Endoscopic, endonasal, trans-sphenoidal hypophysectomy: retrospective analysis of 171 procedures

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Abstract

Introduction: Endoscopic, transnasal management of pituitary gland neoplasms is a widely accepted alternative to the traditional microscopic approach. This study aimed to determine outcomes and complication rates for the largest UK series of endoscopic, trans-sphenoidal hypophysectomies reported to date.

Methods: We performed a retrospective analysis of 136 primary resections and 35 revision cases performed at a tertiary referral centre.

Results and analysis: Total tumour resection was confirmed in over 85 per cent of primary and revision cases, with biochemical remission in 60 per cent. The incidence of complications such as epistaxis, sphenoid sinus problems, endocrine insufficiency, visual disturbance, post-operative haemorrhage, cranial nerve injury and mortality was significantly lower, compared with similar series using the microscopic approach.

Conclusion: Despite its steep 'learning curve', our series demonstrates that the endoscopic approach not only allows superior anatomical visualisation and therefore facilitates full oncological resection of tumours, but also reduces the incidence of peri-operative complications.

Key words: Hypophysectomy; Endoscopic Surgical Procedure; Sphenoid Sinus; Complications; Costs

Introduction

Transnasal, endoscopic management of pituitary gland neoplasms is widely accepted as an alternative to the traditional microscopic approach. The first documented trans-sphenoidal hypophysectomy was performed by Schloffer in 1907,[1] using a lateral rhinotomy approach. Other surgeons followed, including Kocher, Hirsch, Chiari and Cushing,[1] the latter using a sublabial, trans-sphenoidal approach. The trans-sphenoidal approach, using an operating microscope, provides direct access to the sella turcica with minimal nasal dissection. Although the endoscope was initially used as an adjunct to the operating microscope, during the 1990s the endoscope began to be used as the sole visualisation tool, as a result of collaboration between neurosurgeons and otolaryngologists.[2–5] Supporters of the endoscopic approach quote superior visualisation, decreased morbidity and reduced in-patient stay as its advantages.[5–7] However, both techniques have their advantages and disadvantages, and a recent systematic review reported similar oncological outcomes and complication rates.[8]

Aims

This paper aims to present our series of endoscopic, endonasal, trans-sphenoidal hypophysectomies performed by a single surgical team over an 18-year period at a tertiary referral centre. This is the largest UK series reported to date. We present our complication rates and compare them to those of other large international series, in order to help determine whether the endoscopic approach with joint surgical input should become the 'gold standard'.

Methods and materials

Operative details

Our standard technique involved a unilateral, endoscopic, endonasal approach to the sella turcica via an anterior sphenoidotomy, with enlargement of the natural sphenoid ostium using powered instrumentation and 0° and 30° rigid endoscopes for visualisation. This was performed as a joint procedure by a consultant otolaryngologist and a consultant neurosurgeon.

Inclusion criteria

We included in the series all patients who underwent an endoscopic, endonasal hypophysectomy for resection of a pituitary neoplasm between June 1990 and May 2008 at the University Hospital North Staffordshire National Health Service (NHS) Trust. The information collated for each patient included demographic data, pathological and operative details, peri-operative complications, and follow-up data.

Pre-operative assessment

All patients were discussed at a multidisciplinary team meeting to ensure suitability for a trans-sphenoidal approach. Large tumours extending lateral to the carotid or above the plane of the optic chiasm were referred to the neurosurgical team for consideration of a transcranial or craniofacial approach. Computed tomography and magnetic resonance imaging scans of the paranasal sinuses were deemed mandatory in all patients undergoing the procedure, in order to demonstrate: (1) bony and soft tissue anatomical variations that may impede the sphenoid sinus ostium; (2) the degree of sphenoid sinus pneumatisation; (3) variations in the attachments of the sphenoidal septae; (4) the size of the sella turcica; (5) the extent of sella turcica erosion; and (6) the degree of tumour extension within the sphenoid sinus.

All patients underwent routine ophthalmic examination, incorporating perimetry, fundoscopy and acuity testing; results were discussed by the multidisciplinary team.

All patients diagnosed with functional adenomas underwent a complete hormonal assay (i.e. haematological and urinary hormonal studies).

