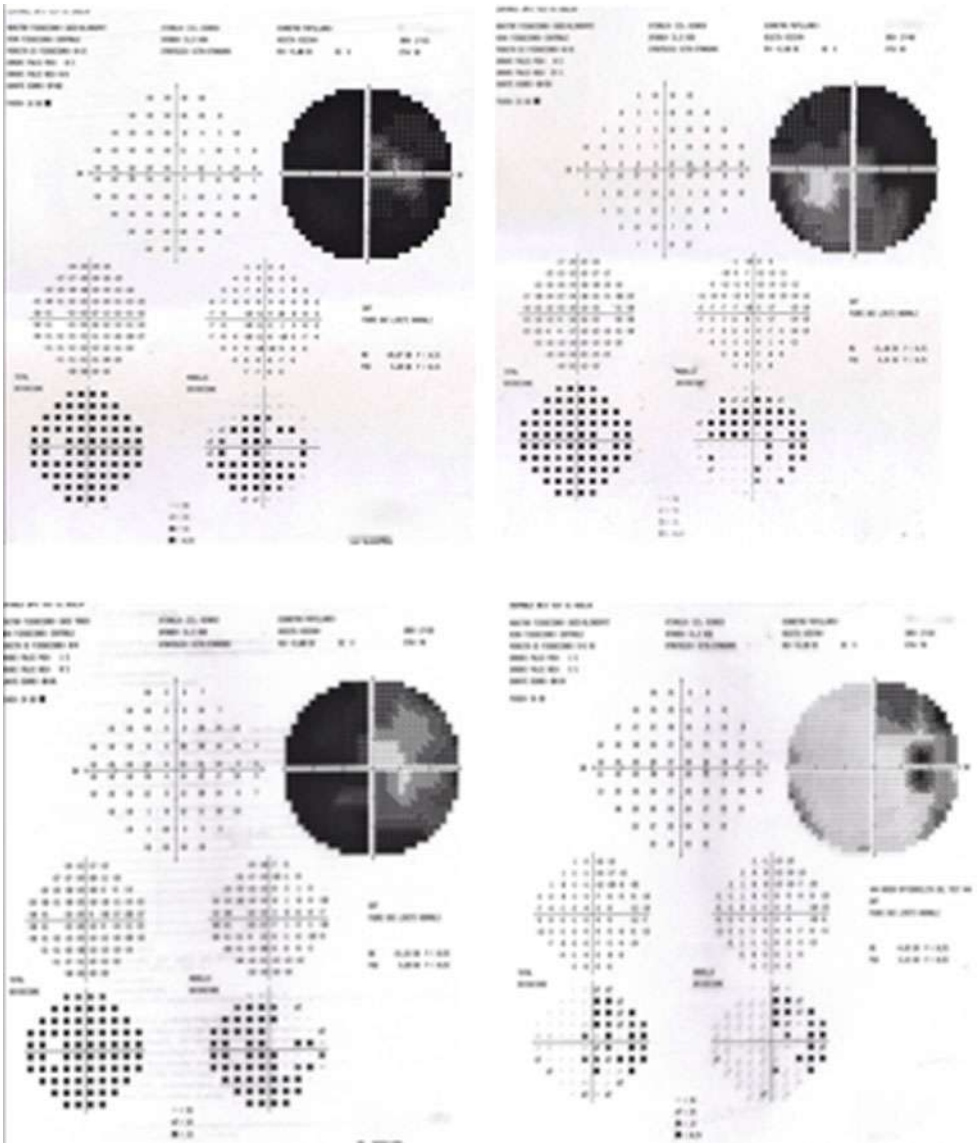

Fig. 5 *Top* Computed perimetry acquired by Humphrey field analyser before surgery in a 71-year-old man with pituitary macroadenoma. The preoperative perimetry shows an important impairment of both eyes: on the left eye, the MD is −28.87, and on the right eye, the MD is −21.50 dB. *Bottom* Computed perimetry acquired by Humphrey field analyser on same patient 6 months after surgery. The postoperative perimetry shows on the left eye a little improvement (MD −21.33 and dMD% 26.1%), and on the right eye, a nearly total recovery (MD −4.85 and dMD% 77.4%).

an acquired dyschromatopsia (mean, −15.2±1.1 dB) than in the normal ones (mean, −9±0.6 dB) and in the presence of the optic disc pallor (mean, −15.8±1.2 dB) with respect to the normal papilla (mean, −9.3±0.6 dB; Mann–Whitney *U* test, $p = 0.0001$). The visual acuity decreased in the eyes with an impaired colour vision (mean, 0.6±0.1 dB) and in the

