Evaluation of the Transcranial Approach to Pituitary Adenomas Based on Quantitative Analysis of Pre- and Postoperative Visual Function

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Abstract

Over a 16-year period, 105 patients with pituitary adenoma accompanied by visual disturbance underwent transcranial intracapsular removal of the tumor followed by radiotherapy. Postoperative recovery of visual function in these patients was compared with the results obtained in other institutions after trans-sphenoidal surgery. The severity of preoperative visual impairment was correlated with the duration of visual impairment, the degree of optic atrophy, the extent of suprasellar tumor infiltration, and age. Trans-sphenoidal surgery appears more effective in patients with mild preoperative visual disturbance, whereas the transcranial approach yields better results in patients with moderate to severe preoperative visual deficits.

Key words: pituitary tumor, transcranial surgery, visual loss, microsurgery

Introduction

In 1907, Schloff'er23) achieved the first successful removal of a pituitary adenoma via the extracranial trans-sphenoidal approach. Cushing later obtained favorable results using an oronasal-midline rhino-septal trans-sphenoidal approach. However, in view of the difficulty of removing parasellar tumors other than pituitary adenoma, as well as the high incidence of postoperative recurrence, after 1929 Cushing used the intracranial transfrontal approach, as described by Frazier7) in 1913, for cases of pituitary adenoma. Over the next 30 years, the intracranial subfrontal approach was widely regarded as the technique of choice to remove pituitary adenomas, despite the success of trans-sphenoidal surgery as applied by Dott,25) Guiot, and Hardy. In the 1960s, Guiot8) and Hardy10-13,19) added intraoperative fluoroscopy, surgical microscopy, and other techniques to their trans-sphenoidal approach, which had somewhat waned in popularity, and showed it to be a relatively safe and quick operative method yielding favorable results not only for adenomas in the sella and those extending into the sphenoid sinus, but also for large pituitary adenomas with suprasellar extension. The technique regained popularity and was further applied to huge pituitary adenomas with extension into the third ventricle, as well as to other intra- and suprasellar tumors. Several authors1,4,9,22) have noted that recovery of visual acuity and visual fields appeared even better with this procedure than with the transcranial approach.

For the past 16 years we have used the trans-sphenoidal approach for intrasellar pituitary adenomas as well as those that extend into the sphenoid sinus. However, we have employed the subfrontal approach for adenomas with marked suprasellar extension resulting in profound visual disturbance, combining this with trans-sylvian, transcallosal and trans-sphenoidal approaches when necessary. The intracranial approach, with intracapsular removal of the adenoma, is a safe technique that eliminates the cause of visual disturbance and allows direct visual surveillance of the optic nerves compressed by the suprasellar tumor, the optic chiasma, and the intracranial blood vessels secondarily exerting pressure on this structure.

Of the many reports on pituitary adenoma, only a few have addressed operative techniques and the degree of postoperative visual recovery in cases involving visual disturbance due to suprasellar extension of a pituitary adenoma. This is partially explain-
ed by the fact that the methods to assess visual function differ from institution to institution. In this study, 105 cases were assessed in accordance with the methods used in other institutions, and the results were compared with those reported elsewhere. In this way the effectiveness of transcranial vs. trans-sphenoidal surgery for pituitary adenomas with suprasellar extension was assessed.

Patients and Methods

Between July, 1969 and June, 1985, we treated 155 patients with pituitary adenoma. They include 72 males and 83 females ranging in age from 17 to 72 years (mean, 44 ± 1). Of these, 138 had impaired visual acuity and fields and underwent surgery. The surgical approach was subfrontal in 111 cases, combined subfrontal and transcallosal in one, combined subfrontal and trans-sphenoidal in 11, and trans-sphenoidal in 15. In each case, the adenoma was removed subcapsularly under an operative microscope. Postoperatively, they all received cobalt-60 irradiation via two opposite 4 × 4 cm portals, for an average dose of 44 Gy over 5 weeks.

Thorough endocrinological study or immunohistological staining of tumor cells was carried out in 79 of the 111 cases in which the subfrontal approach was used. Growth hormone-secreting adenomas were diagnosed in six patients, prolactin (PRL)-secreting adenomas (serum PRL > 100 ng/ml) in nine, a follicle-stimulating hormone-secreting tumor in one, and non-functional tumors in 63. Two of the 111 patients (1.8%) died of postoperative complications—one of intracranial hemorrhage and the other of acute renal failure due to postoperative antibiotic administration.