Complications

Complications were categorised according to anatomical location and/or system involvement, as described by Cappabianca *et al.*,[5] as follows: (1) nasofacial (i.e. approach complications including epistaxis); (2) sphenoid sinus (i.e. sphenoid sinusitis); (3) sella turcica (i.e. cerebrospinal fluid (CSF) rhinorrhoea); (4) suprasellar (incorporating central nervous system trauma, bacterial meningitis and swelling of residual tumour mass); (5) parasellar (incorporating a variety of complications including cranial nerve injury); and (6) endocrine complications (further categorised into anterior or posterior pituitary insufficiency).

The study opted to omit anaesthetic-related complications such as deep vein thrombosis and pulmonary embolism.

Remission criteria

Remission criteria were defined by our local departmental protocols, which were based on current consensus statements. In the case of functional adenomas, the remission criteria were defined as: (1) suppression of growth hormone levels to less than 2 mU/l subsequent to an oral glucose tolerance test;[9] (2) normalisation of age- and gender-corrected insulin-like growth factor 1 levels;[10] (3) mean growth hormone level of less than 5 mU/l, on a day curve in acromegalic patients;[9] (4) serum prolactin level of less than 400 mU/l;[11] (5) normalisation of gonadal function (i.e. normal fertility in both genders, menses and absence of galactorrhoea in women, and sexual function in men with prolactin-secreting adenomas); and (6) 8 a.m. serum cortisol level of less than 50 nmol/l post-operatively, with normalisation of urinary free cortisol levels in the case of Cushing's disease.[10]

Remission criteria for non-functional adenomas were less rigorous; these were defined by either (1) enhancement of vision (or prevention of further deterioration of visual status), or (2) resolution of any other clinical manifestation documented pre-operatively.

Results and analysis

Patient demographics

We identified a total of 201 procedures, involving 164 patients who underwent endoscopic, endonasal hypophysectomy for pituitary neoplasm resection between June 1990 and May 2008 at the ENT and neurosurgery departments of the University Hospital North Staffordshire NHS Trust. Records were obtained for a total of 171 procedures, involving 136 patients. Ninety-one of the procedures involved female patients and 80 involved male patients. Patients had a mean age of 53.1 years (range, 18.3–83.4 years). Thirty records (28 patients) were excluded due to missing and/or incomplete data.

Pathology

The tumour types and extent of removal for the 171 operative procedures are shown in Table I. One hundred and sixty-four procedures were undertaken with curative intent, while the remaining seven (three primary and four revision) were performed initially for diagnosis (Table II). A total of 136 (79.5 per cent) procedures were primary interventions; the remaining 35 (20.5 per cent) were revision procedures. The latter procedures included patients who underwent primary surgery at either our centre or another UK centre, and who did not achieve satisfactory remission post-operatively. The majority of patients presented with macroadenomas (116 procedures, 67.8 per cent) or microadenomas (32 procedures, 18.7 per cent).

Macroadenomas

Primary excision of functional adenomas. Total resection was achieved in 20 of 22 (90.9 per cent) growth hormone secreting tumours, in all three (100 per cent) adrenocorticotrophic hormone (ACTH) secreting tumours, in the one (100 per cent) thyroid-stimulating hormone secreting tumour, in all three (100 per cent) luteinising hormone and follicle-stimulating hormone

TABLE I
TUMOUR TYPES AND REMOVAL EXTENT*

Tumour		Patients (n)		Removal extent (procs; n)			
				Primary procs†		Revision procs‡	
Type	Size	Male	Female	Total	Sub	Total	Sub
Non-functional adenoma	Macro	41	18	53	9	13	2
	Micro	0	4	3	1	0	0
Prolactin-secreting adenoma	Macro	1	0	2	0	0	0
	Micro	0	4	4	0	0	0
GH-secreting adenoma	Macro	0	6	3	0	2	1
	Micro	1	10	8	1	1	0
ACTH-secreting adenoma	Macro	0	6	3	0	2	1
	Micro	1	10	8	1	1	0
TSH-secreting adenoma	Macro	0	1	1	0	0	0
	Micro	0	0	0	0	0	0
LH/FSH-secreting adenoma	Macro	1	3	3	0	1	0
	Micro	0	0	0	0	0	0
Craniopharyngioma		0	3	2	1	0	0
Rathke's cleft cyst		1	7	5	0	3	0
Meningioma		1	2	1	2	0	0
Other**		1	5	2	1	3	0