Table 1 Preoperative visual function and postoperative outcome in 73 patients surgically treated for pituitary macroadenoma

	Before surgery		After surgery	
Visual field	Normal 0/73		Recovery	31/73 (43%)
	Impaired 73/73 (100%)	Monolateral 24/73 (32.9%)	Improved	42/73 (57%)
		Bilateral 49/73 (67.1%)	Unchanged	0/73
Visual acuity	Normal 27/73 (37%)		Recovery	13/46 (28.3%)
	Impaired 46/73 (63%)	Monolateral 23/46 (50%)	Improved	21/46 (45.6%)
		Bilateral 23/46 (50%)	Unchanged	12/46 (26.1%)
Colour vision	Normal 38/62 (61.3%)		Improved	(12/24) (50%)
	Impaired 24/62 (38.7%)		Unchanged	12/24 (50%)
Optic disc	Normal 33/65 (50.8%)		Improved	5/32 (15.6%)
	Temporal pallor/atrophy 32/65 (49.2%)		Unchanged	27/32 (84.4%)

presence of the optic disc pallor (mean, 0.5±0.1 dB) compared to the normal eyes (mean, 0.8±0.1 dB and 0.8± 0.1 dB, respectively; Mann–Whitney *U* test, $p=0.0001$). The preoperative values of MD, visual acuity, colour vision and optic disc pallor were independent of adenoma type and patient sex (Mann–Whitney *U* test and chi-square, $p>0.05$).

Table 2 reports the statistical analysis of the relationships between all the considered preoperative visual parameters and duration of symptoms, tumour cranio-caudal diameter and age. Postoperative outcomes for all the four variables are analysed in Table 3. Table 4 summarises the results of logistic regression between the preoperative characteristics and the postoperative visual field defect outcome. Multivariate logistic regression showed that the factors independently predictive for a complete recovery were low preoperative MD absolute value ($p=0.008$), low cranio-caudal diameter of the tumour ($p=0.02$), and young age ($p=0.0001$).

The mean postoperative relative improvement in the visual field defect (dMD%) was 69.4%±2.9 (range, 0–100); the median was 74%. The dMD% was correlated with the preoperative visual acuity (Spearman's correlation coefficient, $p=0.0001$) and inversely related with the preoperative MD (Spearman's correlation coefficient, $p=0.007$) and age (Spearman's correlation coefficient, $p=0.017$). The dMD% was higher: when preoperative normal colour vision (77.3%±4) rather than impaired one was present (56.3%±4.9; Mann–Whitney *U* test, $p=0.0031$); in eyes with a preoperative normal optic disc (76.7%±3.3%) compared to a pale one (49.5%±5.1%; Mann–Whitney *U* test, $p=0.0001$); in patients under 50 years (72.6%±5.5) compared to the ones over 50 years (65.1%±3.2; Mann–Whitney *U* test, $p=0.0278$); in tumours with cranio-caudal diameter less than 30 mm (76.2%±3.6) compared to bigger ones (64.6%±4.6 Mann–Whitney *U* test, $p=0.0185$). The dMD% was not influenced by sex, adenoma type (Mann–Whitney *U* test, $p>0.05$) and duration of the preoperative symptoms (Spearman's correlation coefficient, $p>0.05$).

Discussion

Although the computerised perimetry is currently used in the clinical practice, studies based on quantitative analysis, using the MD value, in patients with pituitary adenoma are scanty [8, 16]. The advantages of computerised over manual perimetry are the higher sensitivity, reliability, standardisation and reproducibility of results. Computerised perimetry not only allows locating the defect but also to quantify its severity, based on the comparison between the patient and a healthy reference population.

