

Review Article

Endoscopic Endonasal Approach to Craniopharyngioma: Extent of Resection and Endocrine Outcomes

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Abstract

Background: Craniopharyngiomas are rare, benign but locally aggressive sellar tumours, and the endoscopic endonasal approach has become a major alternative to transcranial surgery.

Objective: To review published series, comparative cohorts and meta-analyses on extent of resection and endocrine outcome after endoscopic endonasal craniopharyngioma resection.

Methods: Narrative review of case series, classification schemes, comparative cohorts, and systematic reviews and meta-analyses of endoscopic versus transcranial resection.

Findings: Pooled series report gross-total resection in two-thirds to over four-fifths of cases. Meta-analyses show higher resection rates and better vision endoscopically, at the cost of more cerebrospinal fluid leaks, which fall toward zero with nasoseptal flap reconstruction. Diabetes insipidus and panhypopituitarism remain common after stalk sacrifice; hypothalamic involvement, more than approach, predicts obesity and cognitive decline.

Conclusions: Endoscopic endonasal surgery gives favourable resection and visual outcomes but needs individualised, hypothalamus-sparing strategies to limit endocrine and metabolic morbidity.

Keywords: Craniopharyngioma; Endoscopic endonasal approach; Gross-total resection; Hypothalamic obesity; Panhypopituitarism

Abstract

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Keywords: craniopharyngioma; endoscopic endonasal approach; gross-total resection; hypothalamic obesity; panhypopituitarism

Introduction

Craniopharyngiomas are rare epithelial tumours of the sellar and suprasellar region, arising from remnants of Rathke's pouch, with an estimated incidence of roughly 0.5 to 2 cases per million person-years and a bimodal age distribution spanning childhood and late adulthood [1]. Although histologically benign, their adherence to the optic apparatus, pituitary stalk, hypothalamus and adjacent vasculature makes them among the most challenging lesions in skull base surgery. For decades,

transcranial microsurgical approaches were the standard of care, but since the early 2000s the expanded endoscopic endonasal approach has offered a ventral, midline corridor that avoids brain retraction and provides direct visualisation of the undersurface of the optic chiasm, infundibulum and third ventricular floor [2].

Two distinct histological subtypes are recognised — adamantinomatous, which predominates in children and shows a bimodal peak in older adults, and papillary, seen almost exclusively in adults — and both, despite their World Health Organization grade I designation, behave clinically as chronic, recurrence-prone diseases that can require multiple operations, radiotherapy, and lifelong endocrine surveillance [1]. This chronicity is central to why extent of resection cannot be considered in isolation from functional outcome: a strategy that maximises tumour clearance at the first operation but destroys hypothalamic or pituitary structures may trade a modest oncological gain for decades of metabolic, cognitive and quality-of-life burden.

This is a narrative review of the published literature, not a report of the authors' own operative series, synthesising case series, classification schemes, comparative cohort studies and meta-analyses that address two questions central to modern practice: how completely can craniopharyngiomas be removed through an endonasal corridor, and at what cost to endocrine, visual and hypothalamic function. Paediatric and adult series are considered together where their conclusions converge, and separately where age-specific differences are reported.

Endoscopic Technique and Classification Systems

The modern expanded endonasal approach removes the tuberculum sellae and planum sphenoidale to expose the suprasellar cistern directly, rather than working around the pituitary gland as in a standard transsphenoidal

operation [2]. Kassam and colleagues proposed a classification based on the relationship between the tumour and the infundibulum: Type I (preinfundibular) tumours displace the stalk posteriorly and often permit stalk preservation; Type II (transinfundibular) tumours engulf the stalk, usually requiring its sacrifice for complete removal; and Type III (retroinfundibular) tumours extend behind the stalk into the third ventricle or interpeduncular cistern, the most technically demanding group [2]. This scheme remains widely used to plan the operative corridor and to counsel patients about the likelihood of stalk preservation.