*Total of 171 procedures. †n = 136 procedures; ‡n = 35 procedures. **Four cases of recurrent pituitary cyst, one case of malignant skull-based neuroendocrine tumour and one case of malignant pituitary teratoma (note that all remaining tumours were benign unless otherwise stated, for the total 171 procedures). Procs = procedures; Total = total tumour removal; Sub = subtotal tumour removal; Macro = macroadenoma; Micro = microadenoma; GH = growth hormone; ACTH = adrenocorticotrophic hormone; TSH = thyroid-stimulating hormone; LH = luteinising hormone; FSH = follicle-stimulating hormone

secreting tumours, and in both (100 per cent) prolactin-secreting tumours.

Primary excision of non-functional adenomas. Total excision was achieved in 53 of 62 (85.5 per cent) procedures.

Revision procedures for functional adenomas. Total excision was achieved in six of seven (85.7 per cent) growth hormone secreting tumours, in two of three (66.7 per cent) ACTH-secreting tumours, and in the one (100 per cent) luteinising hormone and follicle-stimulating hormone secreting tumour.

Revision procedures for non-functional adenomas. Total excision was achieved in 13 of 15 (86.7 per cent) tumours.

Microadenomas

Primary excision for functional adenomas. Total resection was achieved in 11 of 13 (84.6 per cent) growth

TABLE II
RESULTS OF DIAGNOSTIC PROCEDURES

Proc type	Pt (age (y), sex)	Histology
Primary	18 M	Teratoma
	45 F	GH-secreting macroadenoma
	57 M	Non-functional macroadenoma
Revision	48 F	Recurrent Rathke's cleft cyst
	33 F	Recurrent Rathke's cleft cyst
	56 F	Meningioma
	61 F	GH-secreting microadenoma

Proc = procedure; Pt = patient; y = years; M = male; F = female; GH = growth hormone

hormone secreting tumours, in eight of nine (88.9 per cent) ACTH-secreting tumours, and in all four (100 per cent) prolactin-secreting tumours.

Primary excision for non-functional adenomas. Total excision was achieved in three of four (75 per cent) tumours.

Revision procedures for functional adenomas. Total excision was achieved in the one (100 per cent) growth hormone secreting tumour and in the one (100 per cent) ACTH-secreting tumour.

There were no instances of non-functional microadenomas that required a revision procedure.

Other

The remaining tumours comprised Rathke's cleft cysts (n = 8, 4.7 per cent), meningiomas (n = 3, 1.8 per cent), craniopharyngiomas (n = 3, 1.8 per cent) and six other pituitary lesions (3.5 per cent) (including an isolated pituitary teratoma, a recurrent pituitary cyst and a skull-based neuroendocrine tumour).

Of those non-adenoma tumours undergoing primary procedures, total resection was achieved in two of three (66.7 per cent) craniopharyngiomas, all five (100 per cent) Rathke's cleft cysts, one of four (25 per cent) meningiomas and two of three (66.7 per cent) other lesions (including a recurrent pituitary cyst and a skull-based neuroendocrine tumour).

A total of three procedures (primary and revision) were abandoned, all due to serious intra-operative arterial or venous bleeding.

Of those non-adenoma tumours undergoing revision procedures, total resection was demonstrated in all

TABLE III
COMPLICATIONS OF PRIMARY AND REVISION PROCEDURES

Complication		Procs involved (*n* (% for each proc type))	
Category	Clinical entity	Primary procs	Revision procs
Nasofacial	Epistaxis	1 (0.7)	0
Sphenoid sinus	Sphenoid sinusitis	2 (1.5)	1 (2.9)
Sella turcica	CSF rhinorrhoea	13 (9.6)	6 (17.1)
Suprasellar	Tumour swelling	0	0
	Bacterial meningitis	0	3 (8.6)
Parasellar	Carotid injury	0	0
	Pseudoaneurysm	0	0
	CN or visual deficit	4 (2.9)	0
Endocrine	Post insufficiency	30 (22.1)	5 (14.3)
	Ant insufficiency	10 (7.4)	5 (14.3)
Mortality		0	0

Procs = procedures; CSF = cerebrospinal fluid; CN = cranial nerve; Post = posterior pituitary; Ant = anterior pituitary

three (100 per cent) Rathke's cleft cysts and all three (100 per cent) other pituitary lesions.