Typically pituitary adenomas cause upper temporal field defect, which progresses in an anticlockwise direction in the left eye and in a clockwise direction in the right eye, and also asymmetric unilateral or bilateral visual field defects may occur. Potential mechanisms of injury include direct disruption of conduction along the axon, impaired axoplasmic flow, demyelisation and ischaemia from compression or stretching of chiasm vessels [12]. Bergland and Ray observed that the blood supply of the optic chiasm arises from a superior and inferior group of vessels, and the crossing fibres in the chiasm receive only the inferior group of vessels. Consequently, an infra-chiasmal compression due to a pituitary tumour can produce a bitemporal hemianopsia [2]. A recent mechanical theory explains that, when an external compressive force is applied to the chiasm, nasal retinal fibres undergo a preferential damage because the pressure applied to the crossing fibres is greater than the one applied to the uncrossed fibres. Pressure is inversely proportional to the area over which the force is applied. The area over which the adjacent crossing fibres are in contact with each other is smaller than that over which the uncrossed fibres are in contact [15]. Pituitary tumours usually compress the chiasmatic crossing fibres, leading first to a bitemporal hemianopsia; they may affect macular fibres and thus cause visual acuity damage at a later stage. In our series, including only patients with visual

Table 2 Preoperative characteristics of 139 eyes

	Duration of preoperative symptoms		Cranio-caudal adenoma diameter		Age	
	>12 months	<12 months	>30 mm	<30 mm	>50 years	<50 years
Visual field (mean deviation=MD, dB)	−14.7±1.1	−10.45±0.6	−13.3±0.9	−10.15±0.8	−12.8±0.8	−10.5±0.9
p value	0.001		0.005		0.05	
Visual acuity (Snellen decimal conversion)	0.6±0.04	0.8±0.03	0.7±0.04	0.8±0.04	0.65±0.4	0.85±0.4
p value	0.0045		>0.05		0.002	
Colour vision (%)	51.4	36.9	49	31.7	47.2	31.9
p value	>0.05		>0.05		>0.05	
Optic disc pallor (%)	43.6	30.2	43.6	21	37.2	29.8
p value	>0.05		0.0085		>0.05	

Table 3 Visual outcome after trans-sphenoidal surgery for pituitary macroadenomas (eyes with preoperative defect)

Defect	Visual field (n=139)		Visual acuity (n=75)		Colour vision (n=49)		Pallor of optic disc (n=43)	
	n	Percent	n	Percent	n	Percent	n	Percent
Improved	133	95.7	50	66.7	25	51	6	14
Complete recovery	68	48.9	25	33.35				
Partial recovery	65	46.8	25	33.35				
Unchanged	6	4.3	25	33.3	24	49	37	86

impairment secondary to pituitary macroadenomas, the visual field defect was the most frequent symptom encountered (100% of eyes), followed by visual acuity decrease (53.9% of eyes), colour vision impairment (41.2% of eyes) and optic disc pallor (34.4% of eyes). The MD value and the visual acuity were correlated between them and were worse when the duration of preoperative symptoms was longer than 12 months. Moreover, they were worse in the patients over 50 years, probably because the younger patients are more able to compensate microvascular deprivation due to tumour compression of small vessels. The optic disc pallor and the colour vision impairment were associated with a high degree of visual defect and acuity impairment, but appeared not to be directly influenced by the duration of preoperative symptoms and age. The cranio-caudal diameter of tumour superior to 30 mm was associated with a higher MD absolute value and a higher frequency of optic disc pallor. In patients with bigger tumour, the visual acuity was lower and the colour vision impairment more frequent compared to patients with smaller tumour, but the difference between the two groups was not significant. Several authors report a correlation between the tumour size and a preoperative field loss [9, 16], but not with the preoperative visual acuity, probably because the role played by the site of compression is more important than the volume of the tumour in affecting the macular fibres. There are no measurable parameters, such as the presence of a prefixed or post fixed chiasm, the position of the suprasellar tumour with respect to the chiasm, the dehiscence of the sellar diaphragm and the vascular anatomy of the chiasm, which may play an important role in determining the visual acuity, the preoperative impairment and the extent of postoperative recovery [9]. In conclusion, we suppose that the most frequent impaired visual function in patients with pituitary macroadenomas is visual field. A longer chiasmal compression and a bigger tumour involve a worse visual field defect, whereas the place of compression is the most important factor in determining the acuity and colour vision impairment, which are damaged functions when the macular fibres are compressed at the chiasmal or optic nerve level [10].