Table 1: Anatomical and hypothalamic-involvement classification systems used to plan endoscopic endonasal resection of craniopharyngioma [2,3].			
System (source)	Category	Definition	Surgical/prognostic implication
Kassam 2008	Type I, preinfundibular	Tumour displaces stalk posteriorly	Stalk preservation often possible
Kassam 2008	Type II, transinfundibular	Tumour engulfs the stalk	Stalk sacrifice usually required for GTR
Kassam 2008	Type III, retroinfundibular	Extension behind stalk into third ventricle	Most technically demanding group
Puget 2007	Grade 0/1	No involvement / abutment-displacement	Lower risk of hypothalamic morbidity
Puget 2007	Grade 2	Frank hypothalamic invasion	High risk of obesity, cognitive and QoL morbidity

Complementing this anatomical classification, Puget and colleagues introduced a grading system based on the degree of hypothalamic involvement seen on preoperative imaging: grade 0 (no involvement), grade 1 (abutment or displacement), and grade 2 (frank invasion of the hypothalamus) [3]. Grade 2 involvement predicts a substantially higher risk of postoperative hypothalamic morbidity regardless of the surgical corridor chosen, and has increasingly been used to temper the pursuit of gross-total resection (GTR) in favour of planned subtotal

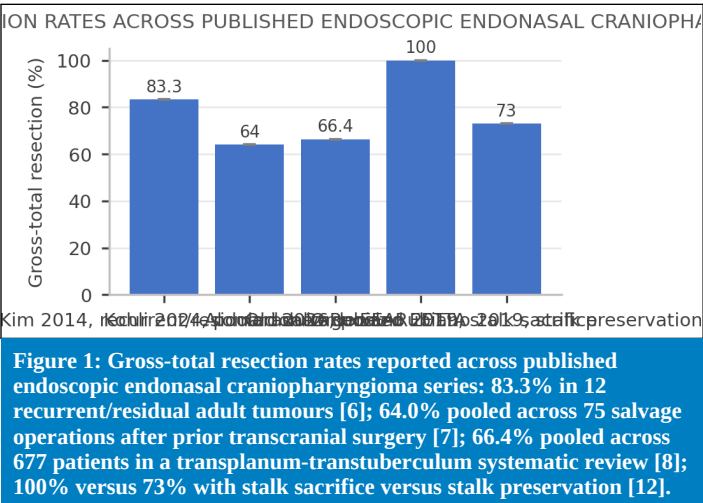
resection with adjuvant therapy [3].

Extent of Resection: Endoscopic versus Transcranial Approaches

Single-institution endoscopic series report GTR in a substantial majority of primary tumours. In a 64-patient Pittsburgh cohort, near-total or gross-total removal was achieved in most cases, with resection rates lower for larger, more invasive or previously operated tumours [4]. Extended EEA techniques developed specifically for residual or recurrent disease were among the earliest to demonstrate that a purely endonasal reoperation could achieve meaningful further resection without a craniotomy [5]. In smaller reoperative series, extended EEA achieved GTR in 10 of 12 adults with recurrent or residual disease (83.3%) [6], while a pooled systematic review of 75 endonasal salvage operations after prior transcranial surgery reported GTR in 64.0%, subtotal resection in 32.0%, and partial resection in 4.0%, with overall recurrence of 17.5% falling to 10.0% after GTR [7]. A broader systematic review of the transplanum-transtuberculum variant across 51 studies and 677 patients found pooled GTR of 66.4% [8].

Table 2: Selected published series and meta-analyses of endoscopic endonasal resection of craniopharyngioma reviewed here [4,6,7,8,9,10,11,12].				
Study (year)	Design	N	GTR	Key comparative finding
Koutourousiou 2013	Single-institution series	64	Majority	Lower GTR with larger, invasive or reoperated tumours
Kim 2014	Recurrent/residual adult series	12	83.3%	Extended EEA effective at reoperation
Kohli 2024	Systematic review, salvage EEA	75	64.0%	Recurrence 17.5% overall, 10.0% after GTR
Alomari 2026	Systematic review, EETTA	677	66.4%	Visual improvement ~80%; CSF leak 9.2%
Na 2022	Meta-analysis, EEA vs TCA	Multiple	Higher with EEA	Lower recurrence with EEA

Study (year)	Design	N	GTR	Key comparative finding
Figueredo 2023	10-yr meta-analysis, EEA vs TCA	Multiple	Higher with EEA	Confirms Na 2022 direction of effect
Li 2024	Meta-analysis, 11 studies	12,212	Higher (paediatric)	Improved adult mortality; higher CSF leak with EEA
Ordóñez-Rubiano 2019	Stalk preservation vs sacrifice	Not stated	100% vs 73%	Permanent DI 95% vs ~49%