Complications

Table III shows data on complications in the present study, while Table IV compares these data with those from two previous studies.

Nasofacial complications. There was one (0.73 per cent) documented case of epistaxis from our cohort of primary procedures, requiring operative intervention.

Sphenoid sinus complications. There were two documented cases (1.5 per cent) of chronic sphenoid sinusitis in our cohort of 136 primary procedures, and one case amongst our 35 revision procedures (2.9 per cent). All episodes were documented within the immediate post-discharge period, and resolved completely following medical intervention.

Sella turcica complications. There were 19 instances of CSF leakage amongst our total 171 procedures (11.1 per cent). Of these 19 episodes, 13 occurred amongst our 136 primary procedures (9.6 per cent), and the remaining six (17.1 per cent) amongst our 35 revision procedures. Amongst the total 171 procedures, there were three cases (1.75 per cent) of major CSF leakage requiring surgical intervention. There were no cases of subarachnoid haemorrhage.

Suprasellar complications. In our primary procedure cohort, there were two documented cases of visual disturbance. All of the three documented cases of bacterial meningitis were found in the revision procedure cohort (three of 35, 8.6 per cent). All cases had an uneventful recovery, with no sustained neurological deficit.

Parasellar complications. This type of complication was only documented in our primary procedure cohort, with a total of four cases (2.9 per cent of 136 procedures).

TABLE IV
POST-OPERATIVE COMPLICATION RATES IN PRESENT AND TWO PREVIOUS STUDIES

Complication	Ciric *et al.*[12]*; surgeon's previous procs (*n*)				Cappabianca *et al.*[5]†	Present study‡
	<200	200–500	>500	Mean		
Septal perforation	7.6	4.6	3.3	6.7	0.00	0.00
Epistaxis	4.3	1.7	0.4	3.4	1.36	1.09
Sinusitis	9.6	6.0	3.6	8.5	2.05	1.63
Carotid artery injury	1.4	0.6	0.4	1.1	0.68	0.0
CNS injury	1.6	0.9	0.6	1.3	0.68	0.0
Haemorrhage or residual tumour swelling	2.8	4.0	0.8	2.9	0.68	0.0
Loss of vision	2.4	0.8	0.5	1.8	0.00	0.00
Ophthalmoplegia	1.9	0.8	0.4	1.4	0.68	2.19
CSF leak	4.2	2.8	1.5	3.9	2.05	10.44 (1.65)**
Meningitis	1.9	0.8	0.5	1.5	0.68	1.63
Ant pituitary insufficiency	20.6	14.9	7.2	19.4	13.6	5.98
Post pituitary insufficiency	19.0	0.0	7.6	17.8	3.42	16.85
Mortality	1.2	0.6	0.2	0.9	0.68	0.00

Data represent the percentage of procedures which involved a complication. *Microsurgical approach. †Endoscopic, endonasal approach; *n* = 146 procedures. ‡*n* = 171 procedures. **Percentage of procedures involving major CSF leak requiring operative intervention. Procs = procedures; CNS = central nervous system; CSF = cerebrospinal fluid; Ant = anterior; Post = posterior

There was one case of a permanent IIIrd and VIth cranial nerve palsy. The remaining three patients had transient post-operative symptoms, including a IIIrd cranial nerve palsy, horizontal diplopia, and partial ptosis with a reduced light reflex. All resolved in the immediate post-operative period.

Endocrine complications. Cases of both posterior and anterior insufficiency were encountered. Regarding posterior insufficiency, 30 cases of cranial diabetes insipidus were documented amongst our 136 primary procedures (22.1 per cent), and five cases amongst our 35 revision procedures (14.3 per cent). Four patients subsequently required life-long desmopressin therapy (all due to primary procedures). New onset anterior pituitary insufficiency was seen in a total of 15 cases from the total 171 procedures (8.8 per cent), demonstrated during routine six-week post-operative endocrine evaluation. Of these 15 documented cases, 10 were found amongst our 136 primary procedures (7.4 per cent), of which four had dual axis deficiency and six had single axis deficiency. Five of the total 15 documented cases were found amongst our 35 revision procedures (14.3 per cent), of which three had dual axis deficiency and two had single axis deficiency.