The frequency in the improvement of the visual function after trans-sphenoidal surgery for pituitary adenomas, reported in the literature, are described in Table 5 [5, 8, 16, 18–20, 23, 25]. In the present study, no patient experienced postoperative deterioration in the visual function. In the literature, including our previously published large series, the reported visual worsening ranged from 0% to 5% [7, 8, 13, 17, 20]. This wide range of published series

Table 4 Prognostic factors and visual field defect outcome

Preoperative value	Complete recovery	Partial recovery	p value
Visual field: mean deviation (MD; dB) (mean±SE)	−15.6±0.8	−8.5±0.6	0.0001
Visual acuity: Snellen decimal conversion (mean±SE)	0.9±0.03	0.6±0.04	0.0001
Colour vision (%)	30%	52.8%	0.014
Optic disc pallor (%)	16.9%	50%	0.0002
Age, years (mean±SE)	47.9±1.8	57.1±1.8	0.0009
Cranio-caudal diameter (mm) (mean±SE)	28.9±0.9	33.3±1.2	0.0023
Duration of symptoms (months) (mean±SE)	6.1±0.8	12.2±1.6	0.006
Sex (%)			>0.05
M	50.6%	49.4%	
F	51.9%	48.1%	
Pituitary adenoma type (%)			>0.05
Non-functioning	82.35%	90.8%	
Secreting	17.65%	9.2%	

SE standard error

Table 5 Visual improvement after pituitary adenomas surgery

Author, year	*N*	Visual field (%)	Visual acuity (%)
Nakane, 1981 [18]	167	90	91
Trautmann, 1983 [25]	714	73	46
Cohen, 1985 [5]	100	74	79
Sullivan, 1991 [23]	34	81	71
Peter, 1995 [19]	53	89	81
Powel, 1995 [20]	67	77	45
Gnanalingham, 2005 [8]	41	95	
Monteiro, 2010 [16]	60 eyes	80	
Present series	73 patients	100	73.9
	139 eyes	95.7	66.7

may be explained considering that the follow-up, the visual parameters that were studied and the method of evaluation used were different. The improvement in the visual function has been described also after 3 years from the surgical decompression and may be divided into three phases [12]. The early fast phase, from surgery to 1 week, is probably due to the removal of the physical blocking of the conduction signal along the axon. The early slow phase, from 1 to 4 months, corresponds to the most consistent improvement; the restoration of the axonal transport and the remyelisation are the main causes of improvement. The late phase, from 6 months to 3 years, is mild or not significant but may be marked in some individuals; the potential mechanisms include the remyelisation and the remodelling within the anterior visual pathways [12]. In our study, we included only patients with a minimum follow-up of 6 months to comprise the early fast and the early slow phases that are the time interval of the most consistent improvement after surgery.

We achieved a complete recovery of the visual field after surgery in 48.9% of eyes and an improvement, without reaching normality, in 46.8%. Our series compare favourably with the previously reported results [19, 20]. Many preoperative factors have been advocated to influence the postoperative visual outcome. Young age, short preoperative duration of symptoms, small field loss and good acuity were the prognostic factors reported in the literature as associated to a better postoperative visual outcome [5, 19, 23, 24]. Suzukawa [24] reported the optic atrophy and a high degree of suprasellar extension as negative prognostic factors, but this study included pituitary adenomas operated trough transcranial approach. A recent study, based on quantitative analysis of the visual field defect, reports that the recovery of the visual field is associated with a shorter duration of symptoms and a smaller preoperative defect in the visual acuity and field. However, on the multivariate analysis, the degree of the preoperative visual field defect was the only independent predicting factor of postoperative recovery [8]. Finally, in the most recent study, factors related to visual recovery were the degree of optic atrophy, the severity of visual field defect and the tumour size [16]. In our analysis, the high MD absolute value, the presence of the optic disc pallor, a high cranio-caudal diameter of pituitary adenoma and the long duration of symptoms were negative prognostic factors for the visual recovery after trans-sphenoidal surgery. The young age, a high preoperative visual acuity and the normal colour vision were positive prognostic factors. Multivariate logistic regression showed that factors, independently predictive for complete recovery, were the low preoperative MD absolute value, the low cranio-caudal diameter of tumour and the young age. Based on these results, we suppose that the duration of preoperative symptoms was an important factor in determining the preoperative MD, but only partially affected the postoperative improvement. This means that a patient with a bad visual impairment has a lower probability of recovery compared to a patient displaying better preoperative MD, even if the onset of symptoms is more recent in the first one. In the subgroup of patients with pituitary apoplexy, the recovery of preoperative visual field defect was complete in all four cases. Even if the number of cases is too low for any meaningful statistical analysis, we explain this excellent outcome, according our result in all the selected population, primary due to a little or mild impairment of the visual field defect present preoperatively in all four apoplectic adenomas. The short duration of symptoms in this subgroup of patients is directly associated with a low preoperative defect, the most important prognostic factor for complete recovery, and so only indirectly related with good postoperative outcome.