Plain skull x-rays, computed tomography (CT), cerebral angiography, fractional pneumoencephalography, and metrizamide CT cisternography were employed to diagnose the pituitary adenoma. The degree of suprasellar extension was assessed with sagittal and coronal pneumoencephalotomography and reformed sagittal and coronal CT and CT cisternographic images. Tumor extension was classified into type A, B, or C in accordance with the system devised by Wilson. Type C tumors with some degree of suprasellar extension in the midline corresponding to the giant pituitary adenoma described by Symon et al. were separately classified as type G.

Optic function was retrospectively assessed with two methods. The first we refer to as the Deutschen Ophthalmologischen Gesellschaft (DOG) system (Fahlbusch, personal communication). With this system, the degree of improvement in binocular visual acuity is first expressed as a percentage of the normal value, taking into consideration monocular visual disturbance on each side. The degree of visual field constriction on both sides is then combined and expressed as one value (the percentage of the normal value). The degree of visual impairment is thus expressed as the sum of the degree of impairment of the visual acuity and of the visual field. For example, a patient with normal visual acuity and fields has 0% impairment, whereas a patient with 0.5 visual acuity in both eyes (20%) and bitemporal hemianopsia (20%) has 40% impairment. A bilaterally blind patient has 100% impairment. The second method is the visual field scoring system (VFSS) developed by Findlay et al., in which visual function is rated on the basis of visual field disturbance alone (Fig. 1).

Vision was preoperatively assessed with these two methods in 130 of the 138 patients with impaired visual acuity and fields. Sufficient data were available for these 130 patients and there were no complicating factors, such as cataracts. Impairment was classified into 10 levels at 10% increments in order to determine the correlation between the degree of visual impairment and each of the following clinical factors: 1) duration (according to patient) of preoperative visual impairment (divided into periods of less than 1 month, 1-3 months, 3-6 months, 6-12 months, 12-24 months, 24-60 months, and more than 60 months); 2) degree of suprasellar extension

Fig. 1 The visual field scoring system (VFSS) described by Findlay et al. A total score of 20 (100%) denotes blindness.
of the pituitary adenoma; 3) degree of optic nerve atrophy; and 4) age of the patient.

Of the patients subjected to the transcranial surgical approach, 105 had no complications, such as disease of the eyes, and their postoperative visual status was also assessed. The DOG system was applied within 1 year of surgery, and the VFSS thereafter. The postoperative recovery of visual function was calculated as follows:

\[
\Delta = \frac{\text{postoperative degree of visual impairment} - \text{preoperative degree of visual impairment}}{\text{preoperative degree of visual impairment}} \times 100
\]

The degree of recovery of visual function was also classified into 10 levels of 10% increments and the correlation with each of the above-listed clinical factors was determined. We calculated \(\Delta\), the actual change between pre- and postoperative visual impairment, for each of our individual patients and those of Fahlbusch and Findlay et al. Next, again for the same groups of patients, we sought correlation between preoperative impairment and average \(\Delta\) for each value level. Finally, utilizing the t-test, we statistically compared the similar mean \(\Delta\) values for their and our patients.

Postoperative visual function, measured quantitatively by the DOG system, was assigned a qualitative rating in which "improvement" indicates postoperative recovery of at least 10%, "deterioration" represents a decrease of more than 10% in visual function, and "normalization" denotes postoperative visual acuity of better than 20/20 in both eyes (with correction) and no residual visual field defect.

Results

I. Correlation between VFSS score and visual acuity

The 130 patients with visual disturbance were divided into four groups according to the VFSS rating: 0-25%, 25-50%, 50-75%, and 75-100%. They were then divided into three groups according to actual visual impairment; less than 20/200, 20/100 to 20/50, and better than 20/40. Comparison of the two assessments revealed statistically significant correlation (Kendall's test, p < 0.01) (Fig. 2).

II. Correlation between preoperative visual impairment and other clinical factors

The preoperative visual status of the 130 patients, as assessed by the DOG and VFSS methods, was subjected to Kendall's correlation test. The results are shown in Figs. 3 and 4. The DOG scores were significantly correlated with all four clinical parameters: duration of visual disturbance, degree of suprasellar tumor extension, degree of optic nerve atrophy, and age. The VFSS ratings were significantly correlated with the extent of suprasellar invasion and the degree of optic nerve atrophy.