Mortality. There were no documented cases of intra- or post-operative mortality in our series.

Other complications. There was a single case of ethmoid mucocele in the primary procedure cohort, which required subsequent operative intervention.

Remission

Total tumour removal was possible in 117 of the 136 primary procedures (86.0 per cent) and in 30 of the 35 revision salvage procedures (85.7 per cent). After excluding exploratory procedures, complete biochemical remission (with control of all pre-operative symptoms and absence of any post-operative complication) was seen for 80 of 133 primary procedures (60 per cent) and eight of 31 salvage procedures (25.8 per cent).

Twenty-two patients underwent further management of their tumours (Table V).

'Learning curve'

We compared the complication rate of the first and second halves of the primary procedure cohort to determine whether there was evidence of a 'learning curve' (Table VI). Of the 136 primary procedures conducted, the first 68 were performed between March 1991 and January 2001 whilst the second 68 were performed between February 2001 and May 2008. Comparison of these two subgroups indicated that, although the incidence of endocrine insufficiency increased in the later subgroup, the total number of CSF leaks

TABLE V				
MANAGEMENT OF PATIENTS WITH UNSUCCESSFUL PRIMARY PROCEDURE				
Tumour size or type (hormone secrn)	Pt (age (y), sex)	Tumour site	Tumour removal	Total EETS (*n*)
*Bilat adrenalectomy pts**				
Micro	25.51 F	S	Total	2
Macro	33.31 F	PS	Subtotal	3[†]
Macro	47.79 F	SS, PS	Total	2
Micro	66.52 F	S	Total	1
Micro	52.21 M	S	Total	1
External beam RT pts				
Macro (NF)	48.62 F	SS, PS	Total	2
Macro (NF)	56.92 M	S, SS, Ant	Subtotal	1
Macro (NF)	68.80 M	S, SS, Ant	Total	3
Macro (NF)	80.26 M	SS, PS, Ant	Total	2
Macro (GH)	20.49 M	SS, PS	Total	1
Macro (GH)	40.53 F	SS, PS	Total	2
Macro (GH)	47.93 F	PS	Total	1
Micro (GH)	59.76 M	S	Subtotal	1
Micro (GH)	66.51 M	SS, Ant	Total	2
Macro (ACTH)	64.13 F	SS, PS	Subtotal	2
Meningioma	72.25 F	S, SS, Ant	Subtotal	1
Other[‡]	41.91 F	SS, PS, Ant, Post	Subtotal	0
γ knife surgery pts				
Macro (NF)	39.35 M	SS, PS	Subtotal	1
Macro (GH)	38.77 M	SS, PS	Total	1
Macro (GH)	45.39 F	SS, PS	Abandoned	3
Macro (GH)	46.20 M	SS, PS	Total	1
Macro (ACTH)	33.75 F	PS, S	Total	2

*All adrenocorticotrophic hormone (ACTH) secreting tumours. [†]Third attempt due to development of Nelson's syndrome. [‡]Skull-based neuroendocrine tumour invading sphenoid, ethmoid and parasellar structures. Secrn = secretion; Pt = patient; y = years; EETS = endoscopic, endonasal, trans-sphenoidal surgery attempts; Bilat = bilateral; Micro = microadenoma; Macro = macroadenoma; F = female; M = male; S = sellar; PS = parasellar; SS = suprasellar; Ant = anterior pituitary; Post = posterior pituitary; RT = radiotherapy; NF = non-functional; GH = growth hormone