The postoperative relative improvement in the visual field (dMD%) increased in eyes with minor preoperative MD absolute value, better visual acuity, normal colour vision, normal optic disc, age younger than 50 years and cranio-caudal tumour inferior to 30 mm. Our results, based on semi-quantitative (complete compared to partial recovery) and quantitative (MD and dMD%) analyses, are consistent.

Conclusion

In the present series, the adoption of the trans-sphenoidal microsurgical approach to pituitary adenomas allowed to achieve an improvement in the visual field defect in the 95.7% of the selected eyes. Our results and most recent literature, based on semi-quantitative and quantitative analyses, suggest that a good preoperative visual function (low MD absolute value), a young age and a low cranio-caudal tumour are positive prognostic factors for a postoperative complete recovery of the visual field defect.

The duration of symptoms was not an independent predictive factor for the postoperative improvement.

Conflict of interest The authors declare that they have no conflict of interest.

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Comments

Miguel A. Arraez, Malaga, Spain

In this article from Barzaghi et al., the authors analyse the results in their series of 73 patients identifying the factors responsible for the visual outcome after transsphenoidal surgery. The interest of this paper is the review of several other parameters different from visual field defect. These other factors impairing vision are frequently forgotten when analysing the impact of pituitary adenomas and transsphenoidal surgery in visual function: this paper nicely explains the physiopathology and mechanisms resulting in impairment of the visual acuity (macular fibres) and colour perception, very seldom reflected in the publications about pitutary adenoma and visual pathways impairment. The authors very honestly pointed out that several transcendent factors responsible for visual damage (prefixed of postfixed chiasm, position and morphology of the tumor, dehiscence of sellar diaphragm, vascularisation of optic apparatus) cannot be properly evaluated.

Michael Buchfelder, Erlangen, Germany

Loss of vision is one of the classical presenting symptoms of pituitary adenomas and for a century we read in the medical literature that mostly surgical decompression of the visual pathways is followed by some recovery. However, the degree of recovery is extremely variable. It may occur by improvement of the visual fields or visual acuity in one eye or bi-laterally. Many investigators have in the past assessed the functional result of pituitary tumour operations in respect to vision and tried to identify prognostic factors, which allowed to predict better or worse results. In the present analysis a cohort of patients have been assessed in a systematic fashion for every individual eye. The prognostic factors predicting good outcome confirm previously published factors, such as young age of the patient, a minor degree of loss of vision and a smaller tumour. An asset of this paper is the excellent methodology with which this clinical study was carried out. Moreover, the authors need to be congratulated for their excellent surgical results. I would just like to

add a word of caution in respect to redo procedures. Since all patients in this study underwent primary surgery, the authors could not confirm what we learn from other publications on this topic, namely that one other important factor is whether the operation is a primary intervention or repeat surgery. In the latter case the degree of recovery is clearly less favourable.

William T. Couldwell, Utah, USA

In this study, the authors have analysed the visual acuity and field defects in single eyes among a series of 73 patients undergoing surgical resection of pituitary macroadenomas. In patients with bigger tumors, the visual acuity was lower and the colour vision impairment more frequent compared to patients with smaller tumors, but the difference between the two groups was not significant. Visual field defects were noted in all patients; the authors note that 95.7% of the affected eyes demonstrated improvement in visual field defect following transsphenoidal surgical removal, over a mean followup period of 27 months. As experienced surgeons intuitively suspect, the degree of improvement was related to the age of the patient (younger better), smaller tumors in cranio-caudal diameter and those with lesser visual field defects. The authors nicely document the improvement in visual fields objectively with the quantitative MD values pre- and postoperatively. Somewhat surprisingly, they noted that the duration of preoperative symptoms was an important factor in determining the preoperative MD, but only partially affected the postoperative improvement, indicating even those patients with long standing defects may gain improvement with surgical decompression.

While they note that the cranio-caudal diameter is important for prediction of improvement, it would have been helpful if they had separately commented on the absolute value of suprasellar extent and the degree of chiasmal and nerve compression. Depending upon the growth pattern of the tumour (downward with erosion of the clivus vs. pure suprasellar growth upward), tumours with the same cranio-caudal diameter may produce quite different compression of the optic pathways. This comment notwithstanding, the authors are to be congratulated on their nice contribution to the literature, which contains real information that is helpful in counseling all patients who suffer from visual loss from a pituitary macroadenoma as to their chances of visual improvement following surgery