Comparative meta-analyses generally favour EEA for extent of resection. A meta-analysis of comparative studies found endoscopic surgery associated with higher rates of GTR and lower recurrence than transcranial surgery [9], a conclusion echoed by a ten-year systematic review and meta-analysis directly contrasting the two approaches [10]. A pooled analysis of eleven studies and over 12,000 patients similarly found that EEA achieved higher GTR in paediatric patients and improved mortality in adults, although at the cost of a significantly higher cerebrospinal fluid (CSF) leak rate across all age groups [11]. Extent of resection is not purely a function of approach, however: when the pituitary stalk is deliberately sacrificed, GTR can approach 100%, compared with roughly 73% when the stalk is preserved, illustrating the direct trade-off between resection completeness and endocrine preservation [12].

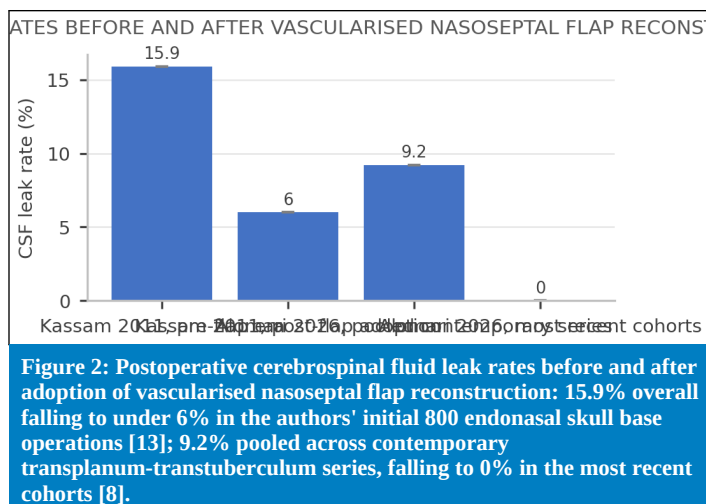
CSF Leak and Skull Base Reconstruction

The wide ventral skull base defect created by an expanded endonasal approach carries an intrinsic risk of postoperative CSF leak and meningitis. In an early series of 800 endonasal skull base operations, the overall CSF leak rate was 15.9%, falling to under 6% after adoption of vascularised tissue reconstruction, alongside a 30-day mortality of 0.9% and permanent neurological morbidity of 1.8% [13]. The vascular pedicle nasoseptal flap, harvested from the septal mucosa on the posterior septal artery, was described specifically to reconstruct these large defects and rapidly became the standard reconstructive technique for expanded endonasal approaches [14]. Contemporary series employing modern vascularised reconstruction report pooled CSF leak rates around 9.2%, falling to 0% in the most recent cohorts [8], though meta-analyses comparing approaches still find CSF leak significantly more common after EEA than after transcranial surgery, underscoring reconstruction technique as a continuing focus of technical refinement [11].

Endocrine Outcomes

Diabetes insipidus (DI) and anterior pituitary hormone deficiency are the most consistent postoperative morbidities after craniopharyngioma resection, whichever approach is used. In a direct comparison of stalk-preserving and stalk-sacrificing endonasal resections, permanent DI occurred in roughly 95% of patients after stalk sacrifice compared with approximately 49% after preservation, at the cost of a lower GTR rate with preservation [12]. In a paediatric endonasal series using a binostril technique, GTR was achieved in all seven children, but all seven also developed postoperative DI and panhypopituitarism, with one CSF leak [15]. A systematic review and meta-analysis focused specifically on endocrine outcome found that the endoscopic approach improved surgical and endocrine outcomes

relative to historical transcranial cohorts in primary resection [11], while an earlier meta-analysis comparing endocrine outcomes between the two approaches found the endocrine morbidity of endonasal surgery broadly comparable to that of transcranial surgery once case mix was accounted for [16]. Reoperation for residual or recurrent tumour through an endonasal corridor is feasible and can achieve further resection, though at continued risk to residual pituitary function [17]. Taken together, these series suggest that the endocrine cost of surgery is driven less by the corridor chosen than by whether the stalk and hypothalamic attachments are deliberately sacrificed to chase a marginal gain in resection completeness, reinforcing the case for individualised, image-guided operative planning rather than a fixed policy of maximal resection.