TABLE VI			
COMPLICATIONS IN FIRST AND SECOND PRIMARY PROCEDURE COHORTS			
Complication		Cohort (procs with compln; n)	
Category	Clinical entity	1st*	2nd†
Nasofacial	Epistaxis	1	0
Sphenoid sinus	Sphenoid sinusitis	0	1
Sella turcica	CSF rhinorrhoea	9	3
Suprasella	Residual tumour swelling	1	0
	Bacterial meningitis	0	0
	Visual complications	2	0
Parasella	Carotid artery injury	0	0
	Pseudoaneurysm	0	0
	Cranial nerve injury	0	2
Endocrine	Post pituitary insufficiency	12	17
	Ant pituitary insufficiency	4	7
Mortality		0	0
None‡		22	27

Procedures: *$n = 68$; †$n = 68$. ‡No complications and full remission. Procs with compln = procedures with complication; CSF = cerebrospinal fluid; Post = posterior; Ant = anterior

reduced and the number of procedures with no complications and full remission increased significantly.

Discussion

The aim of any oncological surgical resection is to balance cosmesis, invasiveness and functional disability with the lowest possible relapse and complication rates, whilst achieving full oncological resection. Technological developments have increased the surgeon's chances of achieving this goal for pituitary tumour surgery. A fully endoscopic approach to the pituitary was proposed by Jankowski et al.[2] in 1992, and since then the popularity of endonasal, endoscopic pituitary surgery has grown rapidly.[2,3,13,14]

The key benefits of the endoscopic technique are: (1) reduced operating time; (2) superior visualisation of the surgical field, normal anatomical structures and the tissue–tumour interface; and hence (3) an increased likelihood of total tumour resection. Using the endoscope also preserves the normal structure of the nasal cavity.

However, this approach still remains controversial, with no single study being able to conclusively demonstrate the superiority of the endoscopic approach over the traditional microscopic approach. Supporters of the microscopic approach cite its stereoscopic view and use of less specialised, cheaper equipment as advantages.

A systematic review of the literature comparing microscopic versus endoscopic pituitary surgery outcomes identified over 3500 studies, only 11 of which met the search criteria. The conclusions of these 11 studies favoured endoscopic surgery, on the basis of favourable operating time, length of hospital stay and post-operative discomfort; however, major outcome criteria (including extent of tumour resection and changes in hormone levels) did not differ significantly.

As the controversy continues, we believe that our series of transnasal, endoscopic hypophysectomies (the largest to date in the UK, and with ongoing data collection), in combination with evidence from the current world literature, will help determine which technique should be adopted as the gold standard.

Trans-sphenoidal surgery has consistently been proven to be safe and effective if performed by experienced surgeons, with a relative mortality rate of less than 1 per cent. However, its relative morbidity remains significant, as demonstrated by Ciric et al.[12] and Cappabianca et al.[5] Although it is impossible to eliminate post-operative complications completely, our findings demonstrate that the incidence of complications can be reduced with more surgical experience and a joint approach involving both neurosurgeons and otolaryngologists.

Complications

Mortality. In contrast to our own results, which included not a single documented case of post-operative mortality (Table III), the microsurgical series presented by Ciric et al.[12] had a mortality rate of 1.2 per cent, with a comparable patient population (i.e. less than 200). Cappabianca et al.[5] used an identical approach, and reported a mortality rate of just 0.68 per cent in a patient population of 146, a value still considerably below the acknowledged average of 1 per cent. More recently, Zhang et al.[15] reported a mortality rate of 0.15 per cent in a population of 678 patients.

Sphenoid sinus complications. Although this category incorporates a variety of potential complications (including mucoceles and sphenoid body fractures), we only encountered chronic sinusitis. All these patients were symptomatic and presented with frontal headaches and mucopurulent discharge. All cases were commenced on medical therapy, and complete resolution of symptoms ensued. Our relatively low incidence of 2 per cent is less than that documented for the microscopic approach.[3,12] This can be attributed to the improved access to the sphenoid ostium region made possible when a trans-sphenoidal retractor is not required.