III. Correlation between postoperative visual recovery and clinical factors

The postoperative visual recovery rates were significantly correlated with all the aforementioned clinical factors as well as the degree of preoperative visual impairment, with the exception of the VFSS rating and the degree of suprasellar extension of the adenoma (Fig. 5).

IV. Postoperative changes in visual function

The difference between pre- and postoperative visual function in the 105 patients subjected to the transcranial surgical approach, as assessed with the DOG (Fig. 6) and VFSS methods, were compared with the results obtained with the trans-sphenoidal approach and reported by Fahlbusch and Findlay et al. Regarding recovery of visual function within 1 year after surgery, the results of trans-sphenoidal surgery reported by Fahlbusch appeared slightly better than those of transcranial surgery in cases where the preoperative visual disturbance was less than 20%. However, when the preoperative visual impairment was more than 30%, transcranial surgery was
more effective (Fig. 7).

In comparing VFSS-measured visual recovery more than 1 year after surgery between our patients and those of Findlay et al.\(^9\) (Fig. 8), their results also appeared somewhat more favorable if preoperative visual impairment was less than 20%. Again, however, in cases in which impairment was 40–60%, we seem to have achieved better results. Few patients had preoperative visual disturbance greater than 70% in either series. As a group, they presented an incoherent pattern quite unlike the more stable patterns of cases with disturbance of 60% or less, eliminating the possibility of a valid comparison. When these data were subjected to the t-test, no statistically significant difference was found between the transcranial and trans-sphenoidal approaches.

V. Qualitative evaluation of postoperative visual recovery

The postoperative visual function of the 105 patients subjected to transcranial surgery was assessed with the DOG method and descriptively classified as “normalization,” “improvement,” “no change,” and “deterioration.” The relationships between these classifications and the degree of suprasellar tumor extension was examined (Table 1). Postoperative normalization or improvement was noted in 88 of the 105 cases (83.8%). In type G (marked) suprasellar extension, no patient showed postoperative normalization of the visual fields, but improvement was observed in about 70%. Deterioration occurred in nine cases, but inappropriate surgical technique was thought to have been the cause in eight of these. Eight patients were found to have no change in their vision, and ophthalmoscopic examination revealed marked optic nerve atrophy, which would explain the lack of improvement despite adequate decompression of the optic nerve.

Discussion

Pituitary adenoma is treated surgically through
Fig. 4 A: Relationship between the duration of preoperative visual impairment and the preoperative VFSS score (n = 130). p < 0.10 (Kendall's test). B: Relationship between the degree of suprasellar extension and the preoperative VFSS score (n = 130). p < 0.01. C: Relationship between the preoperative color of the optic disc and the preoperative VFSS score (n = 92). p < 0.01. D: Relationship between age and the preoperative VFSS score (n = 130). p > 0.10.

Fig. 5 Correlations between the degree of suprasellar extension, the preoperative degree of optic atrophy, the duration of preoperative visual disturbance, age, the preoperative visual score, and the extent of postoperative recovery. *p < 0.01, **p < 0.05, p < 0.10 (Kendall’s test).

Fig. 6 Results obtained within 1 year of transcranial surgery (n = 105) (DOG scores). Solid lines indicate postoperative visual improvement. Dotted lines denote deterioration. •: preoperative visual loss, ○: no change in vision.

either the transcranial or the trans-sphenoidal approach. In considering which procedure to use, it is extremely important to know what the effect will be on postoperative recovery of visual function. There have been many reports regarding this issue, but most have been little more than summaries of post-
operative results based on methods of visual assessment peculiar to the authors' institution which makes valid comparisons difficult, if not impossible.

In the study reported here, the pre- and postoperative visual function of 105 patients with pituitary adenoma was retrospectively assessed with the DOG system and VFSS. The results of transcranial surgery were thus expressed as the actual change in visual function and then compared with the results of trans-sphenoidal surgery as reported by Fahlbusch and Findlay et al. In our cases, a correlation was confirmed between the degree of visual impairment, as determined by VFSS, and the degree of impairment of visual acuity. The correlations we obtained between the extent of preoperative visual impairment, as assessed by the DOG system and VFSS, and the duration of impairment, the degree of optic nerve atrophy, and the degree of suprasellar extension are similar to those of Findlay et al. Postoperative recovery of visual function was also well correlated with these clinical factors, as well as with age and the degree of preoperative visual impairment. These results strongly indicate that early detection, diagnosis, and treatment of pituitary adenoma complicated by impairment of visual acuity and fields will enhance the likelihood of postoperative recovery of visual function.