Hypothalamic Involvement, Obesity and Quality of Life

Long-term morbidity after craniopharyngioma resection is driven at least as much by hypothalamic injury as by endocrine replacement needs. Puget's grading system demonstrated that grade 2 hypothalamic involvement predicts substantially worse postoperative hypothalamic morbidity, independent of surgical corridor [3]. In a paediatric cohort, hypothalamus-sparing surgery was

associated with a markedly decreased risk of severe obesity compared with aggressive resection that damaged the hypothalamus, supporting a shift toward planned subtotal resection with adjuvant radiotherapy when hypothalamic invasion is present [18]. Beyond weight gain, hypothalamic involvement in childhood-onset craniopharyngioma predicts long-term cognitive performance and psychosocial health in adult survivors, with impairment persisting decades after surgery despite comprehensive hormone replacement [19]. These findings collectively argue that the choice between maximal resection and hypothalamus-sparing subtotal resection with radiotherapy should be individualised according to preoperative hypothalamic involvement rather than pursued uniformly through any single surgical corridor.

Visual Outcomes

Because craniopharyngiomas typically abut or compress the optic chiasm and nerves, visual outcome is a key measure of surgical success. In a dedicated analysis of visual outcomes after EEA, the majority of patients with preoperative visual deficits improved after decompression, with direct chiasmal visualisation cited as an advantage of the ventral endonasal trajectory over lateral transcranial approaches [20]. Pooled data across the broader transplanum-transtuberculum literature likewise report visual improvement in approximately four-fifths of patients [8], and even in the more difficult salvage setting after prior transcranial surgery, vision improved in 60% of reoperated patients [7]. Meta-analyses comparing approaches have generally found visual outcomes to be at least as favourable with EEA as with transcranial surgery, consistent with the direct, unobstructed view of the undersurface of the chiasm afforded by the endonasal corridor [9,10].

Paediatric versus Adult Series

Paediatric craniopharyngiomas are managed with the

same anatomical principles as adult tumours but carry distinct considerations: growth and pubertal development, long expected survival over which hypothalamic obesity and cognitive morbidity accumulate, and technical constraints related to nasal cavity size in young children. Case series of transsphenoidal and endonasal resection in children report high rates of GTR, comparable to adult cohorts, but with correspondingly high rates of postoperative DI and panhypopituitarism [21,15,22], echoing an earlier cohort of 36 children in which endocrine sequelae including growth hormone deficiency, DI and disordered puberty were near-universal at presentation and after treatment regardless of surgical technique [23]. A systematic review and meta-analysis of endonasal endoscopic surgery for paediatric sellar and suprasellar lesions found favourable resection rates and an acceptable complication profile across pooled paediatric series [24], and a further systematic review focused specifically on paediatric craniopharyngioma corroborated these findings while highlighting substantial heterogeneity in outcome reporting across studies [25]. Notably, a systematic review of surgery and radiotherapy for paediatric craniopharyngioma found that subtotal resection combined with radiotherapy achieved 5-year progression-free survival statistically indistinguishable from gross-total resection alone (73% versus 77%), supporting a less aggressive, hypothalamus-sparing strategy in children when adjuvant radiotherapy is available [26].

Conclusion

Across foundational technique papers, single-institution outcome series, paediatric cohorts and comparative meta-analyses, the published literature supports the endoscopic endonasal approach as a highly effective corridor for craniopharyngioma resection, generally matching or exceeding transcranial surgery for extent of

resection and visual outcome. Cerebrospinal fluid leak, historically the approach's principal weakness, has fallen substantially with vascularised nasoseptal flap reconstruction, though it remains more frequent than after transcranial surgery. Diabetes insipidus and panhypopituitarism remain near-universal when the pituitary stalk is sacrificed to achieve maximal resection, and hypothalamic involvement — more than the choice of surgical corridor — is the dominant predictor of long-term obesity, cognitive impairment and quality of life. The recurring theme across this literature is that extent of resection should not be pursued uniformly: anatomical classification by infundibular relationship and grading of hypothalamic involvement together allow an individualised balance between oncological control and preservation of endocrine and hypothalamic function, in both paediatric and adult populations.

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