Sella turcica complications. Our incidence of CSF leaks (10.4 per cent; Table VI) appears excessive in comparison with other studies;[15] however, this value incorporated all post-operative CSF leaks, whether isolated, intermittent or major. The incidence of major CSF leaks requiring surgical intervention was 1.63 per cent, significantly lower than rates for other studies.[15] Further details of the management of these CSF leaks have been published elsewhere.[16]

Suprasellar and parasellar complications. A significant proportion of our study complications were suprasellar or parasellar in origin. The anatomical location and pathophysiology of these complications resulted in

prevalence rates similar to those encountered when using the traditional surgical approach. There were three cases of bacterial meningitis with septicaemic presentation, all of which resolved without sustained neurological deficit. The remaining documented complications were ophthalmic in origin: two cases of IIIrd cranial nerve palsy, one case of VIth cranial nerve palsy, and one case of combined IIIrd and VIth cranial nerve palsy. Ciric *et al.*[12] found an increased incidence of suprasellar and parasellar complications following procedures done by neurosurgeons who had performed less than 500 such procedures; our study results support this finding. Such comparisons between studies do not take into account differing tumour anatomy, and it is evident that integration of this variable would enable more accurate comparison of complication rates. For example, macroadenomas with significant parasellar extension have more frequent cranial nerve complications, compared with microadenomas.[12]

Endocrine complications. These types of complications are almost universal, given the almost inevitable intra-operative disruption of blood flow due to rigorous tumour resection. Despite this high incidence, our series clearly demonstrates reduced post-operative rates of both posterior and anterior pituitary insufficiency, compared with larger series utilising microscopic surgery.

- **Endoscopic, endonasal surgery is an alternative to microscopic surgery for pituitary neoplasms**
- **The best surgical approach has not been established**
- **This retrospective analysis of 171 endoscopic procedures found complete tumour resection in 86 per cent**
- **Ten of 13 commonly recorded complications were less frequent, compared with microscopic surgery series**
- **Operating time, in-patient stay and costs were reduced**
- **This evidence supports adoption of the endoscopic approach as the 'gold standard'**

Revision surgery and remission rates

Despite the high incidence of complete tumour removal in both primary and revision (salvage) procedures, there were still a number of patients who failed to achieve full biochemical and symptomatic control post-operatively. Our figures in this respect are in line with those of other studies,[15] and may be explained by the significant number of patients who were referred for exploratory and debulking surgery. In many of these

patients, the significant degree of tumour extension may have reduced the potential for total abolition of all biochemical abnormalities and symptoms, without risking significant peri-operative complications. In cases such as these, it is difficult to define success in terms of full biochemical and symptomatic remission; however, only 22 patients required further tumour management, in the form of radiotherapy, adrenalectomy or gamma knife surgery.

Limitations and learning curve

The main limitation of the endoscope is the reduced depth perception in the visual field, due to the two-dimensional images generated. Previous problems with diminished clarity and resolution, due to image degradation, have now been overcome with the use of digital chip cameras.

As with any new operative procedure, training in endoscopic, endonasal, trans-sphenoidal hypophysectomy involves a steep learning curve while the operating surgeon acquires the necessary skills, and this may cause an initial, transient rise in the incidence of peri-operative complications. We compared the complication rates of earlier and later primary procedure cases in order to determine whether a surgical learning curve was apparent in our data. (Revision cases were excluded from this analysis, as we felt that the complication rate of these cases was affected by the surgical complexity and was not due solely to the surgeon's technical skill.) The most notable difference between our earlier and later primary procedure cases was an increase in the incidence of endocrine insufficiency. However, more positively, the number of CSF leaks reduced and the number of patients who enjoyed full biochemical remission without surgical complications increased. These differences may have been due to improved surgical skills over time, improved visualisation in later years with the use of image guidance systems, and a more aggressive surgical approach as surgeons became more adept at the procedure. It would thus be reasonable to anticipate that, in the future, our incidence of complications will diminish further as we approach the 500-procedure threshold described in the Ciric microscopic approach series.[12]

Conclusion

Although we present a relatively modest series compared with the significant numbers evaluated in the USA and China, the results of our growing UK cohort demonstrate the superiority of the endoscopic, transnasal, trans-sphenoidal hypophysectomy technique compared with its microscopic surgery predecessor. Not only does our study demonstrate a reduction in complication rates for 10 of 13 post-operative complication categories, compared with previous data for the microscopic approach, but our results are in line with, and in some categories superior to, other studies using an identical approach.[5,12] These results, combined with the advantages of reduced post-

operative discomfort, in-patient stay and cost, will add weight to the argument that the endoscopic approach to the pituitary should become the preferred technique.

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