In comparing our results after transcranial surgery with those achieved with trans-sphenoidal surgery, we found that, for patients with mild preoperative visual impairment, trans-sphenoidal surgery yielded better outcomes. On the other hand, in patients with preoperative impairment of more than 30% and those with less than 5/8 normal visual acuity bilaterally and visual field impairment more serious

Table 1  Correlation between type of suprasellar extension and postoperative recovery of visual function

<table>
<thead>
<tr>
<th>Type of suprasellar extension*</th>
<th>No. of cases</th>
<th>Normalization (%)</th>
<th>Improvement (%)</th>
<th>Unchanged (%)</th>
<th>Deterioration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3</td>
<td>1 (33.3)</td>
<td>1 (33.3)</td>
<td>1 (33.3)</td>
<td>—</td>
</tr>
<tr>
<td>B</td>
<td>17</td>
<td>8 (47.1)</td>
<td>8 (47.1)</td>
<td>—</td>
<td>1 (5.9)</td>
</tr>
<tr>
<td>C</td>
<td>72</td>
<td>19 (26.4)</td>
<td>42 (58.3)</td>
<td>5 (6.9)</td>
<td>6 (8.3)</td>
</tr>
<tr>
<td>G</td>
<td>13</td>
<td>—</td>
<td>9 (69.2)</td>
<td>2 (15.4)</td>
<td>2 (15.4)</td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td>28 (26.7)</td>
<td>60 (57.1)</td>
<td>8 (7.6)</td>
<td>9 (8.6)</td>
</tr>
</tbody>
</table>

*According to Symon et al. and Wilson.
than bitemporal upper quadrantanopsia according to the DOG system, as well as patients with impaired macular vision according to the VFSS, the transcranial procedure was superior to the trans-sphenoidal approach in terms of restoring visual function. This difference, however, was not statistically significant, perhaps because of the large difference in the numbers of patients in the studies compared. It must be noted, however, that our results may have been confounded by the facts that there was no single neurosurgeon specifically treating pituitary adenomas at our institution, and that technical errors occurred in some cases prior to the mastery of the then-new technique of microsurgery, resulting in damage of the optic nerve by mechanical compression or by the monopolar coagulator.

Transcranial surgery is reportedly superior to trans-sphenoidal surgery in selected cases, for several reasons. First, it is not possible to foresee, in case of pituitary adenoma with suprasellar extension, whether or not the sellar diaphragm can be lowered during trans-sphenoidal surgery. Second, as a pituitary adenoma with suprasellar extension often invades the parasellar regions, some cranial nerves and vessels around the tumor can become displaced. Finally, in cases of tumors with suprasellar extension, preoperative neuroradiological studies often have failed to differentiate between pituitary adenoma and other sellar or parasellar tumors, such as craniopharygioma, meningioma, chordoma, and osteochondroma at the base of the skull. With this in mind, it would appear that in cases of large pituitary adenomas with suprasellar extension, intracapsular removal of the adenoma with good visibility of the surrounding brain, nerves, and blood vessels is not only safe but also required to decompress the optic nerve and chiasm.

Trans-sphenoidal surgery appears to be indicated in cases of pituitary adenomas located within the sella, those extending into the sphenoid sinus, and those with no parasellar extension but with mild suprasellar extension, and for emergency decompression in the event of pituitary hemorrhage and nearly all adenomas in elderly patients. In such cases, we have performed either trans-sphenoidal surgery or trans-sphenoidal combined with transcranial surgery. The indications for trans-sphenoidal surgery have recently been broadened to include various types of pituitary adenomas, but our results confirm that transcranial surgery is the procedure of choice in many cases of pituitary adenoma accompanied by visual disturbance.

We found only two reports on trans-sphenoidal surgery for pituitary adenoma with which we could compare our results of transcranial surgery on the basis of ophthalmological data. Postoperative recovery of visual function should be assessed in a consistent fashion in all institutions, and comparative studies carried out. It is to be hoped that neuro-ophthalmologists will develop a new means of evaluating visual function so that certain types of deficits, such as the impairment of macular vision, can be clearly expressed, whether quantitatively or descriptively.

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References


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